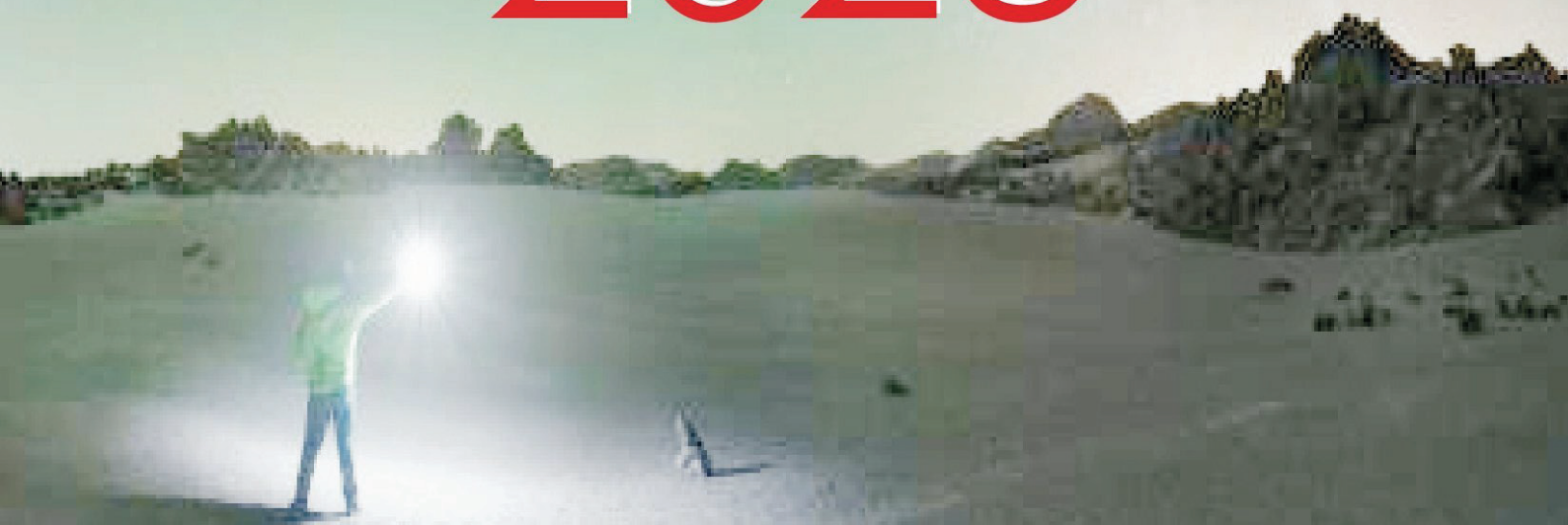
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INDIA METEOROLOGICAL DEPARTMENT
आदित्यात् जायते वृष्टिः

Years of Service to the Nation
राष्ट्र सेवा के 150 वर्ष

वार्षिक प्रतिवेदन
ANNUAL REPORT
2023



भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT
पृथ्वी विज्ञान मंत्रालय, भारत सरकार
Ministry of Earth Sciences, Govt. of India

वार्षिक प्रतिवेदन

ANNUAL REPORT

2023



INDIA METEOROLOGICAL DEPARTMENT

(MINISTRY OF EARTH SCIENCES)

(GOVT. OF INDIA)

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INDIA METEOROLOGICAL DEPARTMENT ORGANIZATION CHART



Shri Kiren Rijiju

Minister of Earth Sciences
Minister of Food Processing Industries



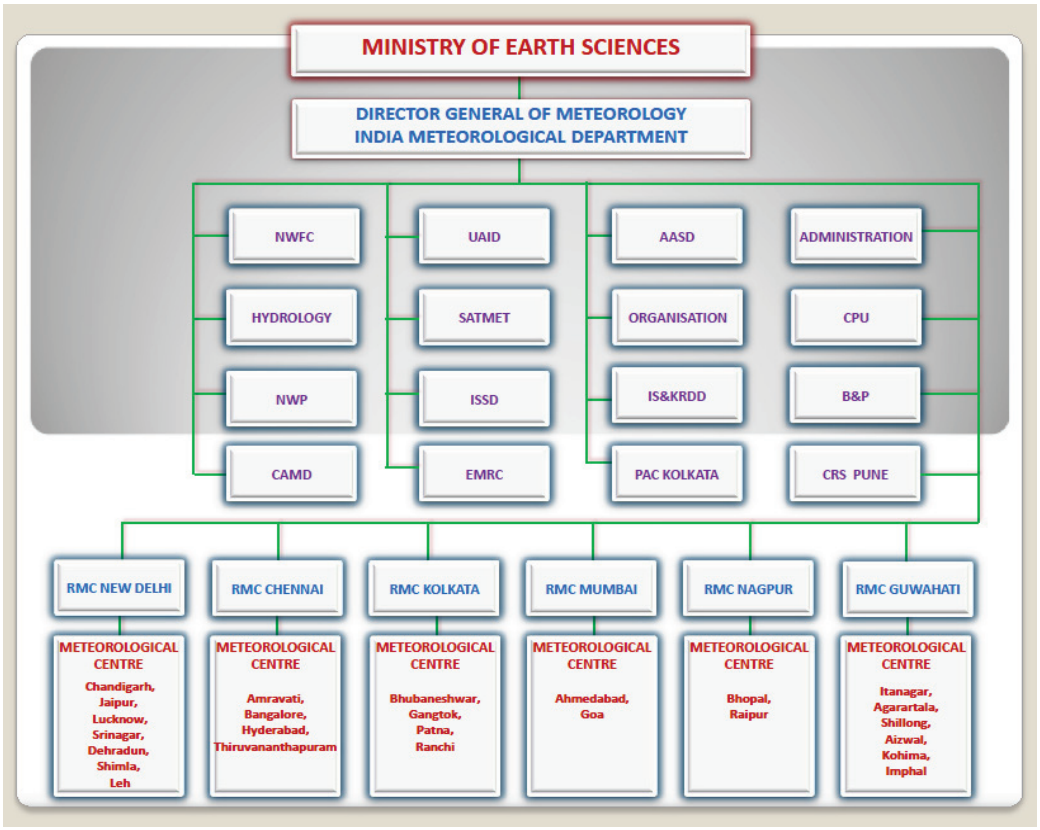
Dr. M. Ravichandran

Secretary
Ministry of Earth Sciences



Dr. Mrutyunjay Mohapatra

Director General of Meteorology
India Meteorological Department



NWFC	:	*National Weather Forecasting Centre*	*AASD*	:	*Agromet Advisory Services Division*
Hydrology	:	*Hydromet Division*	*Organisation*	:	*Organisation*
NWP	:	*Numerical Weather Prediction*	*IS&KRDD*	:	*Information Science & Knowledge Resource Development Division*
CAMD	:	*Central Aviation Meteorological Division*	*PAC Kolkata*	:	*Positional Astronomy Centre, Kolkata*
UAID	:	*Upper Air Instruments Division*	*Administration*	:	*Administration*
SATMET	:	*Satellite Meteorology Division*	*CPU*	:	*Central Purchase Unit*
ISSD	:	*Information Systems and Services Division*	*B&P*	:	*Budget & Planning*
EMRC	:	*Environment Monitoring & Research Centre*	*CRS Pune*	:	*Climate Research & Services, Pune*

FOREWORD

It is a great privilege to present the Annual Report of India Meteorological Department (IMD) for the year 2023. The report highlights significant activities of the department during the year. The department has been playing a leading role in the field of Earth and Atmospheric Sciences by providing eminent services in meteorology and allied fields. The safety are critical for protecting life and property, safeguarding the environment and for efficient management of natural resources for sustainable development.

During 2023, the IMD progressively strode towards modernization of scientific infrastructure in the fields of meteorological observations, information systems and numerical modelling. It helped to render better services in areas of disaster management, agriculture, aviation, shipping, fisheries, energy and transport etc. IMD's services of very short range (up to 6 hrs), short range (up to 3-days in advance), medium range (up to 4-10 days in advance), extended range (up to 4 weeks in advance) and long range (monthly and seasonal) forecast alongwith severe weather (cyclones, thunderstorms, heavy rainfall, heat wave, cold wave, fog, etc.) warnings continuously improved to meet the demands of the user agencies, disaster managers, emergency response groups, stakeholders and general public.

As a part of R&D, IMD encourages through publication of quarterly journal MAUSAM. The international research journal MAUSAM (formerly Indian Journal of Meteorology, Hydrology & Geophysics) has entered into 75th year of its publications and has been made online (https://mausamjournal.imd.gov.in/index.php/MAUSAM) since 2021. Since then the journal has been making its way to advancement in the world of scientific journals reaching the Impact Factor of 0.906 in 2022 as perWeb of Science. All the research articles (since the origin of 'MAUSAM', 1950) have been uploaded on the website with Digital Object Identifiers (DOI's). The scientists in IMD have published 110 research papers in peer reviewed national and International journals during the year 2023.

IMD monitors the climate parameters and provides annual climate statement to the country, WMO and IPCC. The annual average global temperature in 2023 was about 1.5 (1.45 $\pm$ 0.12) °C above the pre-industrial levels (1850-1900). The 2023 is the 9th consecutive year (2015-2023) that annual global temperatures have reached at least 1 °C above pre-industrial levels, according to all datasets compiled by WMO. The annual mean land surface air temperature averaged over India during 2023 was +0.65 ^{o}C above the long-term average (1981-2010 period). The year 2023 was the second warmest year on record since nationwide records commenced in 1901.

During Pre-monsoon season, the maximum temperature over South Peninsular India (34.45 °C) was the 9th highest since 1901. In the month of March, the heat wave conditions were observed mainly over Coastal Karnataka, Saurashtra & Kutch and Konkan & Goa during first fortnight of the month. In the month of April, the heat wave/severe heat wave conditions were observed mainly over parts of Bihar, Gangetic West Bengal, Sub-Himalayan West Bengal & Sikkim, Coastal Andhra Pradesh, Odisha, Punjab, Haryana, Chandigarh & Delhi, Jharakhand and Uttar Pradesh during 13 - 19 April. In the month of May, the heat wave/severe heat wave conditions were observed mainly over Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat, Gangetic West Bengal, Haryana, Chandigarh & Delhi, Vidarbha, Sub Himalayan West Bengal & Sikkim, Coastal Andhra Pradesh, Madhya Maharashtra and Jharakhand at isolated places.

The rainfall for the country as a whole, for the Annual (Jan- Dec) 2023 has been recorded as 1102.8 mm which is 95% of its LPA of 1160.0 mm. In all, category wise, Out of 36 meteorological subdivisions, one subdivision received large excess, 2 subdivisions received excess, 27 received normal rainfall, 6 sub-division received deficient rainfall and No subdivision remained in Large Deficient & No Rain category.

During the Southwest Monsoon Season 2023, most sub-divisions of the country received excess/normal rainfall except Nagaland, Manipur, Mizoram & Tripura, Jharkhand, Bihar, Gangetic West Bengal, East Uttar Pradesh, South Interior Karnataka and Kerala & Mahe. During the season, out of 36 meteorological subdivisions, 3 subdivisions received excess rainfall, 26 received normal rainfall and the remaining 7 subdivisions received deficient rainfall.

During 2023, 09 cyclonic disturbances, CDs (maximum sustained wind speed (MSWS) ≥ 17 knots) developed over the North Indian Ocean (NIO) against the normal of 11.2 per year during 1965-2022. There were 3 CDs over Arabian Sea (Normal : 2.3 per year) (Above Normal), 6 over Bay of Bengal (Normal : 7.8 per year) (Below Normal). Overall, Basin-wise activity wrt formation of CDs was above normal over Arabian Sea and below normal over Bay of Bengal.

Extremely Severe Cyclonic Storm "BIPARJOY" over the Arabian Sea (06 - 19 June, 2023) intensified into an Extremely Severe Cyclonic Storm (ESCS) over eastcentral AS in the early morning (0530 hrs IST) of 11th June and maintained its intensity till 2030 hrs IST of 12th June, 2023.

Severe Cyclonic Storm MICHAUNG (01-06 December, 2023) over Bay of Bengal crossed south Andhra Pradesh coast between Nellore and Machilipatnam, close to south of Bapatla during 1230 to 1430 hours IST of the 5th December, 2023 as a Severe Cyclonic Storm with maximum sustained wind speed of 90-100 kmph gusting to 110 kmph.

IMD, Ministry of Earth Sciences in active collaboration with ICAR, State Agricultural University and Other Institutes is rendering the weather forecast based Agromet Advisory Services (AAS) to the farmers at district/block level. Presently there are 223 Agromet observatories, 3 Evapotranspiration Stations, 9 Soil Moisture Stations and 17 Dew gauge stations in the country. There are 200 Agro AWS also installed across the country, these Agro AWS are equipped with soil moisture and soil temperature sensors also.

Agromet Advisories and weather forecast are provided to the users' community through various mode, millions of Farmers are benefited by the services through SMS, whatsapp and other social media.

IMD has taken various specialized initiatives for the power sector in the area of renewable energy (solar & wind) and grid management. IMD provides wind speed and direction and Global horizontal irradiance (GHI) forecasts for renewable forecasting. IMD historical Day-wise Max-Min temperature has been provided for solar and wind power plants site selection and design. Provisioning of weather and now-casting APIs, alerts, cyclone tracking and RADAR imagery has been done for better grid management and safety of power infrastructure. For Hydro power, IMD is providing ERF rainfall forecast over river catchment areas which has helped hydro power plants in safety of manpower and machinery.

IMD has been associated with various organizations in the health sector on improving Heat Wave Early Warning System and strengthening of Heat Action Plans (HAP) nationally. IMD issues impact based forecasts and issues risk based warning for cold wave and heat wave events. These

warnings are disseminated to the Ministries of Home Affairs, Health, National, State & District Disaster management Authorities, Chief Secretaries / Health Secretaries of states etc. Climate information for the coming two weeks is issued by IMD for the transmission windows of temperature favourable for development of vector borne diseases like malaria and dengue based on GFS and ERFS.

Under Global Maritime Distress Safety System (GMDSS) scheme, India has been designated as one of the 16 services in the world for issuing Sea area bulletins for broadcast through GMDSS for MET AREA VIII (N), which covers a large portion of north Indian Ocean.

Weekly monitoring and prediction of basin averaged rainfall and volume of water for 101 river sub basins of India based on ERF has been started in the year 2019 and are being regularly uploaded in IMD Pune website.

India Meteorological Department (IMD) has created Urban Meteorological Services for over 150 urban regions across various city types in India to enhance its Early Warning System (https://internal.imd.gov.in/pages/city_weather_main_mausam.php;). These Urban Integrated Services include the incorporation of detailed urban data observations, urban canopy models, urban vegetation analysis, and land use assessment to evaluate exposure, vulnerability, and soil permeability impact on hazards. Additionally, these systems involve ensemble prediction, uncertainty quantification, and a multi-disciplinary approach to model initialization processes effectively.

Finally, I sincerely thank all the employees of IMD for their support and commitment throughout the last year and I look forward to your continued support in our journey towards setting higher levels of excellence. My special thanks to Dr. V. K. Soni, Scientist 'F' and Mr. Sunny Chug, Scientist 'D', Information Science & Knowledge Resource Development Division (IS&KRDD) (Formerly Publication Section) and their team in the division for their sincere efforts in compilation, editing and publication of this Annual Report 2023.

Dr. Mrutyunjay Mohapatra
Director General of Meteorology

Document Control Sheet

India Meteorological Department

Ministry of Earth Sciences (MoES)

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14.	Abstract	This report highlights the progress made by the India Meteorological Department during the year 2023. The Department is continuously augmenting its observational, forecasting and information systems to render improved services in areas of agriculture, aviation, shipping, fisheries, environment, water, health, energy, transport etc. During the period (2023) 40 DCWIS, 67 FSM-RVR are installed at different Airports. Two more indigenously developed DWRs: One X-band DWR at Pallikarnai, Chennai and One C- band at Veravali, Mumbai have been added in IMD radar network. Latest version of Polar WRF model has been operationalized to provide day-to-day 72 hours weather forecast at 3 km resolution for the Maitri and Bharati region in the Antarctica. A national Radar data centre has been established at IMD, New Delhi for archival and retrieval of radar data. Radar data products are also provided to various users. Location specific information of lightning is also being generated in the radar data center and is available in the web page. A unique audio alert system announces the location and number of lightning occurrences district wise which alerts the forecaster and other end users to severe weather events. IMD has also planned the procurement of Wind profilers under MoU with ISRO, Bangalore.
15.	Key words	IMD Annual Report 2023, MoES, Publication, Mausam, Weather.

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CHAPTER 1

INDIA METEOROLOGICAL DEPARTMENT - OVERVIEW

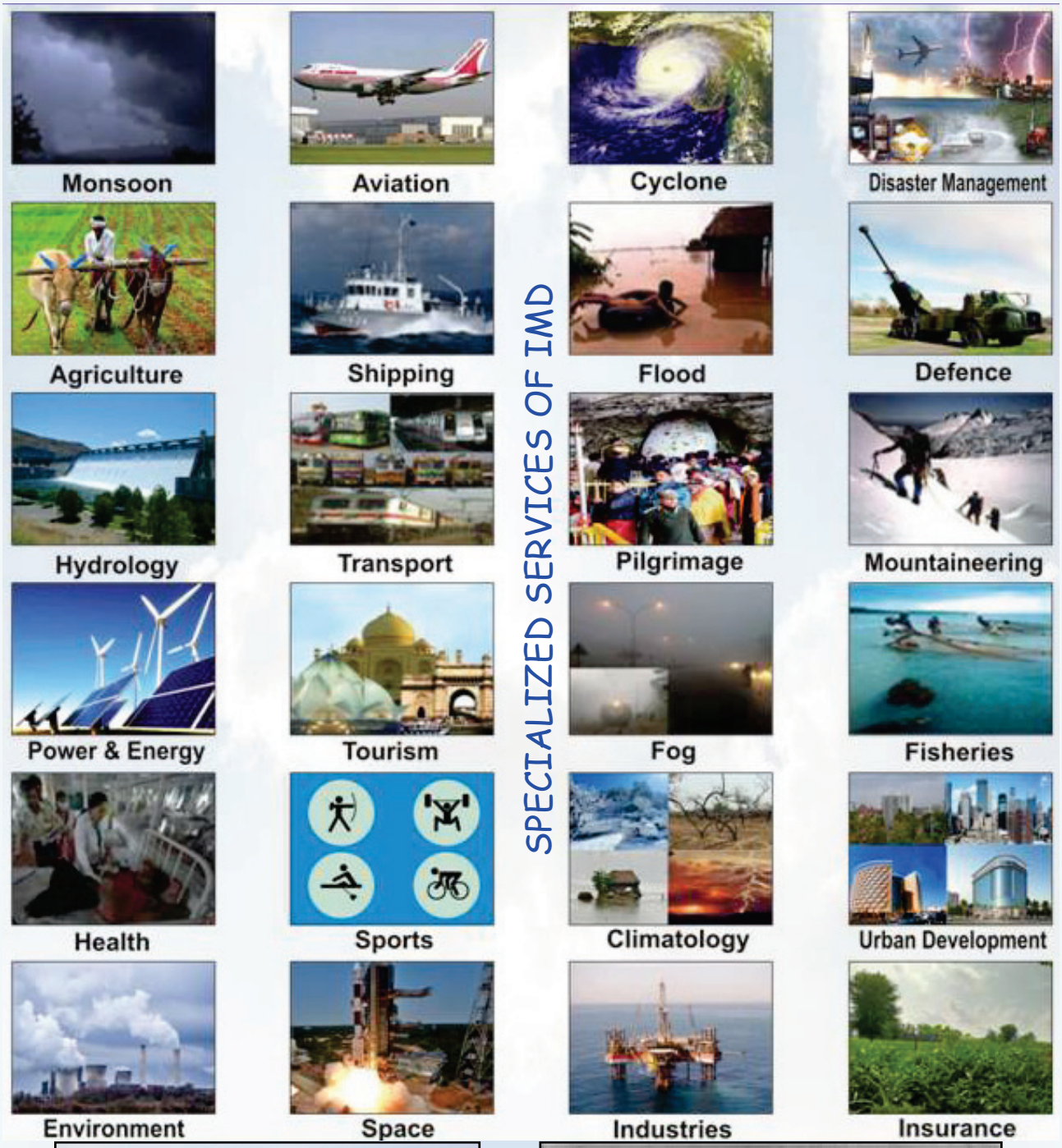
India Meteorological Department, Ministry of Earth Sciences is the National Meteorological Service of the country and the principal Government agency in all matters relating to Meteorology, Seismology and allied discipline and provides weather and climate services to the public and specialized sectors.

It's mandate is:

- To take meteorological observations and to provide current and forecast meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc.
- To warn against severe weather phenomena like tropical cyclones, norwesters, duststorms, heavy rains and snow, cold and heat waves, etc., which cause destruction of life and property.
- To provide meteorological statistics required for agriculture, water resource management, industries, oil exploration and other nation-building activities.
- To conduct and promote research in meteorology and allied disciplines.
- To detect and locate earthquakes and to evaluate seismicity in different parts of the country for development projects.

A disastrous tropical cyclone struck Calcutta in 1864 and this was followed by failures of the monsoon rains in 1866 and 1871. In the year 1875, the Government of India established the India Meteorological Department, bringing all meteorological work in the country under a central authority. Mr. H. F. Blanford was appointed Meteorological Reporter to the Government of India.

From a modest beginning in 1875, IMD has progressively expanded its infrastructure for meteorological observations, communications, forecasting and weather services and it has achieved a parallel scientific growth. IMD has always used contemporary technology. In the telegraph age, it made extensive use of weather telegrams for collecting observational data and sending warnings. Later IMD became the first organization in India to have a message switching computer for supporting its global data exchange. One of the first few electronic computers introduced in the country was provided to IMD for scientific applications in meteorology. India was the first developing country in the world to have its own geostationary satellite, INSAT, for continuous weather monitoring of this part of the globe and particularly for cyclone warning. IMD has continuously ventured into new areas of application and service, and steadily built upon its infra-structure in its history of 150 years. It has simultaneously nurtured the growth of meteorology and atmospheric science in India. Today, meteorology in India is poised at the threshold of an exciting future.



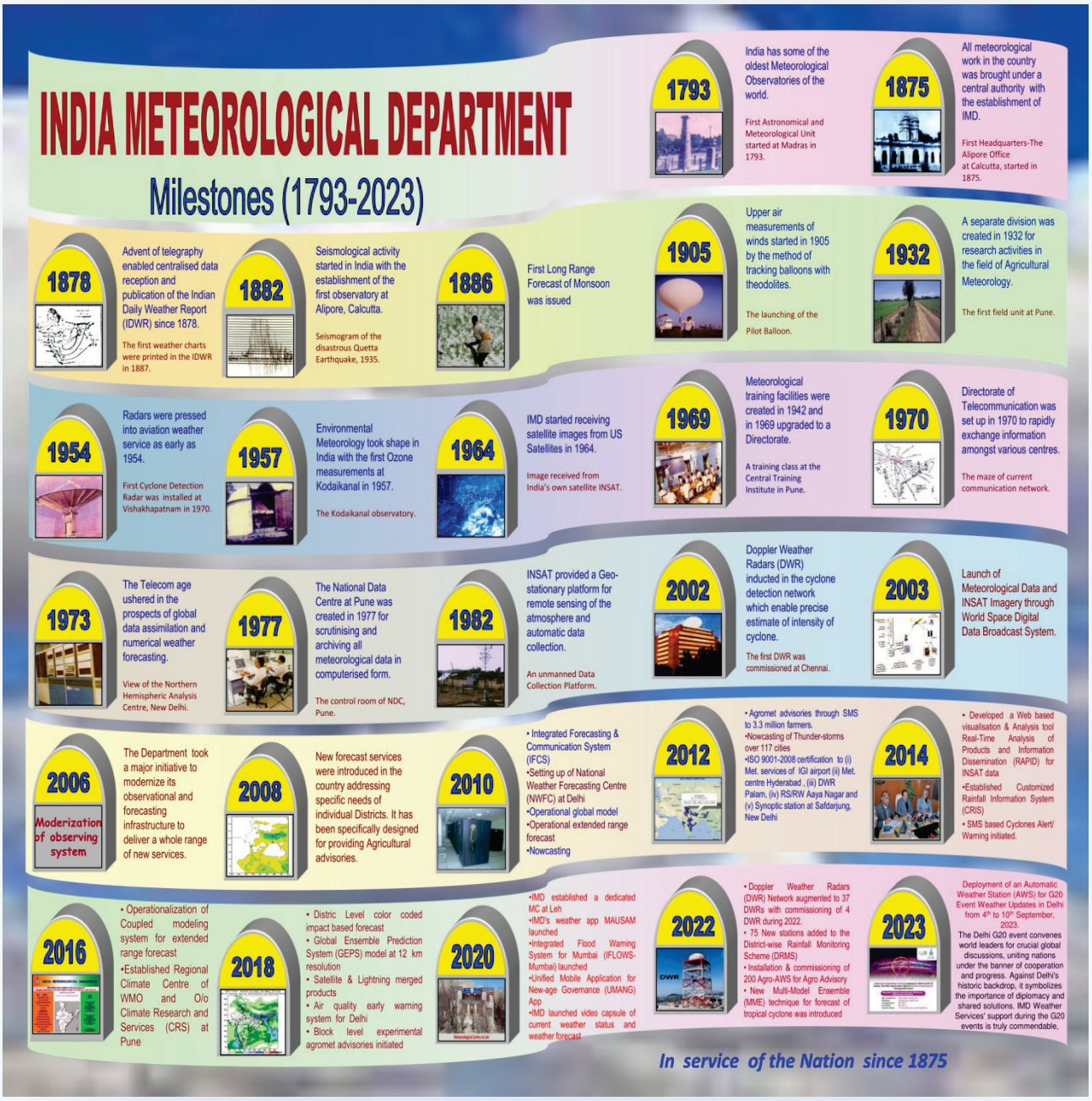


India Meteorological Department (IMD)

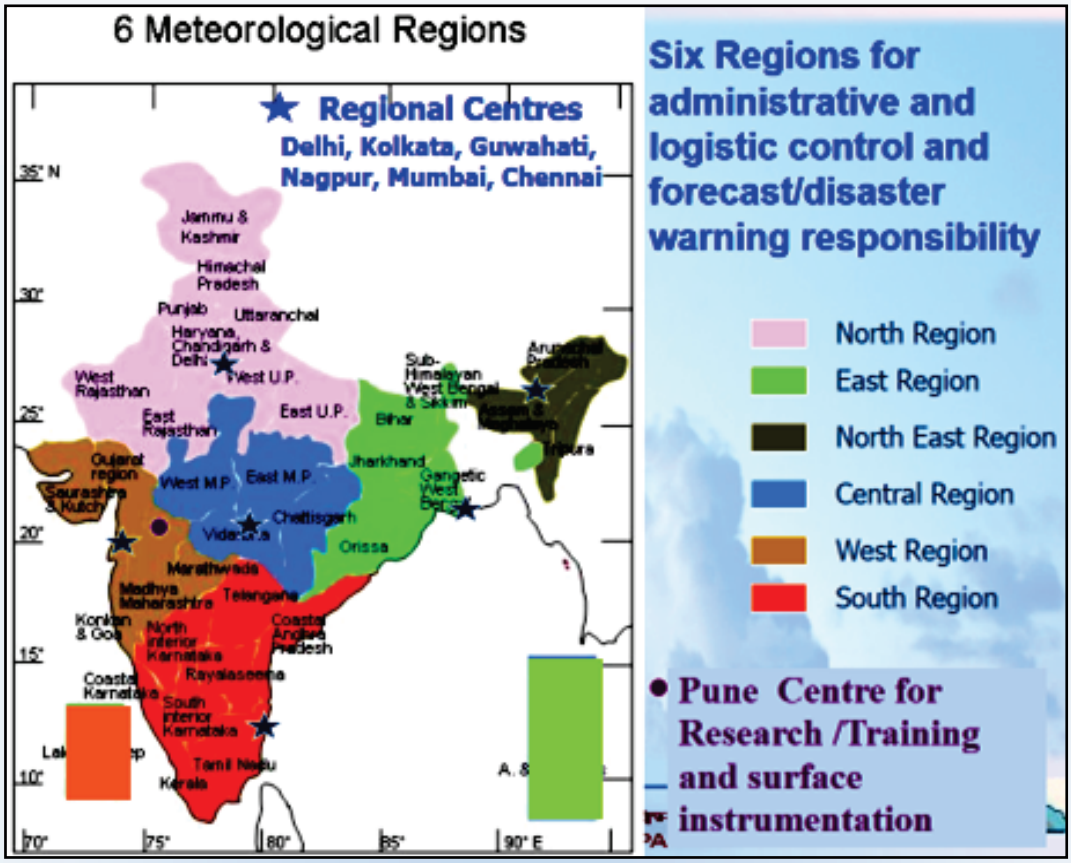


Alipore Observatory, Kolkata founded in 1877

India had some of the oldest meteorological observatories of the world and the first astronomical and meteorological unit started at Madras in 1793. Thus, meteorological observation in India was taken even prior to the establishment of the department in 1875. Since then IMD has achieved many milestones during the period from 1793 to 2023.



The Director General of Meteorology is the Head of the India Meteorological Department, with headquarters at New Delhi. For the convenience of administrative and technical control, there are 6 Regional Meteorological Centres (RMCs), with regional headquarters at Mumbai, Chennai, New Delhi, Kolkata, Nagpur and Guwahati. Under the Head of RMCs, there are different operational units such as Meteorological Centres, Forecasting Offices, Agromet. Advisory Centres, Flood Meteorological Offices and Cyclone Detection Radar Stations.



India Meteorological Department has continued its efforts for the improvement of observing, warning and dissemination mechanism/systems all through 2023. Its improved services rendered in respect of very short (up to 6 hrs), short (up to 3-days in advance), medium (up to 7-10 days in advance), extended (up to 15 to 20 days in advance), long (monthly and seasonal) range and severe weather (cyclones, thunderstorms, extreme rainfall) forecasts have been built to meet the demands of the user agencies, disaster managers, emergency response groups and other stakeholders in an organized manner in 2023. Its short, medium, extended & long range and cyclone forecasts were appreciated all over the world.

In March, the heat wave conditions were observed mainly over Coastal Karnataka, Saurashtra & Kutch and Konkan & Goa during first fortnight of the month. In April, the heat wave/severe heat wave conditions were observed mainly over parts of Bihar, Gangetic West Bengal, Sub Himalayan West Bengal & Sikkim, Coastal Andhra Pradesh, Odisha, Punjab, Haryana, Chandigarh & Delhi, Jharakhand and Uttar Pradesh during 13 - 19, April. In the month of May, the heat wave/severe heat wave conditions were observed mainly over Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat, Gangetic West Bengal, Haryana, Chandigarh & Delhi, Vidarbha, Sub Himalayan West Bengal & Sikkim, Coastal Andhra Pradesh, Madhya Maharashtra and Jharakhand at isolated places.

The rainfall for the country as a whole, for the Annual (Jan - Dec) 2023 has been recorded as 1102.8 mm which is 95% of its LPA of 1160.0 mm. In all, category wise, Out of 36 meteorological subdivisions, one subdivision received large excess, 2 subdivisions received excess, 27 received normal rainfall, 6 subdivision received deficient rainfall and No subdivision remained in Large Deficient & No Rain category.

During 2023, 09 Cyclonic Disturbances (maximum sustained wind speed (MSW) ≥ 17 knots) developed over the North Indian Ocean (NIO) against the normal of 11.2 per year during 1965-2022. There were 3 CDs over Arabian Sea (Normal : 2.3 per year) (Above Normal), 6 over Bay of Bengal (Normal : 7.8 per year) (Below Normal). Overall, Basin-wise activity wrt formation of CDs was above normal over Arabian Sea and below normal over Bay of Bengal.

All the cyclonic disturbances were monitored and predicted with sufficient lead time and great accuracy. IMD maintained continuous watch over the NIO and monitored all the disturbances with issue of extended range outlook (valid for next 15 days), daily tropical weather outlook (valid for next 5 days), daily detailed prognostic and diagnostic report during October-December (valid for next 7 days) and 6hourly/3hourly/ hourly structured bulletins on formation of cyclonic disturbance period.

The CDs were monitored with the help of available satellite observations from INSAT 3D and 3DR, polar orbiting satellites, available ships & buoy observations in the region, Doppler Weather Radars (DWR) and observations from coastal observatories. Various global models and dynamical-statistical models run by Ministry of Earth Sciences (MoES) institutions including IMD, NCMRWF, IITM and INCOIS were utilized to predict the genesis, track, landfall and intensity of the CDs as well as associated severe weather including heavy rainfall, strong winds and storm surge. A digitized forecasting system of IMD was utilized for analysis and comparison of various observations and numerical weather prediction models guidance, decision making process and warning products generation. The forecasts were mainly based on multi-model ensemble techniques developed indigenously by IMD.

Various parts of the country experienced Extreme Weather Events like extremely heavy rainfall, floods, landslide, lightning, thunderstorm, cyclone etc. A few of them are mentioned below. The causalities caused by these extreme events mentioned here are based on the media and the government reports from disaster Management Authorities.

Cold Wave: A total of 5 persons reportedly claimed dead, during winter 2023, because of the Cold Wave.

Snowfall: A total of 12 persons claimed dead and 12 persons injured. In which 4 persons were reportedly claimed dead & one person missing, during winter and 8 persons reportedly claimed dead & 11 persons injured, during Pre Monsoon season, 2023 due to snowfall.

Snow avalanche: One person died and 5 others were injured in the Chamoli district of Uttarakhand on 4 June due to snow avalanche during, 2023.

Lightning: Total 692 persons reportedly claimed dead, more than 430 persons injured and about 1510 livestock perished, during 2023 because of Lightning.

Thunderstorm: Total 47 persons reportedly claimed dead, 81 persons injured and 79 livestock perished during Pre Monsoon season, because of Thunderstorm.

Heavy Rains, Floods & Landslide: Total 706 persons reportedly claimed dead, 207 persons injured, 186 persons missing & 33,187 livestock perished, during 2023 because of heavy rains, floods & Landslide.

Gale: Total 7 persons reportedly claimed dead, 18 persons injured and 2 livestock perished, because of Gale during 2023.

Heat Wave: Total 119 persons reportedly claimed dead because of Heat Wave during 2023.

Hailstorm: Total 2 persons reportedly claimed dead, 4 persons injured and more than 350 livestock perished during Pre Monsoon season.

Cyclonic Storm: 7 persons reportedly claimed dead due to heavy rain-related incidents associated with Extremely Severe Cyclonic Storm “BIPARJOY” [6 to 19 June] from Rajsamand, Jalore districts & parts of Rajasthan. A total of 24 persons were reportedly claimed dead during December, because of Severe Cyclonic Storm MICHAUNG.

SUMMARY OF MAJOR ACHIEVEMENTS IN 2023

Enhancement in Modelling & Weather and Climate Services

- **HWRF-Ocean (HYCOM/POM-TC) coupled model**

During pre-monsoon and post-monsoon cyclone seasons of 2023, the movable triple nested HWRF-Ocean (HWRF/POM-TC) coupled model with horizontal resolutions of 18 km, 6 km and 2 km delivered five days forecasts four times a day at 0000 UTC, 0600 UTC, 1200 UTC and 1800 UTC for tropical cyclones formed over north Indian Ocean (NIO). The data assimilation component of HWRF, regional GSI Data Assimilation, generated mesoscale analysis for intermediate and innermost nests which are then merged to generate analysis for all three domains. The model parent domain (18 km horizontal resolution) remained stationary whereas the intermediate domain (6 km horizontal resolution) and the inner most domains (2 km horizontal resolution) moved to track the storm centre. During the Year 2023, seven Cyclonic storms formed over North Indian Ocean (NIO) namely MOCHA, BIPARJOY, TEJ, HAMOON, MIDHILI AND MICHAUNG. The Real time cyclic (4 times at day) HWRF model run during all tropical cyclones provided real time track and intensity forecast for 120 hours lead time along with other products. These were disseminated to RSMC, New Delhi and various other users in addition to dedicated HWRF webpage on IMD-NWP website.

- **E-WRF Operationalization**

EWRF is operational from March 2022 to till date, IMD NWP division has operationally implemented the model EWRF. Presently four different products (Lightning Flash Density, Max Reflectivity and Hourly rainfall and Significant Hail Parameter (SHIP)) from the Electric-WRF model have been updated in the IMD NWP internal website. In the E- WRF modelling system, ground-based lightning flash rate has been assimilated for the improvement of the model forecast. The details of these products available in the NWP website (https://nwp.imd.gov.in/).

Presently due to the limitation of the computational resources, we are running the model at three different times in a day to cover the entire 48 hours of the day. Each run utilizes the latest lightning data assimilation that helps to improve the forecast effectively.

- **Mausamgram – Public Access**

The NWP division developed jointly with ISSD division, and released the Mausamgram (Dynamic Meteogram) Version 1.0 on 15-01-2024 during the IMD's 150th foundation celebration day by the Vice President of India to the public usage https://mausamgram.imd.gov.in. This public mausamgram is an interactive and dynamic meteogram which provides location specific weather forecast information (Temperature, Rainfall, Relative Humidity, Windspeed, Winddirection, Cloud Cover) 1-hourly for next 1.5 days, 3-hourly for next 5 days, 6-hourly for next 10 days. Users can select their desired location over an Interactive India Map or User can search location through the options given in the website. Also it supports search location by block level, districts levels, village levels, latitude & longitude, and through area postal pin codes as well. This weather information is generated operationally and automatically by the mulimodel mean of 5 Global NWP models (IMDGFS, NCUM, ECMWF, JMA, NCEP) and 2 Regional NWP models (IMDWRF, NCUM-R). The same weather information is also accessible by the "Mausam" Mobile App, which is utilizing this NWP multi model mean forecasts output which are taking information from this Mausamgram website.

- Impact based forecast (IBF) for Agriculture (Cold Wave/Hailstorm/Heavy Rainfall/ HeatWave/Thunderstorm with Gusty winds etc.) and Agromet Advisories based on the IBF have been issued for different districts of various States and UTs across the country in co-ordination with National

Weather Forecasting Centre (NWFC), New Delhi, Regional Meteorological Centres (RMCs)/ Meteorological Centres (MCs), AMFUs and DAMUs during the year.

- 110 research papers were published by IMD scientist in national and international journals. 11 Meteorological Monograph published by IMD. 694 bi-weekly District AAS bulletins and 3075 Block AAS Bulletins [1396 Block level Agromet Advisories by Agromet Field Units (AMFUs) and 1679 Block level Agromet Advisories by District Agromet Units (DAMUs)] have been prepared and uploaded in the website of Agrimet Division, Pune. Impact based forecast (IBF) for Agriculture (Heavy Rainfall / Hailstorm / Heat Wave / Thunderstorm with Gusty winds / Cold Wave) and Agromet Advisories based on the IBF have been issued for different districts of various States and UTs across the country in coordination with NWFC, New Delhi, RMCs/MCs, AMFUs and DAMUs. Heavy rainfall warning was issued by India Meteorological Department due to Cyclonic Storm "Mocha" over Bay of Bengal during 9 to 14 May 2023. During the period 1715493 SMSs have been sent to 760489 number of farmers in the States of Assam, Nagaland, Manipur, Mizoram and Tripura. Special Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division. Heavy rainfall warning was issued by India Meteorological Department due to Cyclonic Storm "Biparjoy" over Arabian Sea during 6 to 19 June 2023. During the period 2,08,36,313 SMSs have been sent to the farmers in the states of Gujarat and Rajasthan. Special Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division.

- IMD issues AQ Early Warning bulletins based on different models. This year the air quality forecast services were extended to other cities. As of now, the services are being provided to 45 cities. It is now planned to extend the air quality forecast services to all the 131 non-attainment cities of India by 2025.

- Collaborative research project on application of INSAT 3D/3DR data and WRF Model for accuracy of Renewable (Solar & Wind) Energy Forecasting. Following work was carried out in collaborative studies:

1. Actual Wind Speed vs. WRF Wind Speed Study

2. Actual GHI Vs. VIS Counts converted GHI

- IMD & Grid India developed an Artificial Intelligence and weather forecast based day-ahead power demand forecasting tool.

Major Installations during the year

- A prototype of a novel rain gauge, an in-house developed snow gauge, and four pollutant detector semiconductor chips on a wafer level developed and demonstrated to the Hon. Secretary MoES on 13th March, 2023.

- Three (03) AWS is installed in Kerala, Manipur and Meghalaya State under 400 AWS Project.

- GPS Based RS Instrument Installed on 19th January, 2023 at MC Ahmedabad.

- Indian Environmental Radiation Monitoring Network (IERMON) System has been installed in the premises of MC Gangtok by BARC on 18th May, 2023.

- During the period (2023) 40 DCWIS, 67 FSM-RVR are installed at different Airports.

- Efforts have been made now to switch over to GPS based fully automatic PB systems from conventional optical theodolite-based observations. For this, GPS based pilot-sonde has been developed and being manufactured in-house in IMD Workshop. In the line of this, 25 stations of PB network now have been upgraded and equipped with GPS-based fully automatic Pilot Balloon systems. Among these, five stations are equipped with IMD-manufactured systems, namely Jammu,

Jaipur, Jodhpur, Sundernagar and Dehradun, while the remaining 20 are outsourced from Indian manufacturers, namely Aminidivi, Amritsar, Allahabad, Bangalore, Bhuj, Churu, Deesa, Gaya, Gangtok, Gopalpur, Gwalior, Karaikal, Lucknow, Minicoy, Mohanbari, Port Blair, Raipur, Sriganganagar and Thiruvananthapuram.

- Surface Ozone is monitored using electro-chemical method with IMD make instrument. Two more stations (Shillong and Ranichauri) have been added in the network and now network comprises total 11 surface monitoring stations including Maitri and Bharati stations.

- Surface Ozone sensors were installed at Global Automatic Weather Station Pune, New Delhi, Thiruvananthapuram, Kodaikanal, Nagpur, Srinagar, Jammu, Antarctica (Maitri), Antarctica (Bharati), Shillong, Ranichauri.

- Conventional agromet observatory has been installed at Agromet Field Unit (AMFU) Jhabua, Madhya Pradesh to enhance weather observations and use in preparation of Agromet Advisories under GKMS scheme.

- High Wind Speed Recorder was installed at Port Blair.

- Two more indigenously developed DWRs : one X-band DWR at Pallikarnai, Chennai and one C- band at Veravali, Mumbai have been added in IMD radar network.

CHAPTER 2

Weather Summary during 2023

1. Winter Season (January-February)

Highlights

During winter 2023 (January-February), the rainfall over India (21.9 mm) was the 8th lowest since 1901. Rainfall over the homogeneous region of Central India (1.9 mm) was the fourth lowest since 1901. During the winter season, in India, the maximum temperature was (27.72 °C with an anomaly of 1.02 °C) the 4th highest and the minimum temperature was (15.22 °C with an anomaly of 0.63 °C) the 6th highest since 1901. The mean temperature was 21.47 °C with an anomaly of 0.83 °C and the 3rd highest after the years 2016 (21.80 °C), 2009 (21.59 °C) since 1901.

During the winter season, over Northwest India, the maximum temperature was (21.28 °C with an anomaly of 1.39 °C) the 9th highest and the minimum temperature was (8.03 °C with an anomaly of 1.14 °C) the 4th highest since 1901. Over East & Northeast India, the maximum temperature was (25.87 °C with an anomaly of 1.35 °C) the 7th highest, and the minimum temperature was (12.34 °C with an anomaly of 1.20 °C) the highest since 1901. Over Central India, the maximum temperature was (29.82 °C with an anomaly of 0.98 °C) the 6th highest since 1901. Over South Peninsular India, the maximum temperature was (31.31 °C with an anomaly of 0.63 °C) the 6th highest since 1901.

Cold wave / Fog conditions

In January, the cold wave/severe cold wave conditions were observed mainly over parts of Bihar, Chhattisgarh, Madhya Pradesh state, Rajasthan state, Uttar Pradesh state, Haryana, Chandigarh and Delhi, Himachal Pradesh, Jharkhand, Odisha, Punjab, North and South Interior Karnataka, Telangana, Uttarakhand and Vidarbha.

In February, dense to very dense fog conditions were observed at isolated places of Punjab, Haryana, Chandigarh & Delhi, Sub Himalayan West Bengal & Sikkim, Uttar Pradesh state, Bihar, Uttarakhand, Rajasthan state, Odisha, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura and Saurashtra & Kutch.

Rainfall Features

Rainfall realized during the season was 55% of its LPA. It was 87% of its LPA during January and 32% of its LPA during February. Except for East Rajasthan, Gujarat Region, Tamilnadu, Puducherry & Karaikal and Lakshadweep, all the remaining sub-divisions received deficient/large deficient or no rain.

During the season, out of 36 meteorological subdivisions, 2 received large excess rainfall, 1 received excess rainfall, 1 subdivision received normal rainfall, 9 received deficient rainfall, 20 received largely deficient rainfall and 3 sub-divisions did not receive any rain (Fig. 1).

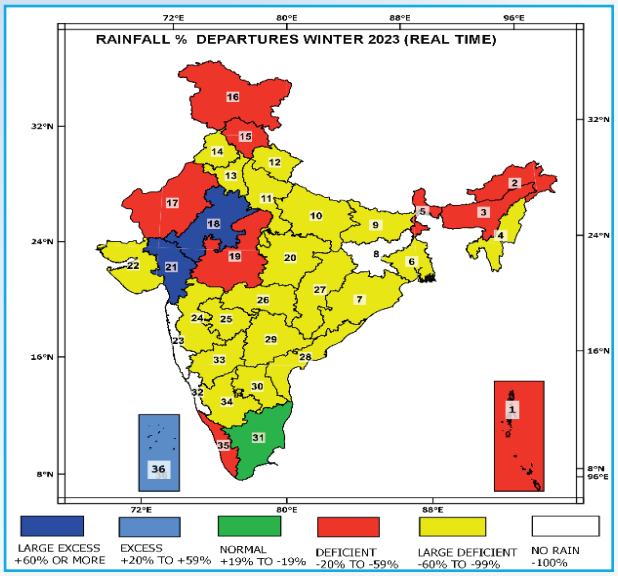


Fig. 1. Sub-divisionwise rainfall percentage departures for winter (January-February) 2023

Fig. 2(a) shows the spatial pattern of rainfall (mm) received during the winter season. Parts of Arunachal Pradesh, Jammu & Kashmir & Ladakh, and Himachal Pradesh received more than 100 mm rainfall. Fig. 2(b) shows the spatial pattern of rainfall anomaly (mm) during the winter season. Rainfall anomaly was generally negative over mostparts of the country except, Arunachal Pradesh,Jammu& Kashmir & Ladakh, East Rajasthan, Gujarat Region, East Madhya Pradesh, Tamilnadu, Puducherry & Karaikal and Lakshadweep. The magnitude of negative rainfall anomaly was more than 40 mm over parts of Assam & Meghalaya, Uttarakhand, Himachal Pradesh, Jammu & Kashmir & Ladakh and Andaman & Nicobar Islands.

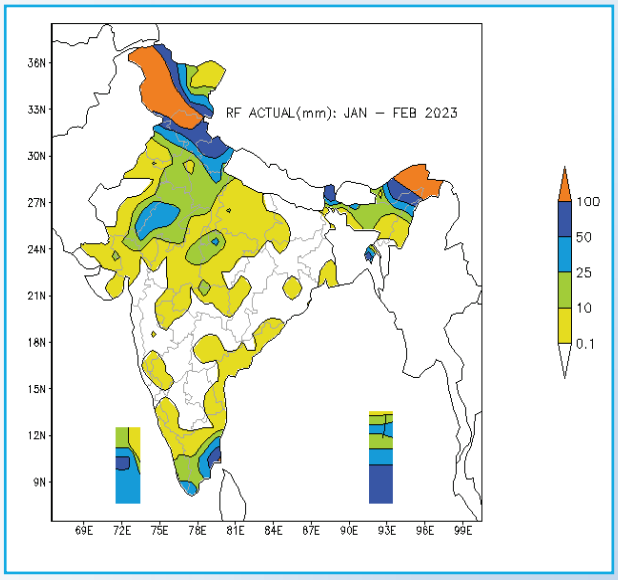


Fig. 2(a). Seasonal rainfall (mm) winter (January-February 2023)

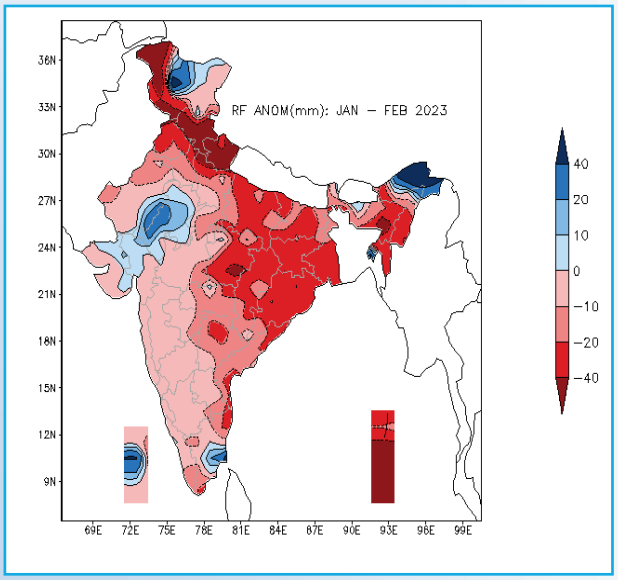


Fig. 2(b). Seasonal rainfall anomaly (mm) for winter (January-February 2023) (Based On 1971-2010 NOR)

Fig. 3 shows the area weight averaged rainfall series for the season over all India and four homogeneous regions since 1951. Seasonal rainfall realized over all India was 55 % of its LPA. Rainfall over all India (21.9 mm) was the 8th lowest since 1901. Prior lowest rainfall years were 1902 (11.5mm), 1918(15.7 mm), 1963(15.9 mm), 1960(16.6 mm), 1918(16.7 mm), 2001(17.4 mm), and 2016 (18 mm).

Considering homogeneous region wise it was 13% of its LPA over Central India, 40% of its LPA over South peninsula, 45% of its LPA over East & North East India, and 69% of its LPA over Northwest India. Rainfall over the homogeneous region of Central India (1.9 mm) was the fourth lowest since 1901. Prior lowest rainfall years were 2006 (0.3 mm), 1925 (0.4 mm), and 1989 (0.7 mm).

Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for measuring drought and is based on only precipitation. This index is negative for drought and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive respectively. Figs. 4 (a&b) show the SPI values for the winter season 2023 (January-February, 2 months cumulative) and period from June 2022-February 2023 (nine months cumulative) respectively.

Cumulative SPI values of the past two months indicate extremely wet/severely wet conditions over parts of Rajasthan state and Gujarat Region state while, extremely dry/severe were observed over parts of Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub Himalayan West Bengal & Sikkim, Uttar Pradesh state, Uttarakhand, Haryana, Chandigarh & Delhi, Punjab, Himachal Pradesh, East Madhya Pradesh and Vidarbha.

Cumulative past nine months' SPI values indicate extremely wet/severely wet conditions over parts of Assam & Meghalaya, Sub Himalayan West Bengal & Sikkim, Odisha, West Uttar Pradesh,

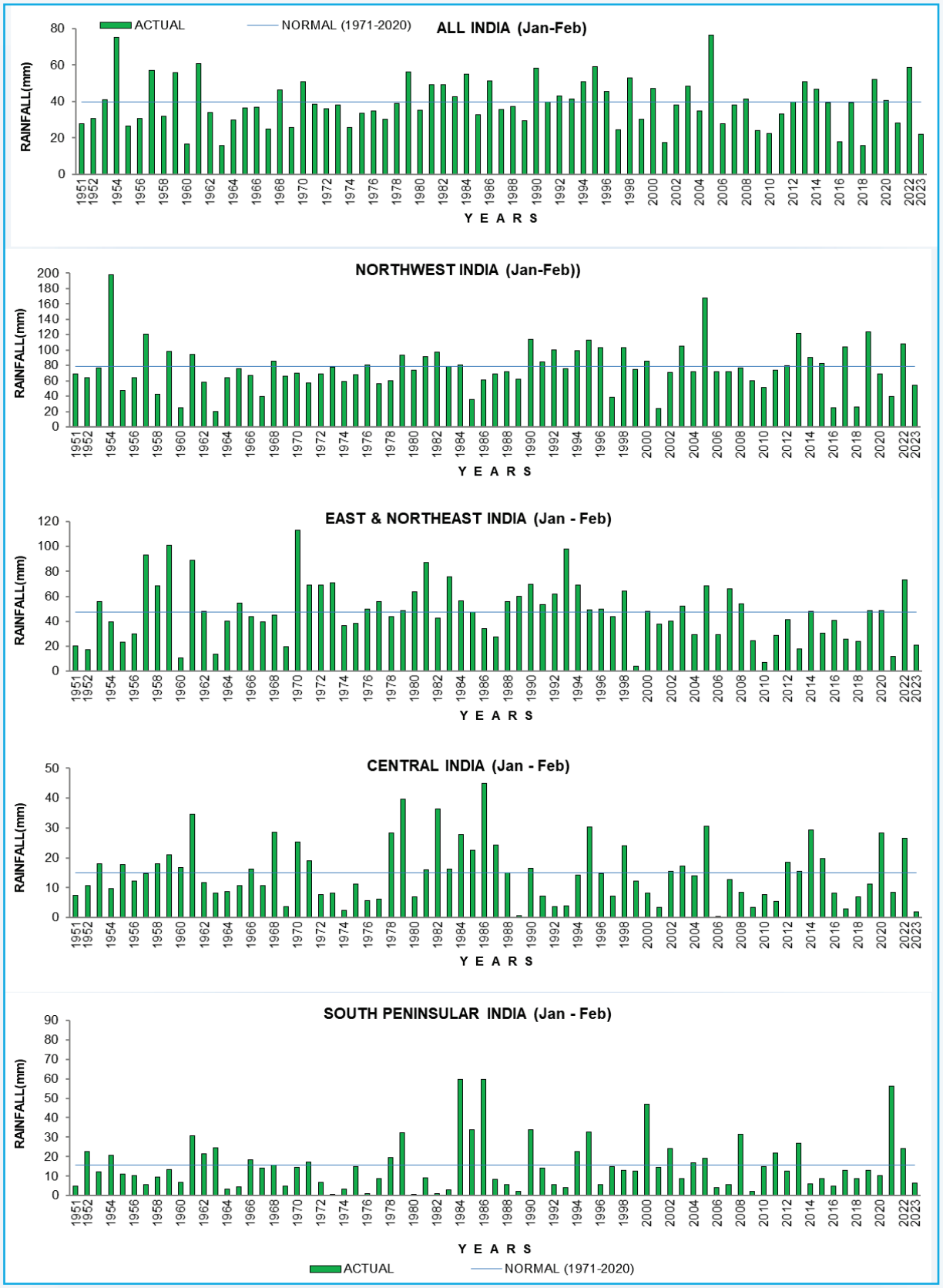


Fig. 3. Time series of area weighted rainfall over the four homogeneous regions for winter (1951 - 2023)

Rajasthan state, Madhya Pradesh state, Gujarat Region, Madhya Maharashtra, Vidarbha, Chhattisgarh, Telangana, Rayalaseema, Tamil Nadu, North Interior Karnataka, and South Interior Karnataka while, extremely dry/severely dry conditions were observed over parts of A & N Islands, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub Himalayan West Bengal &

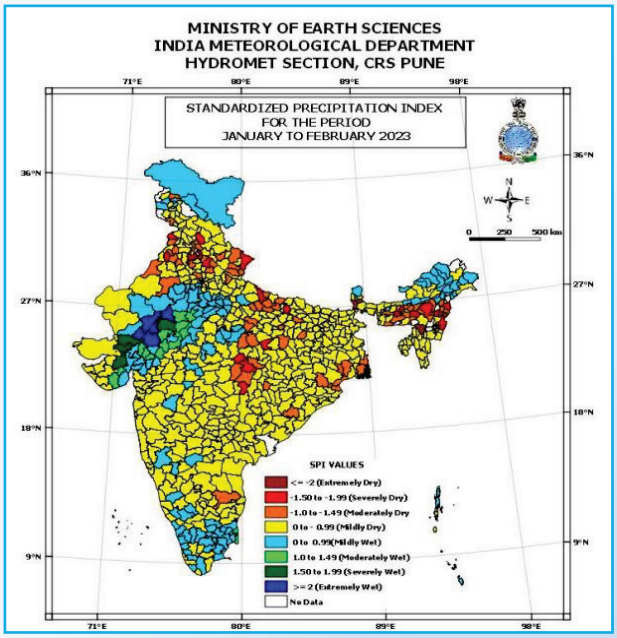


Fig. 4(a). Standardized precipitation index (SPI) for Two Months (January- February 2023)

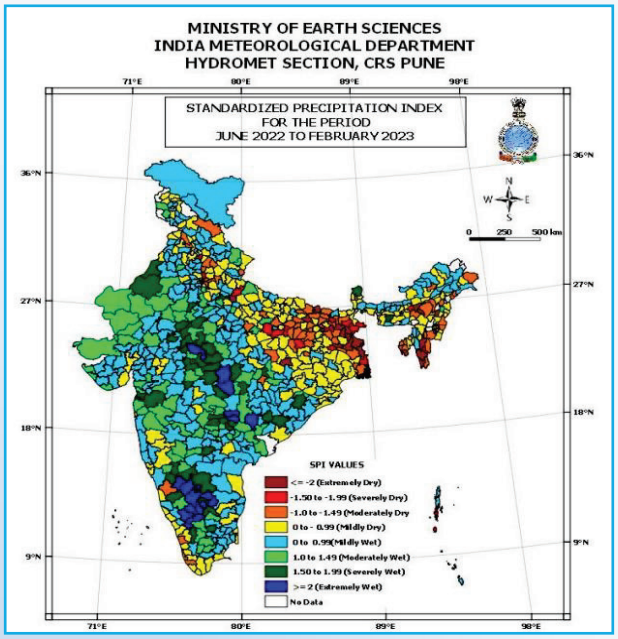


Fig. 4(b). Standardized precipitation index (SPI) for Nine Months (June 2022 - February 2023)

Sikkim, Gangetic West Bengal, Jharkhand, Bihar, Uttar Pradesh state, Haryana, Chandigarh & Delhi, and Chhattisgarh.

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood is shown in Fig. 5. OLR anomaly was positive over most parts of the country, adjoining Arabian Sea and northern parts of Bay and was within 0 to $10W/m^2$. OLR anomaly was negative over the southern parts of Bay and was within 0 to $-10W/m^2$.

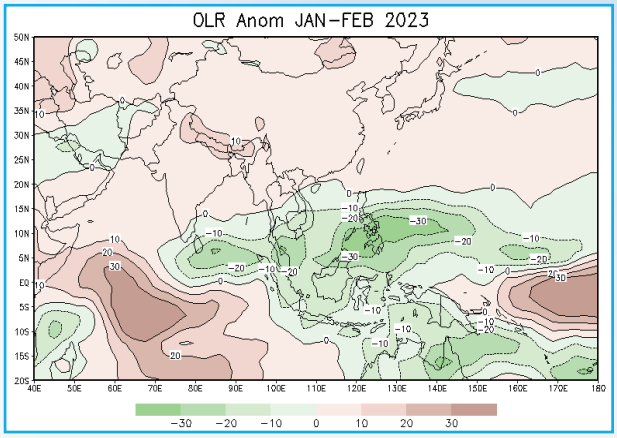


Fig. 5. OLR Anomaly (W/m^2) For Winter (January-February) 2023 (Source Data : CDC / NOAA, USA) (Based on 1991-2020 Climatology)

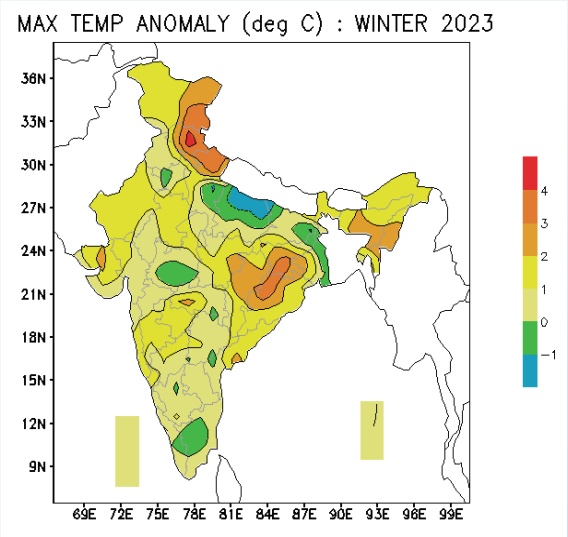
Temperature

Mean seasonal maximum and minimum temperature anomalies are shown in Figs. 6(a&b) respectively. The maximum temperature was above normal over most parts of the country, except some parts of northwest India (Haryana state, Uttar Pradesh state), east India, central India (West Madhya Pradesh) and south peninsular India. Maximum temperature anomaly was more than 4 °C over parts of Himachal Pradesh. Maximum temperature anomaly was more than 3 °C over parts of Ladakh state, Himachal Pradesh, Uttarakhand, Jharkhand, Chhattisgarh, and Odisha. Maximum temperature anomaly was less than -1 °C over parts of East Uttar Pradesh and Bihar.

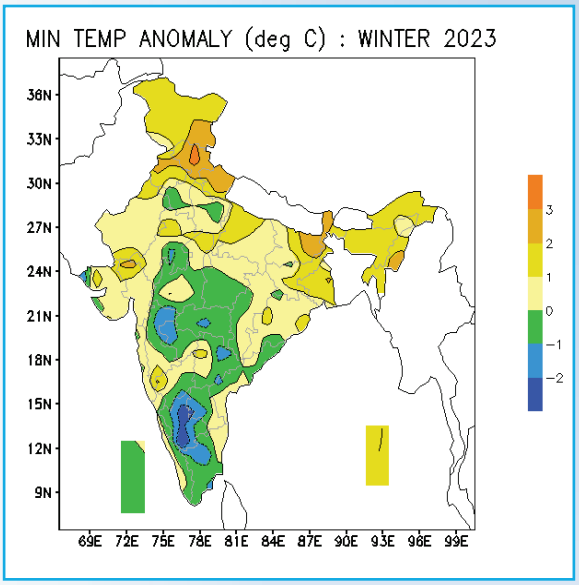
The minimum temperature was above normal over most parts of the country, except for some parts of northwest India, central India, south peninsular India, and Lakshadweep.

The minimum temperature anomaly was more than 3 °C over parts of Himachal Pradesh. The minimum temperature anomaly was more than 2 °C over parts of Ladakh state, Himachal Pradesh, Uttarakhand, Punjab, Sub Himalayan West Bengal & Sikkim, Bihar and Manipur. The minimum

temperature anomaly was less than -2 °C over parts of South Interior Karnataka and Rayalaseema.



Figs. 6(a). Mean seasonal temperature anomalies (°C) for winter (January-February) 2023, (a) maximum (Based on 1981-2010 Normals)



Figs. 6(b). Mean seasonal temperature anomalies (°C) for winter (January-February) 2023, (b) minimum (Based On 1981-2010 Normals)

Fig. 7 shows the mean temperature for the country as a whole for the winter season since 1971. Five-year moving average values are also shown. The mean temperature for the season this year was 21.47°C with an anomaly of 0.83°C and the 3rd highest after the years 2016 (21.80°C), 2009(21.59°C) since 1901. The mean temperature over Northwest India (14.66 °C with an anomaly of 1.26 °C) was the 5th highest, East & Northeast India (19.11 °C with an anomaly of 1.28 °C) was the 2nd highest and Central India (22.43 °C with an anomaly of 0.71 °C) was the 9th highest since 1901.

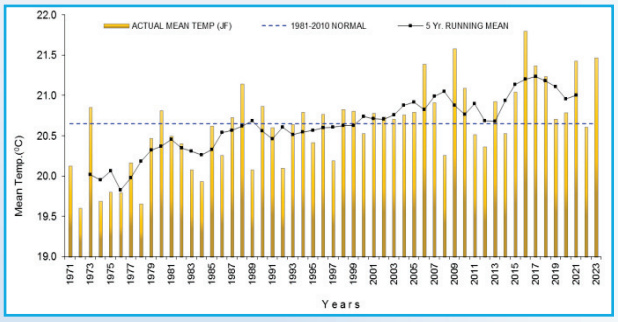


Fig. 7. Time series of mean temperature averaged over India (vertical bars) and five-year running mean (continuous line) for January-February (1971-2023)

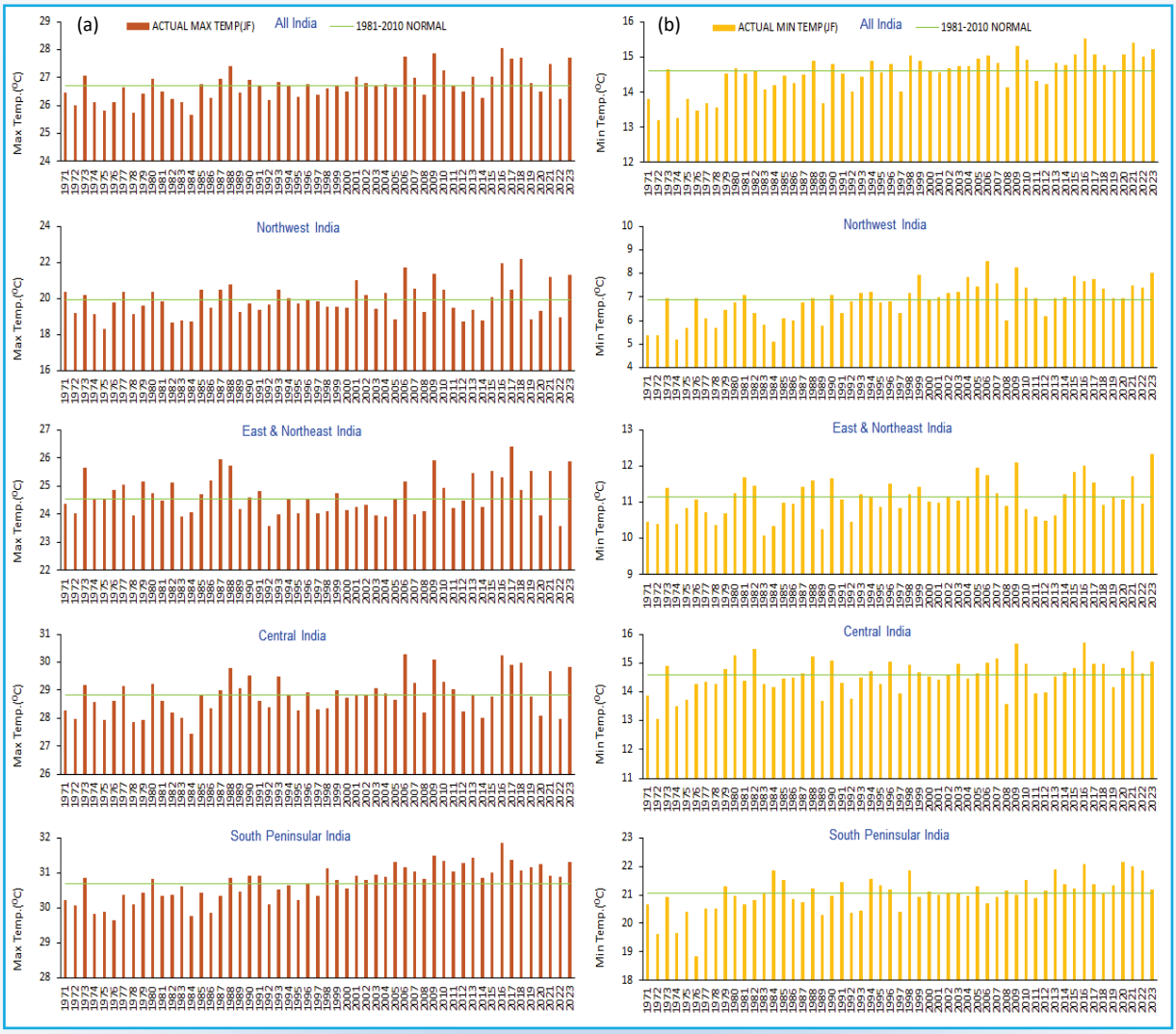
Figs. 8(a&b) shows the maximum andminimum temperature series respectively for the country as a whole and the four homogeneous regions during the winter season since 1971. The maximum and minimum temperature was above normal over all the homogeneous regions and the country as a whole.

Over all India, the maximum temperature was (27.72 °C with an anomaly of 1.02 °C) the 4th highest and the minimum temperature was (15.22 °C with an anomaly of 0.63 °C) the 6th highest since 1901. Over Northwest India, the maximum temperature was (21.28 °C with an anomaly of 1.39 °C) the 9th highest, and the minimum temperature was (8.03 °C with an anomaly of 1.14 °C) the 4th highest since 1901.

Over East & Northeast India, the maximum temperature was (25.87 °C with an anomaly of 1.35 °C) the 7th highest and the minimum temperature was (12.34 °C with an anomaly of 1.20 °C) the highest since 1901. Over Central India, the maximum temperature was (29.82 °C with an anomaly of 0.98 °C) the 6th highest since 1901. Over South Peninsular India, the maximum temperature was (31.31 °C with an anomaly of 0.63 °C) the 6th since 1901.

Significant Weather Events for Winter Season (January-February) 2023

From 1st January to 31st January, a total of 9 persons were reportedly claimed dead & one



Figs. 8(a&b). Time series of temperature for the country as a whole and the four homogeneous regions for January-February (1971-2023)

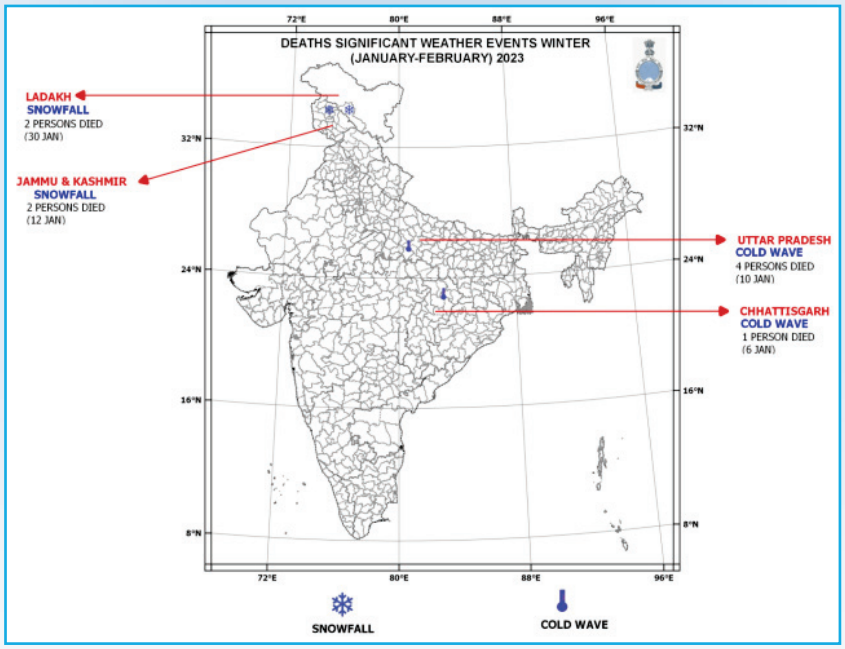


Fig. 9. Deaths due to significant weather events during winter (Jan- Feb) 2023 (Based on real time media report)

person missing. While in February no death or damage is reported due to any weather events. The details of causalities are based on real-time media reports.

Fig. 9 shows deaths due to significant weather events during Winter Season (January-February 2023) (Based on real-time media reports).

Cold Wave

A total of 5 persons reportedly claimed dead, during winter 2023, because of the Cold Wave.

Snowfall

A total of 4 persons were reportedly claimed dead & one person missing, during winter 2023, because of Snowfall.

Depression over Bay of Bengal

Under the influence of a cyclonic circulation over east Equatorial Indian Ocean and adjoining Southeast Bay of Bengal in the lower tropospheric levels, a Low-Pressure Area formed over the same region in the morning (0530 hrs IST/0000 UTC of 27th January, 2023. It lay over Southeast Bay of Bengal and adjoining east Equatorial Indian Ocean in the remaining parts of that day and on the next day. It concentrated into a well-markedlow-pressure area over Southeast BoB adjoining east EIO at 0300 UTC of 29th January, 2023. Under favourable environmental conditions, it concentrated into a depression over Southeast and adjoining Southwest BoB at 0300 UTC of 30th January, 2023 at about 670 km east-southeast of Trincomalee (Sri Lanka), 810 km east-northeast of Colombo (Sri Lanka) and 880 km east-southeast of Karaikal (India). It moved west-northwestwards till noon (1130 hrs IST/0600 UTC) of 31st January. Thereafter, it recurved southwestwards and crossed Sri Lanka coast between Batticaloa and Trincomalee near latitude 7.8° N and longitude 81.6° E during 0330 to 0430 hours IST of 2nd February, 2023.

Continuing to move further southwestwards, it weakened into a well-marked low pressure area over Comorin and adjoining Gulf of Mannar and west coast of Sri Lanka during midnight (around 2330 hrs IST/1800 UTC) of 2nd February, 2023. The track of the Depression is given in the Fig. 10, below:

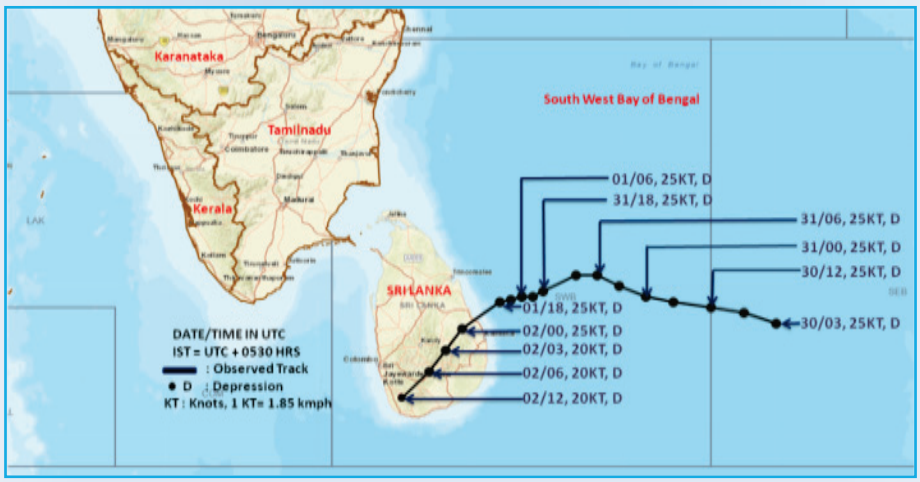


Fig. 10. The track of the Depression

Salient features of the system

The system exhibited recurving track. It moved west-northwestwards till 1200 UTC of 30th January and thereafter recurved west-southwestwards. The system was mainly steered west-northwestwards by the east-southeasterly winds prevailing in the periphery of upper tropospheric ridge near 15° N. Thereafter, the system showed slight weakening and thus the steering level changed to middle tropospheric levels. The system was thus steered west-southwestwards under the influence of east-northeasterly winds in the lower-middle tropspheric levels. The system exhibited very slow movement prior to landfall, as there was a phase lock between the westerly trough with axis near 82° E & extension upto 15° N and another trough in easterly across the centre of depression with axis near 82° E & extension upto 13° N. The life period of the system was 3 days and 15 hours.

2. Pre-monsoon Season (March-May)

Highlights

During Pre-monsoon season, the maximum temperature over South Peninsular India (34.45 °C) was the 9th highest since 1901.

Rainfall over homogeneous region of Central India (84.9 mm) was 3rd highest since 1901 after the years 1933 (106.1 mm) and 1990 (101.6 mm).

Rainfall over homogeneous region of Northwest India (152.0 mm) was 9th highest since 1901 after the years 1983 (236. 6 mm), 2015 (216.0 mm), 1982 (213.8 mm), 1987 (176.2 mm), 1926 (163.7 mm), 1986(159.8 mm), 1957 (157.3 mm) and 1963 (155.4 mm).

Rainfall over homogeneous region of East & northeast India (242.1 mm) was 6th lowest since 1901. Prior lowest rainfall years were 1903 (220.3 mm), 1979 (236.2 mm), 1908 (239.3 mm), 1901 (240.3 mm) and 1960 (240.7 mm)

Heat Wave Conditions

In the month of March, the heat wave conditions were observed mainly over Coastal Karnataka, Saurashtra & Kutch and Konkan & Goa during first fortnight of the month.

In the month of April, the heat wave/severe heat wave conditions were observed mainly over parts of Bihar, Gangetic West Bengal, Sub Himalayan West Bengal & Sikkim, Coastal Andhra Pradesh, Odisha, Punjab, Haryana, Chandigarh & Delhi, Jharakhand and Uttar Pradesh during 13 - 19 April.

In the month of May, the heat wave/severe heat wave conditions were observed mainly over Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh, Gujarat, Gangetic West Bengal, Haryana, Chandigarh & Delhi, Vidarbha, Sub Himalayan West Bengal & Sikkim, Coastal Andhra Pradesh, Madhya Maharashtra and Jharakhand at isolated places.

Advance of Southwest Monsoon

Southwest Monsoon advanced into some parts of southeast Bay of Bengal, Nicobar Islands and south Andaman Sea on 19th May, 2023. The Northern Limit of Southwest Monsoon passed through Lat. 5°N / Long. 85°E, Lat. 6.5°N / Long. 90°E, Nancowry and Lat. 10°N / Long. 98°E. It remained at this position till 29th May. It advanced into some parts of southwest Bay of Bengal, some more parts of southeast Bay of Bengal, entire Andaman, Nicobar Islands, Andaman Sea and some parts of eastcentral Bay of Bengal on 30th May, 2023. The Northern Limit of Southwest Monsoon passed through Lat. 5 °N / Long. 80 °E, Lat. 6.5 °N / Long. 83 °E, Lat. 10 °N / Long. 88 °E, Lat. 14 °N / Long. 92 °E and Lat. 17 °N / Long. 95 °E. It remained at this position till 31st May.

Fig. 1 depicts the isochrones of advance of southwest monsoon.

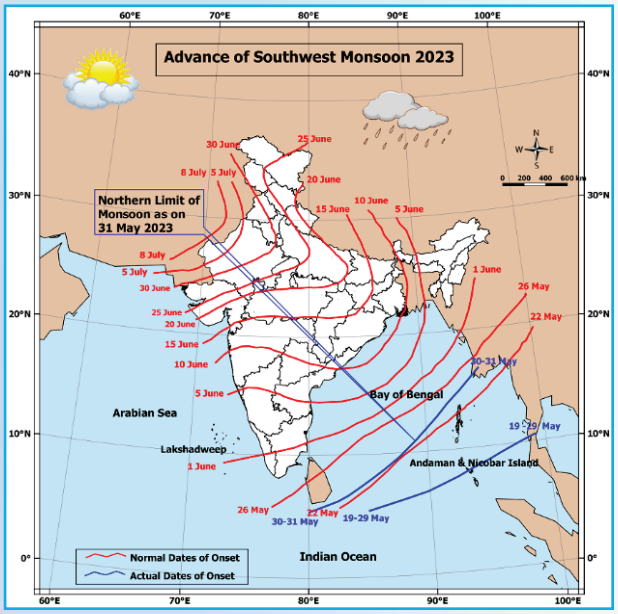


Fig. 1. Advance of Southwest Monsoon

Rainfall Features

Rainfall realized during the season was 112% of its LPA. It was 126% of its LPA during March, 105% of its LPA during April and was 110% of its LPA during May. During the season, most of the sub divisions received large excess/excess/normal rainfall, except sub divisions from northeast, Konkan & Goa, Coastal Karnataka, Kerala & Mahe and both the islands.

During the season, out of 36 meteorological subdivisions, 17 received large excess rainfall, 4 received excess rainfall, 7 subdivision received normal rainfall, 6 received deficient rainfall and 2 received large deficient rainfall (Fig. 2).

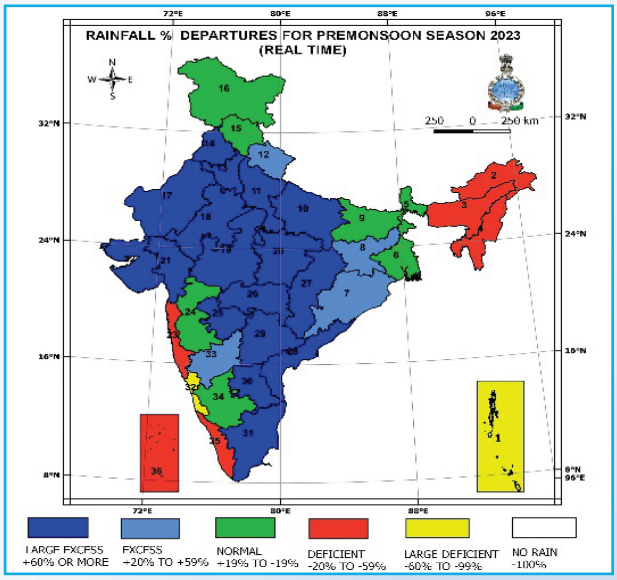


Fig. 2. Divisionwise rainfall percentage departures for pre-monsoon (Mar-May) 2023

Fig. 3(a) shows the spatial pattern of rainfall (mm) received during the season. Parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub Himalayan West Bengal & Sikkim, Jammu & Kashmir & Ladakh and Himachal Pradesh received more than 400 mm rainfall.

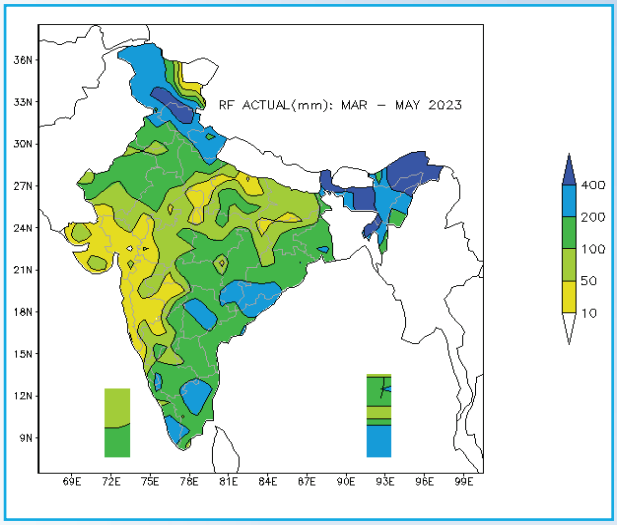


Fig. 3(a). Seasonal rainfall pre-monsoon (Mar-May) 2023

Fig. 3(b) shows the spatial pattern of rainfall anomaly (mm) during the season. Rainfall anomaly was generally positive over most parts of the country, except east & northeastern parts, Jammu & Kashmir & Ladakh, Konkan & Goa, Karnataka state, Kerala & Mahe and both the islands. Rainfall anomaly was more than 100 mm over parts of Sub Himalayan West Bengal & Sikkim, Uttarakhand, Himachal Pradesh, East and west Rajasthan, Haryana, Chandigarh & Delhi, Punjab, Odisha, Chhatisgarh, East and west Madhya Pradesh, Coastal Andhra Pradesh, Telangana, Rayalaseema, Tamilnadu, Puducherry & Karaikal. Magnitude of negative rainfall anomaly was more than 100 mm over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Bihar, Jammu & Kashmir & Ladakh, Coastal Karnataka, Kerala & Mahe and both the islands.

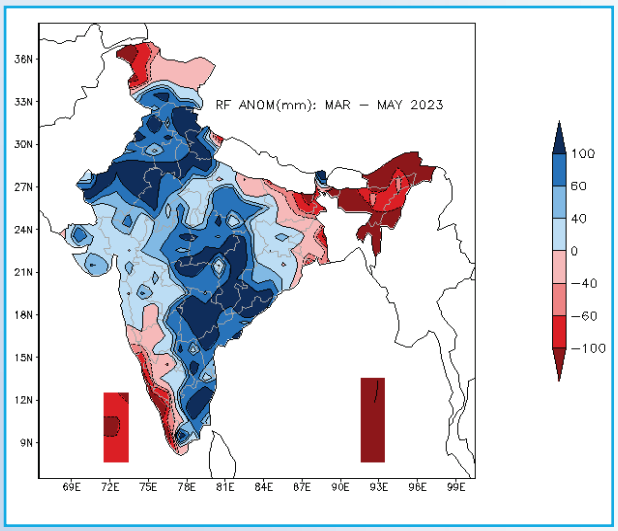


Fig. 3(b). Seasonal rainfall anomaly (mm) Pre-monsoon (Mar-May) 2023 (Based on 1971-2020 NOR)

Fig. 4 shows area weight averaged rainfall series for season over all India and four homogeneous regions since 1951. Seasonal rainfall realized over all India was 112 % of its LPA.

Considering homogeneous region wise it was 236% of its LPA over Central India, 137% of its LPA over south peninsula, 65% of its LPA over East & North East India and 133% of its LPA over Northwest India. Rainfall over homogeneous region of Central India (84.9 mm) was 3rd highest since 1901 after the years 1933 (106.1 mm) and 1990 (101.6 mm).

Rainfall over homogeneous region of Northwest India (152.0 mm) was 9th highest since 1901 after the years 1983 (236. 6 mm), 2015 (216.0 mm), 1982 (213.8 mm), 1987 (176.2 mm), 1926 (163.7 mm), 1986(159.8 mm), 1957 (157.3 mm) and 1963 (155.4 mm).

Rainfall over homogeneous region of East & northeast India (242.1 mm) was 6th lowest since 1901. Prior lowest rainfall years were 1903 (220.3 mm), 1979 (236.2 mm), 1908 (239.3 mm), 1901 (240.3 mm) and 1960 (240.7 mm).



Fig. 4. Time series of area weighted rainfall over all India and four homogeneous regions for pre-monsoon (1951-2023)

Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for monitoring drought and is based on only precipitation. This index is negative for dry, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. Figs. 5(a&b) give the SPI values for the Pre-monsoon season this year and for the period from past monsoon season, i.e., June 2022-May 2023 (12 months cumulative) respectively.

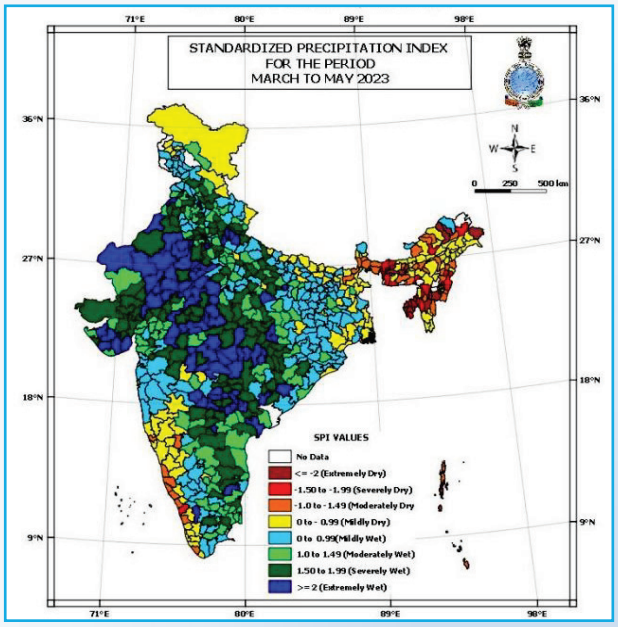


Fig. 5(a). Standardized Precipitation Index (SPI) for (3) Three Months

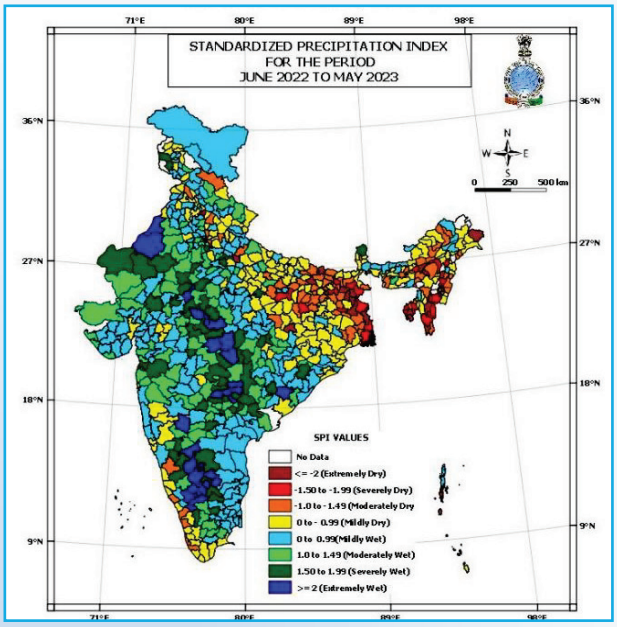


Fig. 5(b). Standardized Precipitation Index (SPI) for (12) Twelve Months

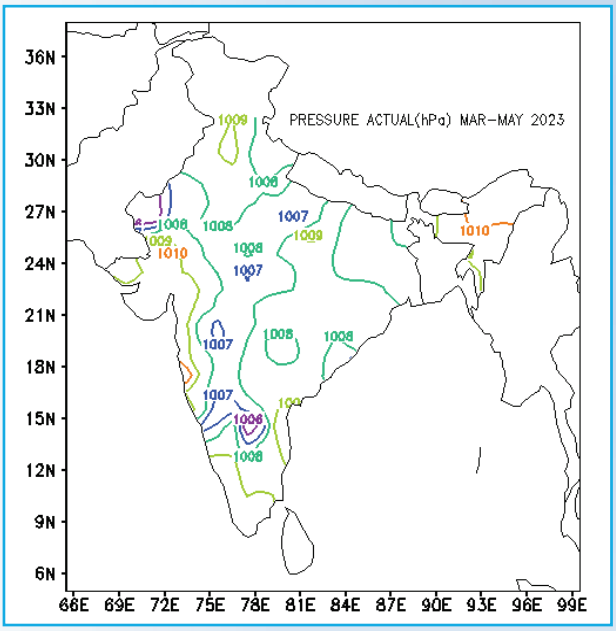


Fig. 6(a). Seasonal mean sea level pressure (hPa) mean (Based on 1981-2010 NORMALS)

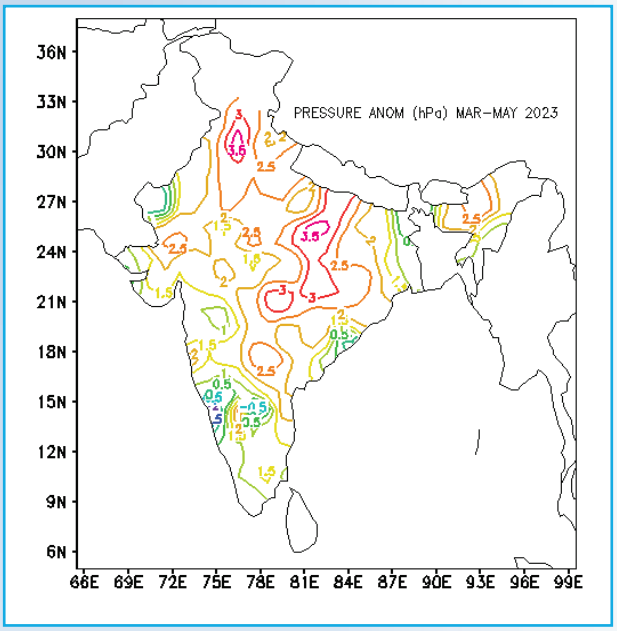


Fig. 6(b). Seasonal mean sea level pressure (hPa) Anomaly (Based on 1981-2010 NORMALS)

Cumulative SPI values of the past three months show extremely wet/severely wet conditions over parts of Odisha, Bihar, Uttar Pradesh state, Uttarakhand, Haryana, Chandigarh & Delhi, Punjab, Himachal Pradesh, Rajasthan state, Madhya Pradesh state, Gujarat state, Madhya Maharashtra, Marathawada, Vidarbha, Chhattisgarh, Andhra Pradesh state, Telangana, Tamilnadu, Puducherry & Karaikal and North Interior Karnataka while, extremely dry/severely dry conditions were observed over parts of A & N Islands, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura and Kerala & Mahe.

Cumulative SPI values of the past twelve months indicate that extremely wet/severely wet

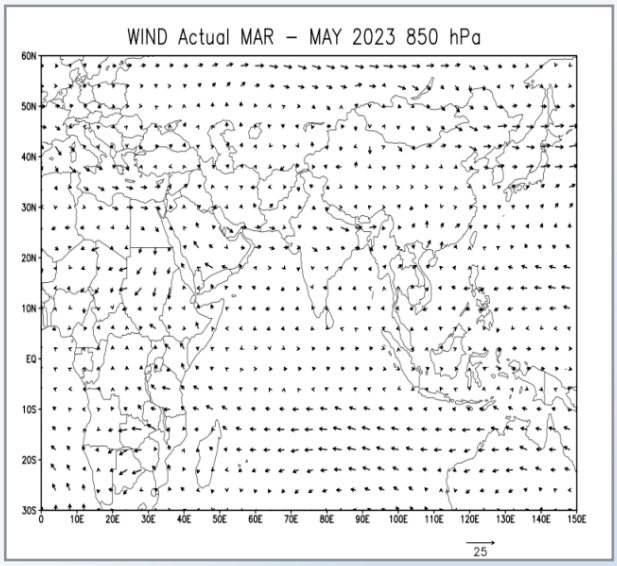


Fig. 7(a). Seasonal wind (m/s) mean at 850 hPa(Operational nwp analysis of IMD GFS T-574)

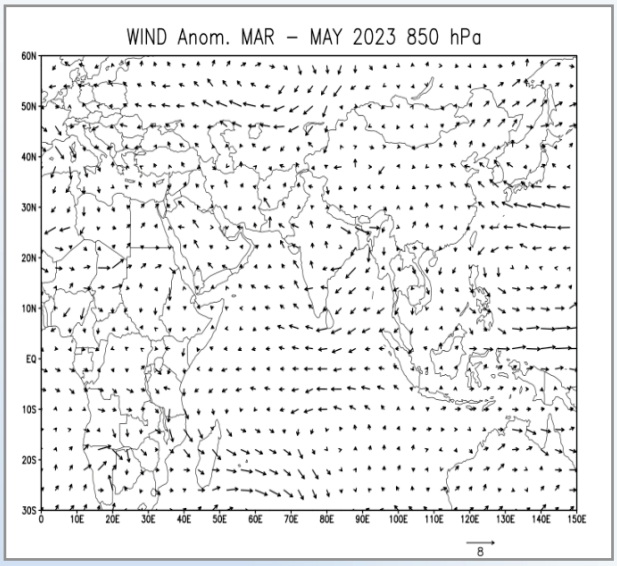


Fig. 7(b). Seasonal wind (m/s) anomaly at 850 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

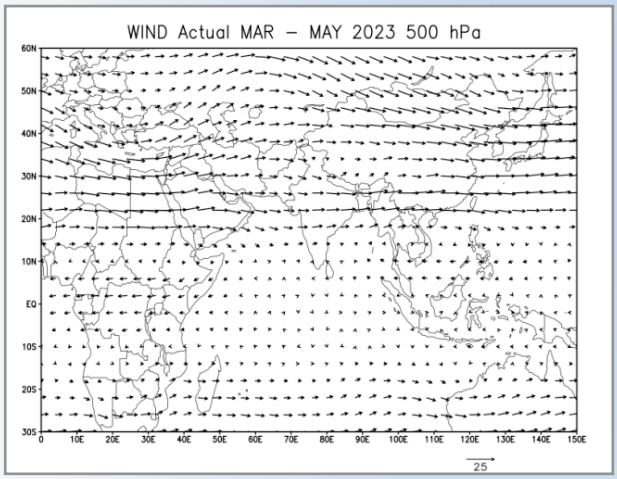


Fig. 8(a). Seasonal wind (m/s) mean at 500 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574)

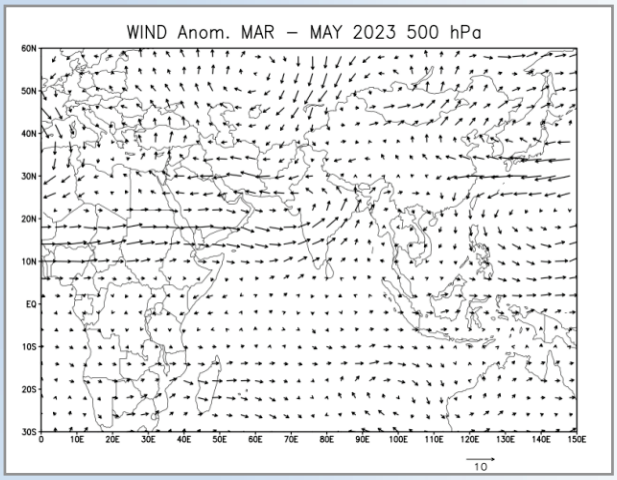


Fig. 8(b). Seasonal wind (m/s) anomaly at 500 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

conditions were observed over parts of Sub Himalayan West Bengal & Sikkim, Odisha, Uttar Pradesh state, Haryana, Chandigarh & Delhi, Jammu & Kashmir, Rajasthan state, Madhya Pradesh state, Gujarat Region, Madhya Maharashtra, Vidarbha, Chhattisgarh, Telangana, Rayalaseema, Tamilnadu, Puducherry & Karaikal, North Interior Karnataka and South Interior Karnataka while, extremely dry/severely dry conditions were observed over parts of A & N Islands, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub Himalayan West Bengal & Sikkim, Gangetic West Bengal, Jharkhand, Bihar, East Uttar Pradesh, Haryana, Chandigarh & Delhi and Chhattisgarh.

Pressure & Wind

Figs. 6(a&b) show the mean sea level pressure & its anomaly respectively. The pressure anomaly was positive over almost all parts of the country. The pressure anomaly was more than +1.5 hPa over

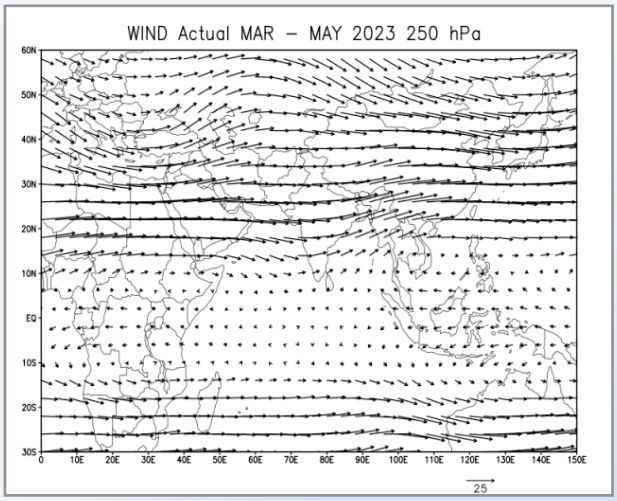


Fig. 9(a). Seasonal wind (m/s) mean at 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574)

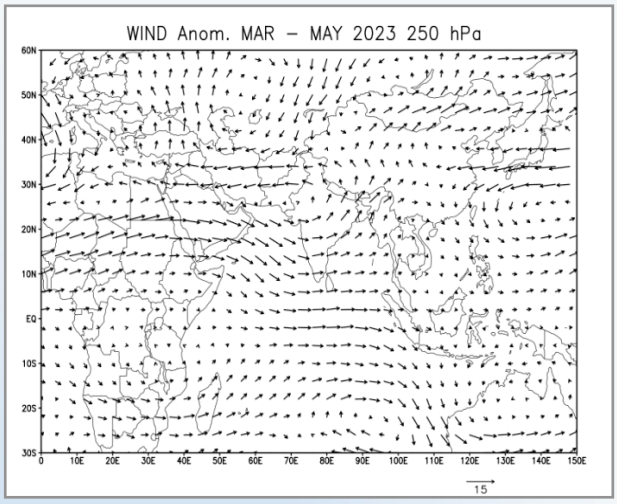


Fig. 9(b). Seasonal wind (m/s) anomaly at 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source: NCMRWF)

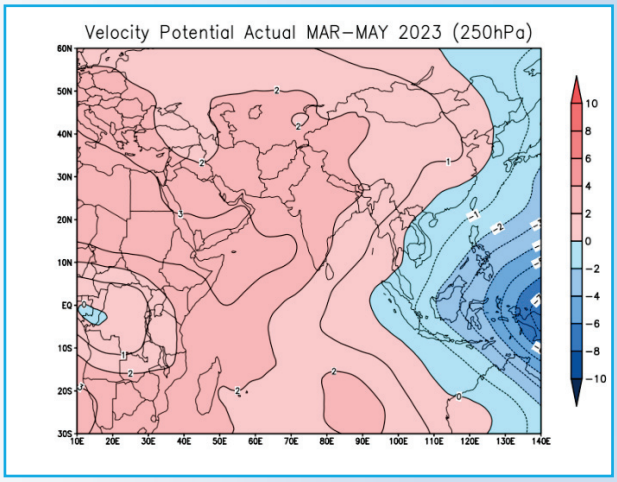


Fig. 10(a). Velocity potential (106m^2/s) Mean at 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574)

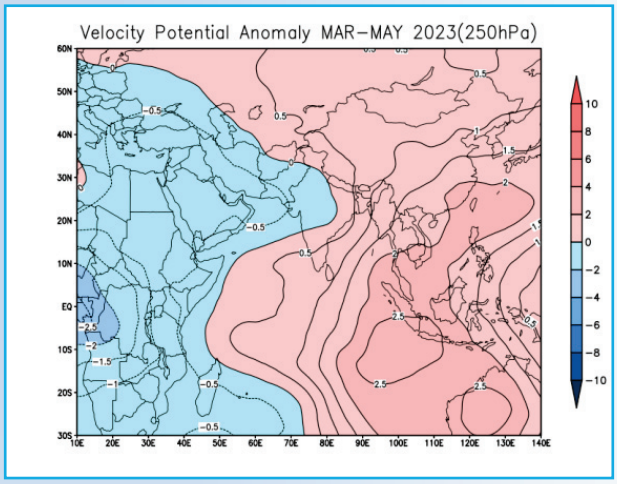


Fig. 10(b). Velocity potential (106m^2/s) Anomaly at 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

most parts of the country. The pressure anomaly was more than +3.0 hPa over east central India and northern India.

(a) Mean Sea Level Pressure (mslp)

Figs. 7(a&b), 8(a&b) and 9(a&b) shows the mean circulation pattern and its anomaly at 850, 500 & 250 hPa levels respectively. At 850 hPa level, an anomalous anti cyclonic circulation was seen over central parts of Bay of Bengal and adjoining central India. At 500 hPa level, an anomalous trough was seen over entire country and adjoining Arabian Sea. This pattern persisted at 250 hPa level also.

Velocity Potential & Stream Function

Figs. 10(a&b) show the 250 hPa mean Velocity Potential & its anomalies. Similarly, Figs. 11(a&b) show the mean stream function & its anomalies at 850 hPa level. Negative values are indicated by dashed lines. Anomaly in the velocity potential at 250 hPa level was positive over most parts of the country except northwest and westcentral region,

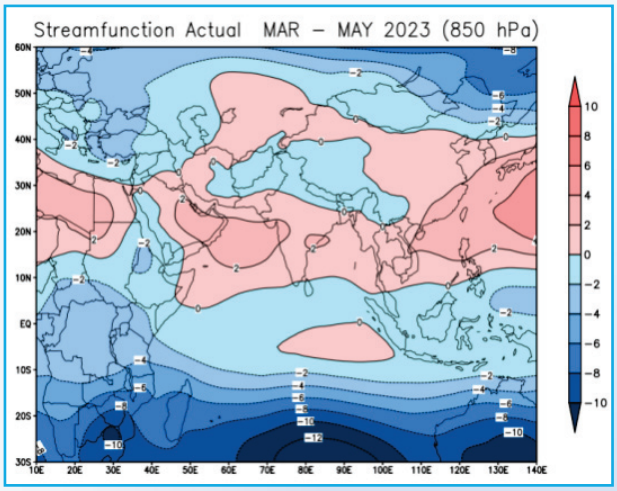


Fig. 11(a). Stream function (106m^2/s) Mean at 850 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574)

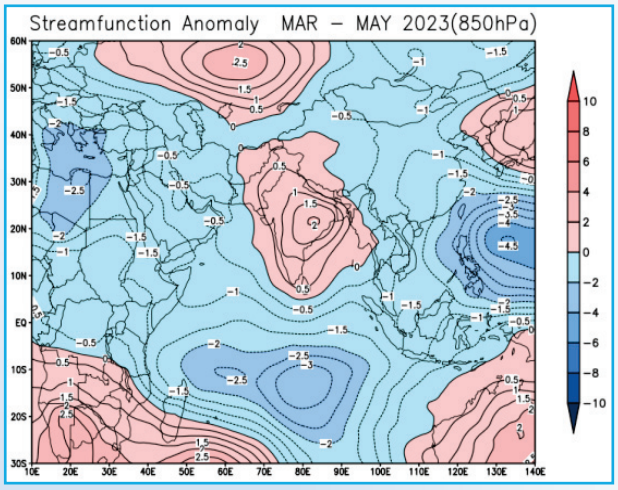


Fig. 11(b). Stream function (106m^2/s) Anomaly at 850 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

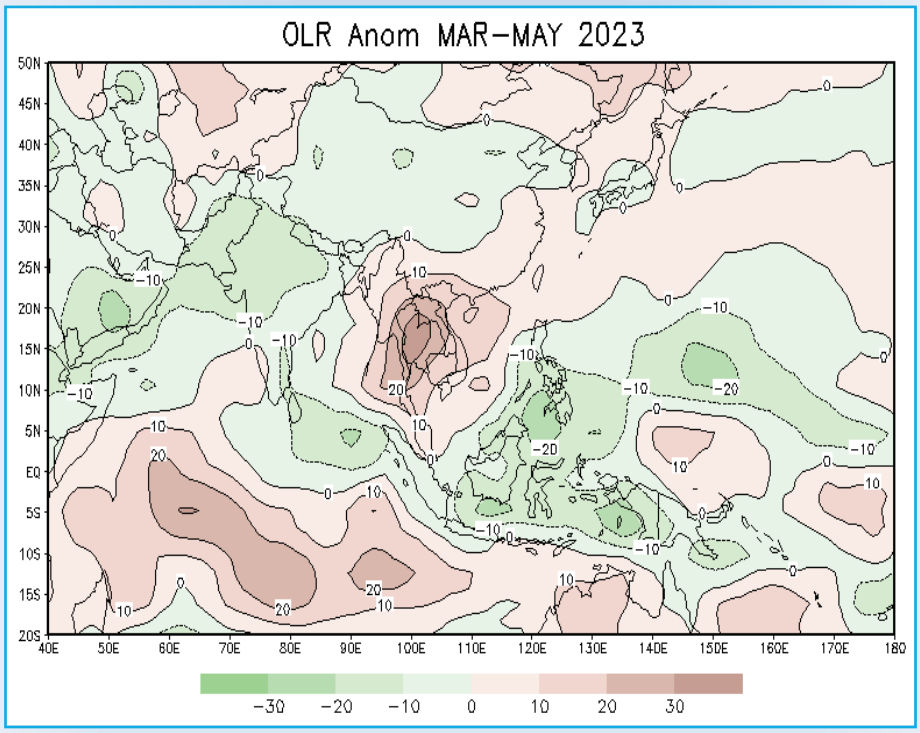


Fig. 12. OLR anomaly (w/m^2) for pre monsoon (MARCH-MAY) 2023 (Source : CDC / NOAA, USA) BASED ON 1991 - 2020 CLIMATOLOGY)

while anomaly in the stream function at 850 hPa level was positive over entire country.

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood is shown in Fig. 12. OLR anomaly was negative over most parts of the country. OLR anomaly was within 0 to -10 W/m^2.

Temperature

Mean seasonal maximum and minimum temperature anomalies are shown in Figs. 13(a&b) respectively. Maximum temperature was below normal over most parts of the country, except some parts of east & northeast India, coastal parts of India and both the Islands. Maximum temperature anomaly was more than 1 °C over

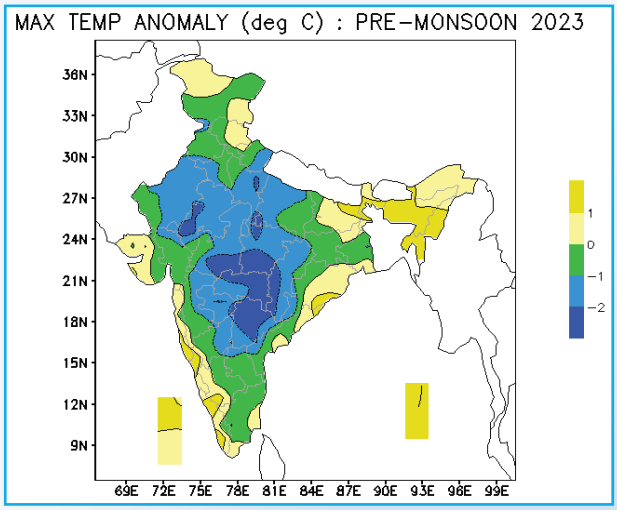


Fig. 13(a). Mean monthly temperatureanomalies (°C) Maximum (Based on 1981-2010 Normals)

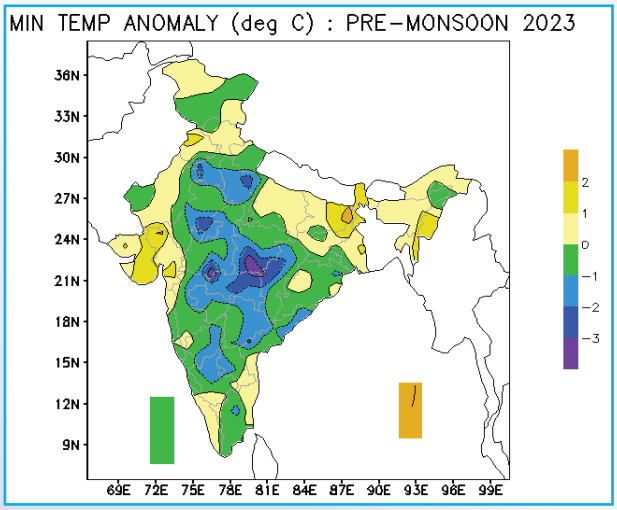


Fig. 13(b). Mean monthly temperature anomalies (°C) Minimum (Based on 1981-2010 Normals)

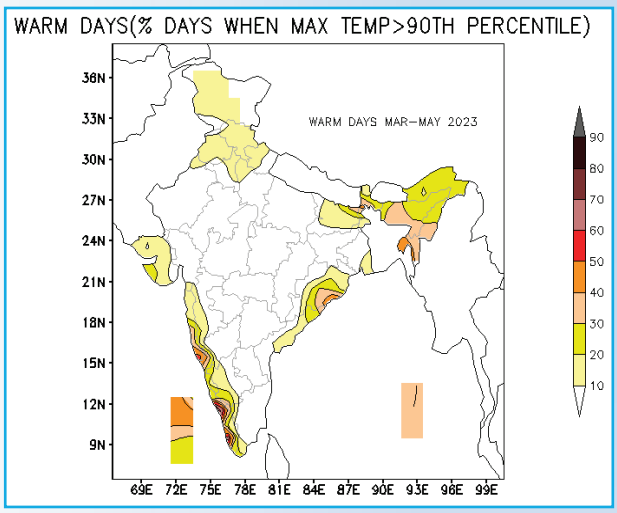


Fig. 14(a). Percentage of Days When Maximum Temperature > 90Th Percentile

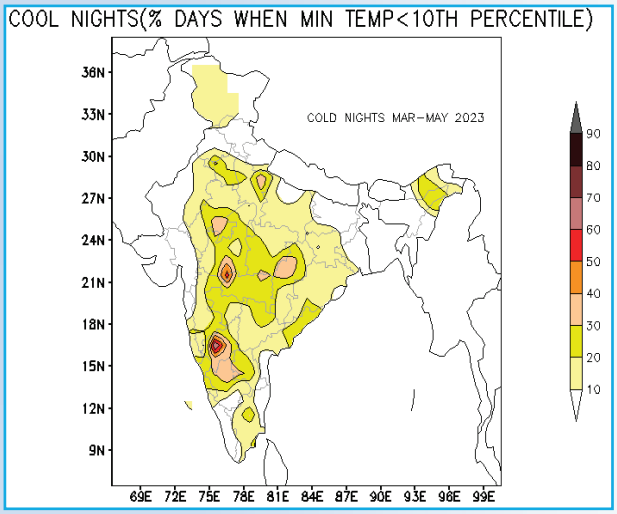


Fig. 14(b). Percentage of Days When Minimum Temperature < 10Th Percentile

parts of Bihar, Sub Himalayan West Bengal, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram, Tripura, Odisha, Coastal Andhra Pradesh & Yanam, Kerala & Mahe, Coastal Karnataka, South Interior Karnataka and both the Islands. Maximum temperature anomaly was less than -2 °C over parts of West Rajasthan, Uttar Pradesh state, Madhya Pradesh state, Chhattisgarh, Vidarbha, Marathwada and Telangana.

Minimum temperature was below normal over most parts of the country, except some parts of east & northeast India, northwest India, west central India, coastal south peninsular India and Andman & Nicobar Island. Minimum temperature anomaly was more than 2 °C over parts of Bihar and Andman & Nicobar Island. Minimum temperature anomaly was less than -3 °C over parts of Madhya Pradesh state and Vidarbha.

Percentage of Warm Days/Cold Nights

Figs. 14(a&b) show the percentage of days when maximum (minimum) temperature was more (less) than 90th (10th) percentile. Over parts of Kerala & Mahe maximum temperature was greater than 90th

percentile for more than 50% of the days of the season. Minimum temperature was less than 10th percentile for more than 50% of the days of the month over parts of North Interior Karnataka and West Madhya Pradesh.

Fig. 15 shows the mean temperature for the country as a whole for the season since 1971. Five year moving average values are also shown. The mean temperature for the season this year was 27.68 °C with an anomaly of 0.06 °C.

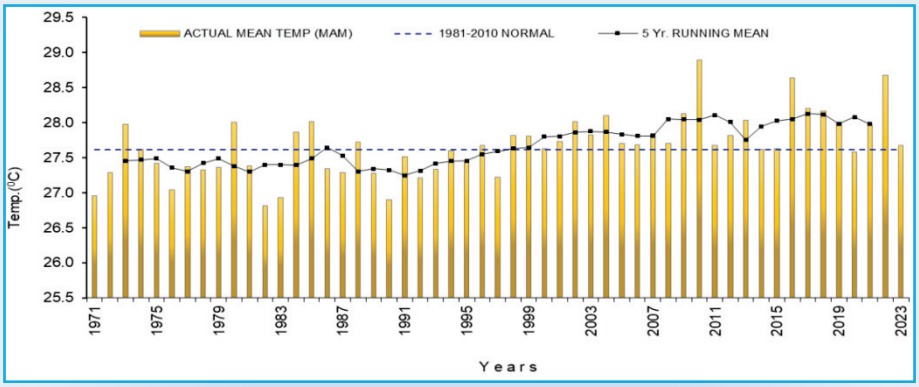
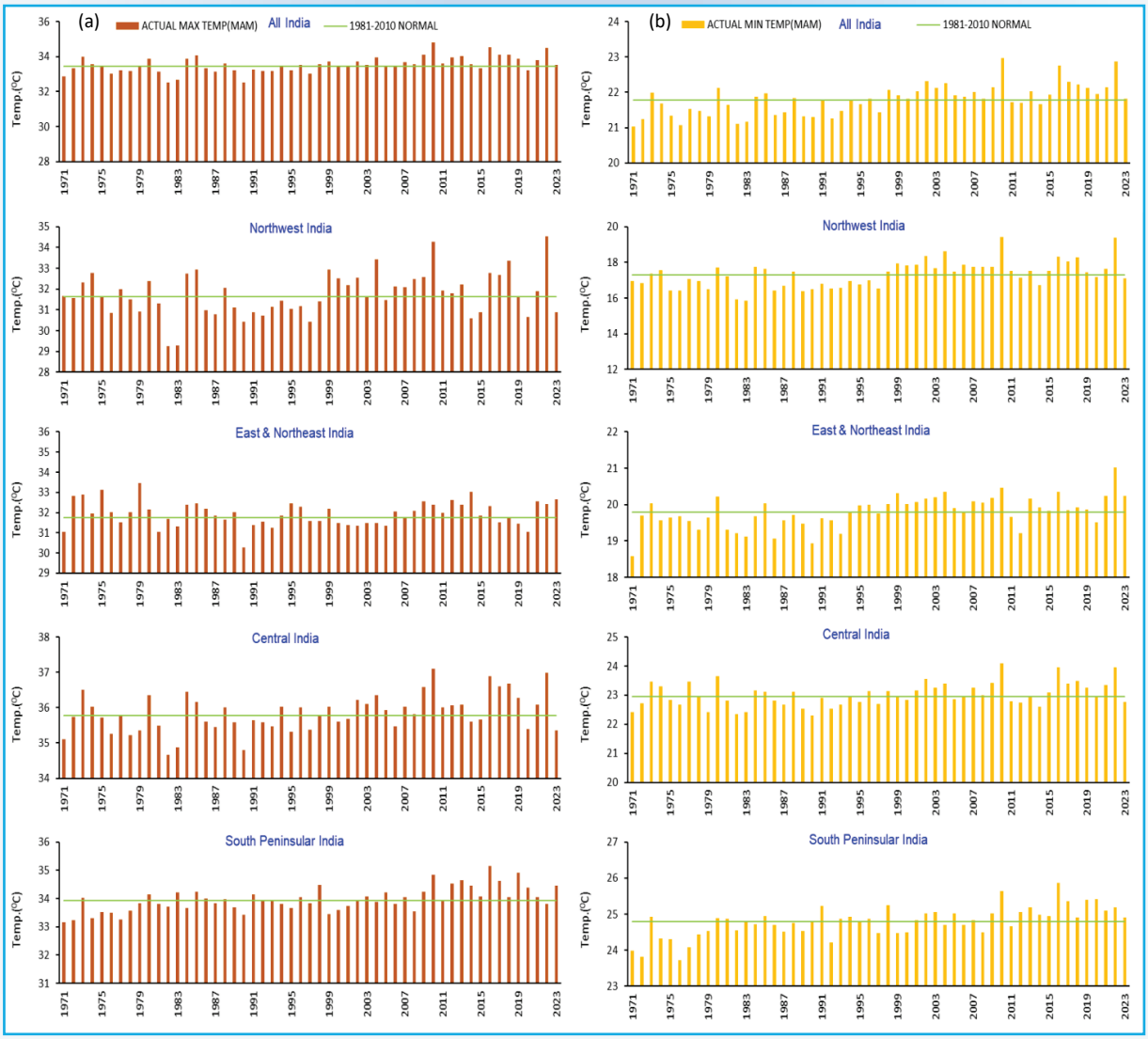


Fig. 15. Time Series of Mean Temperature Averaged Over India (Vertical Bars And Five Year Running Mean (Continous Line) For Mar-May (1971-2023)



Figs. 16(a&b). Time Series of Temperature for the Country As A Whole And The Four Homogeneous Regions For Mar-May (1971- 2023) (a) Maximum (b) Minimum

Figs. 16(a&b) shows the maximum and minimum temperature series respectively for the country as a whole and the four homogeneous regions during the season since 1971. Both maximum and minimum temperatures were below normal over all the homogeneous regions except over East & Northeast India and South Peninsular India. Over the country as a whole both maximum and minimum temperature were normal during this season. Maximum temperature over South Peninsular India (34.45 °C) was the 9th highest since 1901.

Low Pressure Systems

During the season an Extremely Severe Cyclonic storm "Mocha" formed over Bay of Bengal during 9th - 15th May. Fig 17 shows track of this system.IMD maintained round the clock watch over the north Indian Ocean and the cyclone was monitored since 27th April, 2023 about 12 days prior to formation of depression on 9th and 17 days prior to the landfall of system over Myanmar-Bangladesh coasts.

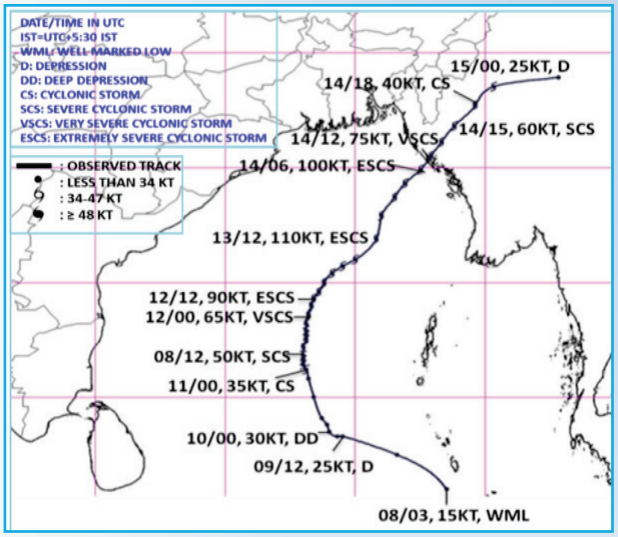


Fig. 17.Observed track of Extremely Severe Cyclonic Storm "MOCHA" over the BoB during (9-15 May, 2023)

Significant Weather Events for Pre-Monsoon Season (March-May) 2023

During Pre Monsoon Season, total 310 persons reportedly claimed dead, more than 320 persons injured, more than 10 persons missing & more than 1270 livestock perished. The details of causalities given below, which are based on real time media reports.

Fig. 18 shows deaths due to significant weather events during Pre Monsoon Season (March-April-May) 2023 (Based on real time media reports).

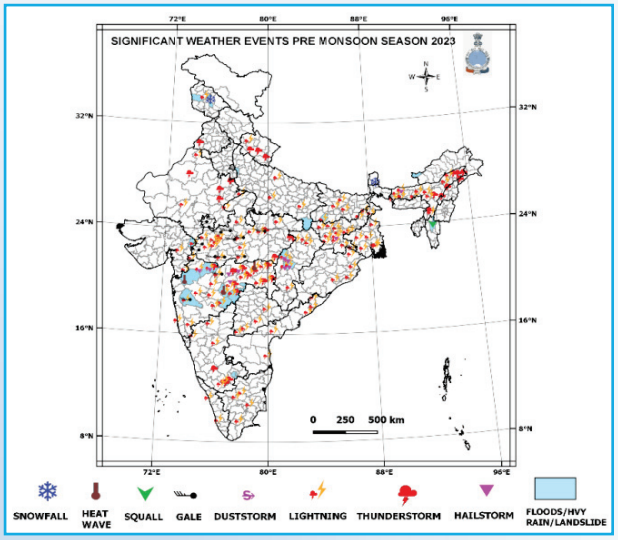


Fig. 18. Significant weather events during pre-monsoon (Mar-May) 2023 (Based on real time media report)

Lightning

Total 219 persons reportedly claimed dead, more than 120 persons injured & about 750 livestock perished, during Pre Monsoon Season, because of Lightning.

Thunderstorm

Total 47 persons reportedly claimed dead, 81 persons injured & 79 livestock perished during Pre Monsoon season, because of Thunderstorm.

Heavy Rains, Floods & Landslide

Total 23 persons reportedly claimed dead, 69 persons injured, 11 persons missing & 87 livestock perished, during Pre Monsoon season, because of heavy rains, floods & Landslide.

Gale

Total 6 persons reportedly claimed dead, 17 persons injured & 2 livestock perished, because of Gale.

Heat Wave

Total 5 persons reportedly claimed dead because of Heat Wave from Nagpur, Nashik & Parbhani districts of Maharashtra on 12th & 21st May.

Hailstorm

Total 2 persons reportedly claimed dead, 4 persons injured & more than 350 livestock perished during Pre Monsoon season. The details are summarized and given in the table below;

Squall

16 persons injured due to Squall in Aizawl, the state capital of Mizoram on 5th May.

3. Southwest (SW) Monsoon (June-July-August-September)

Highlights

During Monsoon, over the country, the mean temperature was 28.77 °C with an anomaly of 0.74 °C, the highest since 1901. Over the country as a whole the maximum temperature was 2nd highest (32.73 °C with an anomaly of 0.78 °C) after the year 1987(32.76 °C) and the minimum temperature was highest (24.80 °C with an anomaly of 0.71 °C) since 1901.

Among the four homogeneous regions, over Northwest India, the minimum temperature was 2nd highest (23.44 °C with an anomaly of 0.72 °C) after the year 2022(23.44 °C) since 1901. Over East & Northeast India the maximum temperature was highest (33.21 °C with an anomaly of 1.58 °C) and the minimum temperature was also highest (25.23 °C with an anomaly of 1.04 °C) since 1901. Over Central India, the minimum temperature was highest (25.13 °C with an anomaly of 0.49 °C) since 1901. Over South Peninsular India the maximum temperature was highest (32.43 °C with an anomaly of 0.99 °C) and the minimum temperature was also highest (25.26 °C with an anomaly of 0.68 °C) since 1901.

Onset Advance and Withdrawal of Southwest Monsoon

Fig. 1(a) depicts the isochrones of the advance of the southwest monsoon and Fig. 1(b) depicts the isochrones of withdrawal of the southwest monsoon. The advance of the Southwest Monsoon began on May 19th in the southeast Bay of Bengal, Nicobar Islands, and south Andaman Sea. By May 30th, it had extended its reach to the southwest Bay of Bengal, more parts of the southeast Bay of Bengal, the Andaman Sea, Andaman and Nicobar Islands, and portions of the east-central Bay of Bengal. Continuing its advance, the monsoon Themonsoon covered areas such as the south Arabian Sea, Maldives and the Comorin region on June 1st, followed by additional parts of the south Bay of Bengal and east-central Bay of Bengal on June 2nd.

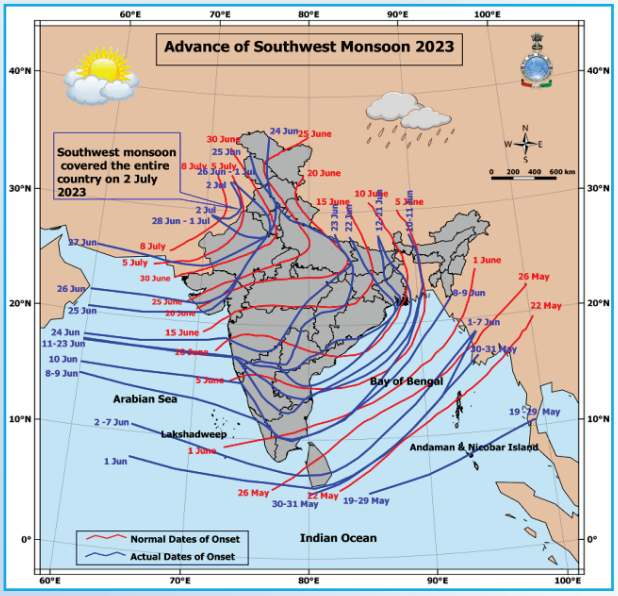


Fig. 1(a). Advance of Southwest Monsoon 2023

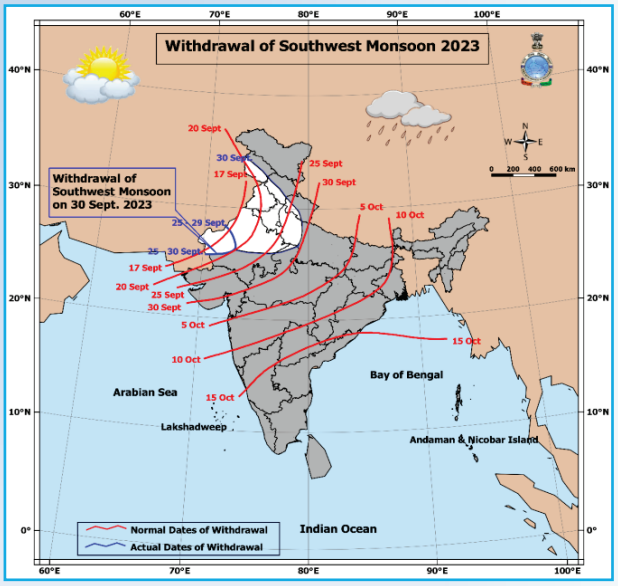


Fig. 1(b). Withdrawal of Southwest Monsoon 2023 Till 30th September

Monsoon reached Kerala on June 8th, 7 days later than the normal date of onset over Kerala. From there, it progressed further, encompassing the central Arabian Sea, remaining parts of Kerala, portions of Karnataka, southwest Bay of Bengal,

east-central Bay of Bengal, northeast Bay of Bengal, northwest Bay of Bengal, most of the north-eastern states, Goa, Konkan, Tamil Nadu, Puducherry, southwest Bay of Bengal, parts of west-central Bay of Bengal, and more parts of Andhra Pradesh, among others, by the second week of June. On June 19th, it extended to more areas, including parts of Karnataka, Andhra Pradesh, west-central and northwest Bay of Bengal, and parts of Gangetic West Bengal and Jharkhand. During the last week of June, it covered a vast expanse, including Odisha, Telangana, Chhattisgarh, Jammu and Kashmir, Ladakh, Uttar Pradesh, Himachal Pradesh, Vidarbha, Haryana, north Arabian Sea, Gujarat, Rajasthan, and more. Finally, on July 2nd, it encompassed the remaining parts of Rajasthan, Haryana and Punjab, effectively covering the entire country, a remarkable six days ahead of the usual date of July 8th.

The withdrawal of the SW-monsoon 2023 began on 25th September [Fig. 1(b)].

Rainfall Features

Most sub-divisions of the country received excess/normal rainfall except Nagaland, Manipur, Mizoram & Tripura, Jharkhand, Bihar, Gangetic West Bengal, East Uttar Pradesh, South Interior Karnataka and Kerala & Mahe. During the season, out of 36 meteorological subdivisions, 3 subdivisions received excess rainfall, 26 received normal rainfall and the remaining 7 subdivisions received deficient rainfall (Fig. 2). Table 1 shows the subdivision-wise rainfall statistics (mm) for the Southwest Monsoon Season 2023.

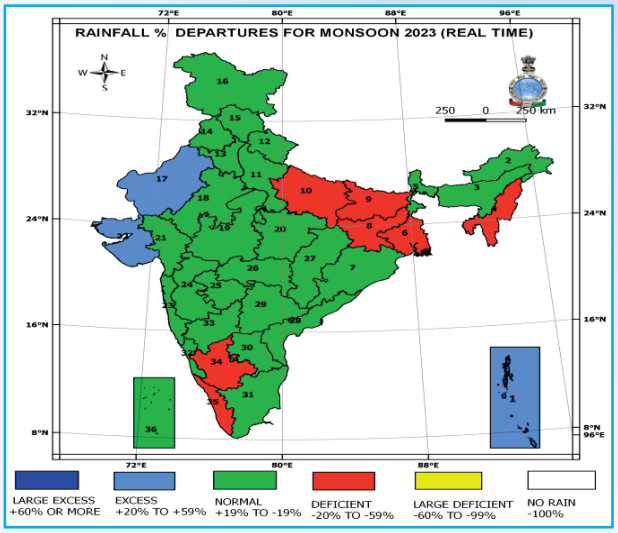


Fig. 2. Sub-divisionwise rainfall percentage departures for the monsoon 2023

Figs. 3(a-d) shows the subdivision-wise distribution of rainfall percentage departures for the four months of the monsoon season (June to September) 2023.

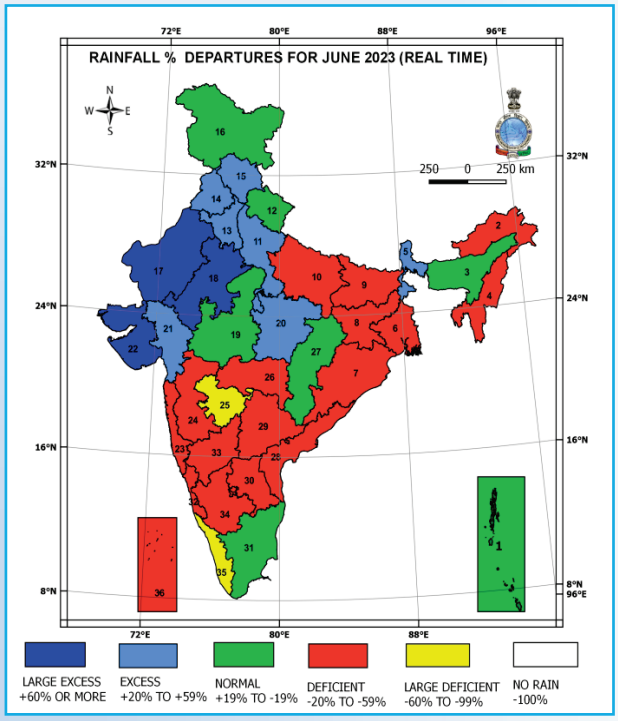


Fig. 3(a). Monthly sub-divisionwise distribution of rainfall percentage departures (June, 2023)

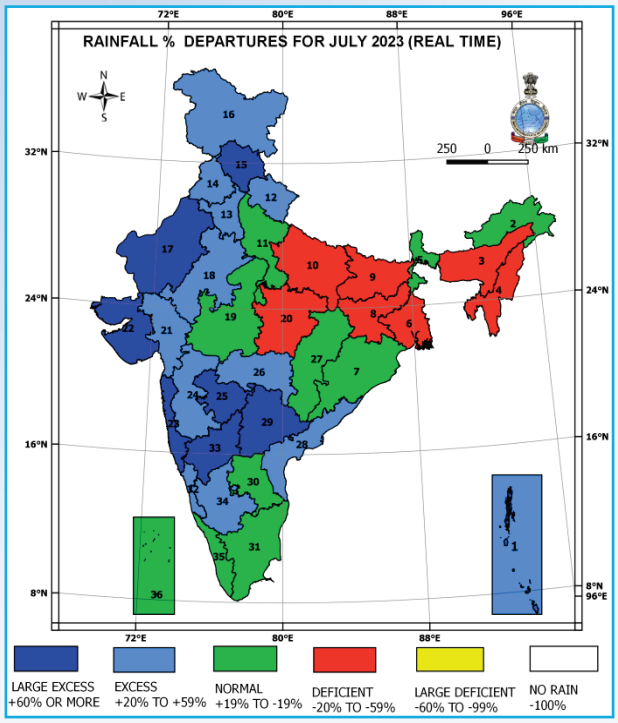


Fig. 3(b). Monthly sub-divisionwise distribution of rainfall percentage departures (July, 2023)

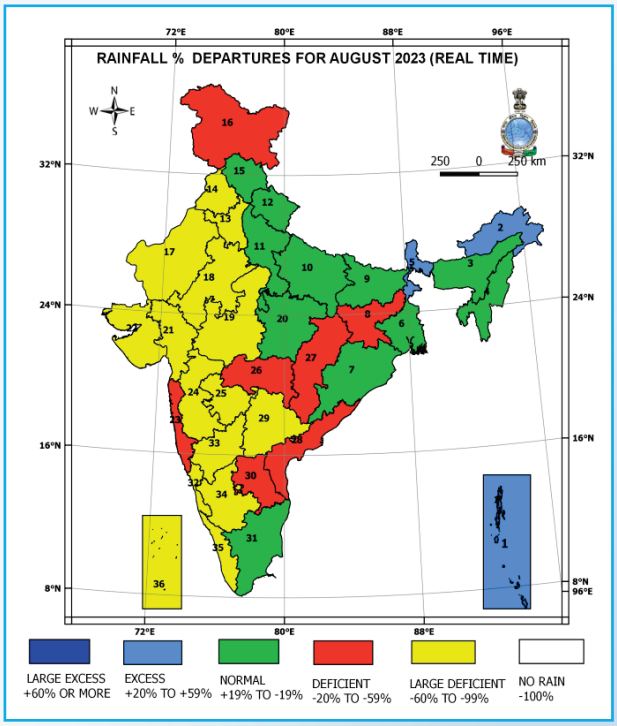


Fig. 3(c). Monthly sub-divisionwise distribution of rainfall percentage departures (August, 2023)

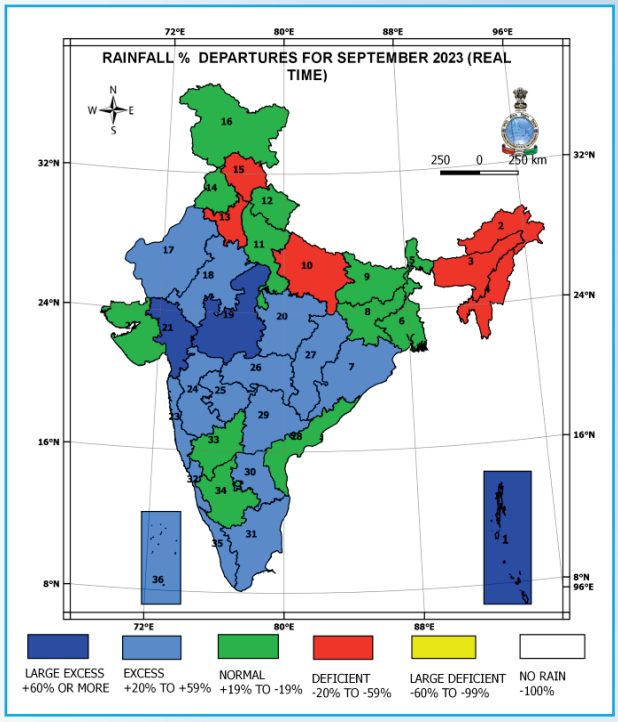


Fig. 3(d). Monthly sub-divisionwise distribution of rainfall percentage departures (September, 2023)

Fig. 4(a) and 4(b) show the spatial pattern of rainfall received during the season and its anomaly (mm) respectively.

Most parts of northeast India, central India, north India, west coast and Andaman & Nicobar Islands received more than 1000 mm rainfall. Parts of Arunachal Pradesh, Assam & Meghalaya, Sub Himalayan West Bengal & Sikkim, the entire west coast, and Andaman & Nicobar Islands received more than 2000 mm of rainfall. Parts of Assam & Meghalaya, Andaman & Nicobar Islands, and the west coast received more than 3000 mm of rainfall.

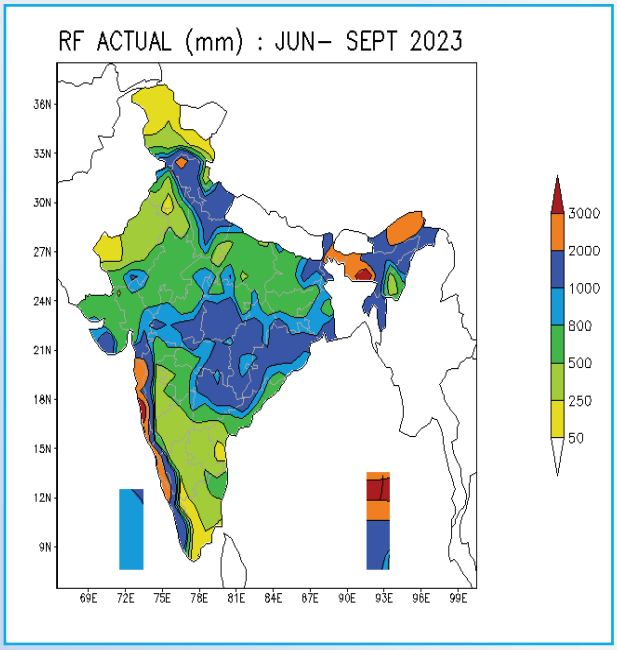


Fig. 4(a). Seasonal rainfall (mm)

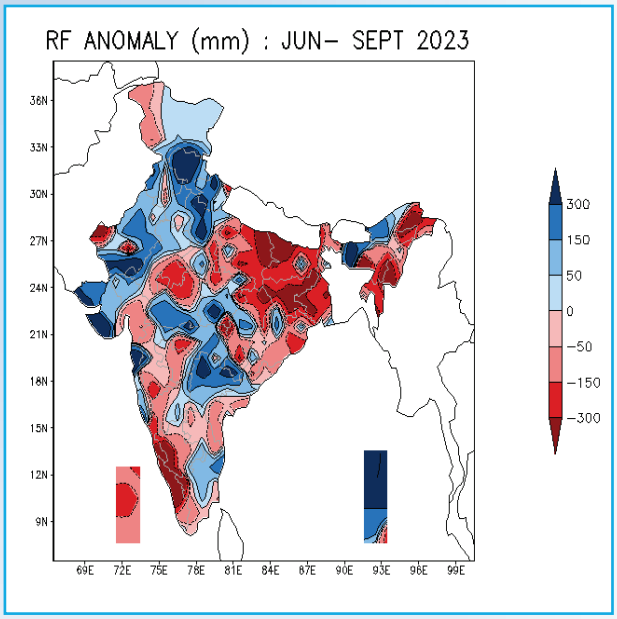


Fig. 4(b) Seasonal rainfall anomaly (mm) (based on 1971-2020 normals)

Positive rainfall anomaly of more than 300 mm was observed over Assam & Meghalaya, Uttarakhand, West Uttar Pradesh, Himachal Pradesh, Saurashtra & Kutch, West Rajasthan,

Konkan & Goa, Telangana and Andaman & Nicobar Islands. The magnitude of negative rainfall anomaly was more than 300 mm over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Bihar, Jharkhand, East Uttar Pradesh, West Rajasthan, South Interior Karnataka, Coastal Karnataka and Kerala & Mahe.

The number of subdivisions that received excess, normal, deficient, or scanty rainfall during each month of the season, actual and Long Period Average (LPA) rainfall and the percentage of LPA for the country as a whole for each month and season is given in the following table:

MONTH		JUNE	JULY	AUGUST	SEPTEMBER	SEASON
Number of subdivisions in different categories	Large Excess	3	7	0	3	0
	Excess	8	12	3	15	3
	Normal	6	10	11	12	26
	Deficient	17	7	7	6	7
	Large Deficient	2	0	15	0	0
	No Rain	0	0	0	0	0
Actual (mm)		151.2	315.9	162.7	190.0	820
LPA (mm)		165.3	280.5	254.9	167.9	869
Rainfall (% of LPA)		**91**	**113**	**64**	**113**	**94.4**

Fig. 5 shows the daily area-weight averaged rainfall (in mm) and its long-term normal over the country as a whole and the four homogeneous regions during the season. For the country as a whole, the average rainfall was above or near normal on 10 days during June, 19 days during July, 4 days during August and 18 days during September.

On almost 13 occasions including the continuous periods of 7-9 July, 8-9 September and 15-17 September it was more than one and a half times its normal value. It was below normal at a stretch on 2-16 June, 20-24 June, 4-18 August, 24 August - 6 September and 26-29 September.

Fig. 6 shows the area weight averaged weekly and cumulative rainfall percentage departure respectively for the country as a whole during the season. Of the seventeen weeks of monsoon season, rainfall was above normal (>+10%) on seven occasions, below normal (<-10%) on seven occasions, and near normal on three occasions. Cumulative rainfall departure was negative during June, Aug, and September and was positive during July. The area-weight averaged rainfall for the monsoon season for All India this year was 94.4% of its LPA value.

The realized rainfall for the season this year was 101% of its LPA over northwest India, 100 % of its LPA over central India, 81% of its LPA over east & northeast India, and 92% of its LPA over south peninsula.

Fig. 7 shows area weighted rainfall series for the monsoon season over all India and four homogeneous regions since 1951.

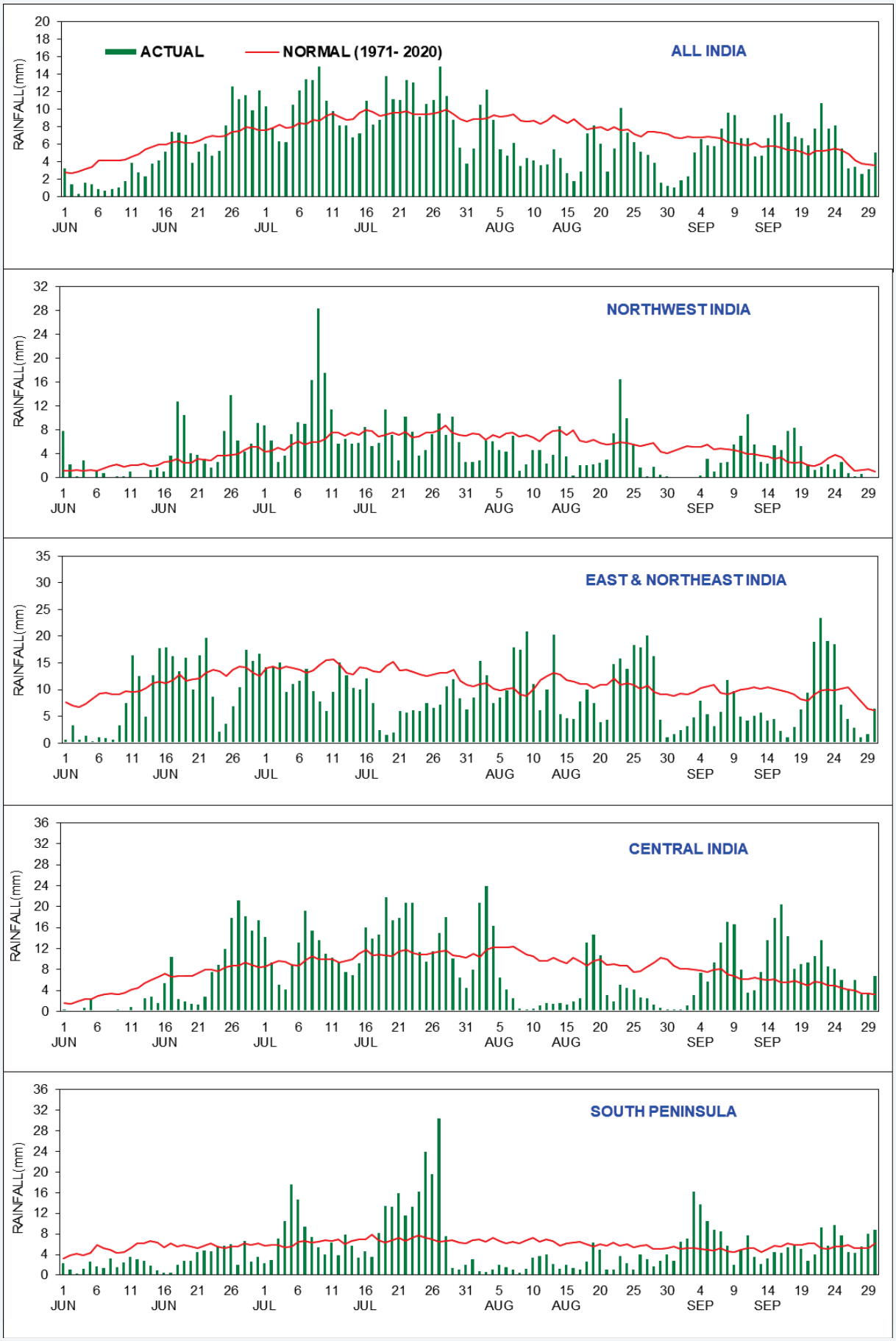


Fig. 5. Daily area weighted rainfall (mm) and its long term normal for the country as a whole and the four homogeneous regions (1st June - 30th September)

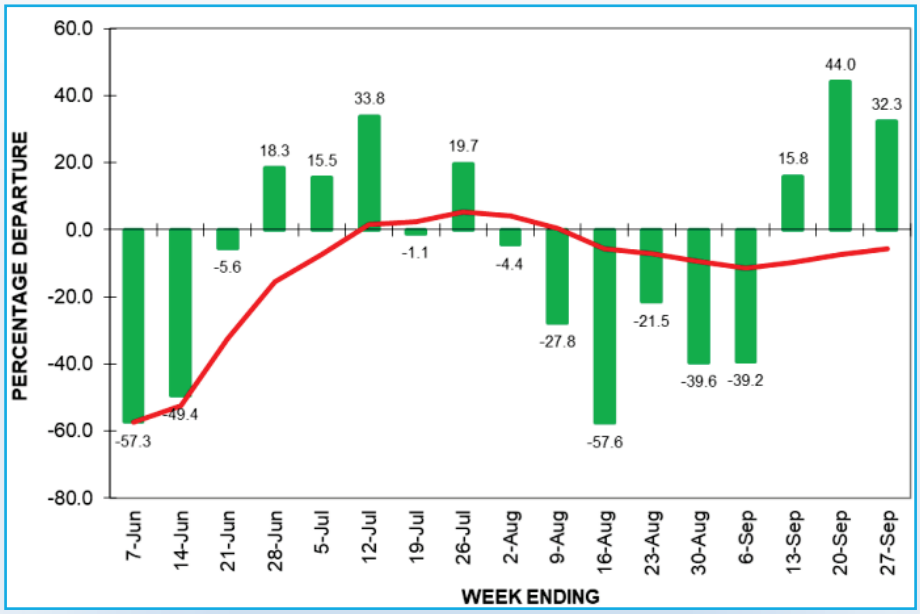


Fig. 6. Week wise and cumulative percentage departure of area weighted rainfall over the country as a whole during June to September 2023

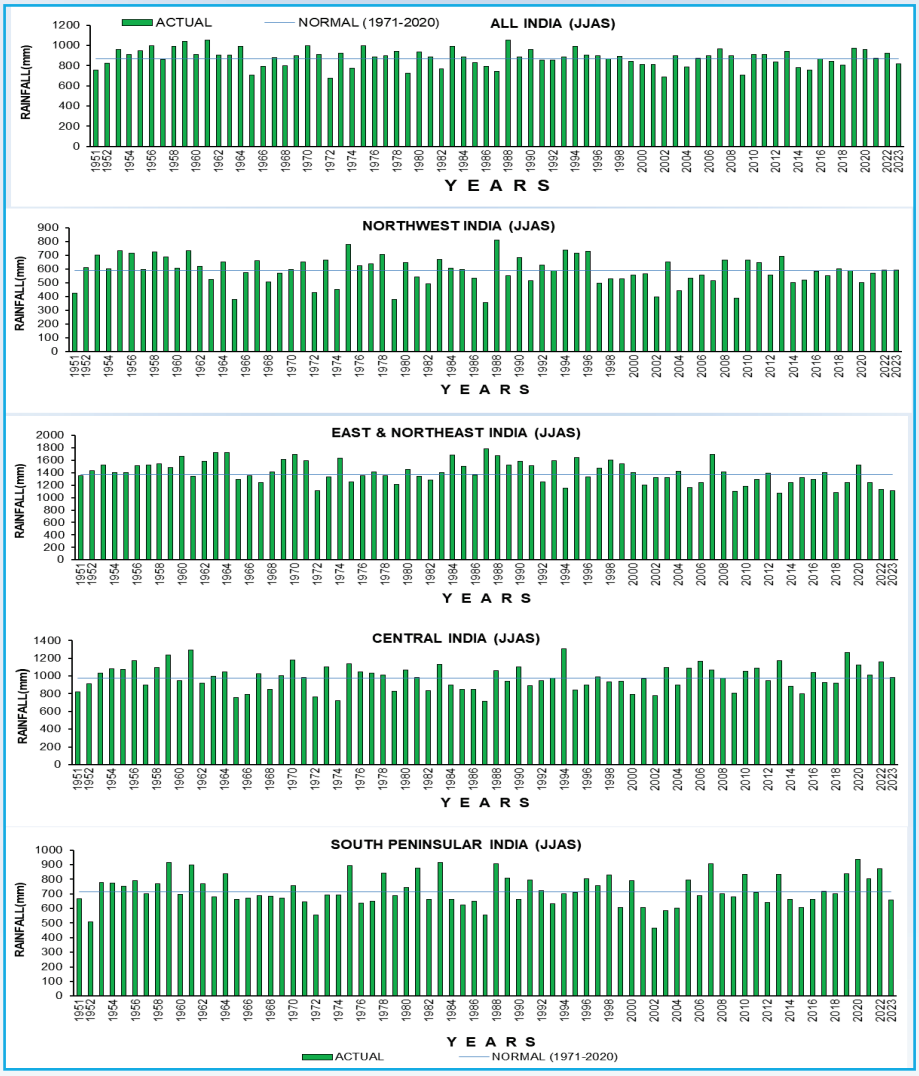


Fig. 7. Time series of area weighted rainfall over all India and four homogenous regions for the monsoon season during the period 1951-2023

Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for monitoring drought and is based only on precipitation. This index is negative for dry and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. Figs. 8(a&b) give the SPI values for the monsoon season (four months) and the year since January 2023 (nine months) respectively. Cumulative past four months' SPI values indicate, extremely wet/severely wet conditions over parts of Andaman & Nicobar Islands, Nagaland, Manipur, Mizoram & Tripura, West Uttar Pradesh, Uttarakhand, Haryana, Chandigarh & Delhi, Himachal Pradesh, West Madhya Pradesh, Saurashtra & Kutch, Chhattisgarh and Tamil Nadu & Karaikal while, extremely dry/severely dry conditions were observed over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Jharkhand, Bihar, Uttar Pradesh state, Madhya Maharashtra, Chhattisgarh, South Interior Karnataka and Kerala & Mahe.

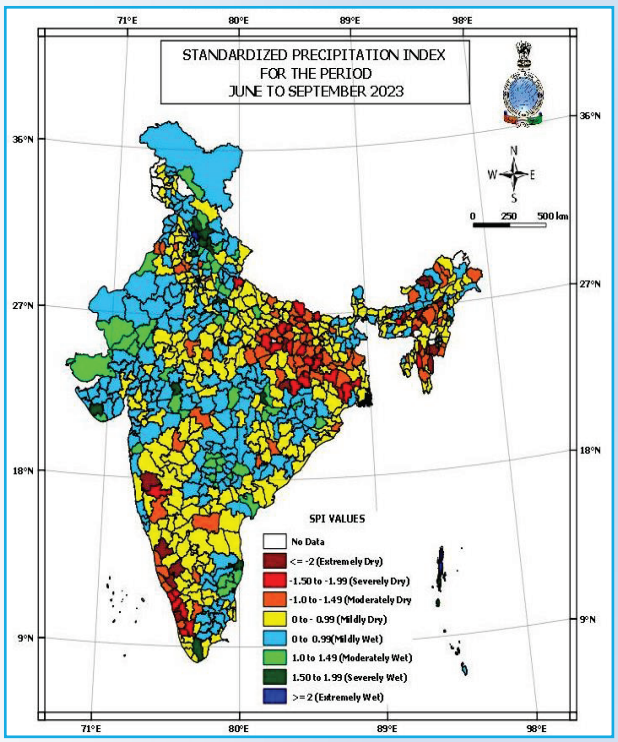


Fig. 8(a). Standardized Precipitation Index (SPI) For Four Months (June-September 2023)

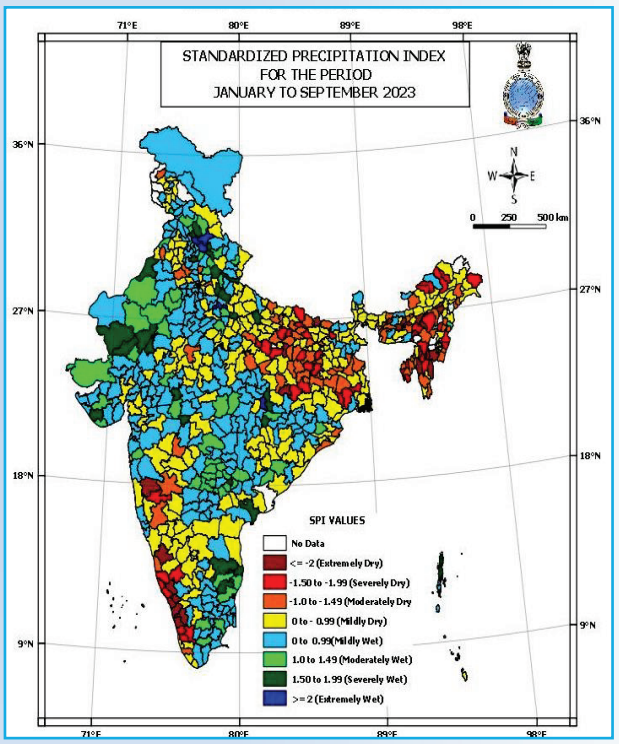


Fig. 8(b). Standardized Precipitation Index (SPI) For Nine Months (January 2023-September 2023)

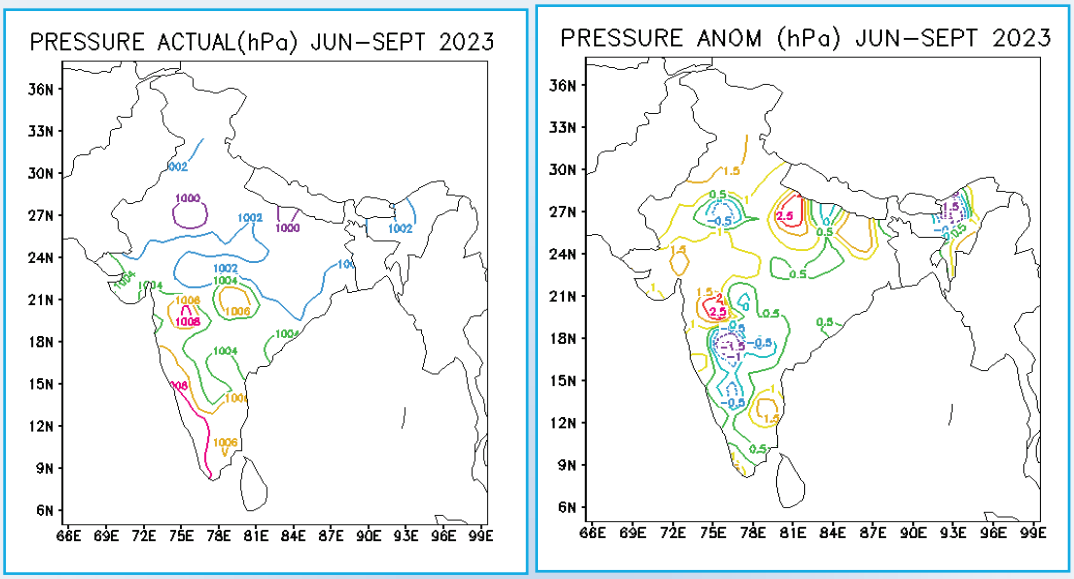
Cumulative SPI values of the nine months indicate, extremely wet/severely wet conditions over parts of Andaman & Nicobar Islands, Uttar Pradesh state, Uttarakhand, Haryana, Chandigarh & Delhi, Himachal Pradesh, Rajasthan state, West Madhya Pradesh, Saurashtra & Kutch, Chhattisgarh, Andhra Pradesh state, Telangana and Tamil Nadu & Karaikal while, extremely dry/severely dry conditions were observed over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Jharkhand, Bihar, East Uttar Pradesh, Madhya Maharashtra, Chhattisgarh, Coastal Karnataka, South Interior Karnataka and Kerala & Mahe.

Pressure & Wind

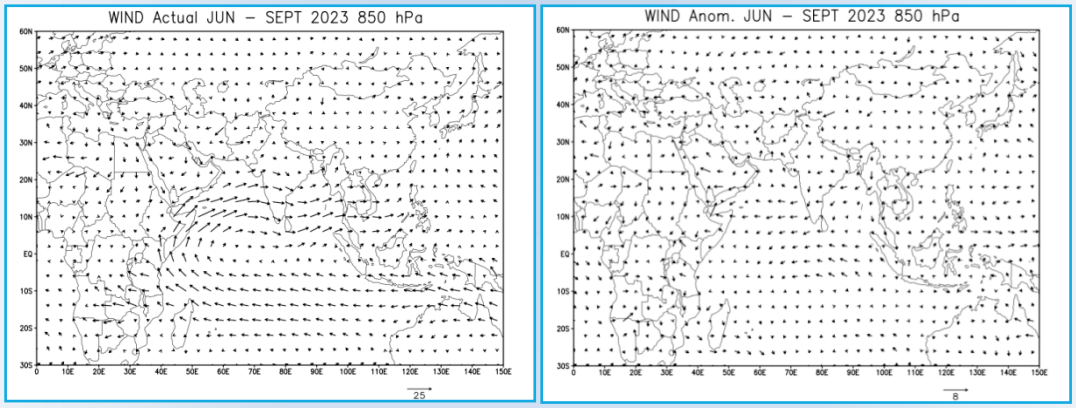
Figs. 9(a&b) show the mean sea level pressure & its anomalies respectively. The pressure anomaly was positive over most parts of the country, except the northern parts of the south peninsula and extreme northeastern parts. Pressure anomaly was within range ± 1.5 hPa over most parts of the country. Pressure anomaly was more than 1.5 hPa

over extreme northeastern parts, central parts, and extreme northern parts.

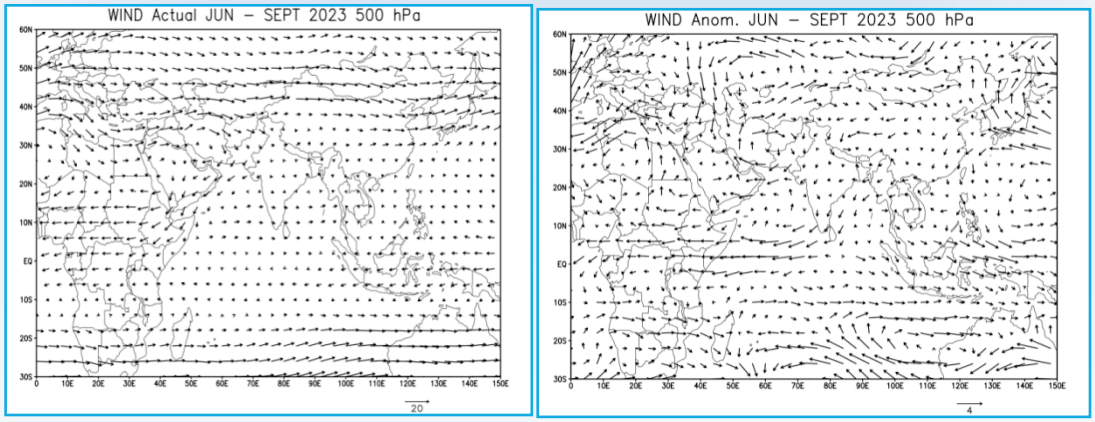
Figs. 10(a&b), 11(a&b) and 12(a&b) show the mean circulation pattern and its anomalies at 850, 500 and 250 hPa levels respectively. The wind anomaly shows weaker than normal low-level monsoon winds [Fig. 10(b)] and upper-level tropical easterly jets [Fig. 12(b)] during the monsoon season.



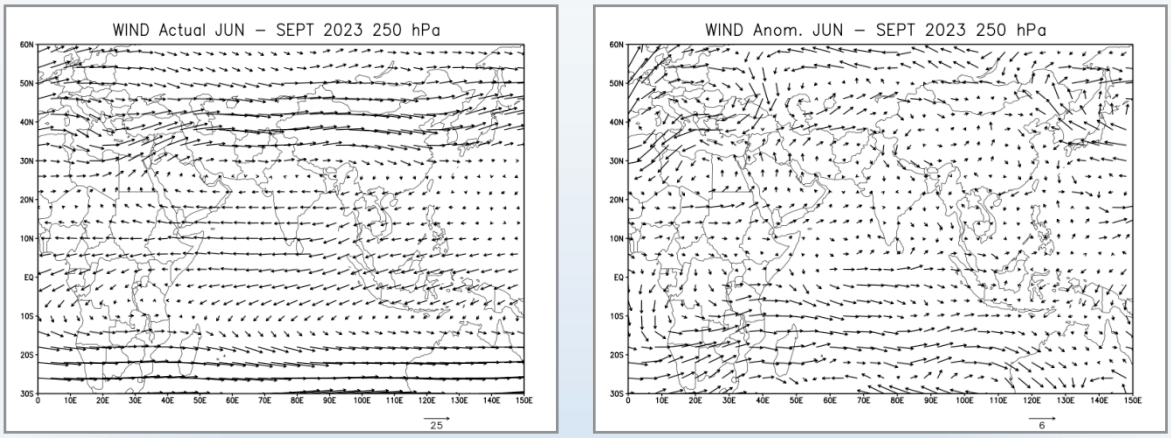
Figs. 9(a&b). Mean Sea Level Pressure (hPa) For Monsoon 2023 (a) Mean Sea Level Pressure (MSLP) (b) MSLP Anomaly (Based on 1981-2010 Normals)



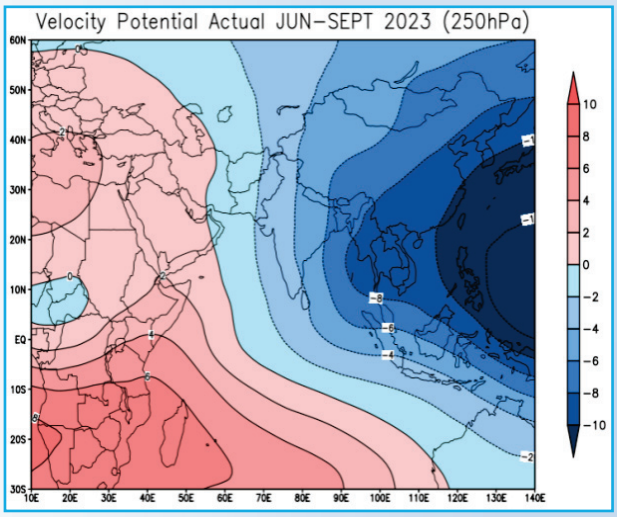
Figs. 10(a&b). Seasonal Wind (m/s) For Monsoon 2023 (a) Mean (b) Anomaly At 850 hPa (Operational Nwp Analysis of IMD GFS T-574 (Anomaly Is Based on 2000-2018 Climatology, Source : NCMRWF)



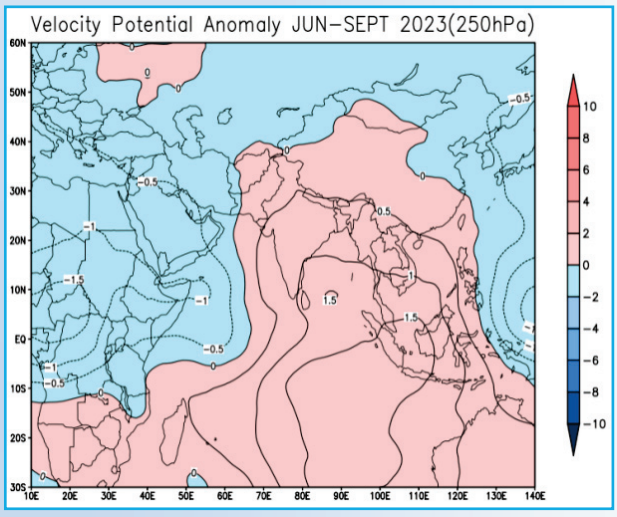
Figs. 11(a&b). Seasonal wind (m/s) for monsoon 2023 (a) mean (b) anomaly at 500 hPa (operational NWP analysis of IMD GFS t-574) (anomaly is based on 2000-2018 climatology, Source : NCMRWF)



Figs. 12(a&b). Seasonal Wind (m/s) For Monsoon 2023 (a) Mean (b) Anomaly At 250 hPa (Operational Nwp Analysis of IMD GFS T-574) (Anomaly Is Based On 2000-2018 Climatology, Source : NCMRWF)



Figs. 13(a). Velocity potential (106M^2/S) for monsoon 2023 Mean at 250 hPa (Operational NWP Analysis of IMD GFS T-574)



Figs. 13(b). Velocity Potential (106m^2/s) For Monsoon 2023) Anomaly At 250 hPa (OperationaL NWP Analysis Of IMD GFS T-574) (anomaly is based on 2000-2018 Climatology, Source : NCMRWF)

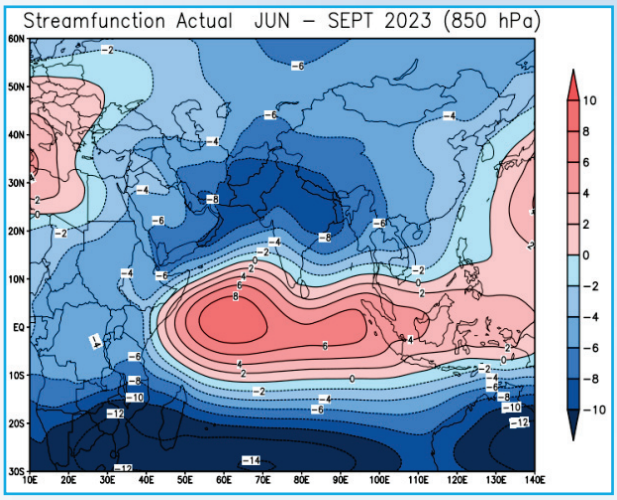


Fig. 14(a). Stream function (106m^2/s) for monsoon 2023 mean at 850 hPa (operationaL NWP analysis of IMD GFS T-574)

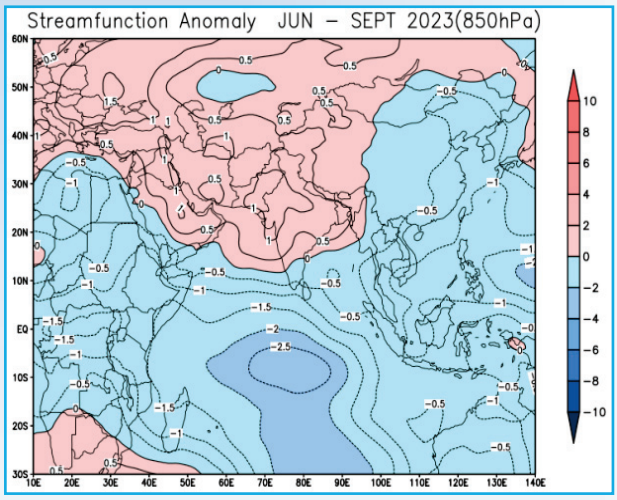


Fig. 14(b). Stream function (106m^2/s) for monsoon 2023 Mean Anomaly At 850 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

Velocity Potential & Stream Function

Figs. 13(a&b) show the 250 hPa mean Velocity Potential & its anomaly respectively. Similarly, Figs. 14(a&b) show the mean Stream Function & its anomalies at 850 hPa level respectively. Negative values are indicated by dashed lines. Anomaly in the Velocity Potential at 250 hPa level was positive (divergence) throughout the country and anomaly in the Stream Function at 850 hPa level was positive over most parts except the extreme south peninsula.

Outgoing Long Wave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood is shown in Fig 15. OLR anomaly was negative throughout the country, except in extreme northern, east & northeastern parts, northern parts of the Bay, and southern parts of the Arabian Sea. OLR anomaly was within the normal range ± 10 W/m^2. OLR anomaly was less than -20 W/m^2 over parts of West Rajasthan.

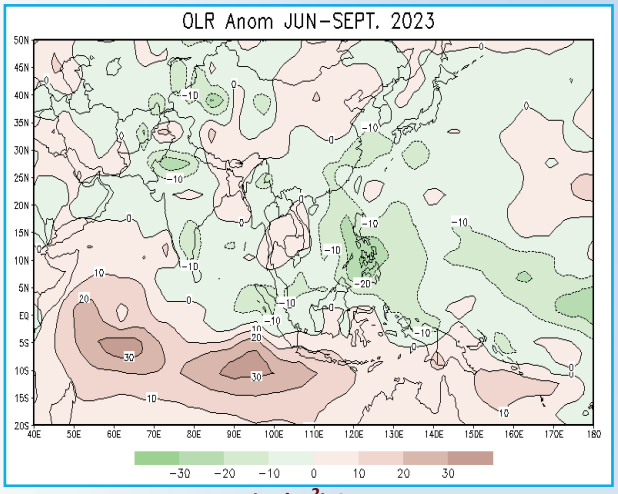
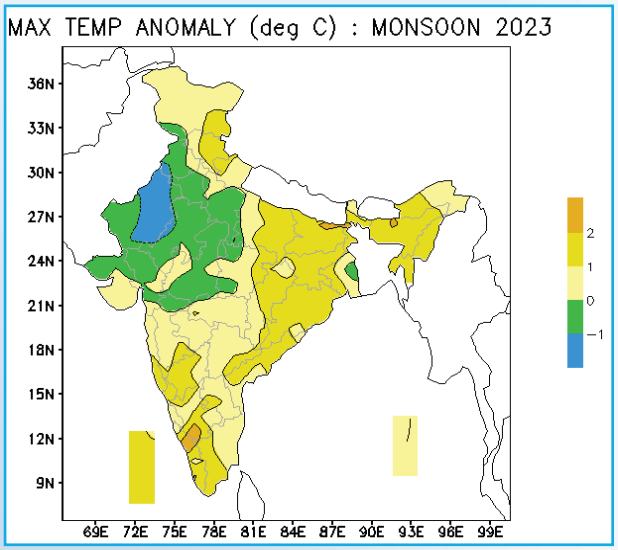


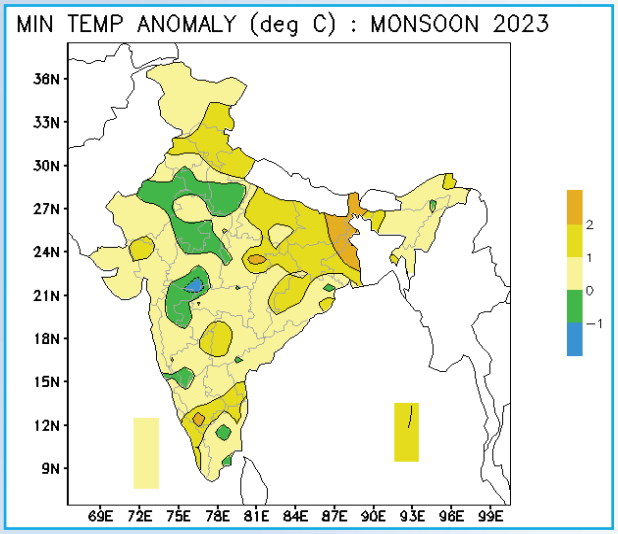
Fig. 15. OLR anomaly (w/m^2) for the monsoon season 2023 (DATA SOURCE : CDC / NOAA, USA) (Based on 1991-2020 climatology)

Temperature

The mean seasonal maximum and minimum temperature anomaly is shown in Figs. 16(a&b) respectively.

Maximum temperature was above normal over most parts of the country, except some parts of northwest India. Maximum temperature anomaly was more than 2 °C over parts of northeastern Assam state, Bihar, Sub Himalayan West Bengal & Sikkim, South Interior Karnataka and Kerala & Mahe. Maximum temperature anomaly was less than -1 °C over parts of Punjab and Rajasthan.

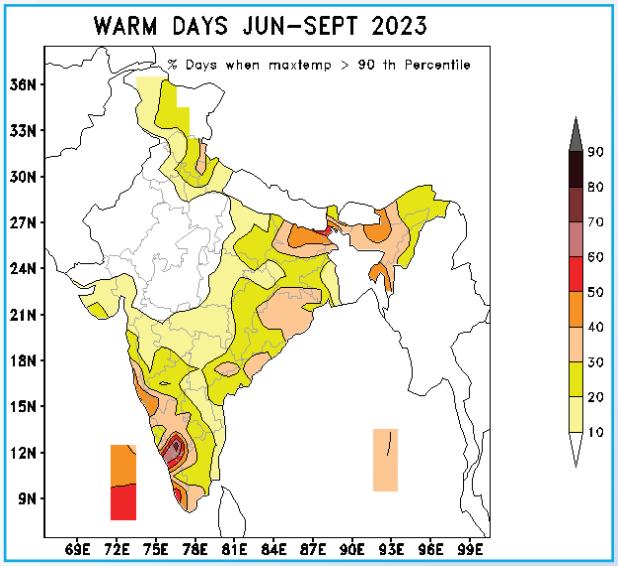


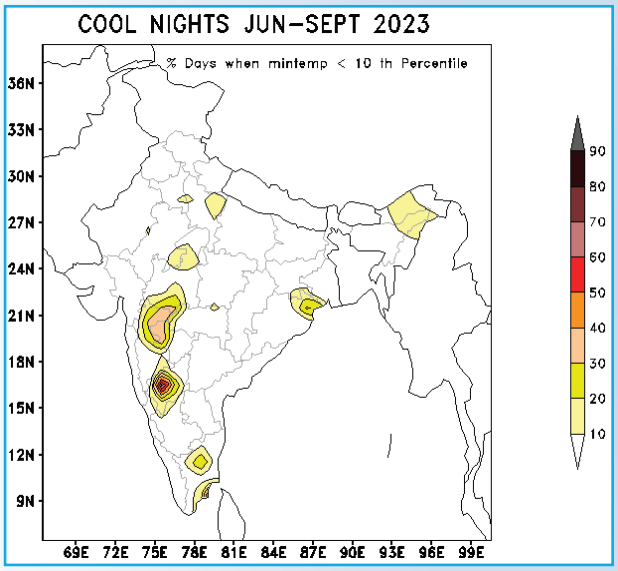


Figs. 16(a&b). Mean seasonal temperature anomalies (°C) for monsoon 2023 (a) Maximum (b) minimum (Based on 1981-2010 normals)

The minimum temperature was above normal over most parts of the country, except for some parts of northwest India, central India, and some pockets of South Peninsular India. The minimum temperature anomaly was more than 2 °C over parts of West Bengal state, Sikkim state, Bihar, Jharkhand, East Madhya Pradesh, and South Interior Karnataka. The minimum temperature anomaly was less than -1 °C over parts of southern West Madhya Pradesh.

Percentage of Warm days / Cold nights





Figs. 17(a&b). (a) Percentage of days when maximum temperature > 90th percentile (b) percentage of days when minimum temperature < 10th percentile

Figs. 17(a&b) show the percentage of days when the maximum (minimum) temperature was more (less) than the 90th (10th) percentile. Over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub Himalayan West Bengal & Sikkim, Bihar, South Interior Karnataka, Kerala & Mahe and Lakshadweep maximum temperature was greater than 90th percentile for more than 40% of the days of the season. The minimum temperature was less than the 10th percentile for more than 40% of the days of the month over parts of North Interior Karnataka.

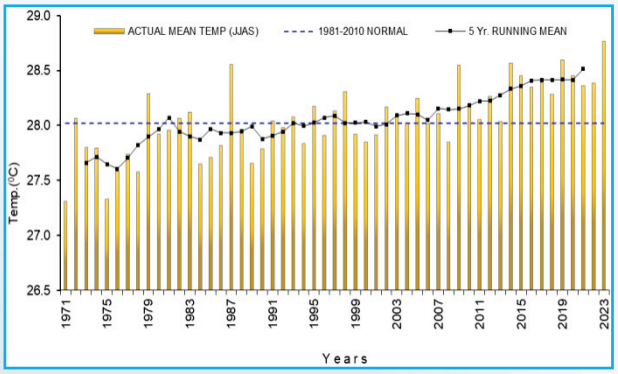
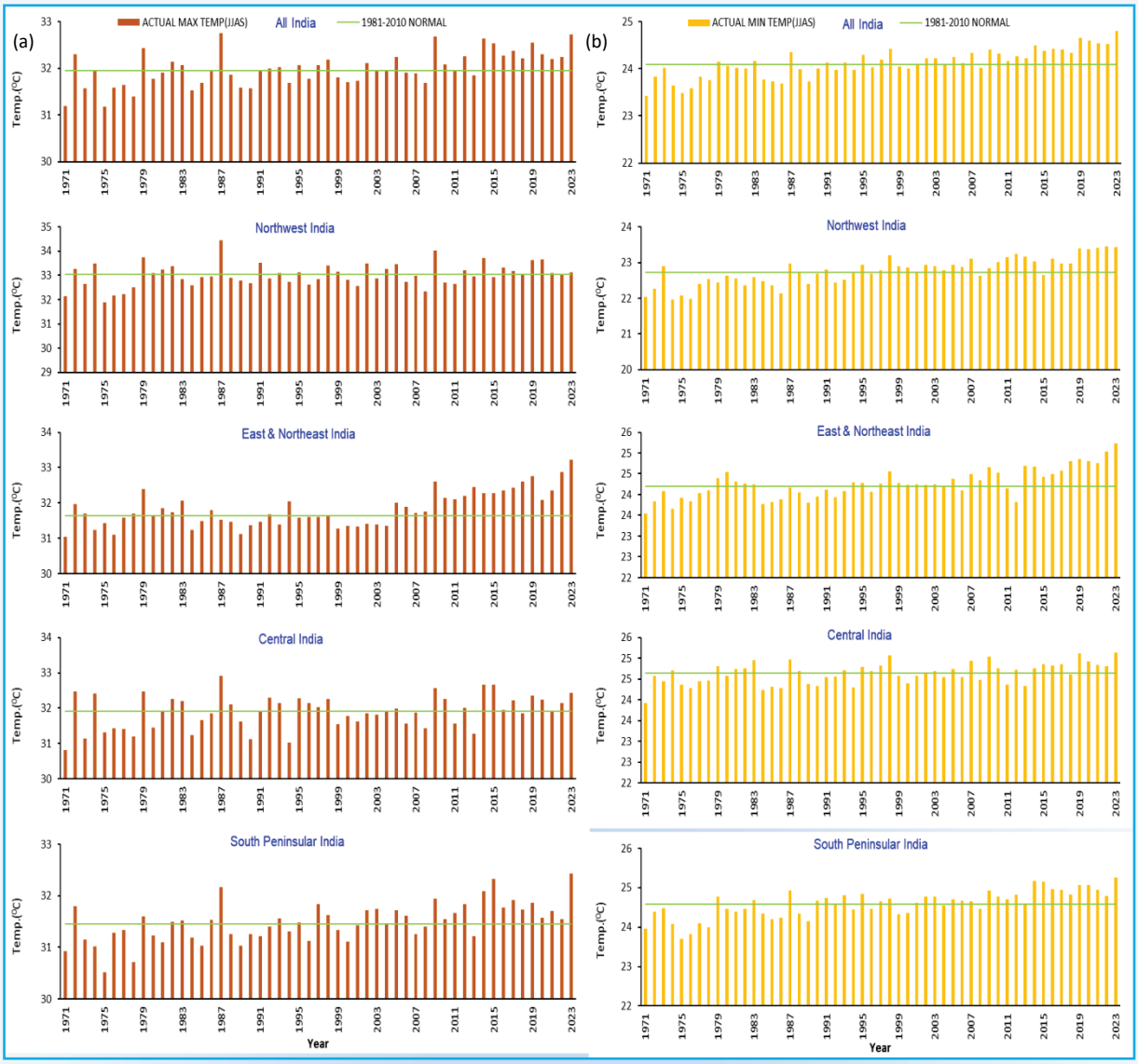


Fig.18. Time series of mean temperature averaged over India (vertical bars and five year running mean (continous line) for the monsoon season (1971-2023)

Fig. 18 shows the mean temperature for the country as a whole for Monsoon since 1971. Five-year moving average values are also shown. The mean temperature for the season this year over the country as a whole was 28.77 with an anomaly of 0.74 °C and the highest since 1901. Over Northwest India, the mean temperature was 8th highest (28.29 °C with an anomaly of 0.40 °C) and in East & Northeast India the mean temperature was highest (29.22 °C with an anomaly of 1.31 °C since 1901. Over Central India, the mean temperature was 3rd highest (28.78 °C with an anomaly of 0.51 °C) since 1901. Over South Peninsular India the mean temperature was highest (28.85 °C with an anomaly of 0.83 °C) since 1901.

Figs. 19(a&b) the maximum and minimum temperature series respectively for the country as a whole and the four homogeneous regions during Monsoon 2023 since 1971. Both the maximum and minimum temperatures were above normal over all the homogeneous regions. Among the four homogeneous regions, over Northwest India, the minimum temperature was 2nd highest (23.442 °C with an anomaly of 0.72 °C) after the year 2022(23.444 °C) since 1901. Over East & Northeast India the maximum temperature was highest (33.21 °C with an anomaly of 1.58 °C) and the minimum temperature was also highest (25.23 °C with an anomaly of 1.04 °C) since 1901. Over Central India, the maximum temperature was 7th highest (32.43 °C with an anomaly of 0.53 °C) and the minimum temperature was highest (25.13 °C with an anomaly of 0.49 °C) since 1901. Over South Peninsular India the maximum temperature was highest (32.43 °C with an anomaly of 0.99 °C) and the minimum temperature was also highest (25.26 °C with an anomaly of 0.68 °C) since 1901.



Figs. 19(a&b). Time series of temperature for the country as a whole and the four homogeneous regions for the monsoon season (1971 - 2023) (a) Maximum (b) minimum

TABLE 2

Temp anomalies over India and four homogeneous regions during monsoon 2023

MONSOON 2023		Max Temp (^{0}C)	Min Temp (^{0}C)	Mean Temp (^{0}C)
ALL INDIA	ACTUAL	32.73	24.80	28.77
	NORMAL	31.95	24.09	28.02
	ANOMALY	0.78	0.71	0.74
NORTHWEST INDIA	ACTUAL	33.13	23.44	28.29
	NORMAL	33.04	22.73	27.88
	ANOMALY	0.09	0.72	0.40
EAST & NORTHEAST INDIA	ACTUAL	33.21	25.23	29.22
	NORMAL	31.63	24.19	27.91
	ANOMALY	1.58	1.04	1.31
CENTRAL INDIA	ACTUAL	32.43	25.13	28.78
	NORMAL	31.91	24.64	28.27
	ANOMALY	0.53	0.49	0.51
SOUTH PENNINSULAR INDIA	ACTUAL	32.43	25.26	28.85
	NORMAL	31.45	24.58	28.01
	ANOMALY	0.99	0.68	0.83

Over the country as a whole the maximum temperature was 2nd highest (32.73 °C with an anomaly of 0.78 °C) after the year 1987(32.76 °C) and the minimum temperature was highest (24.80 °C with an anomaly of 0.71 °C) since 1901.

Table 2 gives temperature anomalies over India and four homogeneous regions during the monsoon season.

Low-Pressure Systems

During the season, fourteen low-pressure systems **(one Extremely Severe Cyclonic Storm (ESCS), one Deep Depression, one Depression, 5 well-marked low-pressure areas, 5 low-pressure areas, and 1 land low-pressure area)** were formed. The frequency and place of origin of these low-pressure systems formed over the Indian region during the monsoon season are **shown in the table below.**

Month/Systems	CS and above	DD	D	WML	LPA	LAND LPA	TOTAL
June	1 (AR SEA)	0	0	2(BOB)	0	0	3
July	0	1(BOB)	0	1	2(BOB)	1	5
August	0	0	0	0	1(BOB)	0	1
September	0	0	1(AR SEA)	2(BOB)	2(BOB)	0	5
	(AS : Arabian Sea)			**(BOB : Bay of Bengal)**			

Fig. 20 shows the track of the intense low-pressure system formed during the season.

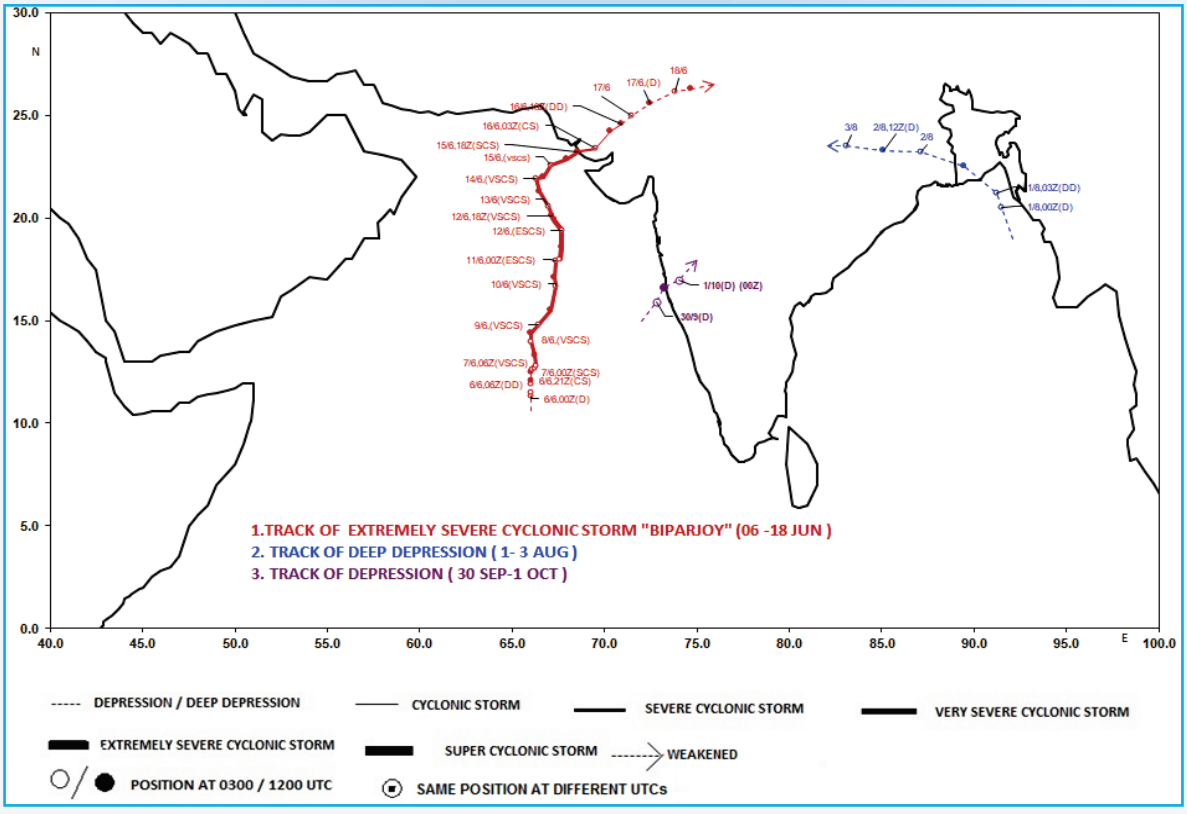


Fig. 20. Tracks of intense low pressure systems formed during the monsoon season

Fig. 21 shows the number of depressions and cyclonic storms formed during the monsoon season since the last 10-year period (2014-2023).

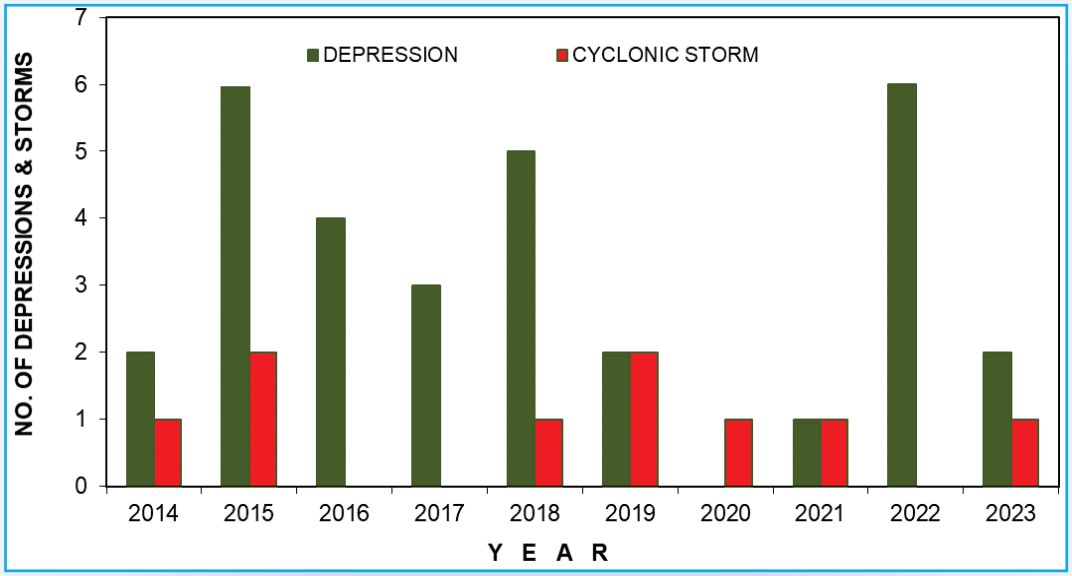


Fig. 21. Number of depressions & cyclonic storms formed during the southwest monsoon season (2014 - 2023)

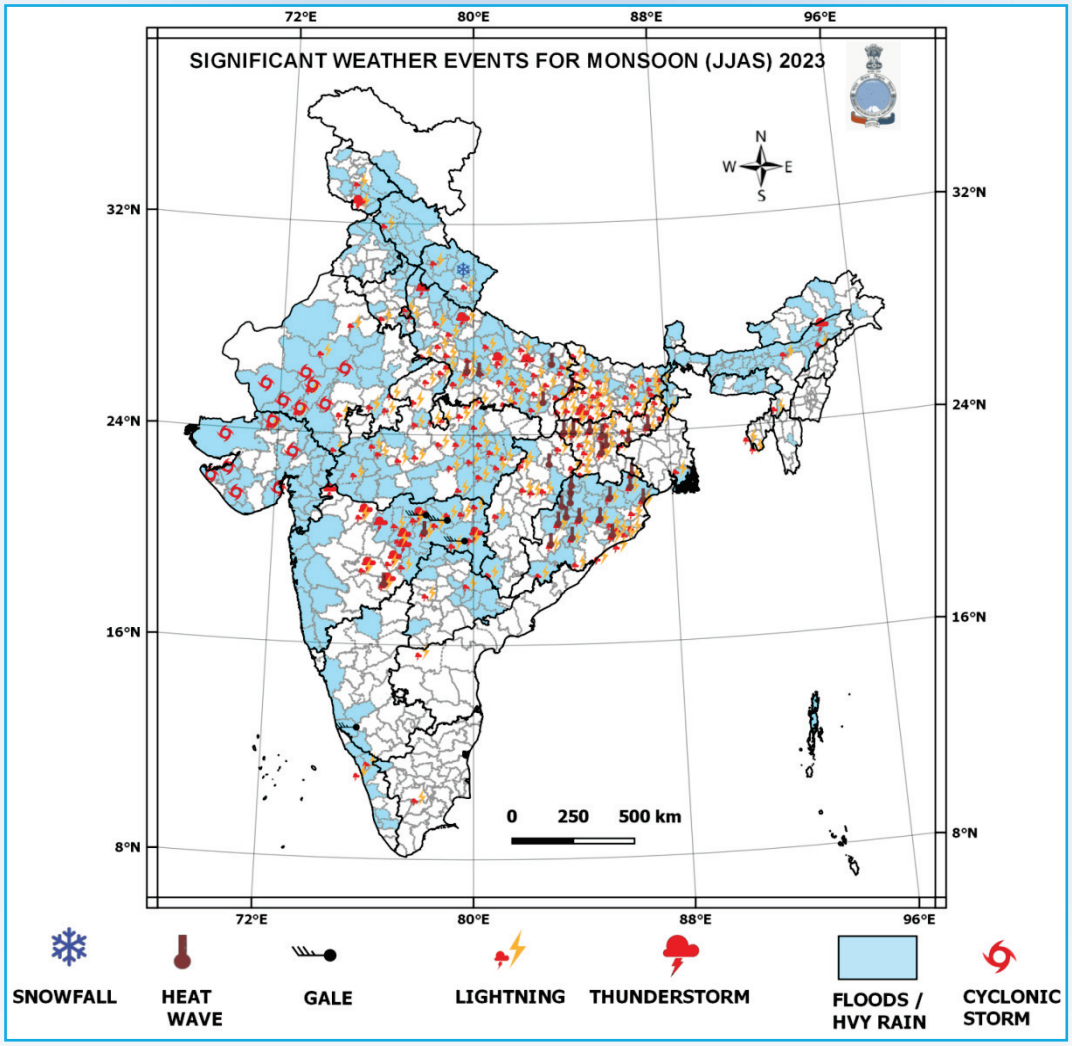


Fig. 22. Significant weather events during the season monsoon 2023 (based on real time media report)

Significant Weather events during Monsoon season

Fig. 22 shows significant weather events during the monsoon season (based on real-time media reports).

During the Monsoon Season, a total of 1105 persons were reportedly claimed dead, more than 380 persons injured, more than 100 persons missing & more than 2200 livestock perished.

Lightning

A total of 428 persons reportedly claimed dead, more than 260 persons injured & more than 620 livestock perished, during the Monsoon Season, because of Lightning.

Thunderstorm

A total of 10 persons were reportedly claimed dead, 5 persons injured & 30 livestock perished during the Monsoon season, because of the Thunderstorm.

Heavy Rains, Floods & Landslide

A total of 544 persons were reportedly claimed dead, 112 persons injured, more than 100 persons missing & more than 1600 livestock perished, during the Monsoon season, because of heavy rains, floods & Landslides.

Heat Wave

A total of 114 persons were reportedly claimed dead because of Heat waves during the Monsoon season.

Cyclonic Storm

7 persons reportedly claimed dead due to heavy rain-related incidents associated with Extremely Severe Cyclonic Storm "BIPARJOY" [6 to 19 June] from Rajsamand, Jalore districts & parts of Rajasthan. While no death was reportedly claimed from Gujarat. But Heavy rains, Floods, and Strong winds affected Banaskantha, Bhavnagar, Devbhoomi Dwarka, Gandhinagar, Jamnagar, Junagadh, Kutch districts of Gujarat and Ajmer, Barmer, Jalore, Jodhpur, Pali, Sirohi districts of Rajasthan.

Gale

A total of 1 person was reportedly claimed dead in the Chandrapur district of Maharashtra on 10 June & 1 person injured in Wardha district of Maharashtra on 11 Jun. Also, Dakshina Kannada district of Karnataka was affected because of Gale on 5 July. Damage to buildings & vehicles was reported from Dakshina Kannada district of Karnataka on 5 July.

Snowfall

One person died & 5 others were injured in the Chamoli district of Uttarakhand on 4 June due to snow avalanche.

4. Post Monsoon Season (Oct-Nov-Dec)

Highlights

During Post-Monsoon season, over the country the mean temperature was 24.24 °C with an anomaly of 1.0 °C and it was highest since 1901. Over the country as a whole the maximum temperature was 3rd highest (29.59 °C with an anomaly of 0.68 °C) and the minimum temperature was highest (18.89 °C with an anomaly of 1.31 °C) since 1901.

Among the four homogeneous regions, over East & Northeast India the maximum temperature was highest (28.87 °C with an anomaly of 1.28 °C and the minimum temperature was also highest (17.08 °C with an anomaly of 1.20° C) since 1901. Over South Peninsular India the maximum temperature was 2nd highest (31.41 °C with an anomaly of 1.01 °C) and the minimum temperature was highest (23.58°C with an anomaly of 1.28 °C) since 1901. The minimum temperature was 2nd highest (19.20 °C with an anomaly of 1.46 °C) over Central India and highest (12.45 °C with an anomaly of 1.25 °C) over Northwest India since 1901.

Northeast Monsoon Activity

The southwest monsoon withdrew from the entire country on 19th October and northeast monsoon rains commenced from 21st October. Rainfall activity over core region of the South Peninsular India (comprising of 5 subdivisions, viz., Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu, Puducherry and Kariakal, South Interior Karnataka and Kerala & Mahe) during the season as a whole

was 94% of its LPA. It was 46% of its LPA during October, 117% of its LPA during November and 229% of its LPA during December.

Rainfall Features

Rainfall realized over the country as a whole during the season was 91% of LPA. Most of the subdivisions received large excess / excess / normal rainfall, except a few from south peninsula, West Uttar Pradesh, Uttarakhand, Himachal Pradesh and Saurashtra & Kutch from remaining parts. During the season, out of 36 meteorological subdivisions, 3 received large excess rainfall, 4 received excess rainfall, 18 received normal rainfall, 10 received deficient rainfall and one sub division received large deficient rainfall (Fig. 1).

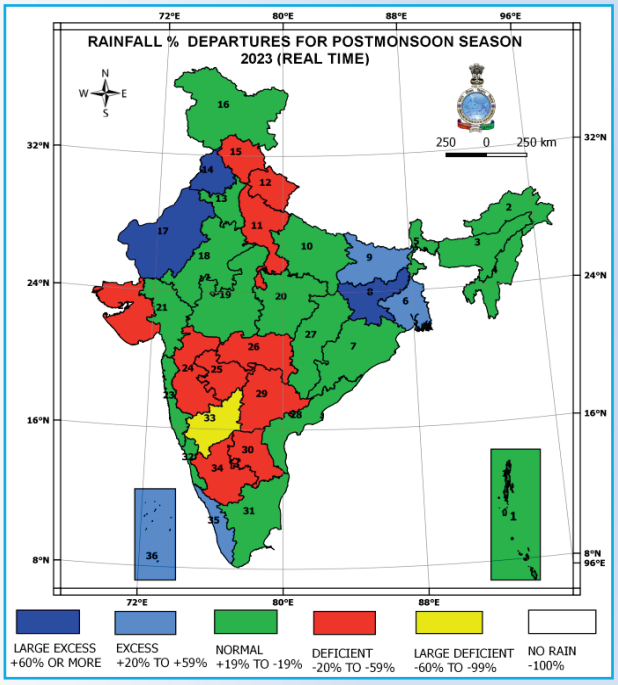
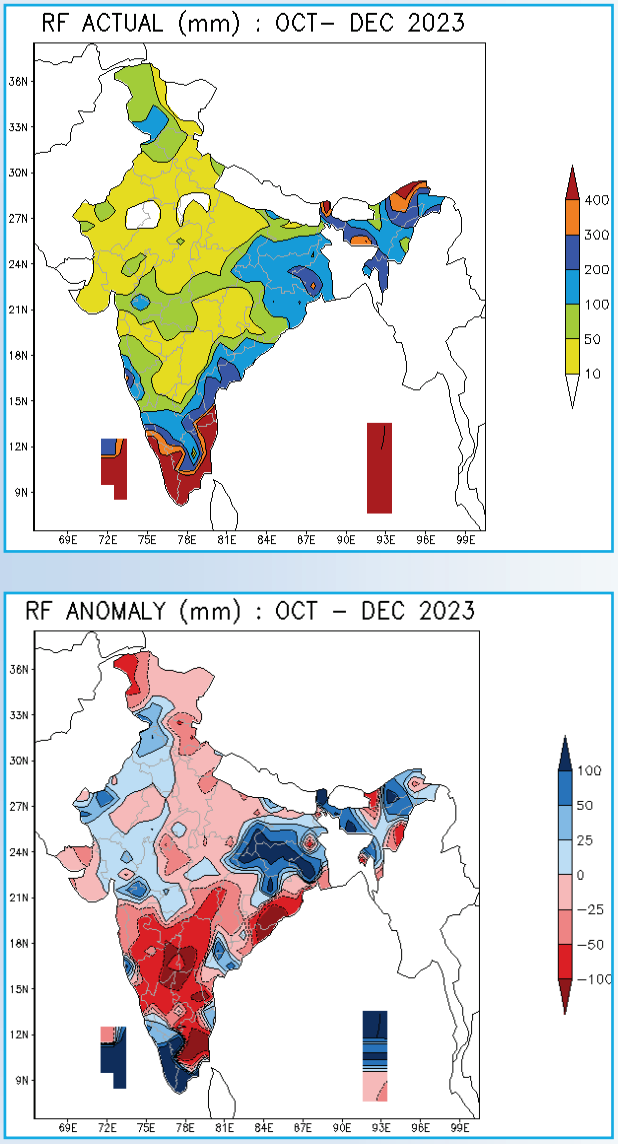


Fig. 1. Subdivisionwise rainfall percentage departure for post-monsoon season 2023

Figs. 2(a&b) show the spatial pattern of rainfall (mm) received during the season and its anomaly respectively. Parts of Arunachal Pradesh, Assam & Meghalaya, Sub Himalayan West Bengal & Sikkim, Rayalaseema, Tamilnadu, Puducherry & Karaikal, Kerala & Mahe and both the islands received more than 300 mm of rainfall. Parts of Arunachal Pradesh, Sub Himalayan West Bengal & Sikkim, Rayalaseema, Tamilnadu, Puducherry & Karaikal, Kerala & Mahe and both the islands received more than 400 mm of rainfall. Rainfall anomaly was more than 100 mm over parts of Arunachal Pradesh, Assam & Meghalaya, Sub Himalayan West Bengal & Sikkim, Gangetic West Bengal, Jharakhand, Bihar, East Uttar Pradesh, Tamilnadu, Puducherry & Karaikal Kerala & Mahe, South Interior Karnataka and both the islands. Magnitude of negative rainfall anomaly was more than 100 mm over parts of Odisha, Coastal Andhra Pradesh, Telangana, Rayalaseema, North Interior Karnataka and South Interior Karnataka.



Figs. 2(a&b). (a) Seasonal rainfall (mm) (b) seasonal rainfall anomaly (mm)

Fig. 3(a) shows the area weight averaged cumulative weekly rainfall percentage departure during the season for the country as a whole. Cumulative rainfall departure was negative during all the weeks of the season except first week. At the end of the post-monsoon season 2023, the rainfall for the country as a whole was 91.5 % of its LPA. Fig. 3(b) shows the area weight averaged cumulative weekly rainfall percentage departure

during the season for the northeast monsoon region of south peninsula. At the end of the post-monsoon season 2023, the rainfall over the northeast monsoon region of south peninsula was 94 % of its LPA.

Similarly, Fig. 3(c) shows the area weight averaged rainfall series for the season since 1901 over the northeast monsoon region of south peninsula.

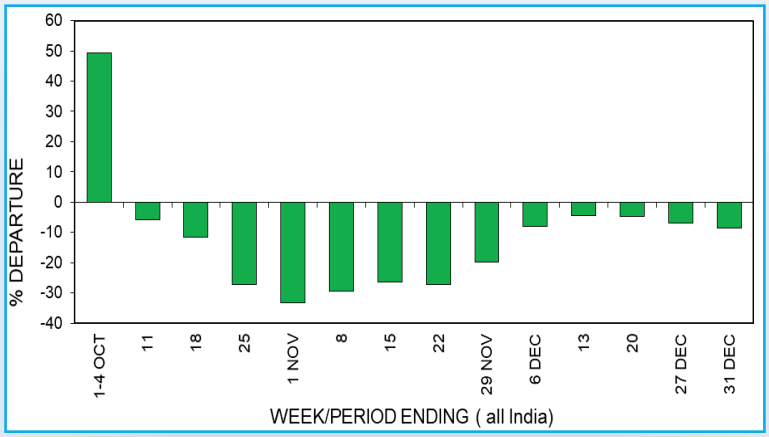


Fig. 3(a). Accumulated percentage departure of area weight averaged cumulative rainfall for post-monsoon (October - December) over the country as a whole

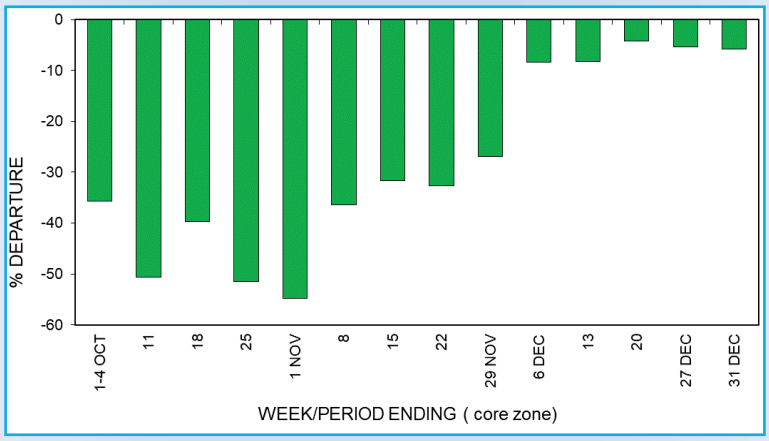


Fig. 3(b). Accumulated percentage departure of area weight averaged cumulative rainfall for post-monsoon (October - December) over the core zone of peninsula

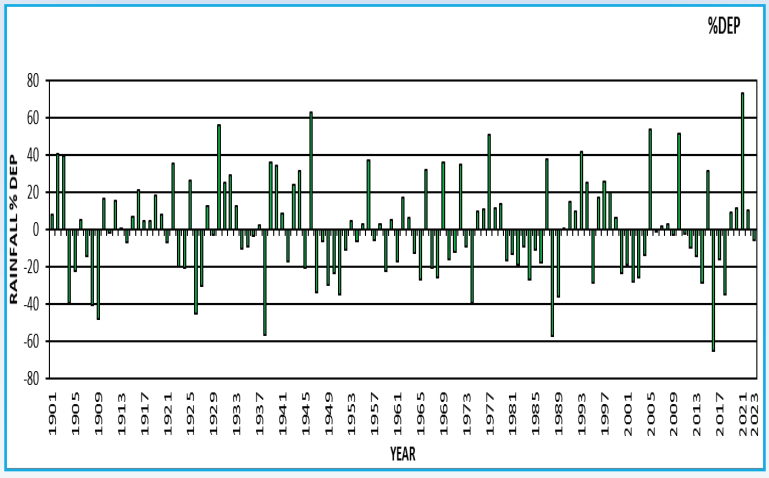


Fig. 3(c). Time series of area weight averaged post - monsoon (October - December) (1901-2023) rainfall over the core zone of peninsula

Fig. 4 shows area weight averaged rainfall series for post-monsoon season over all India and four homogeneous regions since 1951. Rainfall realized over the country as a whole was 91.5% of its LPA during the season. It was 99% of its LPA over northwest India, 78 % of its LPA over central India, 110% if its LPA over east & northeast India and 87% of its LPA over south peninsula.

Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for measuring drought and is based only on precipitation. This index is negative for dry and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. Figs. 5 (a&b) give the SPI values for the northeast monsoon season (October to December 2023, i.e., 3 months cumulative) and the year (January-December 2023, i.e., 12 months cumulative) respectively.

Cumulative SPI values of the past three months indicate extremely wet-severely wet conditions over parts of Bihar, Chhattisgarh, Jharkhand, West Rajasthan, Odisha, Tamil Nadu, East Madhya Pradesh, East Uttar Pradesh, Jammu & Kashmir, Kerala, Punjab, S.H. West Bengal & Sikkim and Gangetic West Bengal while extremely dry-severely dry conditions were observed over parts of North Interior Karnataka, South Interior Karnataka, Andhra Pradesh state, Vidarbha, Telangana, Arunachal Pradesh, Jammu & Kashmir, Nagaland, Manipur and Mizoram & Tripura.

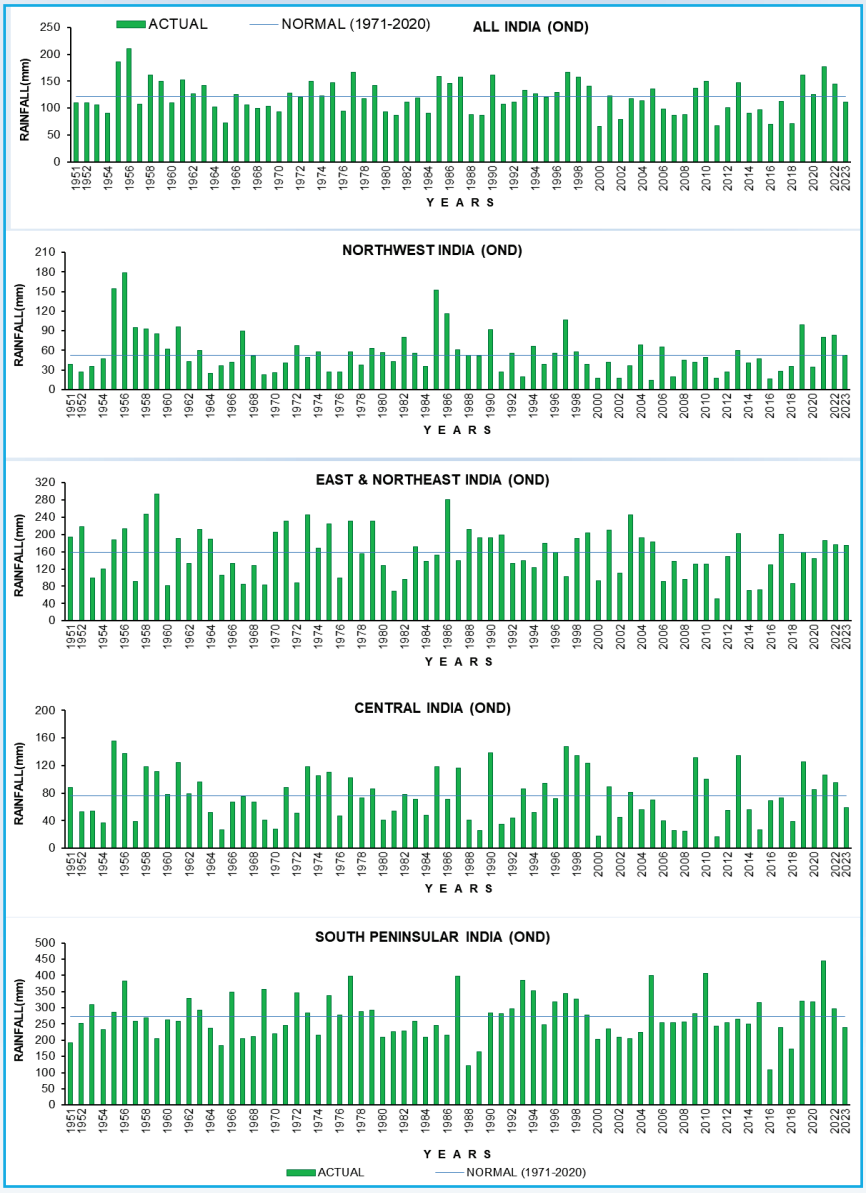
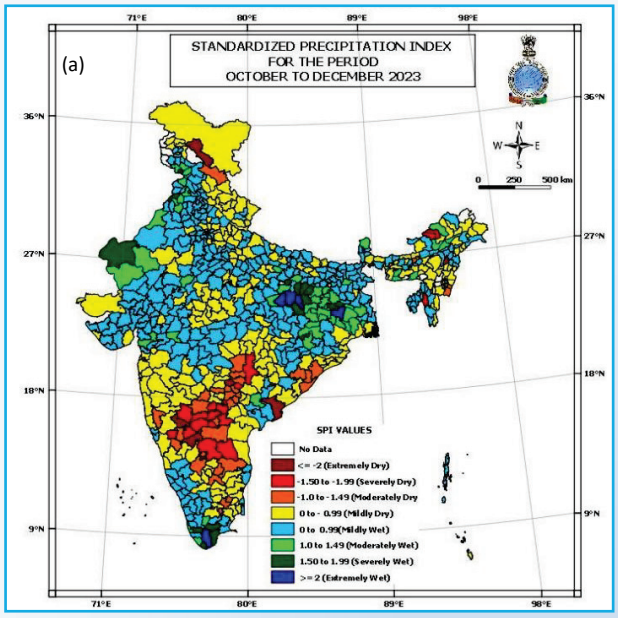
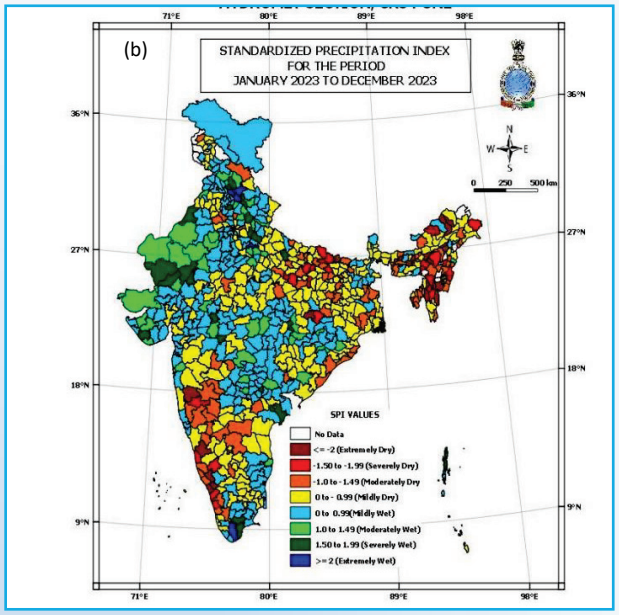
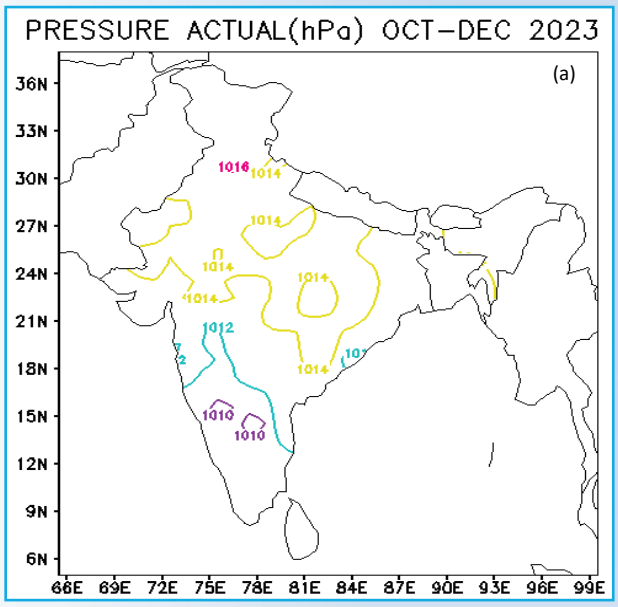


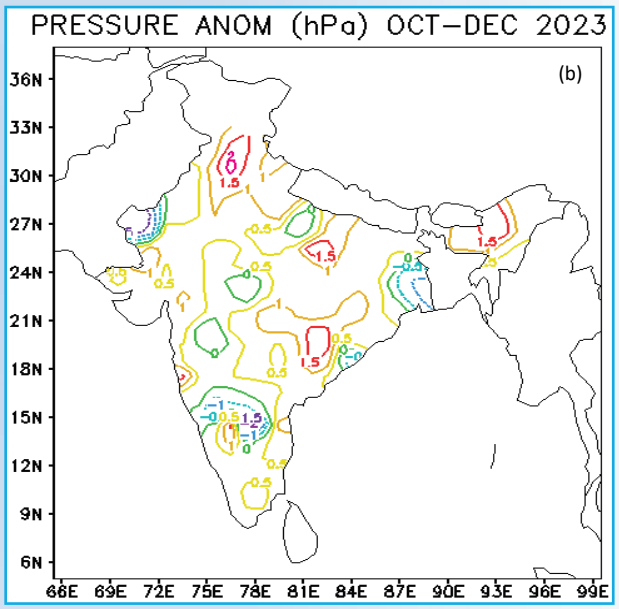
Fig. 4. Time series of area weight averaged rainfall over all India and four homogeneous regions for post - monsoon season (1951-2023)





Figs. 5(a&b). Standardized Precipitation Index (SPI) For (a) Three Months (b) Twelve Months





Figs. 6(a&b). Mean Sea Level Pressure (hPa) For Post-Monsoon 2023(a) Mean (b) Anomaly (Based on 1981 - 2010 Normals)

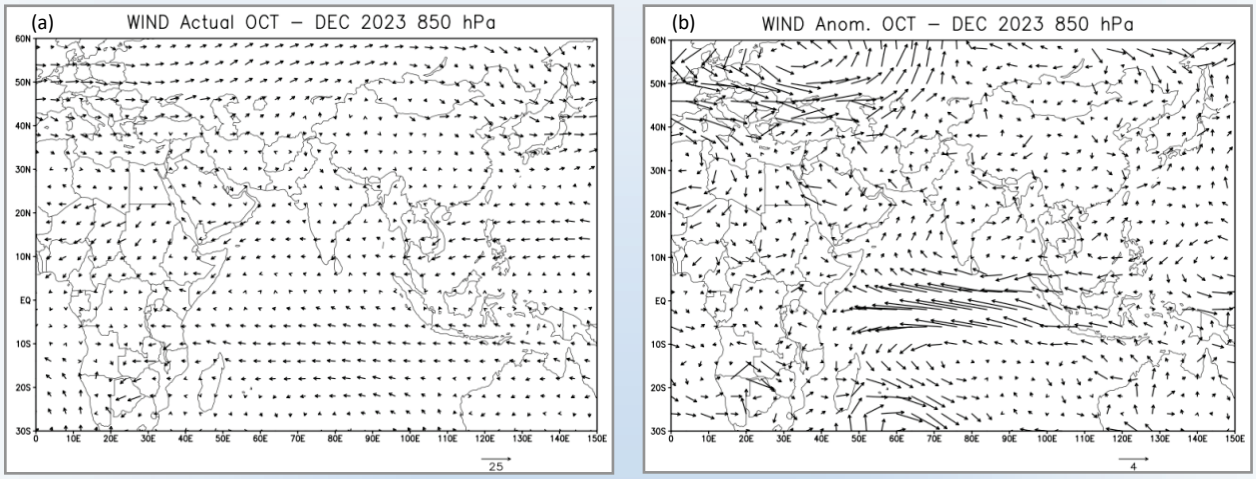
Cumulative SPI values of the past twelve months indicate extremely wet-severely wet conditions over parts of Uttar Pradesh state, Rajasthan state, West Madhya Pradesh, Saurashtra & Kutch, Coastal Andhra Pradesh, Haryana, Chandigarh & Delhi, Chhattisgarh, Tamil Nadu, Telangana, A & N Islands, Himachal Pradesh and Uttarakhand while extremely dry-severely dry conditions were observed over parts of East Uttar Pradesh, Bihar, South Interior Karnataka, Chhattisgarh, Madhya Maharashtra, Coastal Karnataka, Arunachal Pradesh, Assam & Meghalaya, Kerala, Nagaland, Manipur, Mizoram & Tripura.

Pressure & Wind

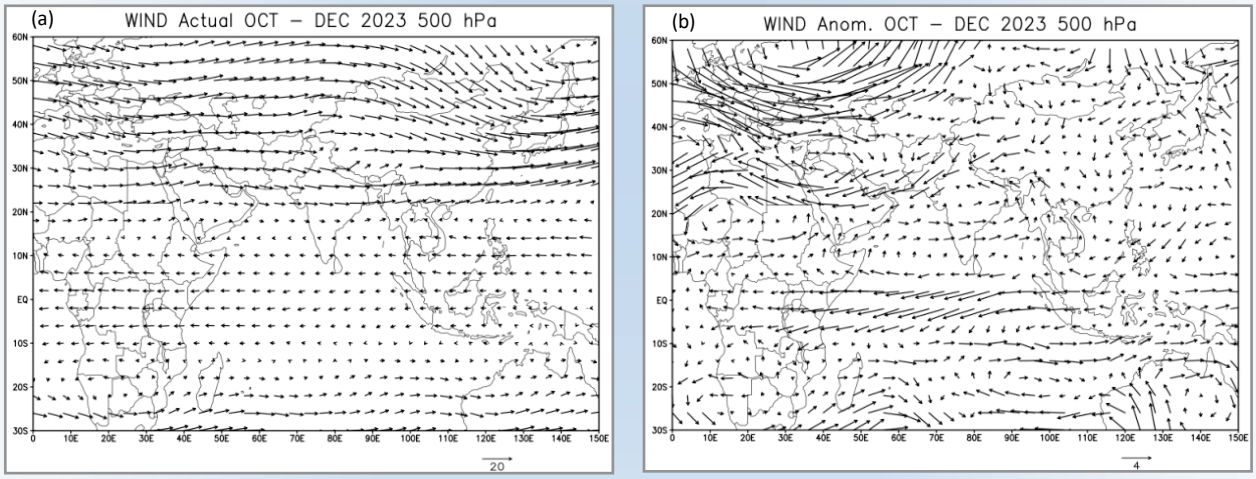
Figs. 6(a&b) show the mean sea level pressure & its anomaly respectively. The pressure anomaly was positive over most parts of country, except some parts of Gangetic West Bengal, West Rajasthan, and some parts of peninsula. The positive pressure anomaly was generally within 0.5 to 1.5 hPa over most parts of the country.

Figs. 7(a&b), 8(a&b) and 9(a&b), show the mean circulation pattern and its anomaly at 850, 500 & 250 hPa levels respectively. Wind anomaly at

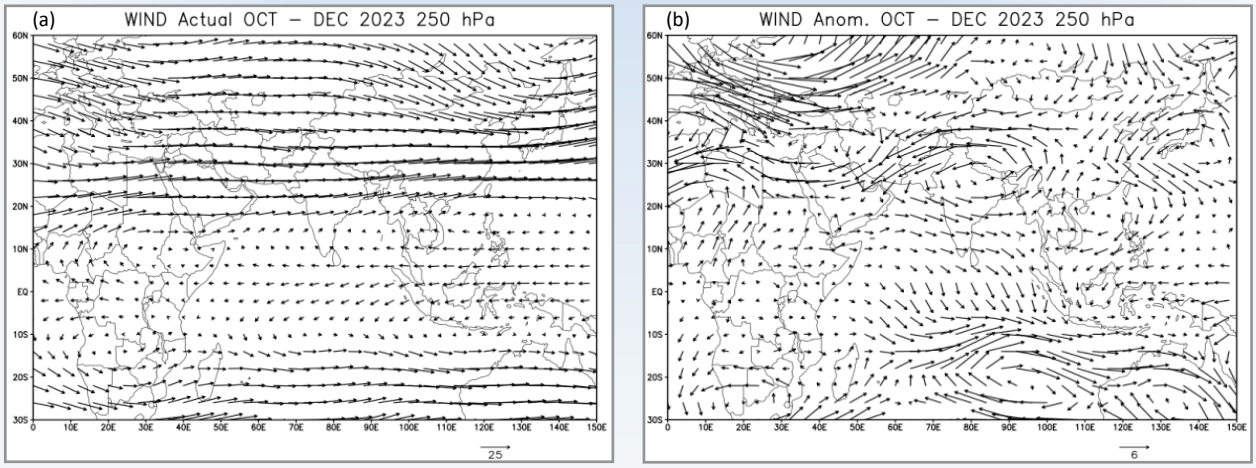
850 hPa shows an anomalous anticyclonic circulation over western parts of peninsula and adjoining Arabian Sea. At 500 hPa level, an anomalous cyclonic circulation was observed over central India and adjoining Arabian Sea and Bay of Bengal. At 250 hPa level, an anomalous cyclonic circulation was observed over central India and adjoining Arabian Sea and Bay of Bengal.



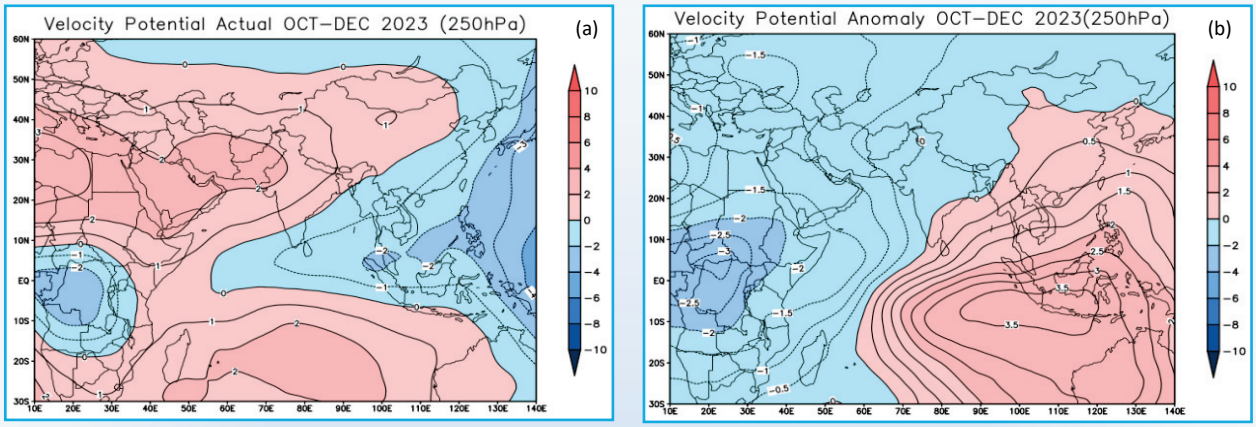
Figs. 7(a&b). Seasonal wind (m/s) for post-monsoon 2023 (a) mean (b) anomaly at 850 hPa (operational nwp analysis of IMD GFS T-574) (Anomaly is based on 2000-2018 Climatology, Source : NCMRWF)



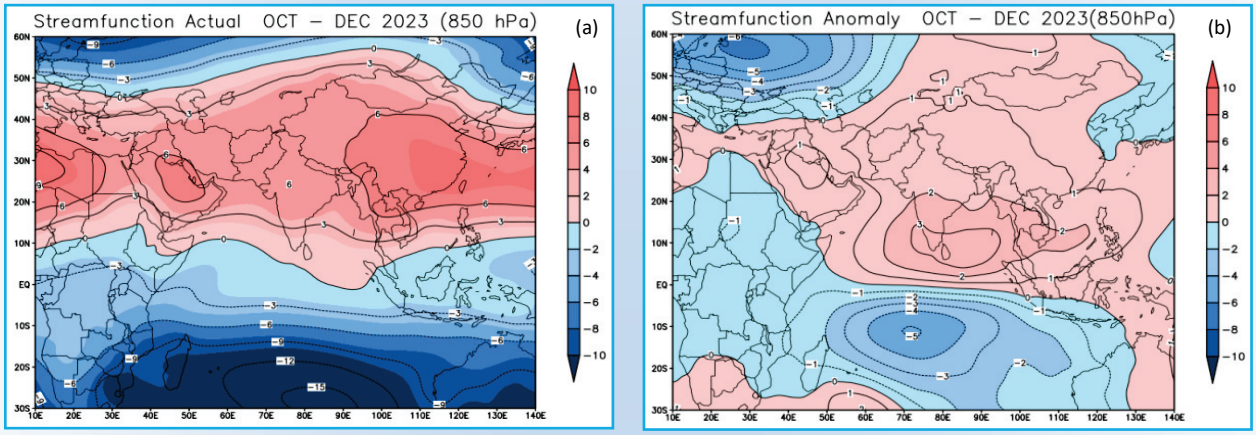
Figs. 8(a&b). Seasonal Wind (m/s) For Post-Monsoon 2023(a) Mean (b) Anomaly at 500 hPa (Operational NWP Analysis of IMD GFS T-574) (Anomaly is based on 2000-2018 Climatology, Source : NCMRWF)



Figs. 9(a&b). Seasonal wind (m/s) for post-monsoon 2023 (a) mean (b) anomaly at 250 hPa (operational NWP analysis of IMD GFS T-574)(Anomaly Is Based on 2000-2018 Climatology, Source : NCMRWF)



Figs. 10(a&b). Velocity Potential (106m^2/s) For Post-Monsoon 2023 (a) MEAN (b) ANOMALY AT 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)



Figs. 11(a&b). Stream function (106m^2/s) FOR POST-MONSOON 2023 (a) MEAN (b) ANOMALY AT 850 hPa(operational NWP analysis of IMD GFS T-574)(anomaly is based on 2000-2018 Climatology, Source : NCMRWF)

Velocity Potential & Stream Function

Figs. 10(a&b) show the 250 hPa mean Velocity Potential & its anomaly. Similarly, Figs. 11(a&b) show the mean Stream Function & its anomaly at 850 hPa level. Negative values are indicated by dashed lines. Anomaly in velocity potential at 250 hPa level was negative throughout the country, except eastern parts of peninsula. Anomaly in the stream function at 850 hPa level was positive throughout the country.

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood is shown in Fig. 12. OLR anomaly was negative over entire country and both the adjoining seas, except some pockets over Coastal Andhra Pradesh and eastern part of Bay of Bengal. OLR anomaly was less than -10 W/m^2 over most parts of the region.

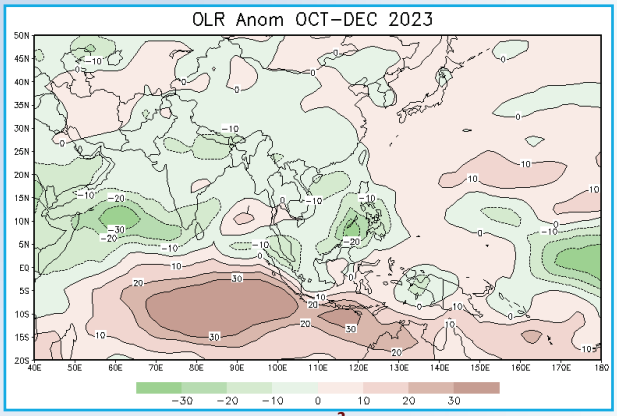
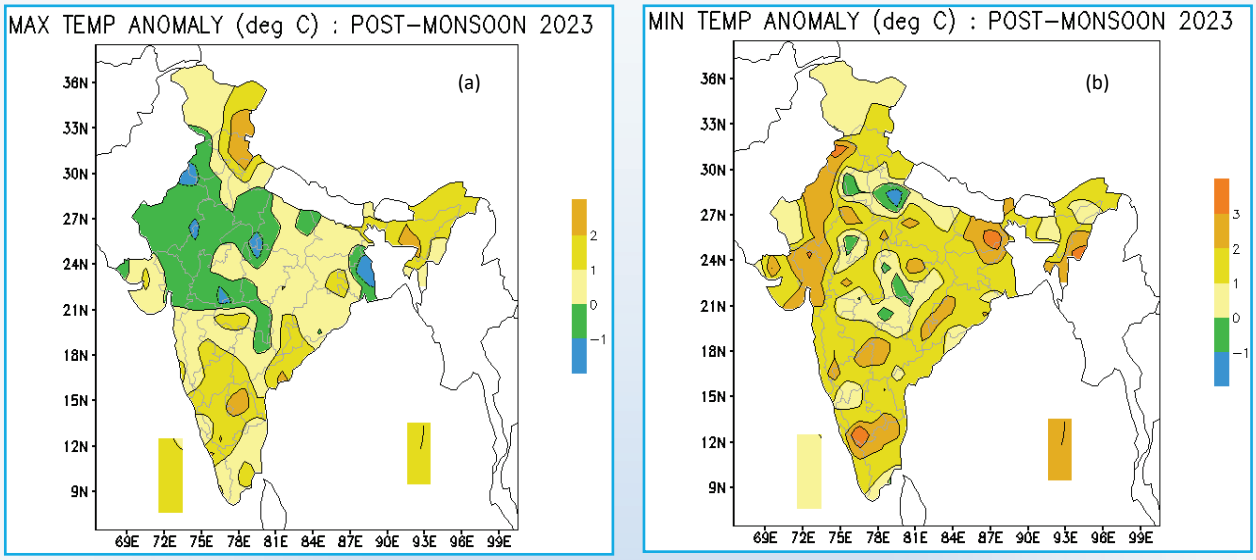


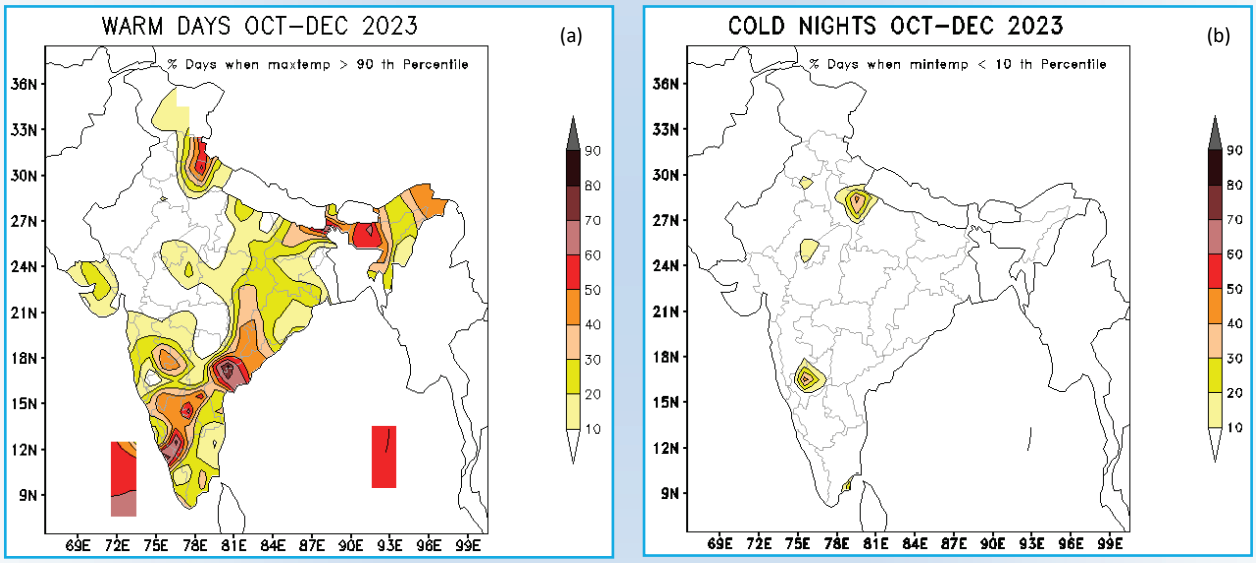
Fig. 12. OLR ANOMALY (W/m^2) FOR POST-MONSOON 2023 (DATA SOURCE : CDC / NOAA, USA) (BASED ON 1991-2020 CLIMATOLOGY)

Temperature

Mean seasonal maximum and minimum temperature anomaly is shown in Figs. 13(a&b) respectively. Maximum temperature was above normal over most parts of the country, except



Figs. 13(a&b). Mean seasonal temperature anomalies (°C) for post-monsoon 2023 (a) Maximum (b) minimum (based on 1981-2010 normals)



Figs. 14(a&b). (a) Percentage of days when maximum temperature > 90th percentile (b) Percentage of days when minimum temperature < 10th percentile

some parts of northwest India, central India and east India. Maximum temperature anomaly was more than 2 °C over parts of Ladakh state, Himachal Pradesh, Uttarakhand, Assam & Meghalaya, Andhra Pradesh state and South Interior Karnataka. Maximum temperature anomaly was less than -1 °C over parts of Punjab, Rajasthan state, Uttar Pradesh state, Madhya Pradesh state and Gangatic West Bengal.

Minimum temperature was above normal over most parts of the country, except some parts of northwest India and central India. Minimum temperature anomaly was more than 3 °C over parts of Punjab, Bihar, Jharkhand, Manipur, Gujarat region, Tamil Nadu, Puducherry & Karaikal and South Interior Karnataka. Minimum temperature anomaly was less than -1 °C over parts of West Uttar Pradesh.

Percentage of Warm days/Cold nights

Figs. 14(a&b) show the percentage of days when maximum (minimum) temperature was more (less) than 90th (10th) percentile. Over parts of Assam & Meghalaya, Uttarakhand, West Uttar Pradesh, Coastal Andhra Pradesh, Telangana, Kerala & Mahe, South Interior Karnataka and both the

islands maximum temperature was greater than 90th percentile for more than 50% of the days of the season. For minimum temperature no such significant distribution was observed.

Fig. 15 shows the mean temperature time series for the country as a whole for Post-Monsoon since 1971. Five year moving average values are also shown. The mean temperature for season this year over the country as a whole was 24.24 °C with an anomaly of 1.0°C and highest since 1901. Over East & Northeast India the mean temperature was highest (22.98 °C with an anomaly of 1.24 °C), South Peninsular India the mean temperature was also highest (27.49 °C with an anomaly of 1.15 °C) and Central India the mean temperature was 2nd highest (25.21 °C with an anomaly of 0.92 °C) since 1901.

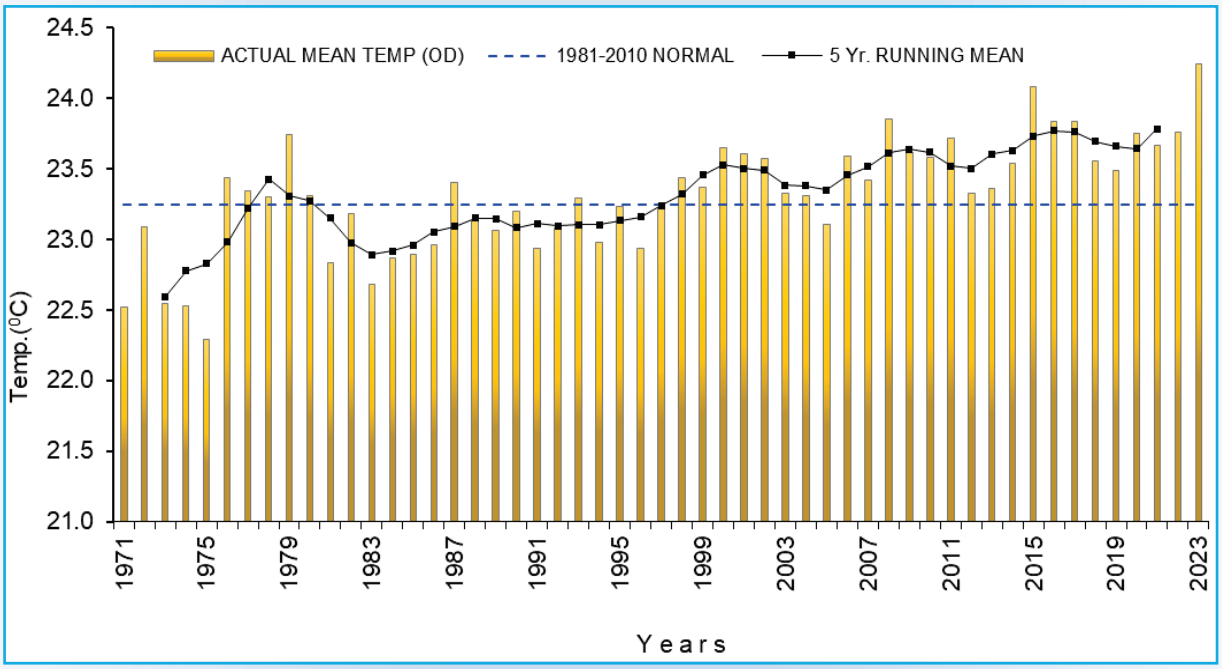


Fig. 15. Time series of mean temperature averaged over India (vertical bars and five-year running mean (continuous line) for the post-monsoon during the period 1971-2023

Figs. 16(a&b) show, the maximum and minimum temperature series respectively for the country as a whole and the four homogeneous regions during Post-Monsoon 2023 since 1971. Both the maximum and minimum temperatures were above normal over all the homogeneous regions except Northwest India, the maximum temperature was normal. Among the four homogeneous regions, over East & Northeast India the maximum temperature was highest (28.87 °C with an anomaly of 1.28 °C) and the minimum temperature was also highest (17.08 °C with an anomaly of 1.20 °C) since 1901. Over South Peninsular India the maximum temperature was 2nd highest (31.41 °C with an anomaly of 1.01 °C) and the minimum temperature was highest (23.58°C with an anomaly of 1.28 °C) since 1901. The minimum temperature was 2nd highest (19.20 °C with an anomaly of 1.46 °C) over Central India and highest (12.45 °C with an anomaly of 1.25 °C) over Northwest India since 1901.

Over the country as a whole the maximum temperature was 3rd highest (29.59 °C with an anomaly of 0.68 °C) and the minimum temperature was highest (18.89 °C with an anomaly of 1.31 °C) since 1901. Table 2 gives temperature anomalies over India and four homogeneous regions during the season.

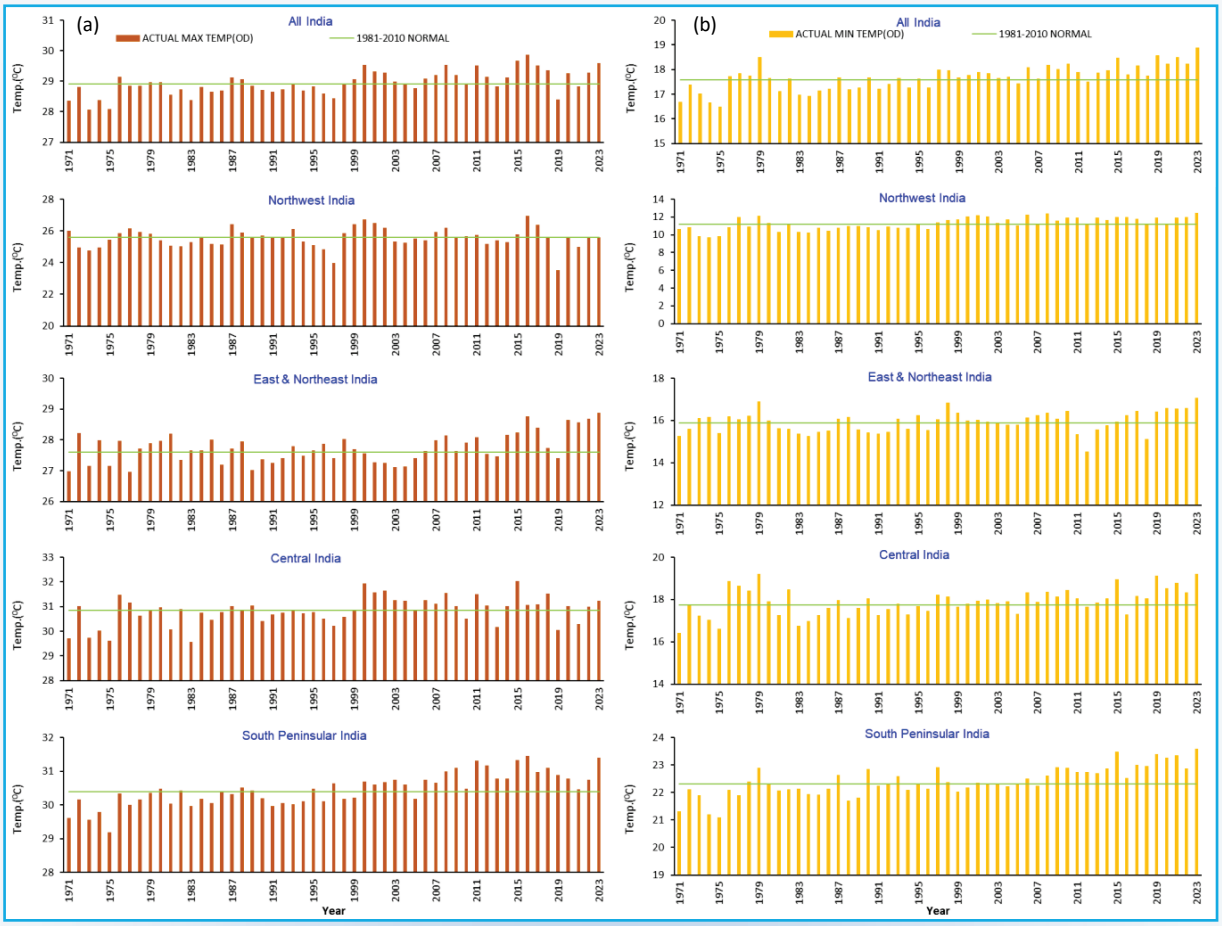


Fig. 16(a&b). Time series of temperature for the country as a whole and the four homogeneous regions forpost-monsoon season ofthe period 1971-2023 (a) MAXIMUM (b) MINIMUM

Low Pressure Systems

During the season, six low pressure systems (1ESCS, 1VSCS, 1SCS, 1CS and 2 low pressure area) were formed. The frequency and place of origin of these low pressure systems formed over the Indian region during the post monsoon season is shown in the table below.

Month /Systems	CS and above	DD	D	WML	LPA
October	1 (BOB),1(AS)				
November	1 (BOB)				1(AS)
December	1 (BOB)				1(AS)
	(AS : Arabian Sea)		**(BOB : Bay of Bengal)**		

During October 2023 one Extremely Severe Cyclonic Storm (ESCS) "TEJ" formed over Arabian Sea during (20 - 25 October). This ESCS TEJ moved nortwestwards towards YEMEN coast. Besides this ESCS one Very Severe Cyclonic Storm "HAMOON" formed over Bay of Bengal during (21 - 25 October). During November 2023 one Cyclonic Storm (CS) "MIDHILI" formed over Bay of Bengal during (15 - 18 November) and one low pressure area formed over Arabian Sea. During December one Severe Cyclonic Storm "MICHAUNG" formed over Bay of Bengal during (1 - 6 December) Fig. 17 shows tracks of these systems formed during season.

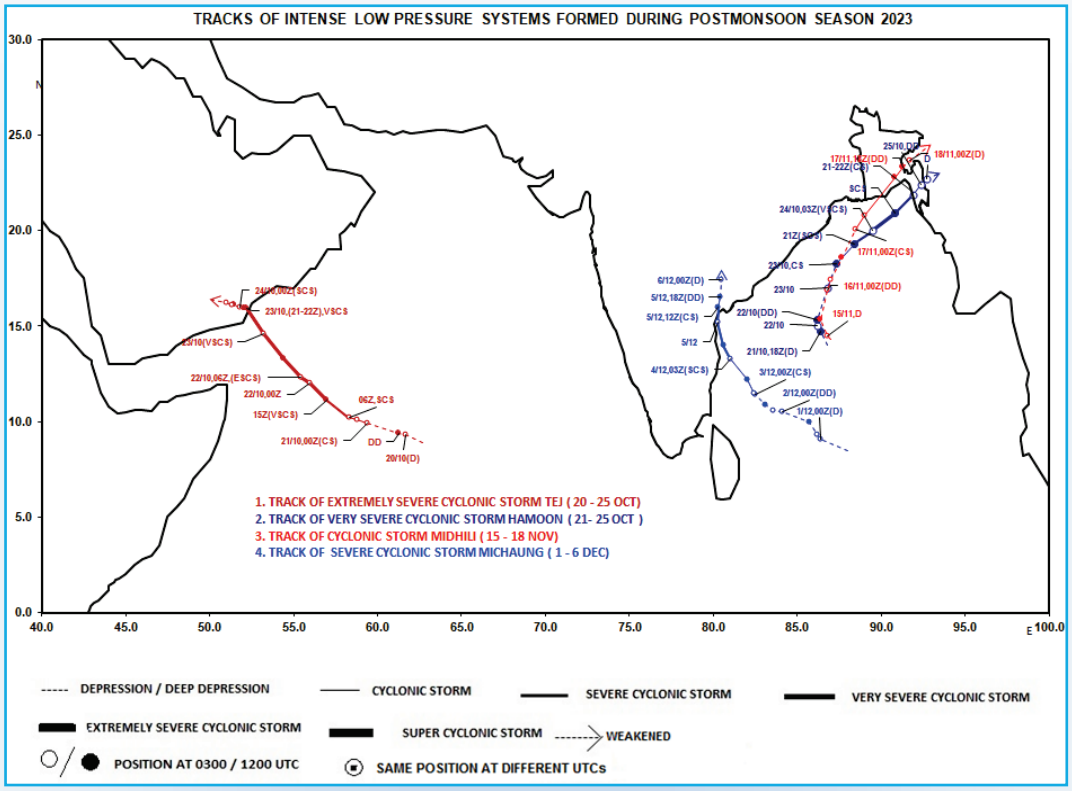


Fig. 17. Tracks of intense low pressure systems formed during post-monsoon season of 2023

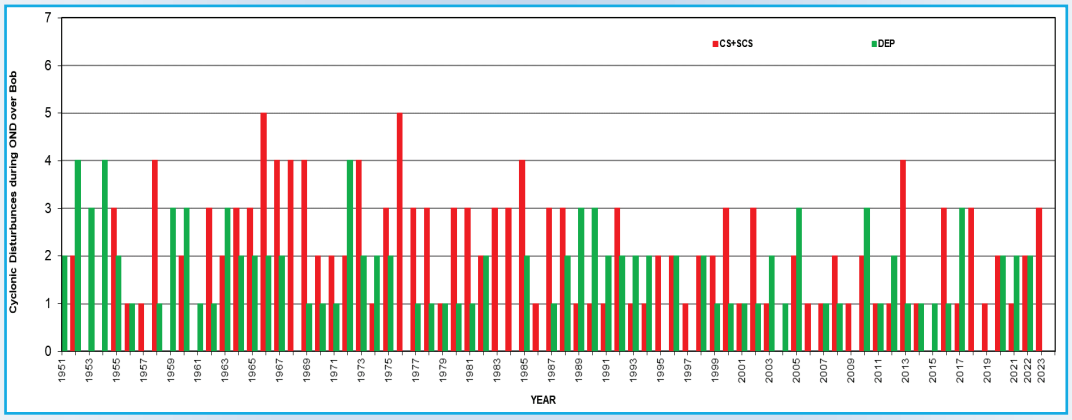


Fig. 18. Time series of frequency of depressions/cyclonic storms formed over Bay of Bengal during the post monsoon season Oct-Dec (1951- 2023)
(Source : Cyclone eAtlas RSMC IMD New Delhi) based on real time data

Fig. 18 shows the number of depressions & storms formed over Bay of Bengal during the post - monsoon season (1951-2023).

Significant Weather Events during Post Monsoon Season 2023

Fig. 19 shows significant weather events during the season (Based on real time media reports). During Post Monsoon Season, a total of 208 persons were reportedly claimed dead, more than 75 persons were injured, more than 75 persons were missing & more than 31,600 livestock were perished. The details of causalities given below, which are based on real time media reports.

Heavy Rains, Floods & Landslide

A total of 139 persons were reportedly claimed dead, 26 persons were injured, more than 75 persons were missing & more than 31,500 livestock were perished during Post Monsoon season because of heavy rains, floods & Landslide.

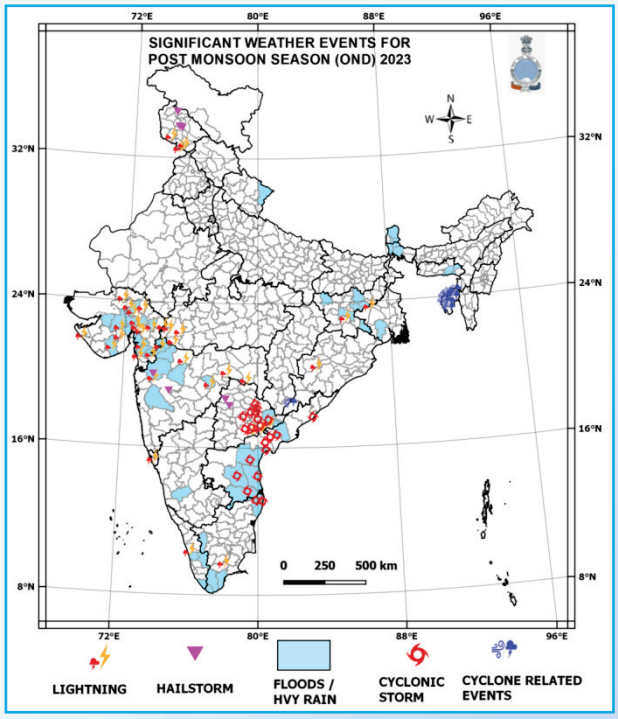


Fig. 19. Significant weather events during post-monsoon season 2023 (based on real time media report)

Lightning

A total of 45 persons were reportedly claimed dead, more than 50 persons were injured & more than 140 livestock were perished, during Post Monsoon season 2023, because of Lightning.

Cyclonic Storm

A total of 24 persons were reportedly claimed dead during December, because of Severe Cyclonic Storm MICHAUNG. The details of the area effected by the events are summarized and given in the table below;

Hailstorm

Due to hailstorm, Bandipora, Kulgam, Shopian districts of Jammu & Kashmir affected on 15th October. Ahmednagar & Nashik districts of Maharashtra affected on 26th November. Nizamabad & Kamareddy districts of Telangana affected on 28th November.

CHAPTER 3

NUMERICAL WEATHER PREDICTION

Global and Regional Modelling (NWP)

GFS Model

Global Forecasting System (GFS T1534L64) model is run operationally at India Meteorological Department (IMD) four times in a day (0000, 0600, 1200 & 1800 UTC) to give deterministic forecast in the short to medium range upto 10 days. The forecast model has a resolution of approximately 12 km in horizontal and has 64 levels in the vertical. The initial conditions for this GFS model is generated from the four-dimensional (4D) ensemble-variational data assimilation (DA) system (4DEnsVar) building upon the grid point statistical interpolation (GSI)-based hybrid Global Data Assimilation System (GDAS) run on High Performance Computing Systems (HPCS) at National Center for Medium Range Weather Forecasting (NCMRWF). The real-time GFS T1534L64 model outputs are generated daily at IMD. This 4DEnsVar data assimilation system has capabilities to assimilate various conventional as well as satellite observations including radiances from different polar orbiting and geostationary satellites. The real-time outputs are made available to operational weather forecasters and various users through the national web site of IMD. Fig. 1 shows the mean rainfall in observations and forecasts (mm) during south west monsoon 2023.

GEFS Model

Global Ensemble Forecast System (GEFS) GEFS is an operational weather model at IMD to address underlying uncertainties in the input data such limited coverage, instruments or observing systems biases, and the limitations of the model itself. GEFS quantifies these uncertainties by generating multiple forecasts, which in turn produce a range of potential outcomes based on differences or perturbations applied to the data after it has been incorporated into the model. Global Ensemble Forecast System (GEFS) at IMD is

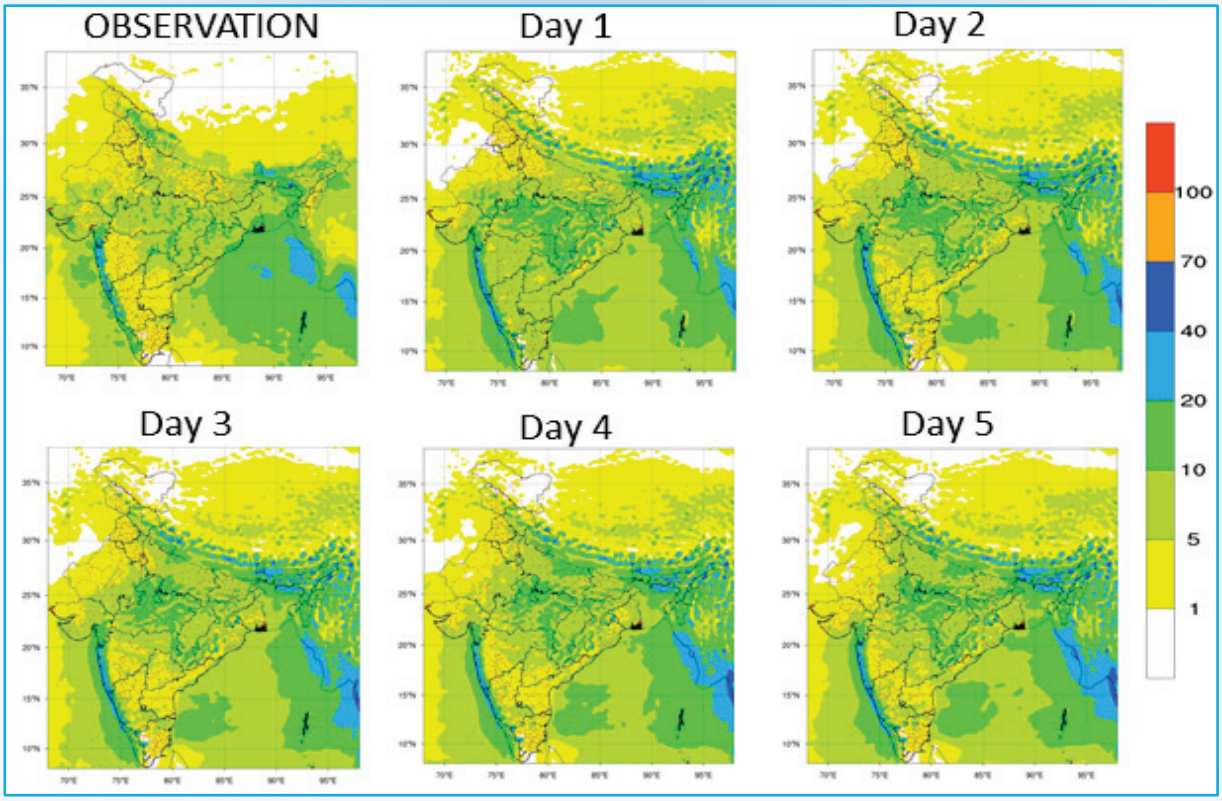
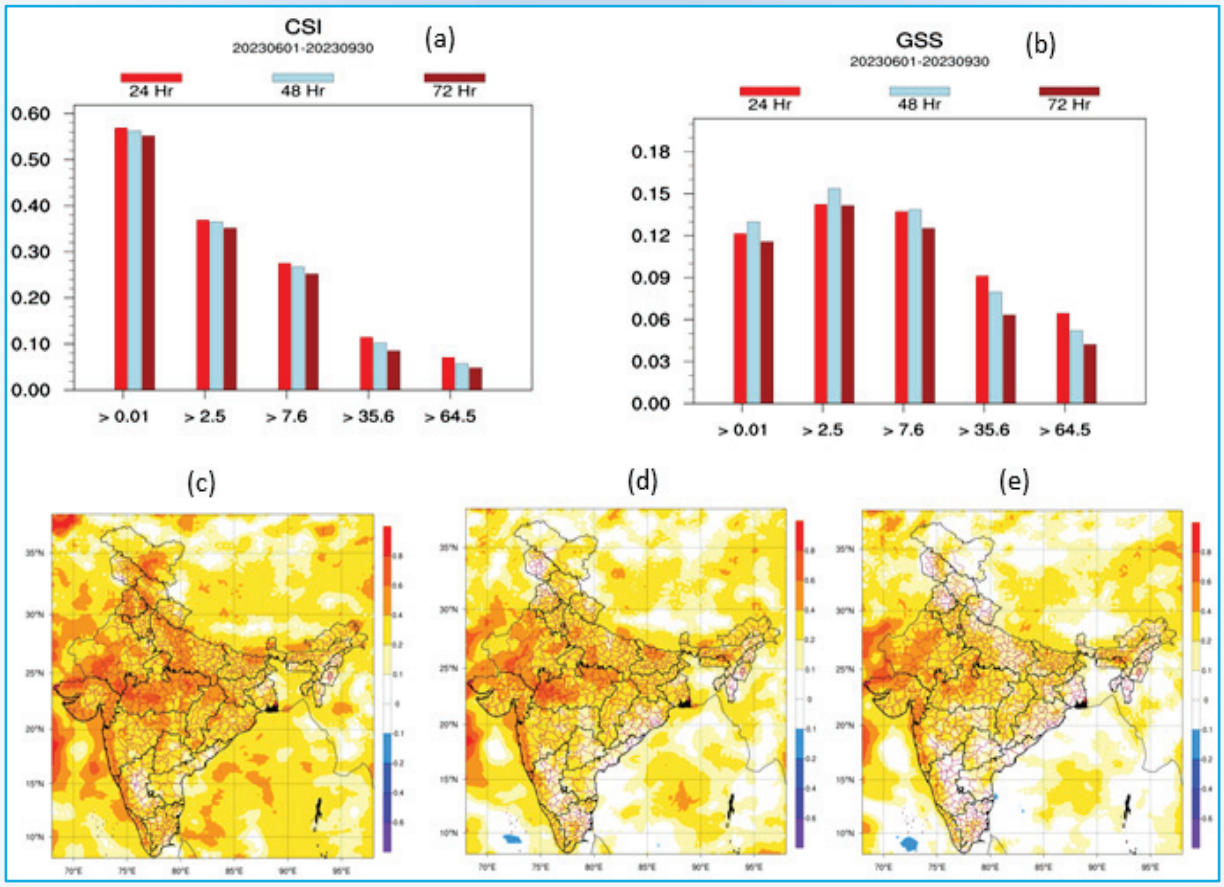


Fig. 1. Mean rainfall (mm) observations and IMD-GFS forecast for forecast hours of 24 hours, 48 hours, 72 hours, 96 hours and 120 hours during south west monsoon 2023

adopted from NCEP and it runs in ~12 km (T1534) resolution. The total number of 21 Ensembles (20 perturbed forecasts + 1 control forecast) constitutes the ensemble system. These 20-ensemble members are generated by Ensemble Kalman Filter (EnKF) method from the forecast perturbation of the previous cycles four times a day (0000, 0600, 1200 and 1800 UTC) at all 64 model vertical levels. These analysis perturbations are added to the reconfigured analysis obtained from the hybrid four-dimensional Ensemble variational data assimilation system (GDASHybrid4DEnsVar) as part of the suite. The 243 hours forecast of GEFS is routinely generated based on 0000 UTC and 1200 UTC initial conditions which include a control forecast starting from GDAS assimilation and 20 (20 perturbations) ensemble members with each perturbed initial condition (Deshpande et al., 2020).

WRF model

During southwest monsoon season 2023, the WRF model (ARW) delivered three days forecasts at 3 km horizontal resolution four times daily at 0000, 0600, 1200 and 1800 UTC with hourly interval. The data assimilation component, regional GSI (Global Statistical Interpolation) takes global GFS analysis and all other conventional quality-controlled observations as its input and generates mesoscale analysis at 3 km resolution. The model produced forecasts over a domain spanning about 5° S to 41° N in north-south and 49° E to 102° E in east-west directions respectively. Fig. 2 portrays skill scores (a) critical success index and (b) Gilbert skill scores for different rainfall thresholds whereas lower row exhibits seasonal averaged spatial correlation coefficient for (c) 24 hours, (d) 48 hours and (e) 72 hours rainfall forecasts with observation.



Figs. 2(a-e). (a) Critical Success Index, (b) Gilbert Skill Score & spatial correlation coefficient averaged over whole monsoon season for (c) 24 hours forecast, (d) 48 hours forecast and (e) 72 hours forecast of rainfall

HWRF-Ocean (HYCOM/POM-TC) coupled model

During pre-monsoon and post-monsoon cyclone seasons of 2023, the movable triple nested HWRF-Ocean (HWRF/POM-TC) coupled model with horizontal resolutions of 18 km, 6 km and 2 km delivered five days forecasts four times a day at 0000 UTC, 0600 UTC, 1200 UTC and 1800 UTC for tropical cyclones formed over north Indian Ocean (NIO). The data assimilation component of HWRF, regional GSI Data Assimilation, generated mesoscale analysis for intermediate and innermost nests which are then merged to generate analysis for all three domains. The model parent domain (18 km horizontal resolution) remained stationary whereas the intermediate domain (6 km horizontal resolution) and the inner most domains (2 km horizontal resolution) moved to track the storm centre. During the Year 2023, seven Cyclonic storms formed over North Indian Ocean (NIO) namely MOCHA, BIPARJOY, TEJ, HAMOON, MIDHILI AND MICHAUNG. The Real time cyclic (4 times at day) HWRF model run during all tropical cyclones provided real time track and intensity forecast for 120 hours lead time along with other products. These were disseminated to RSMC, New Delhi and various other users in addition to dedicated HWRF webpage on IMD-NWP website. The verification (error) score for Extremely Severe Cyclonic Storm (ESCS) BIPARJOY formed during the month of June, 2023 is presented in Table 1. The Fig. 3 represents the different product generated from operational HWRF-HYCOM coupled model for the ESCS-BIPARJOY during June 2023.

TABLE 1

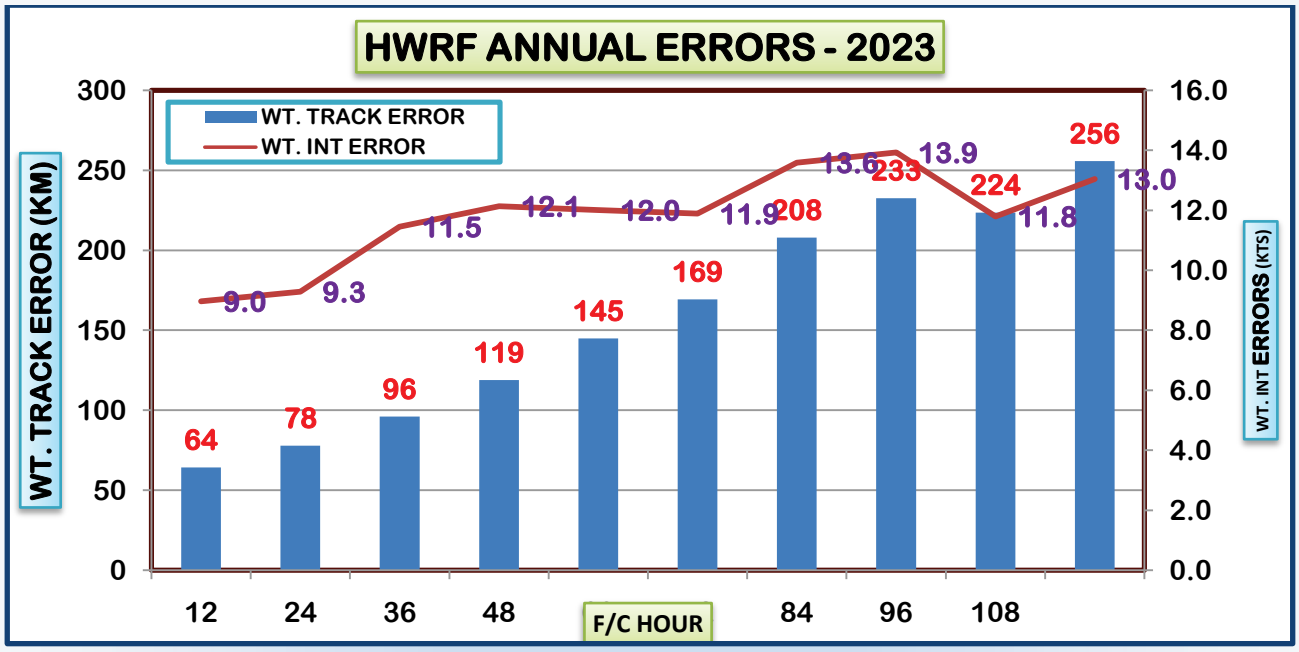
Coupled HWRF-HYCOM Track and intensity forecasts Error Statistics for ESCS BIPARJOY
(*Number of forecasts verified is given in the parentheses)

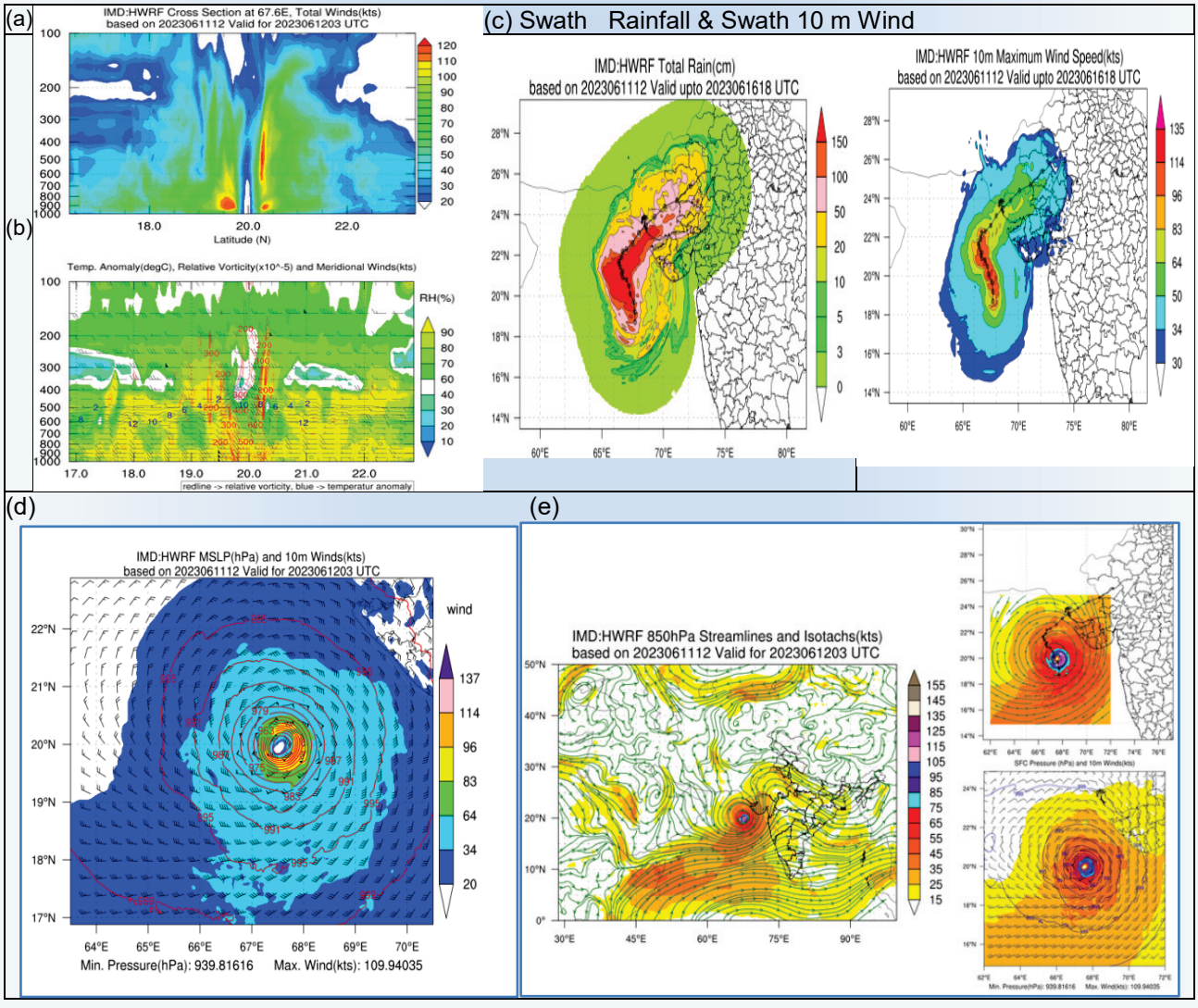
Errors \ Lead Time	12 Hr (42)	24 Hr (42)	36 Hr (42)	48 Hr (41)	60 Hr (39)	72 Hr (37)	84 Hr (35)	96 Hr (33)	108 Hr (30)	120 Hr (29)
Direct Position Errors (DPE) (km)	63	77	93	110	128	157	187	214	231	259
Along Track Errors (AT) (km)	43	57	74	86	101	129	141	158	180	191
Cross track Errors (CT) (km)	68	69	61	68	75	84	114	133	138	157
Landfall Point Errors (km)	45	53	37	69	79	76	81	48	57	18
Landfall Time Errors (hr)	0	0	0	0	+3	+6	+3	-3	-3	+3
Average Absolute Intensity Errors (AAE) (kts)	10.5	12.4	13.1	12.5	11.3	12.1	13.6	12.6	11.8	13.7
Root Mean Square Intensity Errors (RMSE) (kts)	12.9	15.7	16.6	16.3	15.1	14.5	16.1	14.8	14.5	16.0

(*Number of forecasts verified is given in the parentheses)

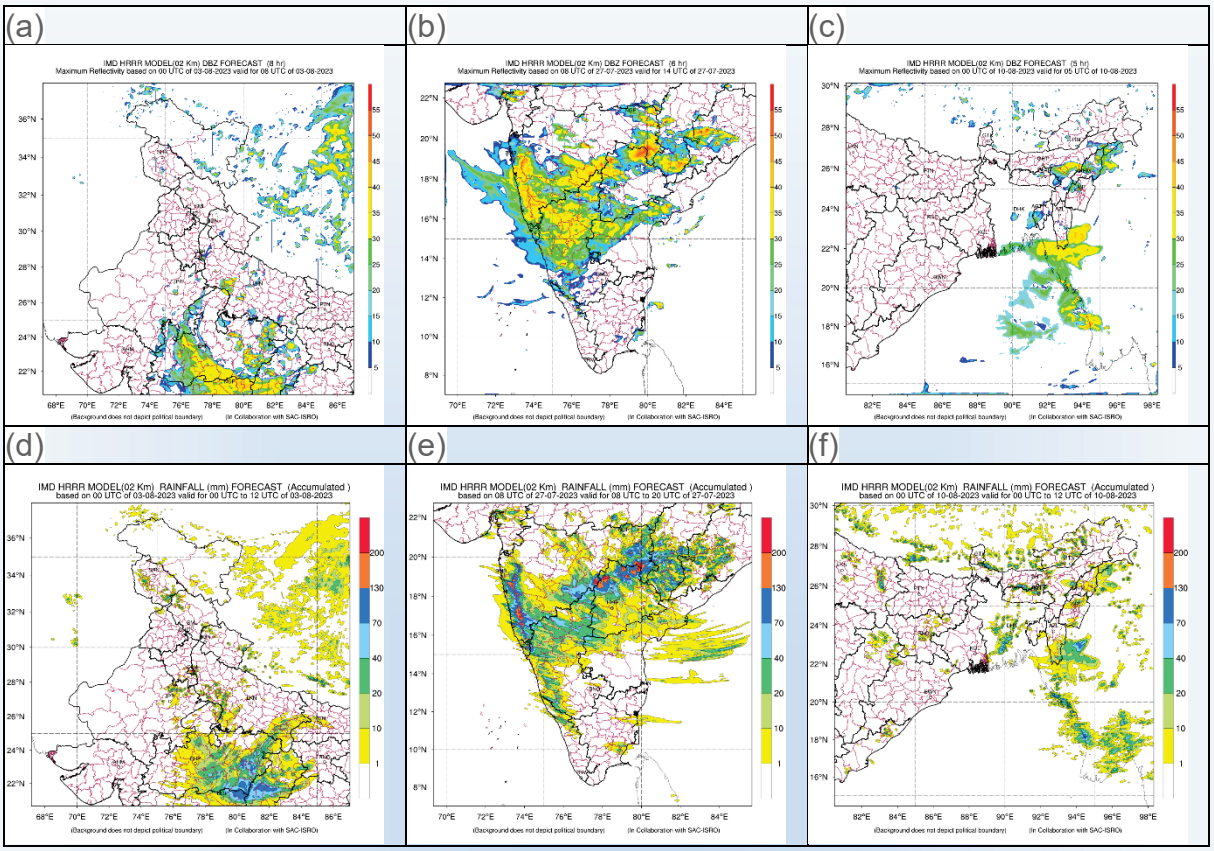
HWRF ANNUAL ERRORS FOR THE YEAR YEAR – 2023

ANNUAL ERROR 2023											
	HOUR	12	24	36	48	60	72	84	96	108	120
TRACK	(Wt.)	64	78	96	119	145	169	208	233	224	256
INT	(wt.)	9.0	9.3	11.5	12.1	12.0	11.9	13.6	13.9	11.8	13.0
RMSE	(wt.)	10.9	11.8	14.3	15.1	14.9	14.3	15.9	16.0	14.5	15.2
No of f/c verified		118	108	98	87	76	66	56	48	36	31





Figs. 3(a-e). ESCS BIPARJOY Zonal Cross-section of (a) Total wind & (b) Humidity and temperature, (c) Swaths of Rainfall & 10 m wind, (d) 10m wind and MSLP of 2 km core domain and (e) Streamlines and Isotachs of combine domain (18x6x2 km)



Figs. 4(a-f). The left column figures (a,b,c) shows the Reflectivity forecast product for North West, South and East & North-East India from HRRR model. The right column figures (d,e,f) shoes the rainfall forecast product for North West, South and East & North-East India from HRRR model

TABLE 2

The annual average intensity forecast errors (kt) AAE and RMSE (root mean square error) of SCIP for all the systems during 2023 (Number of forecast verified given in the parentheses)

Lead time →	12 hr	24 hr	36 hr	48 hr	60 hr	72 hr	84hr	96hr	108hr	120hr
IMD-SCIP (AAE)	4.8(27)	6.1(23)	9.4(21)	10.3(17)	12.4(15)	10.8(12)	10.8(10)	13.8(8)	17.5(6)	20.8(6)
IMD-SCIP (RMSE)	6.2	7.4	12.0	12.4	15.2	14.0	14.6	19.2	20.1	27.1

Performance of MME and SCIP for forecasting tropical cyclones over the North Indian Ocean during the year 2023

(a) Mean track forecast error (km) of MME - 2023

The annual average track forecast errors [Direct position error (DPE)] of multi-model ensemble (MME) during the year 2023 are computed. The annual average is computed for the five cyclonic storms MOCHA, BIPARJOY, TEJ, HAMOON and MICHAUNG over the North Indian Ocean (NIO) during the year 2023. The track forecast errors were 59 km, 101 km, 168 km, 178 km and 199 km for MME for the forecast hours 24h, 48h, 72h, 96h and 120h respectively.

(b) Mean Intensity forecast error (kt) of SCIP - 2023

The annual average intensity forecast errors of SCIP model are shown in Table 2. The absolute

average error (AAE) was 6.1 kts at 24h, 10.3 kts at 48h, 10.8 kts at 72h, 13.8 kts at 96 h and 20.8 kts at 120 h for all the five cyclonic storms (MOCHA, BIPARJOY, TEJ, HAMOON and MICHAUNG) over the NIO during the year 2023. The Root Mean Square (RMSE) errors were 7.4 kts at 24h, 12.4 kts at 48h, 14.0 kts at 72h, 19.2 ktsat 96 h and 27.1 kts at 120 h.

High Resolution Rapid Refresh (HRRR) MODEL

The HRRR model is based on Weather Research and Forecasting (WRF) Model's ARW core and takes the initial and boundary condition from the IMD-GFS global model. Utilising the WRF Data Assimilation system (WRF-DA), the RADAR data is assimilated in HRRR model every 10 min over a 1-h period. The HRRR is hourly updated, cloud-resolving, convection-allowing atmospheric model, with horizontal resolution of 2 km and provides reflectivity and rainfall forecast for next 12 hours. The HRRR model is run in cyclic mode every hour for three domains covering entire mainland of India, viz., North-West Domain, East & North-East Domain and South Peninsular India domain and forecast products are updated on the NWP website after every two hours. The forecast product from HRRR model is shown in Fig. 4.

Extended Range Forecasts

A coupled model with a suite of models from CFSv2 coupled model has been developed, implemented and operationalized in IMD in 2017 for generating operational Extended Range Forecast products for different users. This suite of models are (i) CFSv2 at T382 (≈ 38 km) (ii) CFSv2 at T126 (≈100 km) (iii) GFSbc (bias corrected SST from CFSv2) at T382 and (iv) GFSbc at T126. The Multi-model ensemble (MME) of the above suite is run operationally for 32 days based on every Wednesday initial condition with 4 ensemble members to give forecast for 4 weeks for days 2-8 (week1; Friday to Thursday), days 09-15 (week2; Friday to Thursday), days 16-22 (week3; Friday to Thursday) and days 23-29 (week4; Friday to Thursday). Active phase in July and September and weak phase in June and August can be seen from the observed daily rainfall and weekly rainfall departure plots shown in Fig. 5 and Fig. 6. Fig. 6 also shows all India weekly rainfall departure in model forecasts and observations for the monsoon

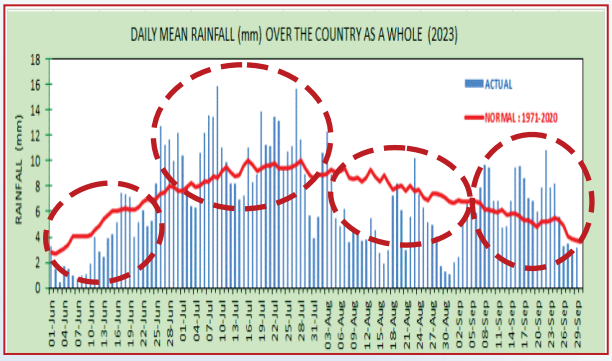


Fig. 5. Daily observed rainfall departure during the monsoon season 2023

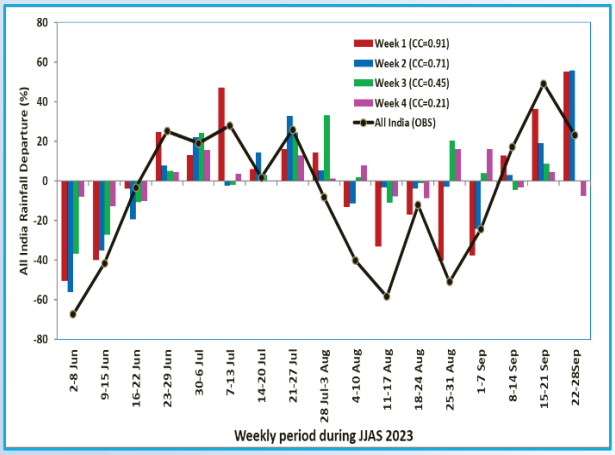
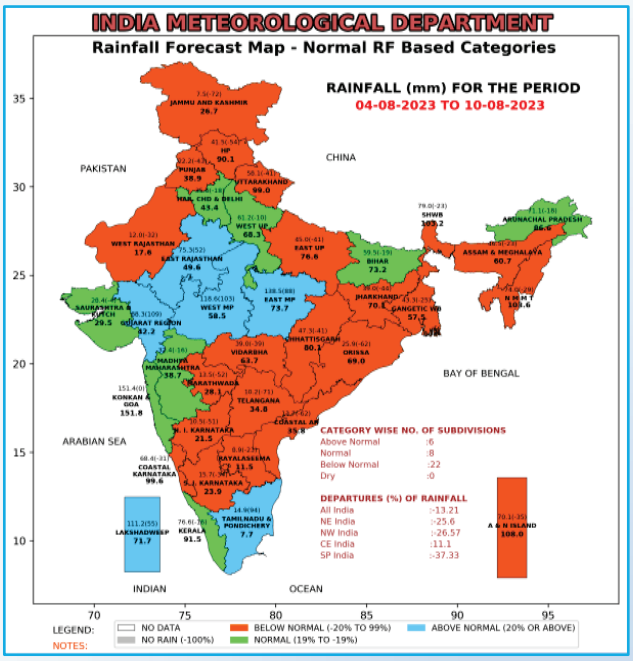


Fig. 6. All India rainfall departure in observations (line) and model forecasts (bars) for different weeks

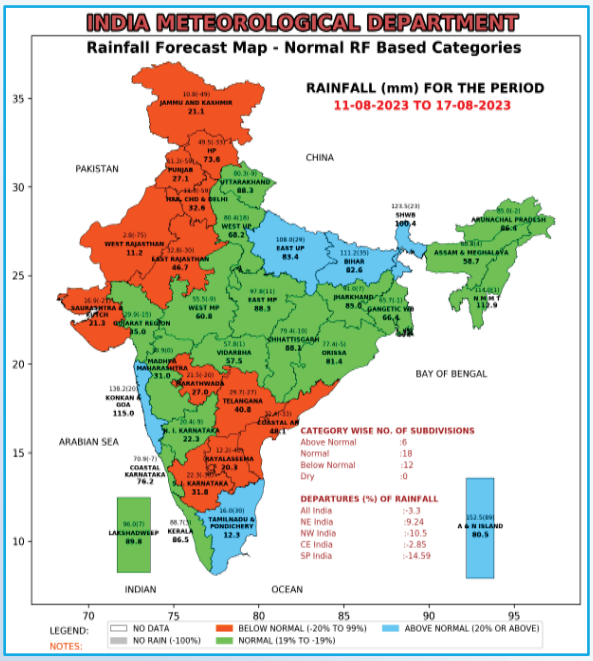
period during June to September. Active and week phases of monsoon are very well captured in the model forecast with significant correlation coefficients in week 1 (0.91), week 2 (0.71) and week 3 forecast (0.45). On smaller spatial scales (homogeneous regions and met subdivision levels) the forecast shows useful skill up to two weeks.

Agromet applications forecast for 36 met subdivisions of India is prepared for two weeks with categorising the subdivisions as below normal, normal, or above normal category depending on the rainfall departure during the week. The two weeks forecast on met-subdivision level is widely used for application in Agriculture for farmers' advisory. The transition of monsoon from above normal to below normal and vice versa is well captured in the extended range forecast. Fig. 7 shows subdivision wise rainfall forecast (departure) in the weak phase of monsoon for the weeks 4-10 August, 2023 and 11-18 August, 2023 based on IC 2nd August, 2023.

(a) Week 1 forecast valid for 4-10 August 2023



(b) Week 2 forecast valid for 11-18 August 2023



Figs. 7(a&b). Subdivision wise rainfall forecast for the week 1 (a) and week 2 (b) based on IC 2nd August, 2023

Met-Subdivision/Districts level extended range forecast

Experimental ERF products are also being prepared for application in other sectors :-

- Agriculture and veterinary sector (The winter frost forecast and extreme low temperature will be used for crop advisory; high temperature for veterinary sector like poultry firm will be used).
- Water sector/Disaster management (The ERF forecast of active and break phases of monsoon, heavy rainfall, severe weather like cyclone etc will be generated for application in hydrological models and reservoirs operations).
- Health sector (indices like heat index, transmission windows for vector borne diseases, cold wave etc will be generated for services in health sector).
- Energy sector (The extreme high and low temperature forecasts products are being generated for potential use in power/energy sector).

Generation of Multimodel Ensemble (MME) forecast for Indian cities, districts and meteorological sub-divisions

IMD generates location based as well as area averaged forecast from five models and also its MME in real time for decision support. The NWP model forecasts available with IMD is of different spatial resolution (Table 3).

TABLE 3

Operational Global models

	Operation Models	Agency	Resolution (km)
1.	GFS	IMD	12
2.	GEFS	IMD	12
3.	GFS	NCEP	25
4.	UM	NCMRWF	12
5.	GSM	JMA	25
6.	IFS	ECMWF	20
7.	EPS	NCMRWF	12

Seven days location-based forecast of rainfall, maximum temperature, minimum temperature, wind speed, wind direction, relative humidity (at 0300 UTC and 1200 UTC) and cloud cover from each model is generated for Indian cities, followed by MME-mean forecasts have been generated. Currently forecast for 1725 cities are generating. Additionally, Meteogram based on above models (Table 4) are also generating for these stations.

Area-averaged forecast of rainfall, maximum temperature, minimum temperature, wind speed, wind direction, relative humidity (at 0300 UTC and 1200 UTC) and cloud cover from each model are

also generated for Indian districts for next 7 days, followed by MME-mean forecasts. Currently, forecast over 748 districts is being generated in real time. Over these spatial domains, forecast of rainfall distribution also calculated by estimating the percentage of grids reporting a rainfall amount greater than 2.5 mm/day. Similarly, rainfall distribution and intensity forecasts are generating for 36 meteorological sub divisions as a decision support to the forecasters. In addition, a heavy rainfall warning system is developed for districts and meteorological sub-divisions based on MME forecast. MME based temperature forecast are also available now for the forecasters. These forecasts are disseminated to the operational forecasters at RMCs and MCs as a decision support while issuing forecast. These forecasts (as digital values) and figures are also available at NWP division website. The district rainfall forecast from different NWP model and MME are compared against IMD observation during the south-west monsoon 2023. A case study is presented in this report to evaluate the performance of MME forecast qualitatively over Indian districts. In order to assess the performance of MME forecast, a case study during 17th September, 2023 is shown in the Fig. 8. The extremely heavy rainfall observed over Gujarat and neighbourhood was well predicted in MME up to day 5.

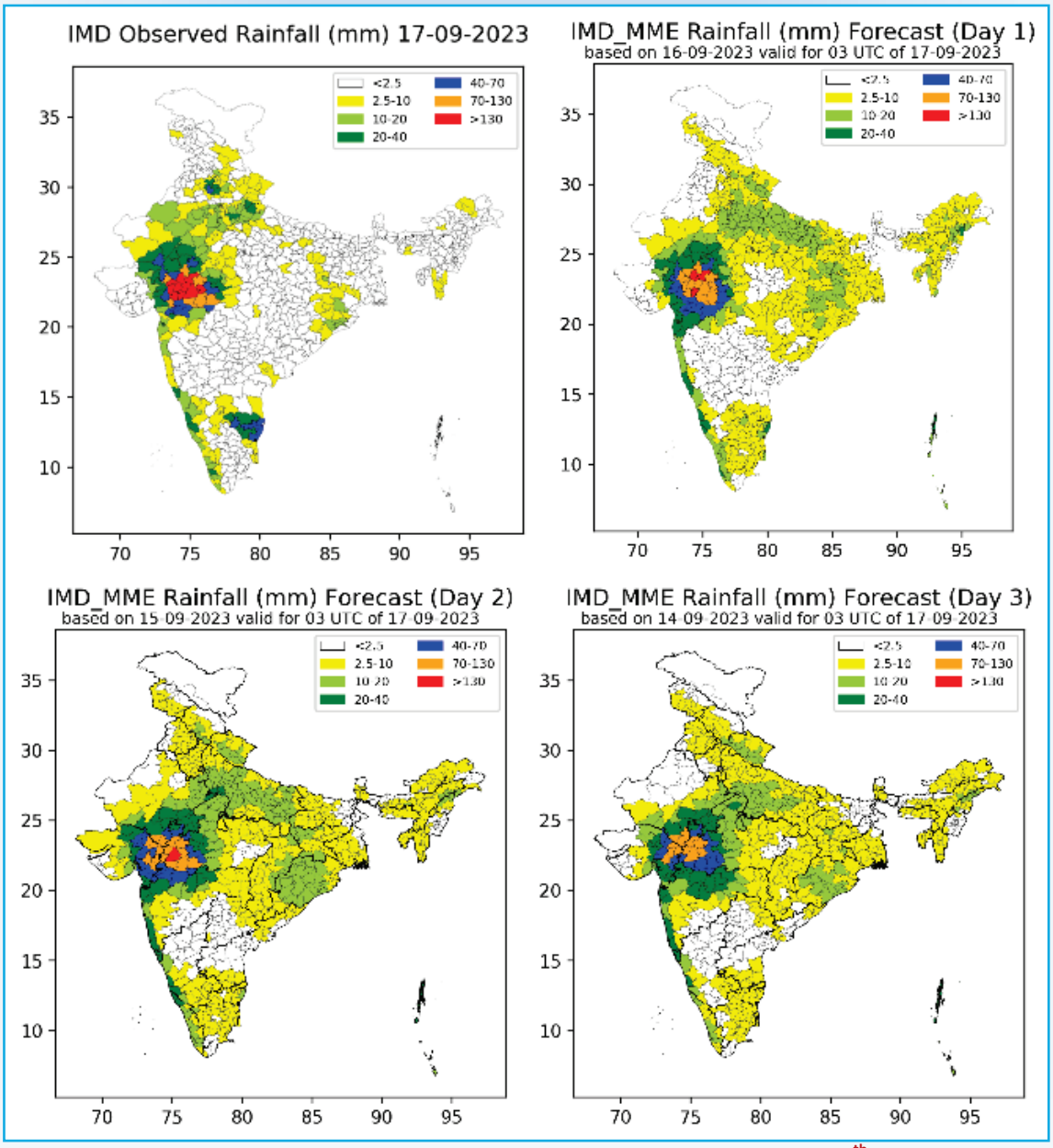


Fig. 8. IMD observed rainfall and MME day 1, day 2 and day 3 rainfall forecast for 17th September, 2023

Assessment of heavy rainfall warning system is presented (Fig. 9) in terms of probability of detection (POD) of heavy, very heavy and extremely heavy rainfall from seven models. From the Fig. 9, it is clear that MME have good skill in predicting extreme rainfall events than the individual models. Similarly, assessment of rainfall forecast has been carried for heavy rainfall events over Indian meteorological sub-divisions for southwest monsoon 2023 and presented in Fig. 10. POD and Critical Success Index (CSI) shows that MME has better skill than individual models up to day 5, in terms of POD and CSI. Among individual models, IMD-GFS and NCUM has better skill compared to other NWP models.

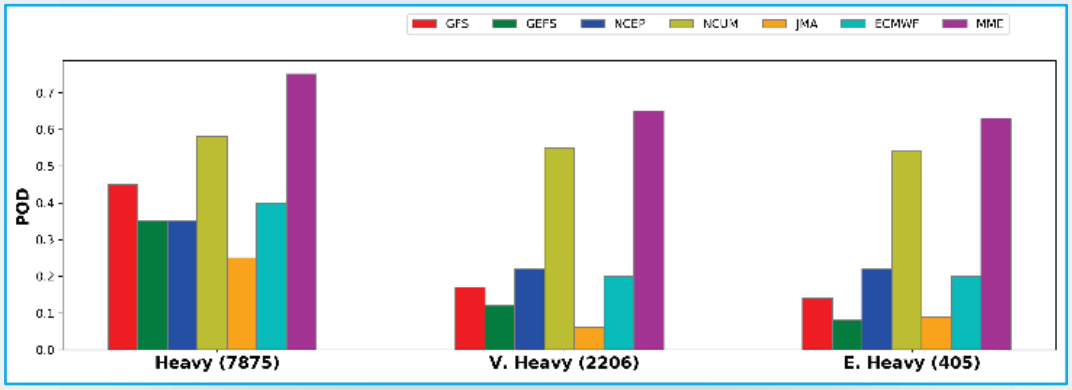


Fig. 9. Probability of detection of day 1 rainfall forecast against IMD observations for heavy, very heavy and extremely heavy rainfall categories. No of events in each category is given in the bracket

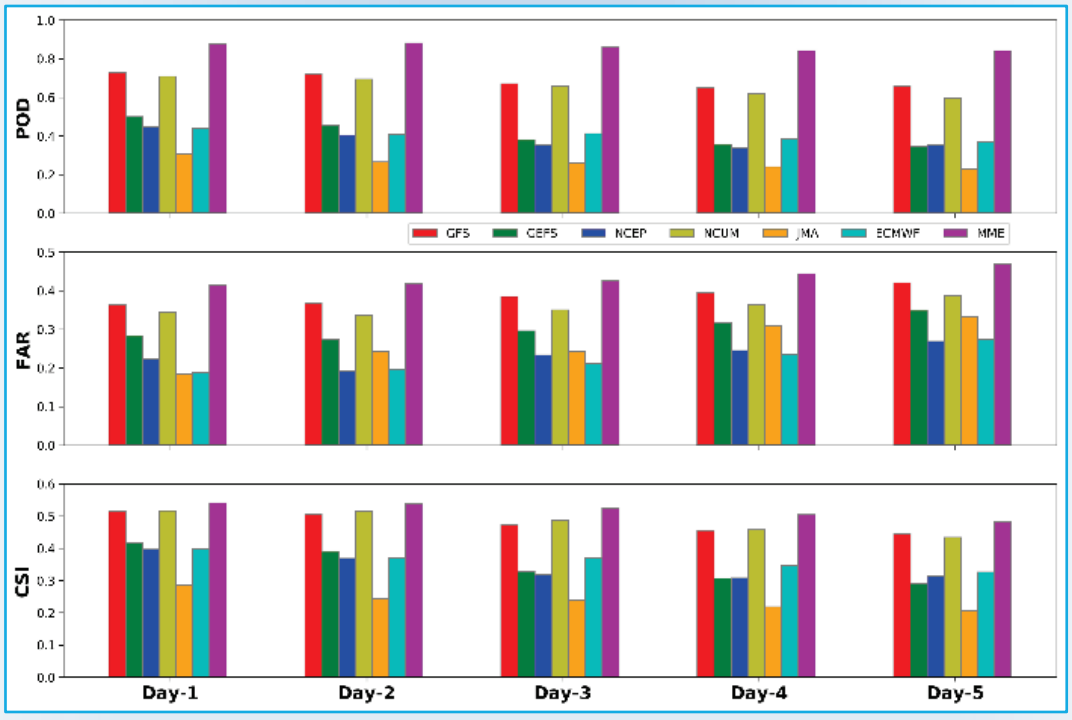


Fig. 10. POD, FAR and CSI of heavy rainfall forecast up to day 5 against IMD observations. No of events in each category is given in the bracket

Development of MME based operational forecast product for 153 river sub-basin

The summer monsoon rainfall is the major water source for most parts of India and people depend on this water source for their livelihood. The rainfall during this season is highly variable over space and time. The rainfall during the southwest monsoon period is the main source of flow discharge in most of the rivers in India.

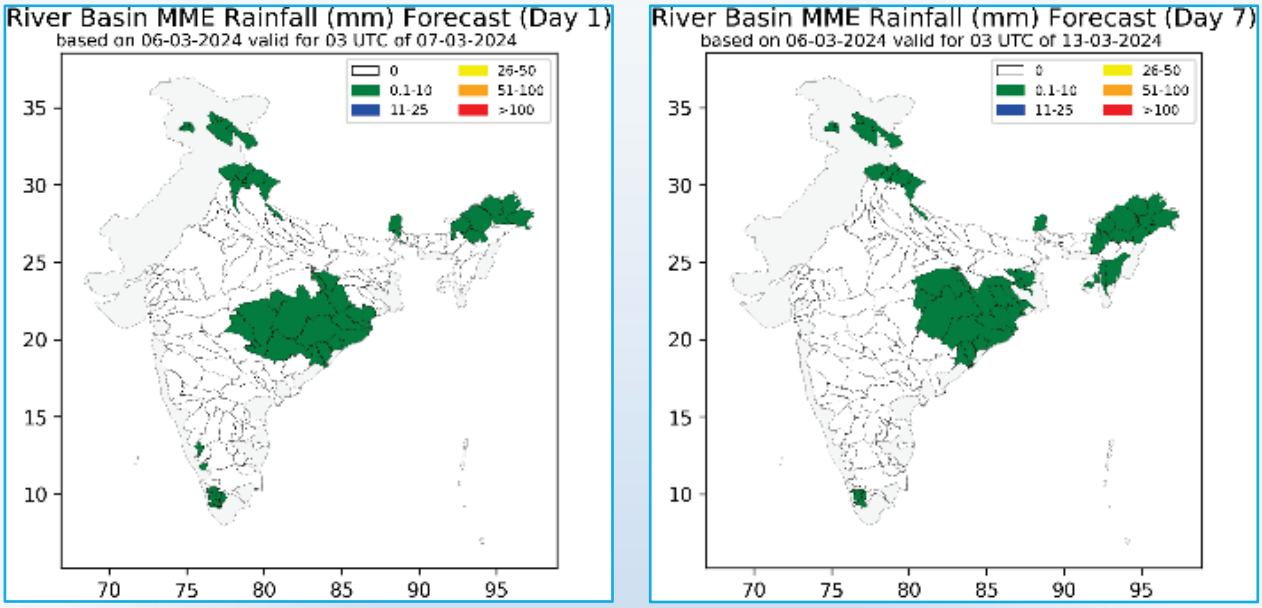


Fig. 11. 153 River sub-basin day-1 and day-7 forecast

The MME forecast product for the 153 river sub-basin is developed and operationalized for the five days forecast. Each day forecast is based on the simple MME of five global models as shown in the Table above. The area average values over each subbasin is computed form the five models and average over the models is represented as MME for that day. Fig. 11 show the two sample plots for day 1 and day 7 operation forecast. These forecasts (as digital values) and figures are also available at NWP division's website.

Development of MARINE Forecast based on MME for GMDSS, Sea Area, Fleet and Coastal forecast

The development of the products for the Marine required computation surface wind, visibility, weather, state of sea information. We utilized data from five global operational model's forecasts (IMD-GFS, GEFS, NCUM, NCEP-GFS and NCUM) daily up to five days. Individual models and their MME based graphical products are generated two time a day based on 0000 UTC and 1200 UTC data and updated on the IMD website for the Marine forecast and bulletin preparations. It is pertinent to mention that the role and the area of operations of the India Navy have significantly increased over the past years in tune with the nation's core interests. Therefore, the additional areas covering Longitude 30°E-120°E Latitude 35°S-40°N are considered vital for naval operations and information regarding weather in these areas is critical for planning and safe conduct of operations. In view of the above, an additional area as mentioned in the Fig. 12 is included in the Fleet forecast. Also ships and buoys data are provided for Day-1 forecast Fig. 12 shows the Extended Fleet Forecast domain including buoys and ships observation for day-1 forecast.

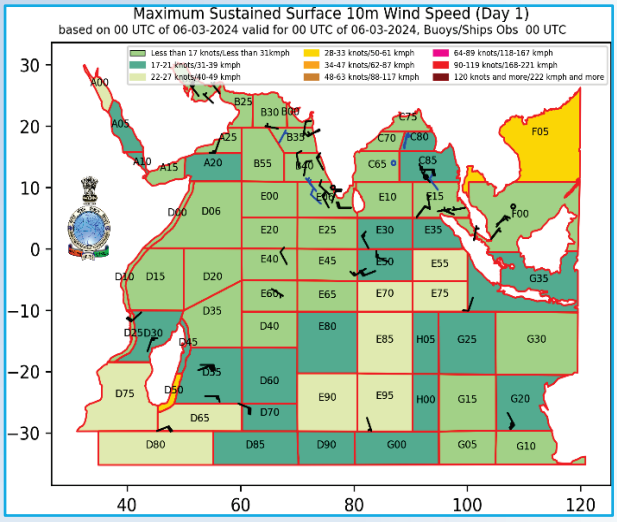


Fig. 12. Extended Fleet Forecast domain including buoys and ships observation for day 1 forecast

Monthly Models Verification Based on Buoys Observation

The monthly statistical computations of models based on buoy observations. Daily data for months as per x-axis in Fig 13 are used to calculate the RMSE, and this same data is made available to forecasters in real-time for specific locations of

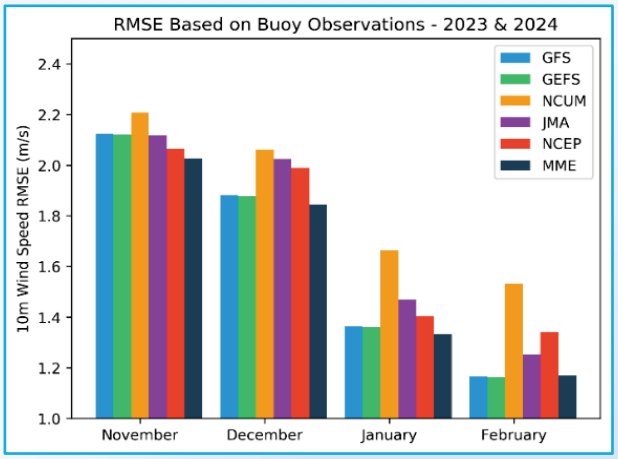


Fig. 13. illustrates the Root Mean Squared Error (RMSE) calculated from buoy observations each month, covering the period from November 1, 2023, toFebruary 29, 2024, for the models specified in the legend

buoys. The figure conveys crucial information to forecasters, indicating that MME products offer greater reliability compared to individual models. This is further emphasized in the RMSE, were the black-coloured MME exhibits lower errors in comparison to any individual model.

The summer monsoon rainfall is the major water source for most parts of India and people depend on this water source for their livelihood. The rainfall during this season is highly variable over space and time. The rainfall during the southwest monsoon period is the main source of flow discharge in most of the rivers in India.

The MME forecast product for the 153 river sub-basin is developed and operationalized for the five days forecast. Each day forecast is based on the simple MME of five global models as shown in the Table above. The area average values over each subbasin are computed form the five models and average over the models is represented as MME for that day. Fig. 10 show the two sample plots for day 1 and day 7 operation forecast. These forecasts (as digital values) and figures are also available at NWP division's website.

Wind Speed Probabilities

The Wind speed is one of the major parameters to identify the intensity of the cyclonic circulation. The IMD-NWP division developed and implemented to monitor the surface (10-meter height) wind speed probabilities exceeding 4 different thresholds which can explain the intensity of the cyclonic circulations using IMDGEFS (21 members) and NEPS (23 members) ensemble models. The four operational wind speed thresholds are ≥ 28 knots (14.4 m/s), ≥ 34 knots (17.5 m/s), ≥ 50 knots (25.7 m/s)≥ 64 knots (32.9 m/s) and its associated categories are such as Deep Depression, Cyclonic Storm, Severe Cyclonic Storm, and Very Severe Cyclonic Storm, respectively. This wind speed forecast probabilities monitor Fig. 14 are produced at every 6 hourly intervals up to 240 hours. The screenshot of operationalized wind speed probabilities plots using IMDGEFS during the Extremely Severe Cyclonic Storm (BIPARJOY) during 6-16 June, 2023.

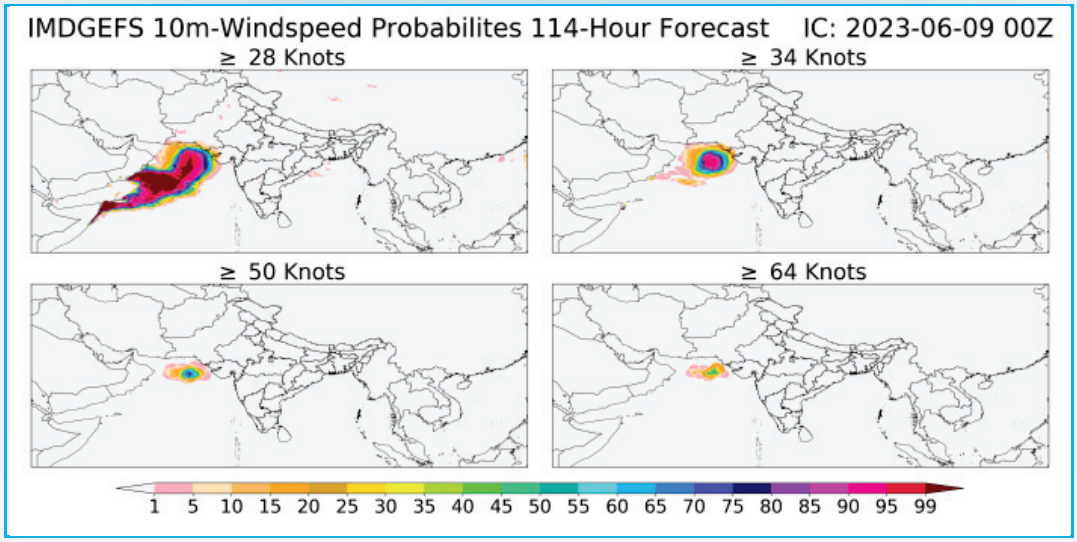


Fig. 14. 10-meter wind speed probability at threshold ≥ 28 Knots, ≥ 34 Knots, ≥ 50 Knots, and ≥ 64 Knots using IMDGEFS (20 ensemble members + 1 Control run) based on initial condition as on 2023-06-09-00Z valid for 114 hour forecast (during ESCS : BIPARJOY)

Multi Model Ensemble Tropical Cyclone Tracker

ECMWF IFS TC Tracker: The European Centre for Medium-Range Weather Forecasts (ECMWF) developed the Integrated Forecasting System (IFS) model for the global numerical weather prediction at medium range timescale and developed Tropical Cyclone tracker (IFS-TC-Tracker). The ECMWF IFS-TC-Tracker source code has been modified by the NWP division of IMD, to feed in multi-model global forecasts outputs and made the individual model TC-tracker lines plot along with multi-model-mean, and the verifications of Tc-Tracker both the visual, and statistical outputs are discussed.

By using these 5 global model outputs including IMDGFS, the IFS-TC-Tracker outputs have been made over north Indian Ocean, operationally at NWP, IMD. All model outputs are being interpolated to T159 Gaussian Grid horizontal resolution before running the IFS-TC-Tracker.

For the operational purpose multiple NWP global models had been utilized on real-time for cyclone track and intensity generationand its MME-Mean of the 4 cyclonic storms over Bay of Bengal during 2023, named as ESCS: MOCHA (2023-05-09-12Z to 2023-05-14-12Z), VSCS : HAMOON (2023-10-21-12Z to 2023-10-24-12Z), CS : MIDHILI (2023-11-15-12Z to 2023-11-17-00Z), SCS : MICHAUNG (2023-12-01-00Z to 2023-12-05-00Z) and 2 cyclonic storms over Arabian Sea during 2023, named as ESCS: BIPARJOY (2023-06-06-00Z to 2023-06-16-12Z) and ESCS : TEJ (2023-10-20-00Z to 2023-10-24-12Z).

For an example, the MME-Mean forecast tracks for ESCS: BIPARJOY along with the Direct Position Error is shown in Fig. 15 and Fig. 16 respectively.

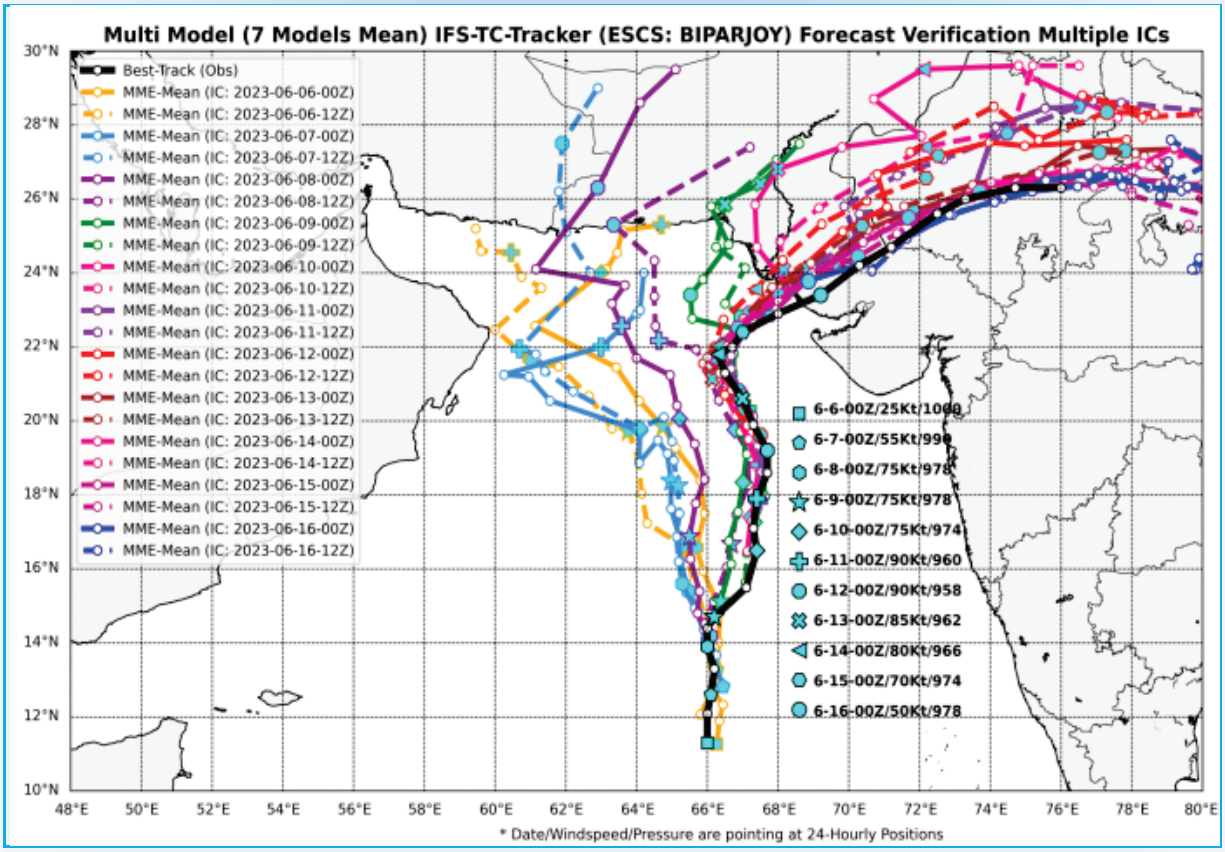


Fig. 15. Eyeball Verification of Real-time production of tropical cyclone tracker outputs ('BIPARJOY Extremely Severe Cyclone Storm during 2023-06-06-00Z to 2023-06-16-12Z) using ECMWF's IFS-TC-Tracker. The best track (observed) is shown in thick black line. The different initial conditions Multi Model Mean is shown in different colors. The TC tracker outputs are displayed at 12-hourly intervals which are marked in black color dots over individual model-colored lines and white color hollow circles over the MMMean blue dots. The observed position, windspeed, MSLP values are marked with different symbols in the legend (top left of figure), also marked over different initial condition model forecast tracks to compare with best track (black line)

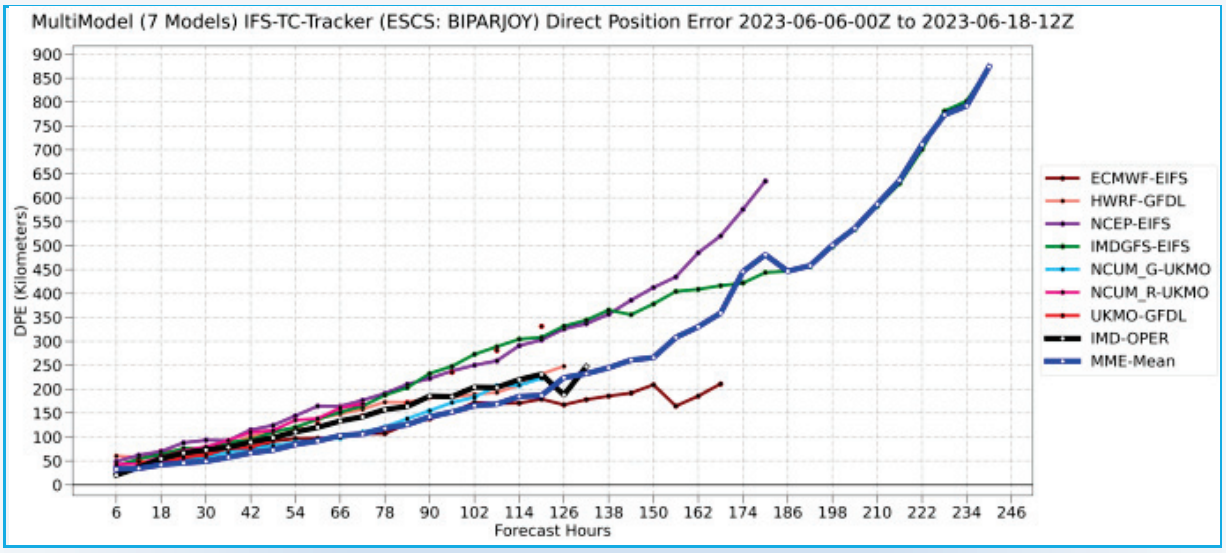


Fig. 16. Statistical Verification - Direct Position Error of BIPARJOY - Extremely Severe Cyclone Storm

Mausamgram – Public Access

The NWP division developed jointly with ISSD division and released the Mausamgram (Dynamic Meteogram) Version 1.0 on 15-01-2024 during the IMD's 150th foundation celebration day by the Vice President of India to the public usage https://mausamgram.imd.gov.in. This public mausamgram is an interactive and dynamic meteogram which provides location specific weather forecast information (Temperature, Rainfall, Relative Humidity, Windspeed, Winddirection, Cloud Cover) 1-hourly for next 1.5 days, 3-hourly for next 5 days, 6-hourly for next 10 days. Users can select their desired location over an Interactive India Map or User can search location through the options given in the website. Also it supports search location by block level, districts levels, village levels, latitude & longitude, and through area postal pin codes as well. This weather information is generated operationally and automatically by the mulimodel mean of 5 Global NWP models (IMDGFS, NCUM, ECMWF, JMA, NCEP) and 2 Regional NWP models (IMDWRF, NCUM-R). The same weather information is also accessible by the "Mausam" Mobile App, which is utilizing this NWP multi model mean forecasts output which are taking information from this Mausamgram website.

Screenshot of Mausamgram (Public Access) Webpage is shown in Fig. 17.

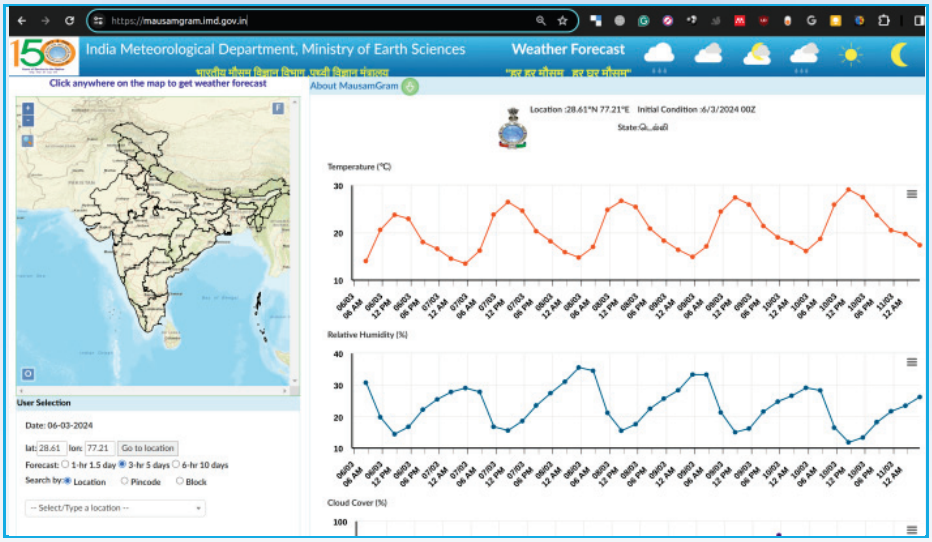


Fig. 17. Screenshot of Mausamgram (Dynamic & Interactive Meteogram) Webpage, where user can click anywhere on the Map (left side) including Ocean, and the corresponding location specific weather information are dynamically fetched from database (multi model mean) and displayed as interactive meteograms (on right side)

Dynamic Meteogram – Forecasters Access

The NWP division developed jointly with ISSD division, and released the Dynamic Meteogram Version 1.0 to the forecaster's access https://meteogram.imd.gov.in/forecaster.html, which contains much more information than public access (mausamgram website). This forecaster meteogram website is an interactive and dynamic meteogram which provides location specific weather forecast information as 1-hourly for next 1.5 days, 3-hourly for next 5 days, 6-hourly for next 10 days. Forecasters can select their desired location over an Interactive India Map or User can search location through the options given in the website. Also it supports search location by block level, districts levels, village levels, and through pincodes as well. This weather information is generated operationally and automatically by the mulimodel mean of 5 Global NWP models (IMDGFS, NCUM, ECMWF, JMA, NCEP) and 2 Regional NWP models (IMDWRF, NCUM-R). Forecasters will be able to select individual model and MME-Mean, also all models together in single view. This forecaster view contains Map information over the RIMES region, not limited to India, thus helps to the outside countries (WMO RIMES region countries).

IMD forecasters are testing this website and it will be communicated to the neighbouring countries meteorological center officially for their operational usage.
https://meteogram.imd.gov.in/forecaster.html
Screenshot of Dynamic Meteogram (Forecasters Access) Webpage is shown in Fig. 18.

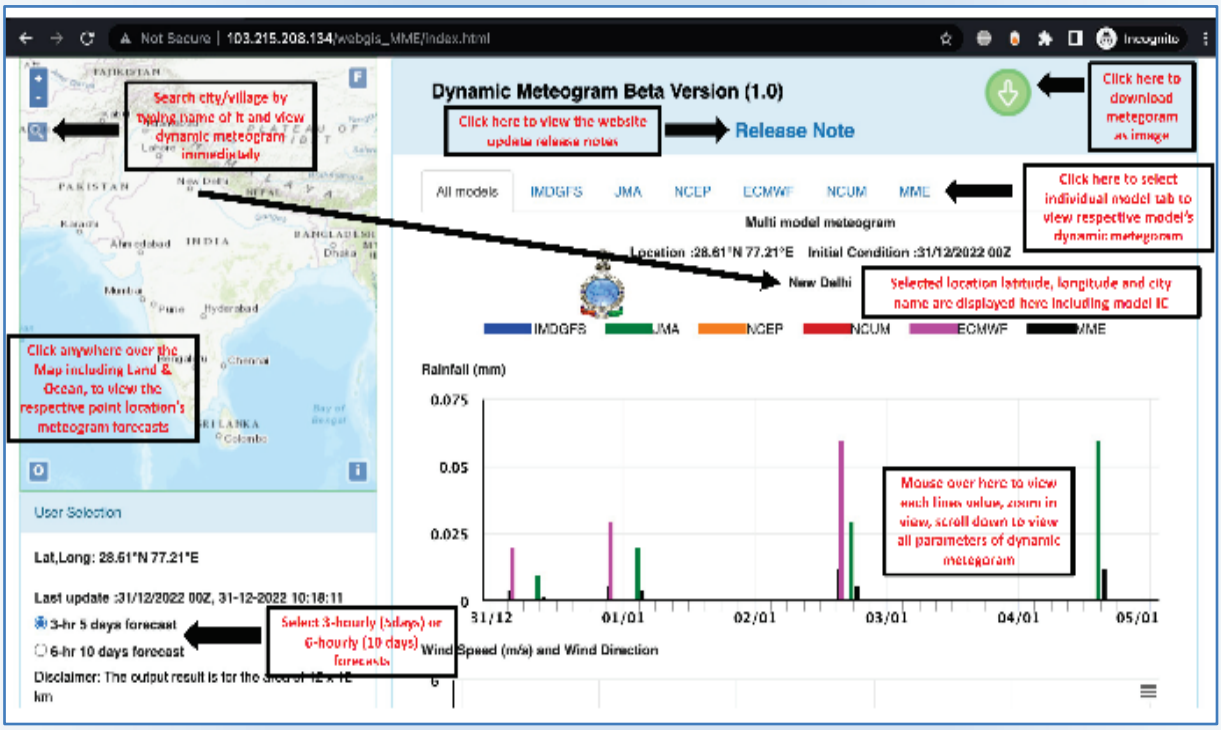


Fig. 18. Screenshot of Dynamic Meteogram Webpage, where user can click anywhere on the Map (left side) including Ocean, and the corresponding Meteograms are dynamically generated and displayed as interactive meteograms (on right side) for 5 global models and MME and all models together

E-WRF Operationalization

EWRF is operational from March 2022 to till date, IMD NWP division has operationally implemented the model EWRF. Presently four different products (Lightning Flash Density, Max Reflectivity and Hourly rainfall and Significant Hail Parameter (SHIP)) from the Electric-WRF model have been updated in the IMD NWP internal website. In the E- WRF modelling system, ground-based lightning flash rate has been assimilated for the improvement of the model forecast. The details of these products available in the NWP website (https://nwp.imd.gov.in/) are depicted below.

Presently due to the limitation of the computational resources, we are running the

EWRF Product Description in the IMD NWP Website

EWRF Model				
Products	Resolution	Forecast hour for Early Run (00 UTC IMD-GFS Based)	Forecast hour for Update Run (00 UTC IMD-GFS Based)	Forecast hour for Last Run (12 UTC IMD-GFS Based)
Lightning Flash Density	3 km	01 UTC (Day 1) to 00 UTC (Day 2)	09 UTC (Day 1) to 00 UTC (Day 2)	13 UTC of Day 1 to 00 UTC (Day 3)
Max Reflectivity	3 km			
Hourly rainfall	3 km			
Significant Hail Parameters (SHIP)	3 km	01 UTC (Day 1) to 00 UTC (Day 2)	------	--------
Accumulated Flash Density Based on 00 UTC GFS data	3 Km	01 UTC (Day 1) to 00 UTC (Day 2)	09 UTC (Day 1) to 00 UTC (Day 2)	
Accumulated Rainfall (mr Based on 00 UTC GFS dat				

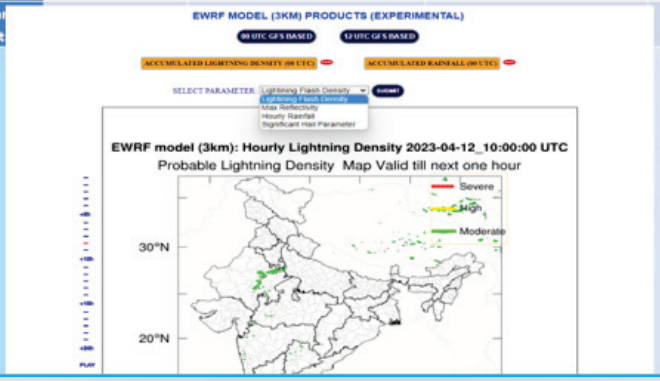


Fig. 19. Table of EWRF Products description along with a screenshot of website product layout

model at three different times in a day to cover the entire 48 hours of the day. Each run utilizes the latest lightning data assimilation that helps to improve the forecast effectively.

Early Run is based on the 0000 UTC IMD-GFS initial conditions with the validity of the forecast being for 24 hours at hourly intervals (0100 UTC to 0000 UTC next day). The Early run products will be available on the website around 0500-0530 UTC (1030 to 1100 IST).

Update Run is also based on the 0000 UTC IMD-GFS initial condition, with the validity of the forecast being for 18 hours at hourly intervals (0700 UTC to 0000 UTC of next day). The Update run's products will be available on the website around 0900 UTC (1430 IST).

Third run is based on the IMD-GFS 1200 UTC initial condition with the validity of the forecast being for 36 hours at hourly intervals (1300 UTC Day 1 to 0000 UTC of Day 3) with usable forecast starting from 1800 UTC of Day 1 to 0000 UTC Day 3. The Third run products will be available on the website around 1800 UTC (1130 to 1200 IST; midnight).

The accumulated three hourly and six hourly Lightning density and rainfall is also added in the website for the convenience of the forecasters.

The individual products pictures have been depicted below in Fig. 20. The Fig. 21 represents the statistical scores of simulated lightning density with respect to observed lightning density for the 1st run of EWRF model based on 0000 UTC initial conditions for the March 2023 averaged over the entire Indian domain. For Mar 2023, average POD is reach upto maximum 0.8 during the initial 3 hours, later on the value gradually reduces to 0.4 within the next 4 hours and maintain the same value till the end of the day. Similar to POD, FAR also shows similar nature, here FAR value reduces upto 0.2 initial 3 hours and later on it gradually increases upto 0.6 during next 7 hours and further showing some reduction in FAR value further at 17 UTC in average it is showing around 0.6 throughout the day, i.e., FAR value is not increasing with time.ETS, Correlation Coefficient all reach upto 0.8 and gradually is reduces to 0.4 at 10th Hour and then again slightly increase at 17 hours and decrease upto 0.4 again and increase thereafter upto 23 hour.

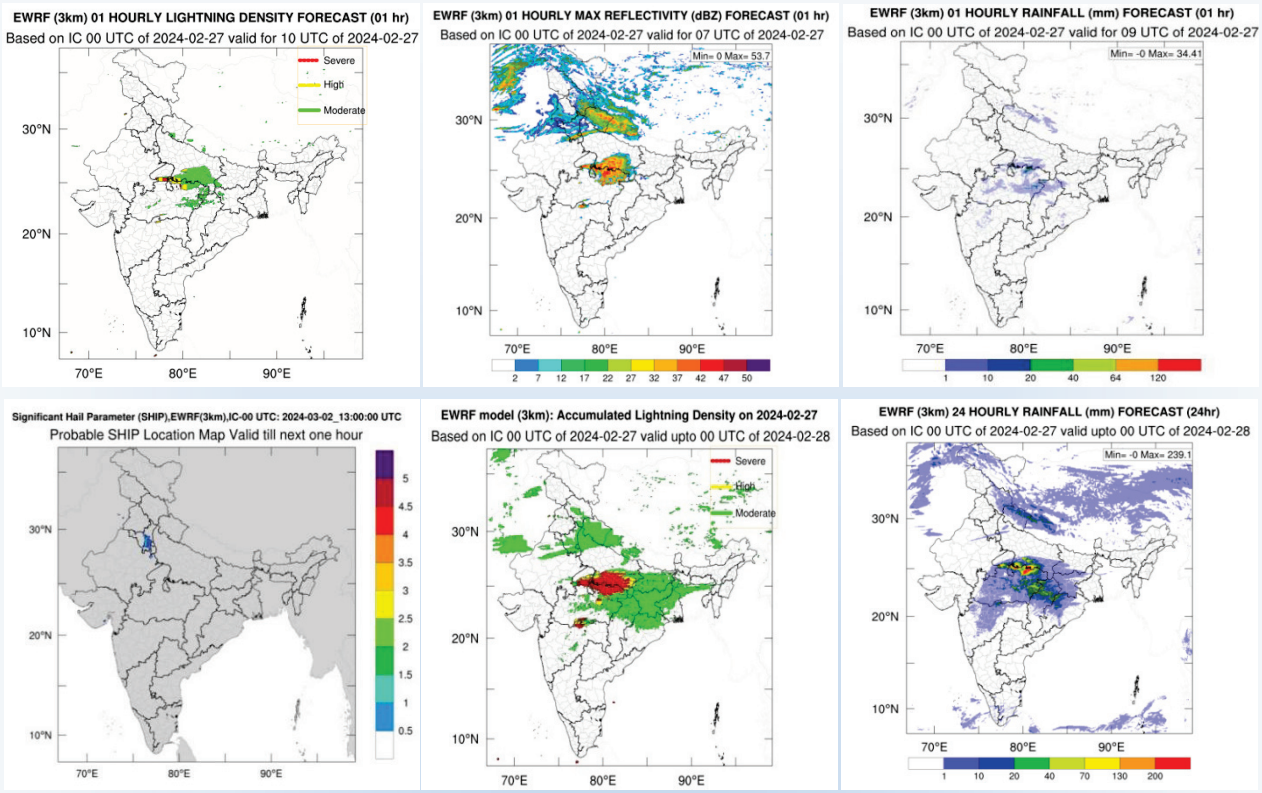


Fig. 20. EWRF products pictures top left is for hourlyLightning density top 2nd left is hourly Max Reflectivity, Top 3rd left is hourly rainfall (mm), bottom left Significant Hail Parameter (SHIP), bottom 2nd left 24 hour Accumulated Lightning density, bottom 3rd 24 hour accumulated rainfall (mm)

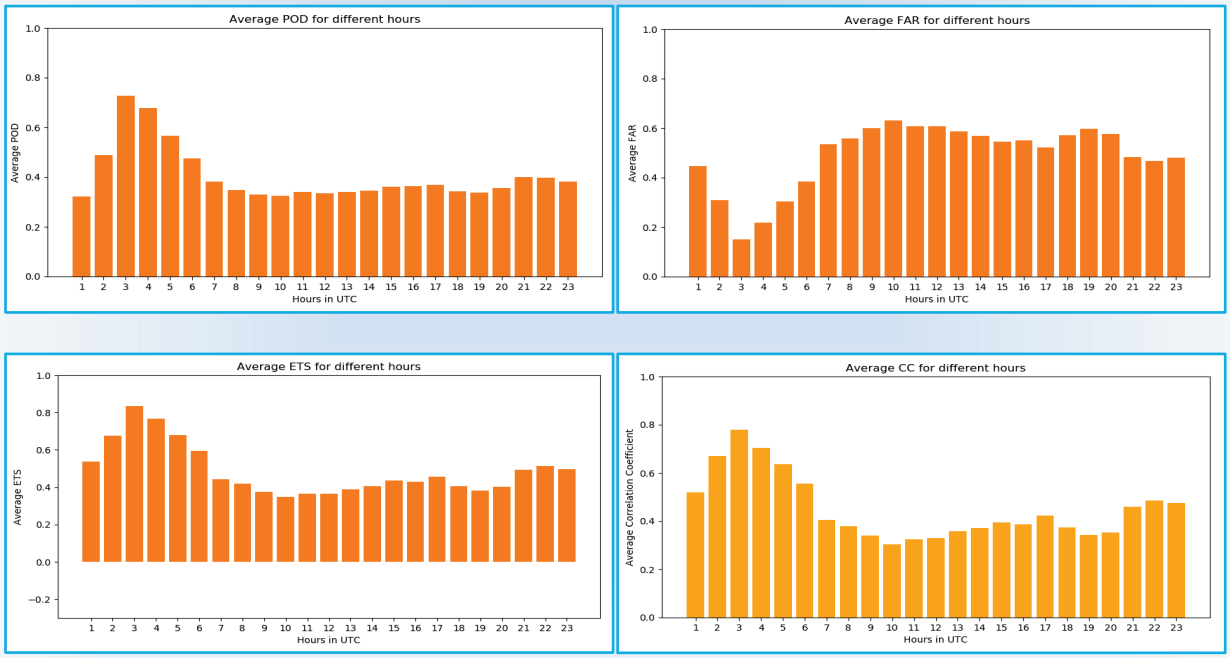


Fig. 21. Statistical scores, like Probability of Detection (POD), False Alarm Ratio (FAR), Equitable Threat Score (ETS), and Correlation Coefficient (CC) of Simulated lightning density and observed lightning density for 1st run of March 2023 averaged over the entire India domain.

All the products available from NWP Division can be accessed in the webpage. https://nwp.imd.gov.in

CHAPTER 4

OBSERVATIONAL NETWORK

One of the mandates of IMD is to take meteorological observations for use by different users. Strengthening of atmospheric observational network and its regular maintenance is absolutely required to sustain and improve skill of weather forecasts. IMD has been augmenting its observing system networks over the past years.

4.1. Upper Air Observational Network

Radiosounding Radiowind (RS/RW) network

India Meteorological Department (IMD) has 56 operational Radiosonde radiowind stations in their upper air network (Fig. 1), as a part of global observing system (GOS) network of WMO. These stations take observations for measuring the vertical profile of the Atmosphere viz Temperature, Pressure, humidity, Wind Speed and Direction, the upper air observations are taken by using balloon borne soundings. These stations are engaged in taking the radiosounding observations twice a day at 0000 UTC and 1200 UTC hours (Figs. 3&4).

As a subset of Global Observing System (GOS) network, World Meteorological Organization (WMO) in collaboration with the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU) established Global Climate Observing system (GCOS) network in 1992, as an outcome of 2nd World Climate Conference. In the upper air domain of GCOS, aiming on further improvement of upper air data quality, IMD established GUAN standard radiosounding observations at its 6 Regional Meteorological Centres (New Delhi, Mumbai, Kolkata, Chennai, Guwahati and Nagpur). The performance of these stations was presented at WMO Technical Conference on Instruments and Methods of Observations (TECO-2016) and a formal claim was made to Secretary General WMO for inclusion of these stations into the GCOS Upper Air Network (GUAN). **Based on the sustained performance, these stations have been included in the WMO- GUAN standard network by GCOS Secretariat, and their performance indicators figures in the summary of NOAA's monthly report with effect from June 2017 on regular basis.**

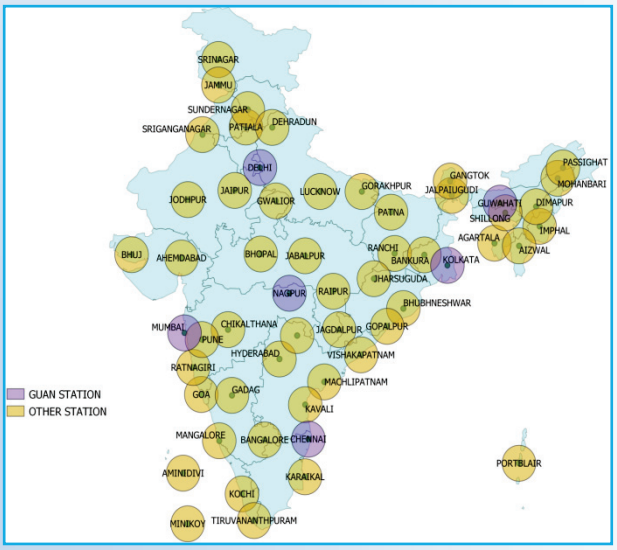


Fig. 1. Existing RS/RW Network of India Meteorological Department

Pilot Balloon (PB) Network

IMD is operating 63 PB observatories (Fig. 2) taking 2 to 4 observations for upper air wind profiles at 0000, 0600, 1200 and 1800 UTC hrs of observations. PB stations were using optical theodolites for balloon tracking manually. Efforts have been made now to switch over to GPS based fully automatic PB systems from conventional optical theodolite-based observations. For this, GPS based pilot-sonde has been developed and being manufactured in-house in IMD Workshop. In the line of this, 25 stations of PB network now havebeen upgraded and equipped with GPS-based fully automatic PB systems. Among these, five stations are equipped with IMD-manufactured systems, namely Jammu, Jaipur, Jodhpur, Sundernagar, and Dehradun, while the remaining 20 are outsourced from Indian manufacturers, namely Aminidivi, Amritsar, Allahabad, Bangalore, Bhuj, Churu, Deesa, Gaya, Gangtok, Gopalpur, Gwalior, Karaikal, Lucknow, Minicoy, Mohanbari,

Port Blair, Raipur, Sriganganagar, and Thiruvananthapuram.

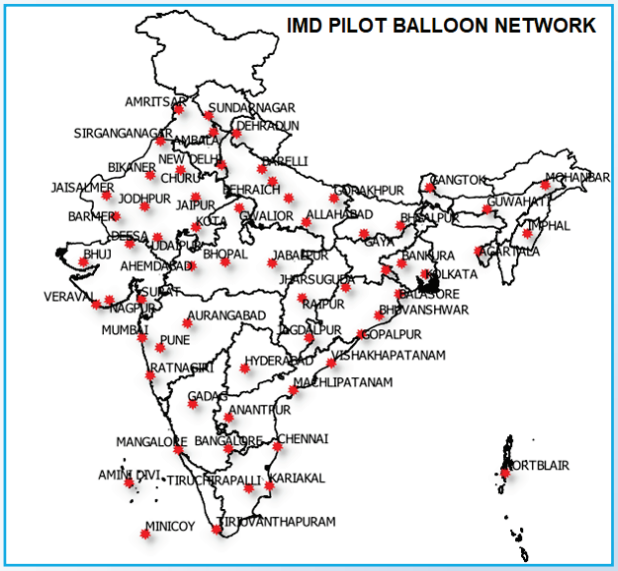


Fig. 2. Upper Air Pilot Balloon (PB) Network of IMD

Achievements during the year

1. Continuation of 06 Nos. of WMO GCOS Upper Air Network (GUAN) standard RS/RW stations at New Delhi, Mumbai, Kolkata, Chennai, Guwahati and Nagpur equipped with GPS based high quality radiosounding systems and extension of guan stations from 6 to 12, by procuring 48,000 Radiosondes.

2. Sustenance of 25 GPS based PB Stations in which 5 stations equipped with IMD manufactured and 20 are outsourced from Indian manufactures.

3. Intensive observation of RS/RW arranged at 20 RS/RW stations (Fig. 3) for participation in Coordinated Monsoon Campaign of IITM.

4. Indigenous GPS PB system (Fig. 4) has been installed and commissioned at 20 PB stations.

5. Successfully procured 56,000 balloons through GeM (150g, 70g and 30g), which are being sent to stations as per requisition.

6. For upgradation of manual PB stations to GPS based stations, procurement of 41,600 Nos. of Pilotsondes along with 52 Nos. Ground Systems from Indian Manufacturers is under process.

7. Provide support to National Technical Research Organisation (NTRO) for their field test at Udaipur.



Fig. 3. RSRW ascents at GOA



Fig. 4. GPS based PB ascent at Gopalpur

4.2. Surface Observational Networks

Automated weather stations measure all the important surface weather observations (Fig. 5). These weather stations provide accurate and frequent readings, have low power requirements, and can operate practically anywhere. The weather monitoring system able to provide localized information on the weather conditions. These are very useful during severe weather conditions and current weather data made available to all in real time even at 1 minute interval also.

AAWS/ARG/AWS can be controlled by electronic devices or computers for automatic weather observation and data collection and transmission. With the utilisation of mobile telemetry, Data acquisition system can be controlled remotely

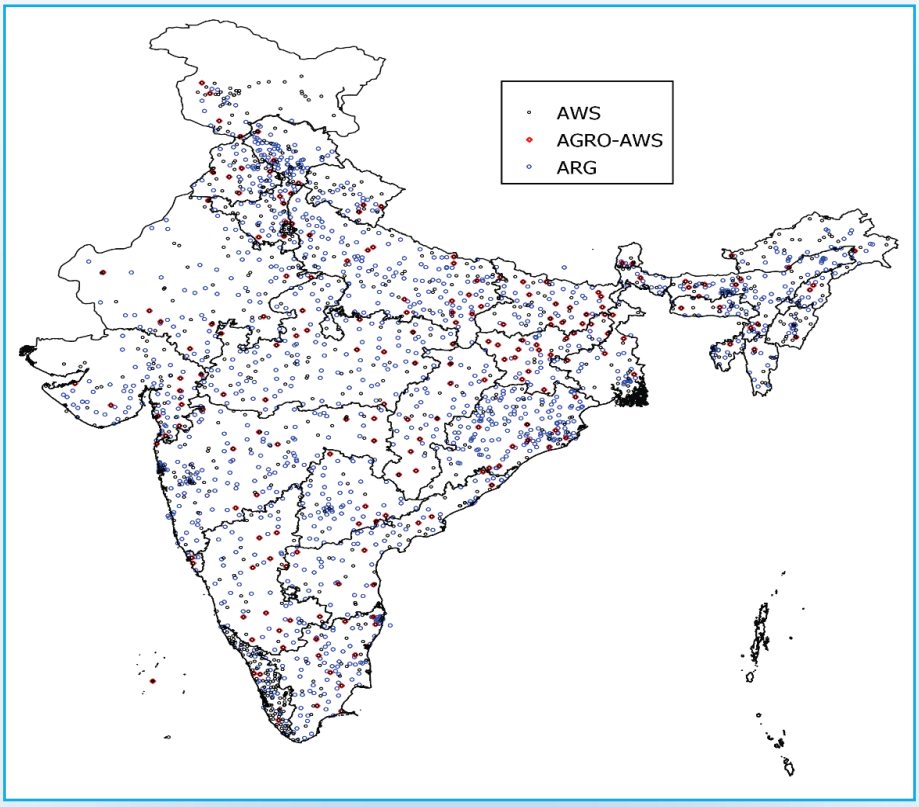


Fig. 5. Surface observation network

through SMS or FTP Server. AWS/ARG can be installed at remote locations and data can be transmitted through satellite communication in real time.

Automatic Weather Station (AWS)

IMD is going for augmentation of surface observation network with AWS (Fig. 6) and established network of 1008 AWS, 200 Agro AWS and 1382 ARG all over India.

Under 400 AWS Project, 168 AWS have been installed (85 AWS are installed in Kerala state, 68 AWS installed in NE states and 15AWS installed in Andhra Pradesh) during 2022- 2023. It consists of 10 meters Tiltable mast and Data acquisition system with four sensors - Temperature and humidly sensors, rainfall sensors Ultrasonic wind sensors at 10 m height, pressure sensors. The data transmission through Mobile telemetry (GPRS communication) at an interval of 15 minutes to IMD server by FTP in real time. The power supply to AWS are 12 V, 65 AH SMF Battery and charged by 40 W Solar Panel.

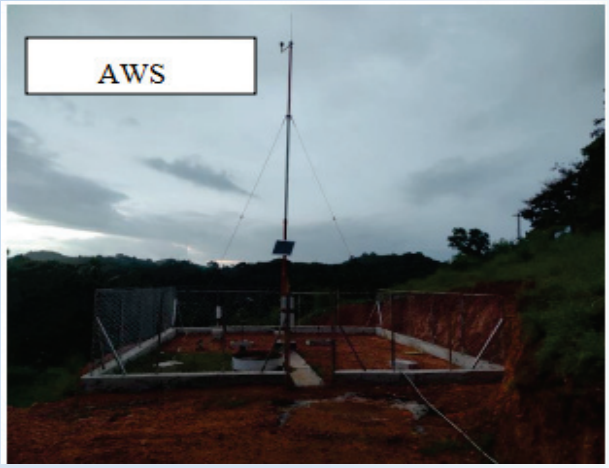


Fig. 6. AWS SITE



Fig. 7. Indigenous Developed Snow Gauge Installed at MC Srinagar & Pahalgam Observatory



Fig. 8. Tmax, Tmin, 24 hrs rainfall data sharing with PMC, PCMC for VMD Pune smart city public display

Aviation Meteorological Instruments

- 117 FSM type RVR installed (Fig. 10) at 66 Airports
- 48 Nos of Drishti System installed at 18 Airports (Fig. 11)
- Total RVR instruments installed at airports is 165nos
- 107 DCWIS installed at 74 Airports
- 112 Frangible (Fig. 9) masts at all Airports
- Met park-level redundancy for critical instruments
- Real-time data sharing with Airport operator

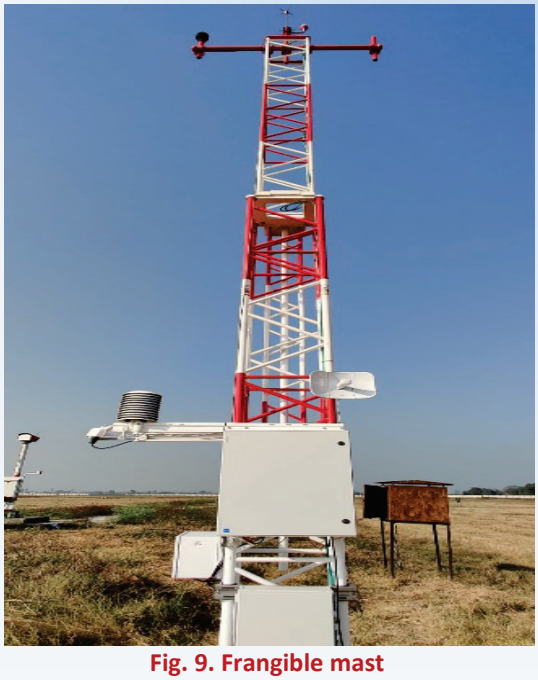


Fig. 9. Frangible mast



Fig. 10. FSM type RVR



Fig. 11. Drishti

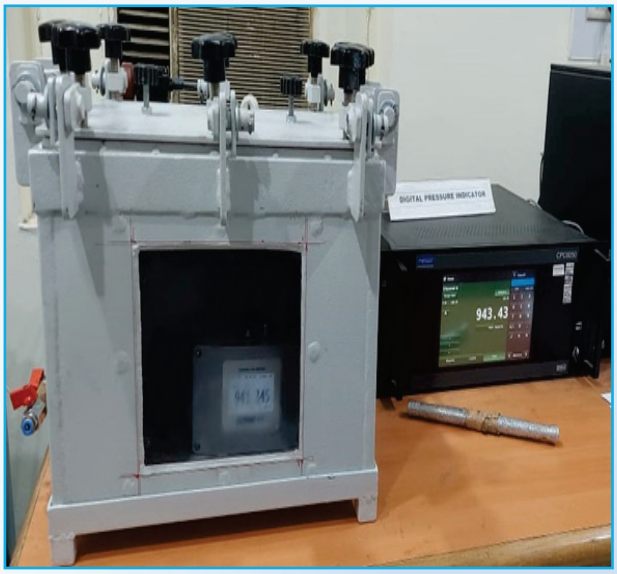


Fig. 12. In-House manufacture pressure chamber



Fig. 13. Wind Sensors Calibration facilities at Pashan, Pune

Solar Radiation network

IMD is an augmentation is solar radiation network with AWS and established network of 47 Solar Radiation stations all over India (Fig. 14).

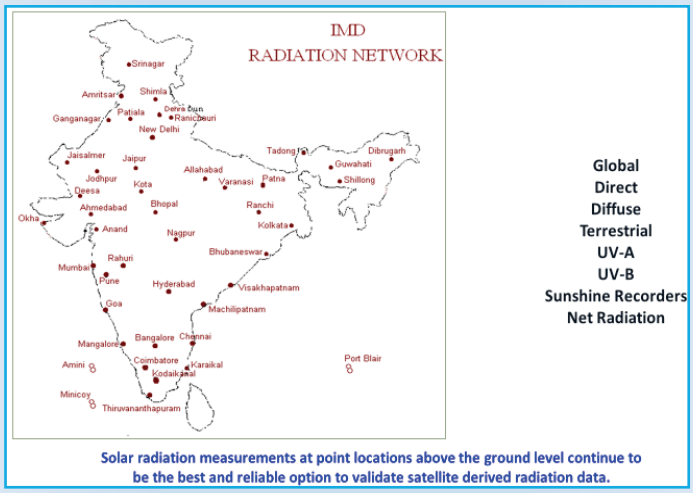


Fig. 14. IMD Radiation Network



Fig. 15. A network of 37 HWSR has been established all over India

4.3. Atmospheric Sciences

Environment Monitoring and Research Center (EMRC)

Environmental Meteorology Services

IMD conducts monitoring and research related to atmospheric constituents that are capable of forcing change in the climate of the Earth and may cause depletion of the global ozone layer and play key roles in air quality from local to global scales. IMD also provides specific services to Ministry of Environment and Forest & Climate Change and other Government Agencies in the assessment of air pollution impacts. IMD contributes in the field of atmospheric environment to the World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) programme. The main objective of GAW is to provide data and other information on the chemical composition & related physical characteristics of the atmosphere and their trends, required to improve understanding of the behaviour of the atmosphere and its interactions with the oceans and the biosphere.

Ozone Monitoring Network

National Ozone Centre of EMRC, IMD is designated as secondary regional ozone centre for Regional Association (RA-II Asia) of World Meteorological Organization. The centre maintains a network of ozone monitoring stations including Maitri and Bharati in Antarctica. The following Ozone components are being monitored at IMD observatories:

- Total Columnar ozone measurement using Dobson and Brewer spectrophotometer. Dobson Spectrophotometer D36 was calibrated and refurbished at Regional Dobson Calibration Center (RDCC) at the Meteorological Observatory Hohenpeissenberg, Germany in 2020. Another Dobson Spectrophotometer D112 was calibrated during WMO International Comparison of Dobson Spectrophotometers (DIC) held at Irene Technical Centre, Pretoria, Gauteng Province, South Africa. Two Brewer Spectrophotometers have been calibrated and refurbished at Canada with the help of WMO.

- Surface Ozone monitoring network using electro-chemical method with IMD make instrument. Two more stations (Shillong and Ranichauri) have been added in the network and now network comprises total 11 surface monitoring stations including Maitri and Bharati stations.

- Measurement of Vertical Distribution of Ozone. Vertical profile of Ozone is monitored using Ozonesonde at New Delhi and Bharati.

Precipitation and Particulate Matter Chemistry Monitoring: IMD is monitoring Precipitation Chemistry through a network of eleven stations since 1970s. The rainwater and particulate matter samples collected from these stations are analyzed in Air Pollution Chemistry Laboratory at IMD, Pune which is equipped with Ion-chromatograph, UV-VIS Spectrophotometer, Semi-micro Balance, pH & Conductivity Meter, Ultra- pure Deionized Water Purification System. A new Atomic Absorption Spectrophotometer has been installed in the laboratory. The IMD laboratory participated in Laboratory Inter comparison Study held in the year 2022 and 2023 organized by Quality Assurance/ Science Activity Centre - Americas, one of five QA/SACs operating to ensure data quality and support science activities in the WMO GAW.

Aerosol Monitoring Network : IMD has established Aerosol Monitoring Network covering different geographic regions of India. The Aerosol Monitoring Network consists of following sub-networks:

(i) Sun-Sky radiometer Network : Environment Monitoring and Research Center, India Meteorological Department has established Aerosol Monitoring Network by installing skyradiometer. The network is used to measure optical properties of aerosols such as Aerosol Optical Depth, Single Scattering Albedo, Size Distribution, Phase Function etc.

(ii) Black Carbon Aerosol Monitoring Network : Black Carbon Monitoring Network of 25 stations for measurement of Spectral Aerosol Absorption Coefficient, Equivalent Black Carbon Concentration and bio-mass burning component is operational.

(iii) Multi-wavelength Integrating Nephelometer Network: IMD has established a network for measurement of aerosol scattering coefficient at New Delhi, Ranichauri, Varanasi, Nagpur, Pune,

Port Blair, Visakhapatnam, Guwahati, Kolkata, Jodhpur, Bhuj, Thiruvananthpuram.

(iv) Chemical Characterization of Aerosols: High Volume Samplers for collecting PM_{10}, $PM_{2.5}$ and Total Suspended Particulate Matter have been installed at Delhi, Ranichauri, Pune and Varanasi. The filter papers are being analyzed for chemical characterization of aerosols at Air Pollution Section, O/o CRS, IMD, Pune.

Air Quality Forecasting and Research

The latest version of Air Quality forecast model "System for Integrated modelling of Atmospheric composition (SILAM v5.8)" has been operationalized for Indian region. Hourly air quality forecast for 96 hours of all criteria pollutants (PM_{10}, $PM_{2.5}$, O_3, CO, NO_2, SO_2 and other species) is being generated for the domain 60-100 °E, 0-40 °N. SILAM is coupled with hourly 3-km IMD-WRF meteorological forecasts model. The latest emission inventories CAMS-GLOB v5.3, 0.1-deg supplemented with EDGAR v4.3.2 for coarse and mineral-fine anthropogenic particulate matter, GEIA v1 lightning climatology and MEGAN-MACC biogenic climatology for isoprene and mono-terpene are used in SILAM model. The model is validated with air quality observations available from CPCB. A very high resolution city scale air quality model "ENvironmental information FUsion SERvice (ENFUSER)" has been also operationalized for Delhi. Hourly air quality forecast for 96 hours of all criteria pollutants (PM_{10}, $PM_{2.5}$, O_3, CO, NO_2, SO_2) is generated for the domain (28.362 °N-28.86 °N, 76.901 °E-77.56 °E) at 30m spatial resolution. The model uses and assimilates a large amount of Geographic Information System (GIS) data to describe the modelling area on a high resolution. This includes a detailed description of the road network, buildings, land-use information, high-resolution satellite images, ground elevation, population data, traffic density etc. SILAM and ENFUSER are developed under a collaborative project with Finnish Meteorological Institute.

Further, to strengthen the forecasting services, the Air Quality Early Warning System (AQ-EWS) was developed under the aegis of Ministry of Earth Sciences in 2018, jointly by the scientists of Indian Institute of Tropical Meteorology (IITM), Pune, India Meteorological Department (IMD), National Centre for Medium-Range Weather Forecasting (NCMRWF). IMD issues AQ Early Warning bulletins based on different models. This year the air quality forecast services were extended to other cities. As of now, the services are being provided to 45 cities.

It is now planned to extend the air quality forecast services to all the 131 non-attainment cities of India by 2025.

The Early Warning System for air quality over Delhi consists of:

Real-time observations of air quality and other relevant meteorological parameters.

Predictions of air pollutant concentration and air quality index for next 4 days and outlook for further 6 days. Prediction of contribution in air quality from biomass burning and dust is also provided.

Air Quality Bulletin, Warning Messages and Alerts for pollution control authorities and general public.

The system also has a feature whereby user can create possible emission reduction scenario to examine the possible projected improvement in air quality in Delhi for the next five days.

Performance Verification of Air Quality Model

Fig. 16 shows the performance diagram summarizing the Success Ratio, POD, bias, and CSI skill scores for (a) Unhealthy category and (b) Very Unhealthy category of study periods. The labelled dashed lines represent bias scores, while labelled solid contours represent the CSI values. Appropriate symbols for different cities and days of forecast are present in the figure legends.

Air Mass Trajectories

Air Mass trajectories using IMD-WRF-HYSPLIT model forecast as well as analysis are available with forward and backward trajectories for 33 cities all over India at 100, 500, 1000 and 2000m for next 24, 48 and 72 hours. Fig. 17 shows the Air Mass trajectories using IMD-WRF-HYSPLIT model.

High Altitude Background Climate Monitoring Station

IMD maintains a Background Climate Monitoring Station Ranichauri, Uttarakhand. Skyradiometer,

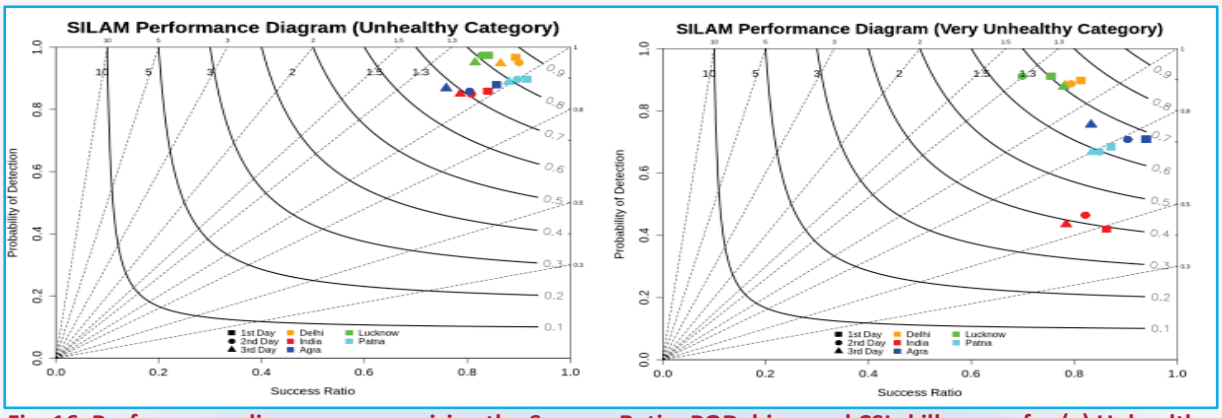


Fig. 16. Performance diagram summarizing the Success Ratio, POD, bias, and CSI skill scores for (a) Unhealthy category and (b) Very Unhealthy category of study periods. The labelled dashed lines represent bias scores, while labelled solid contours represent the CSI values. Appropriate symbols for different cities and days of forecast are present in the figure legends

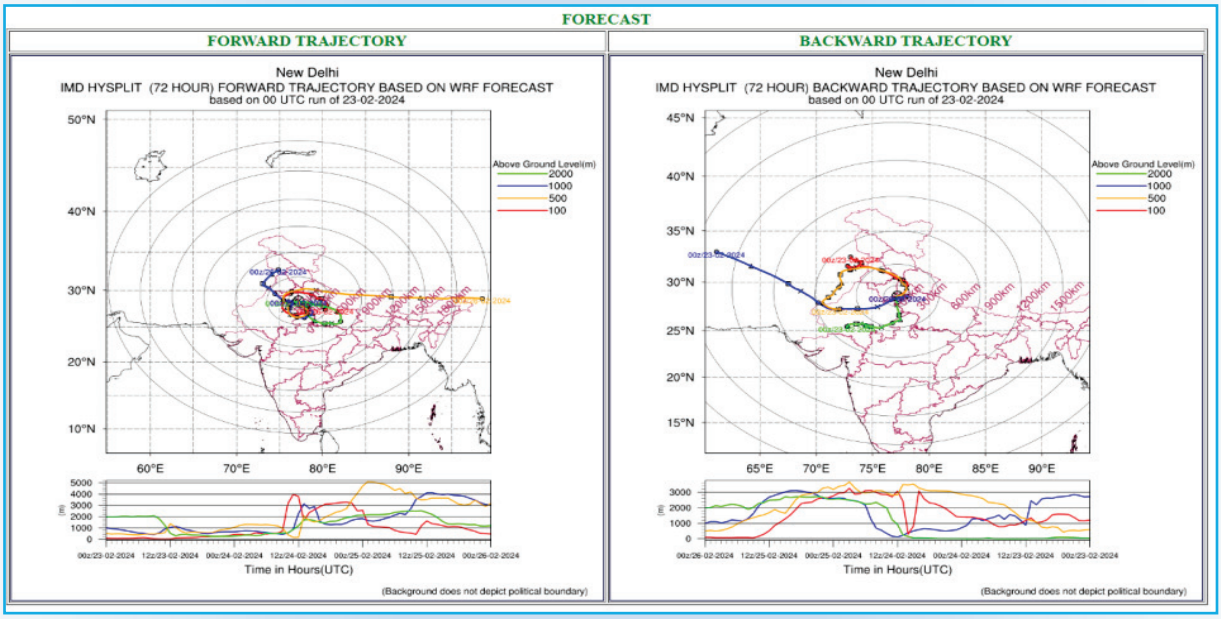


Fig. 17. Air Mass trajectories using IMD-WRF-HYSPLIT model

Aethalometer, Differential Mobility Particle Sizer, Nephelometer, Solar Radiation monitoring equipment, Precipitation Chemistry and Surface Ozone Analyzer have been installed at the station. The site Online GHGs monitoring System for measurement of CO_2, N_2O, CH_4 and CO concentration has been installed at Ranichauri.

POLAR METEOROLOGICAL RESEARCH DIVISION (PMRD)

Polar Meteorological Research

India Meteorological Department has been an integral part of all the Indian Scientific Expedition to Antarctica (ISEA) since the very first expedition during 1981-82. IMD started meteorological and ozone observations at Maitri station from January, 1990 (from 9th ISEA) and are ongoing till date. A meteorological observatory was commissioned in 2015 by IMD at Bharati, another

Indian station in Antarctica. The observations vertical profile of ozone is also carried out at Bharati regularly.

Latest version of Polar WRF model has been operationalized to provide day-to-day 72 hours weather forecast at 3 km resolution for the Maitri and Bharati region in the Antarctica. The NWP products are routinely made available on the IMD web site to support of Antarctic Expedition. Two

IMD officials each at Maitri and Bharati have proceeded as expedition member of 43 ISEA. Figs. 18 and 19 are showing spatial plot and meteogram respectively.

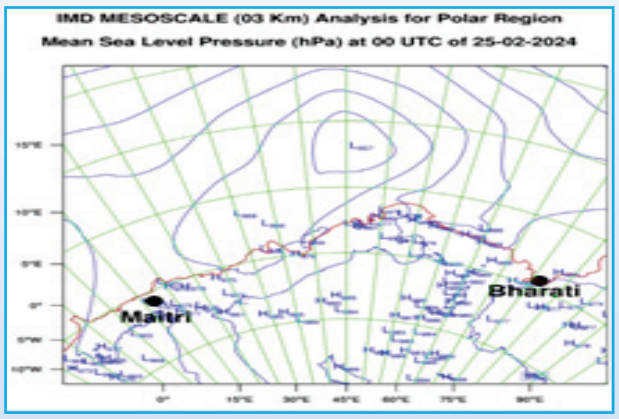


Fig. 18. Spatial plot of mean sea level pressure (hPa) over polar region

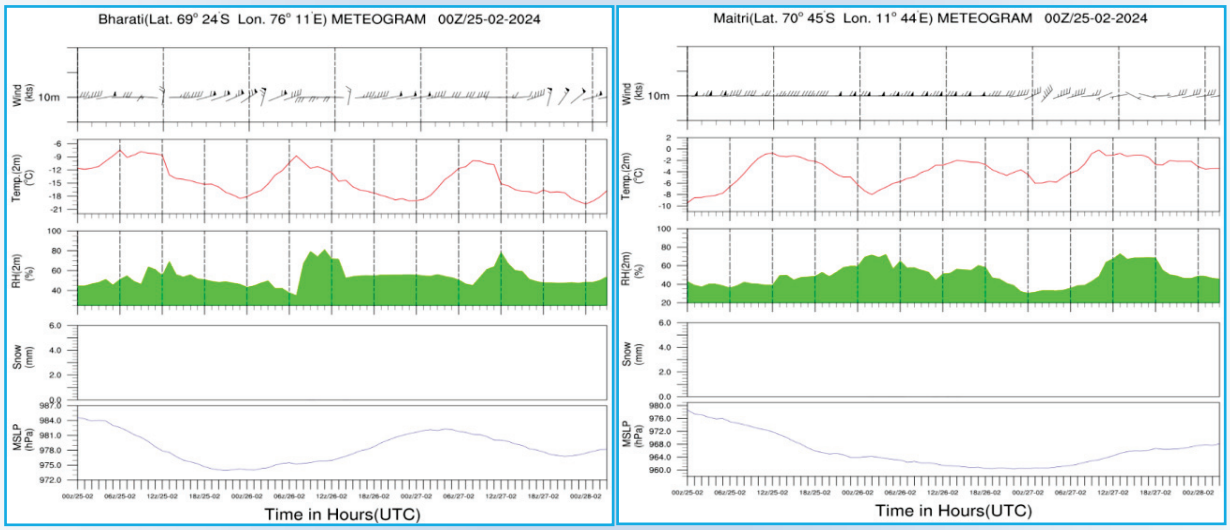


Fig. 19. Meteogram of T2m (oc), RH at 2m (%), Wind (Kts), MSLP (hPa) and Snow (mm) over Bharati and Maitri stations

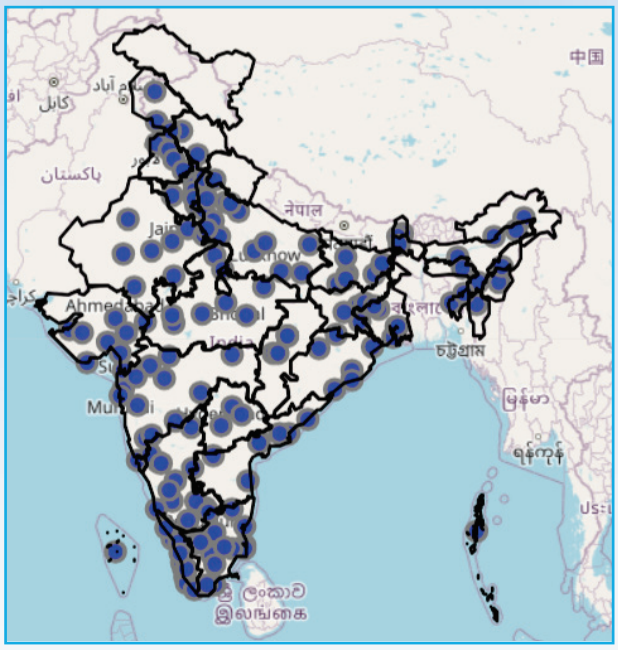


Fig. 20. List of cities covered under IMD UMS

Urban Meteorological Services

According to the WMO, urban areas experiencing rapid change require Urban Integrated Services that include weather, climate, hydrology, and air quality infrastructure such as data, observations, and predictions to support both traditional and emerging urban services. Specialized services have been developed over time for advanced Monitoring, Detection, and Early Warning of severe weather events like tropical cyclones, thunderstorms, cyclones, coastal inundation, flooding, air quality issues, health-related concerns, dust storms, heavy rains, snowfall events, cold and heat waves, and more. These services also extend to climate services for purposes like building codes, zoning, planning, and design.

The India Meteorological Department (IMD) has created Urban Meteorological Services for over 150 urban regions across various city types in India to enhance its Early Warning System (https://internal.imd.gov.in/pages/city_weather_main_mausam.php; Fig. 20). These Urban Integrated Services include the incorporation of detailed urban data observations, urban canopy models, urban vegetation analysis, and land use assessment to evaluate exposure, vulnerability, and soil permeability impact on hazards. Additionally, these systems involve ensemble prediction, uncertainty quantification, and a multi-disciplinary approach to model initialization processes effectively.

IMD has prioritized Urban Meteorological Services due to increasing demand. This initiative aims to offer specific severe weather alerts for the capital by leveraging dense observational networks, detailed forecasts, early warning systems for multiple hazards, and climate services that support Sustainable Development Goals. As urban centers, including smart cities and megacities, continue to grow in India, there is a crucial requirement to enhance infrastructure and deliver comprehensive environmental and weather services. The integrated urban meteorological services ensure continuous monitoring and forecasting of hydro-meteorological risks at different levels, including the prediction of:

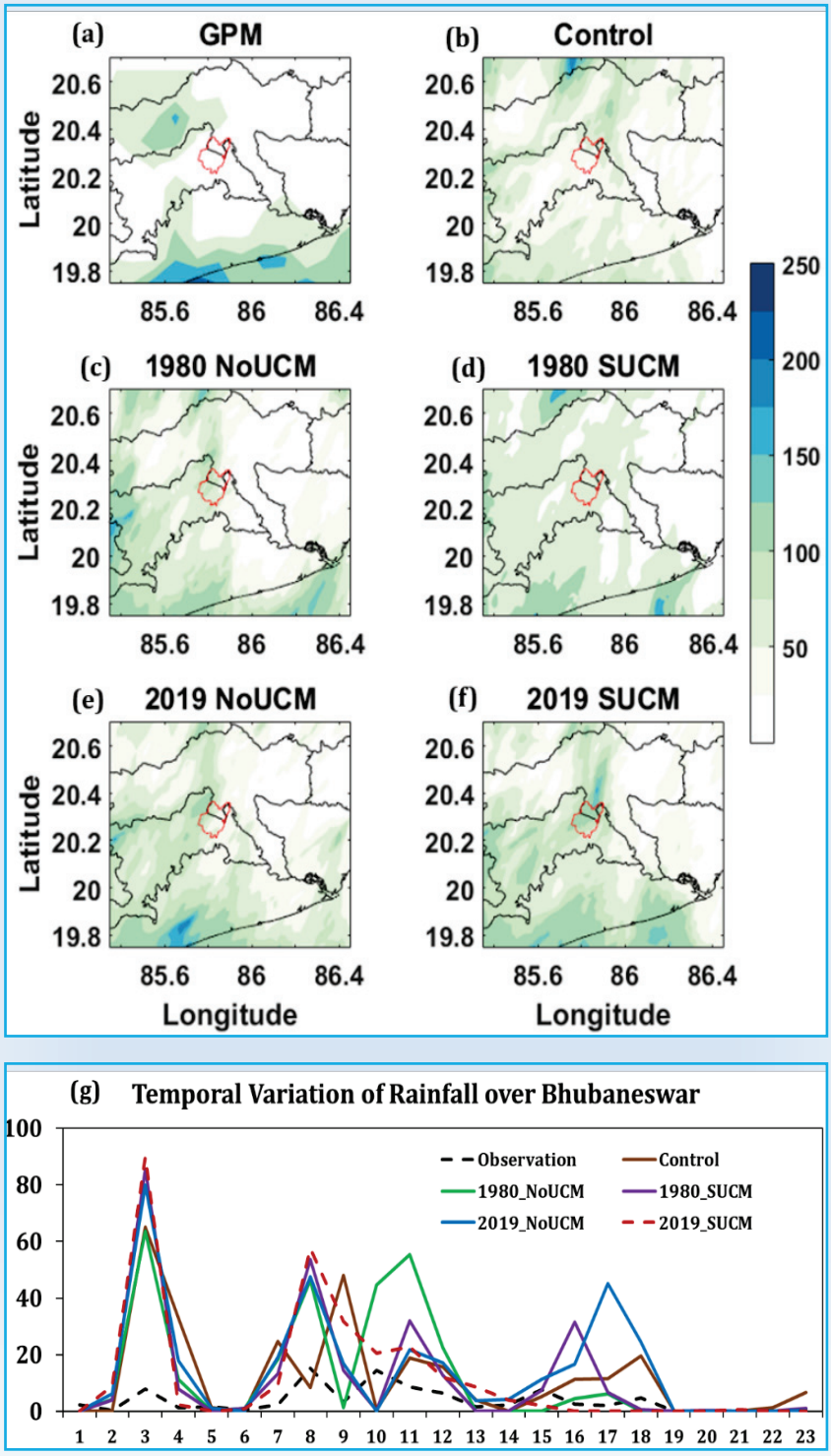
Heat waves and cold wave
Fog
Cyclone
Floods
Drought
Strong winds and Squalls
Hailstorms
Thunderstorms and lightning
Impact-based warnings for localized convective activities

R&D efforts in Urban Meteorological Services

Cities' expansion and the focus of resources in urban areas affect the environment's ability to sustain. This results in unfavorable outcomes like higher air pollution levels, escalating urban heat stress, health issues, transportation challenges, and increased energy consumption. Moreover, there are lasting repercussions on resilience caused by alterations in rainfall patterns and extremes. Therefore, continuous R&D efforts have been made by the Urban Meteorology and Climate Cell (UMCC) to understand the characteristics of weather events over urban agglomeration.

Urbanization involves altering land use and cover, leading to significant differences in land surface features between urban and rural areas. India, the world's second-most populous country, is undergoing rapid urbanization. In recent years, there has been an increase in the frequency of intense rainfall events in India's major cities. These changes in rainfall patterns, influenced by urbanization, have disrupted the water cycle. Consequently, studying the impact of urban development on rainfall has become increasingly crucial. Numerous research studies, including observational and modeling analyses, have extensively explored how urban processes affect rainfall patterns in and around major cities. Therefore, a study has been conducted to examine how urban development impacts the intensity and features of rainfall in a specific region. We analyzed four significant rainfall incidents using the urbanized version of the Weather Research and Forecasting (WRF) model to simulate these scenarios. Numerical experiments were performed by integrating snapshots of the land-surface attributes of the Bhubaneswar urban area during heavy rainfall events. Urban Land Use Land Cover (LULC) sensitivity experiments are conducted to quantify the impact of urbanization on rainfall, and LULC maps have been incorporated in the inner domain only. Land use maps for Bhubaneswar-

Cuttack city have been derived for 1980 and 2019 from United States Geological Survey (USGS) imageries with the help of ArcGIS software. A total of five experiments for each rainfall case have been carried out with different LULC and Urban Canopy Model (UCM) named Control, 1980_NoUCM, 1980_SUCM, 2019_NoUCM, and 2019 SUCM. Here Control is referred to as simulation with default land use. 1980_NoUCM suggests the model simulation with 1980 LULC without incorporating the UCM layer, whereas 1980_SUCM suggests the model simulation with 1980 LULC and single-layer UCM. Similarly, 2019_NoUCM and 2019_SUCM are the same as 1980_NoUCM and 1980_SUCM but with 2019 LULC incorporation.



Figs. 21(a-g). Spatial representation of rainfall for 20072018 case from (a) GPM observation, (b) Control run, (c) 1980 NoUCM, (d) 1980 SUCM, (e) 2019 NoUCM, (f) 2019 SUCM, and (g) 3-hourly temporal trend of rainfall (mm) from observation and model outputs

The incorporation of LULC in the WRF model reveals that the rainfall intensity has increased in the 2019 LULC simulation compared to the 1980 LULC simulation (Fig. 21). The model can capture the rainfall in the control experiment but does not accurately predict the spatial distribution of rainfall. Shifting of rainfall occurred in the 2019 LULC with single-layer UCM simulation, and more amount of rainfall occurred over the boundary of the urban-rural area. This maximum intensified rainfall only occurred for a brief period, i.e., almost one hour, due to the urban heating effect. Further diagnostic studies also supported the same Then, the statistical analysis of model-derived rainfall has been carried out, and for this, the object-oriented CRA method has been used. From CRA analysis, it is found that the 2019_SUCM simulation accurately captures the spatial and volumetric distribution of heavy rainfall (Table 1).

TABLE 1

Quantile representation of error decomposition from CRA method

	MSE Displacement (%)	MSE Volume (%)	MSE Pattern (%)
Control	43.49	0.24	56.27
1980_noUCM (Feature 1)	40.54	3.25	56.21
1980_noUCM (Feature 2)	19.83	16.31	63.86
1980_SUCM	21.07	0.36	78.57
2019_NoUCM	12.77	3.31	83.92
2019_SUCM (Feature 1)	30.26	0.11	69.63
2019_SUCM (Feature 2)	49.22	0.45	50.33

4.4. Radar Observations

Radars Current Status

Weather radar network of India is managed by IMD, and consists of thirty Nine (39) Doppler weather radars (RADARs) presently, spreading across the country (Fig. 22). Radar images are also being received from 05 ISRO and 01 IITM radars.

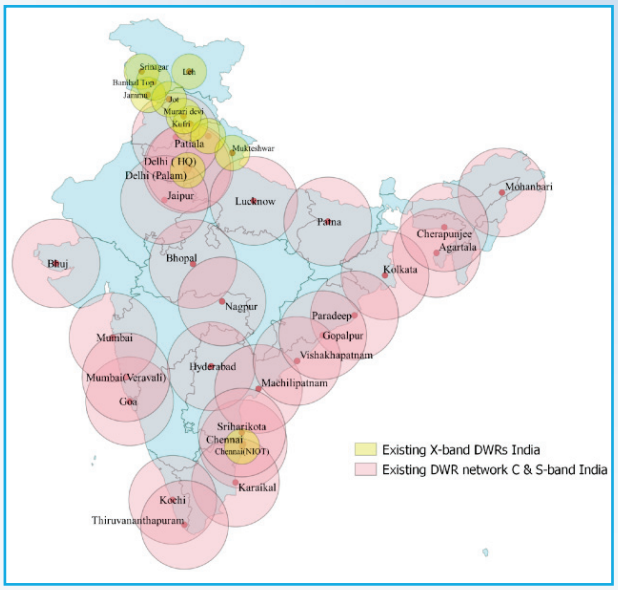


Fig. 22. Network of Radar

Among the Radars of IMD, S-band RADARs are installed at Chennai, Kolkata, Machilipatnam, Visakhapatnam, Paradip, Hyderabad, Nagpur, Patna, Lucknow, Patiala, Karaikal, Bhopal, Agartala, Mohanbari, Delhi (Palam) and Goa.

Two C-band Polarimetric RADARs are installed at Delhi (HQ) and Jaipur. Two Dual polarized S-band RADARs installed at Kochi and Gopalpur are also being utilized for severe weather monitoring.

10 X-Band RADARs have been installed at Ayanagar, Jammu, Kufri, Mukteshwar, Surkanda Devi, Banihal Top, Murari Devi, Jot, Lansdowne and one mobile Radar in Leh.

India has a network of 13 RADARs covering the Indian Coast line. Eight radars (Chennai, Kolkata, Machilipatnam, Visakhapatnam, Paradip, Gopalpur, SHAR, Karaikal) on the East Coast and five radars (Kochi, Goa, Mumbai, Bhuj, and VSSC) on West Coast. Recently, two more indigenously developed DWRs : one X-band DWR at Pallikarnai, Chennai and one C-band at Veravali, Mumbai have been added in IMD radar network.

IMD also utilizes the data inputs from Doppler weather radars of ISRO located at VSSC

Thiruvananthapuram (C-Band), Sohra / Cherrapunji (S-Band) and SHAR (Sriharikota-S Band).

Network of Radar

Radars of IMD are being used for detection of rainfall, hail storm, thunder storms and for tracking of cyclonic storms. Various meteorological and hydrological products derived from RADAR data using algorithms are extremely useful to the forecasters for estimating the storm's center, direction of movement, structure and intensity. The existing RADARs have also been networked to provide near real time data to super computers for ingesting into numerical weather prediction (NWP) models for short range forecasting. Composite images are also being generated centrally. Data is also converted to scientific formats such as NetCDF, HDF5, and Opera BUFR for assimilation in NWP models. A national Radar data centre has been established at IMD, New Delhi for archival and retrieval of radar data. Radar data products are also provided to various users. Open source GIS platforms are used to display the radar data on the web pages. UAI division has now combined radar data with lightning data and satellite imagery for a unified display on the website using GIS platform (Fig. 23). This now provides accurate positional information of the location of the storm cells.

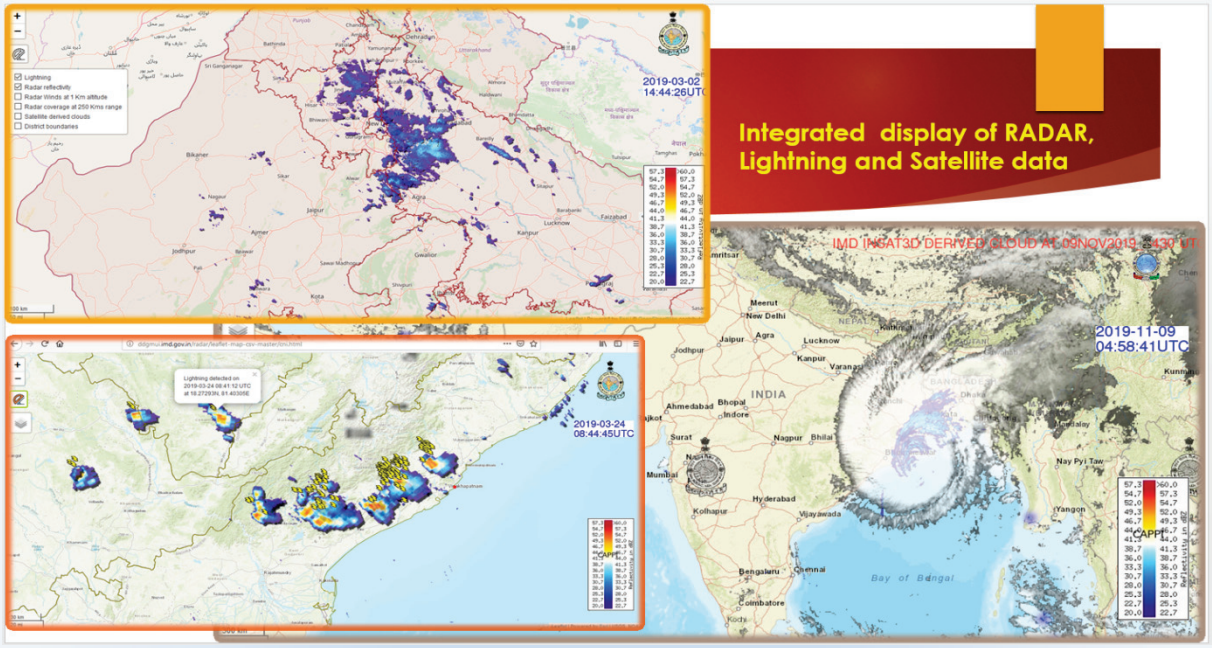


Fig. 23. Integrated display using RADAR, Lightning and Satellite data

Location specific information of lightning is also being generated in the radar data center and is available in the web page. A unique audio alert system announces the location and number of lightning occurrences district wise which alerts the forecaster and other end users to severe weather events.

Future Plan

The Radar division is involved in implementation of modernization of Radar Network by replacing old conventional Radars with state of art RADARs. IMD has a plan to induct more than 70 RADARs in its network in a phased manner to bring the entire Country and coasts under RADAR coverage.

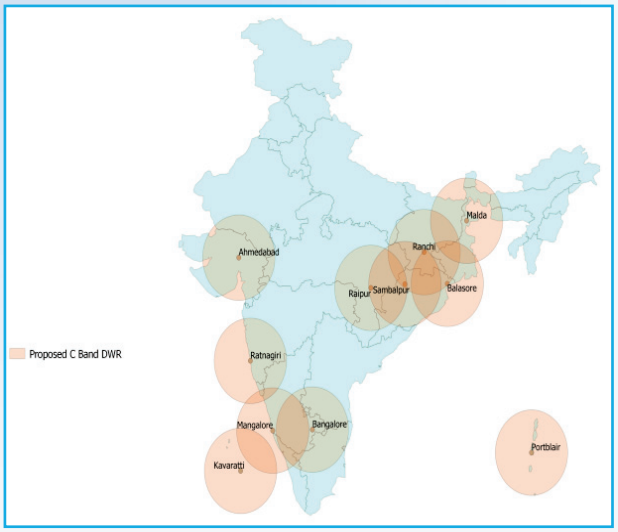


Fig. 24. Proposed C-band Doppler weather radars

It is proposed (Figs. 24, 25 & 26) to install 10 X-Band DWRs and 01 C-Band DWR in North East India, 11 C-Band Radars in the plains of country and 10 more X-band Radars in various cities across India.

X-band DWRs under IHMP Scheme have already been installed at Leh, Banihal Top, Kufri, Mukteshwar, Surkanda Devi, Murari Devi, Jot, Jammu, Ayanagar & Lansdowne.

For improved efficient management, there are also plans, to establish a Weather Radar Operation Center, which would be responsible for weather radar related activities of the department. It will manage radar network, archival, dissemination of data, development of algorithms, network planning and related R&D.

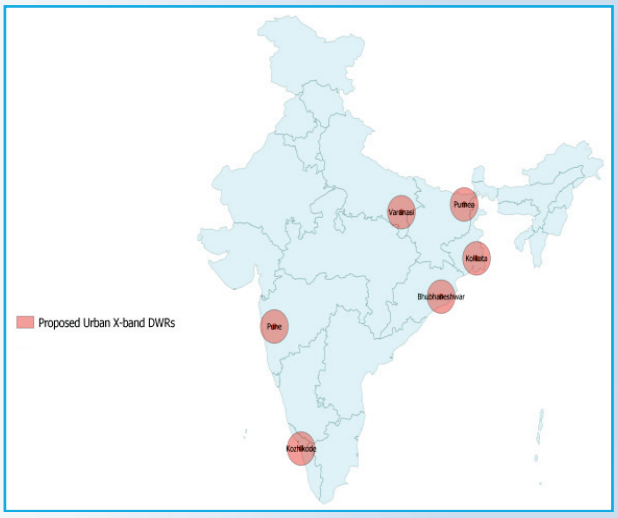


Fig. 25. Proposed X-band DWRs for Urban Meteorology

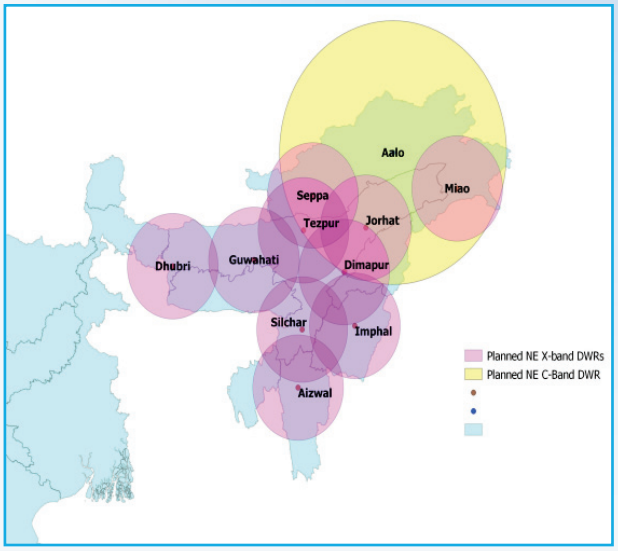


Fig. 26. Proposed Radar network in North East India

The network of proposed radars is presented in Fig. 27 given below.

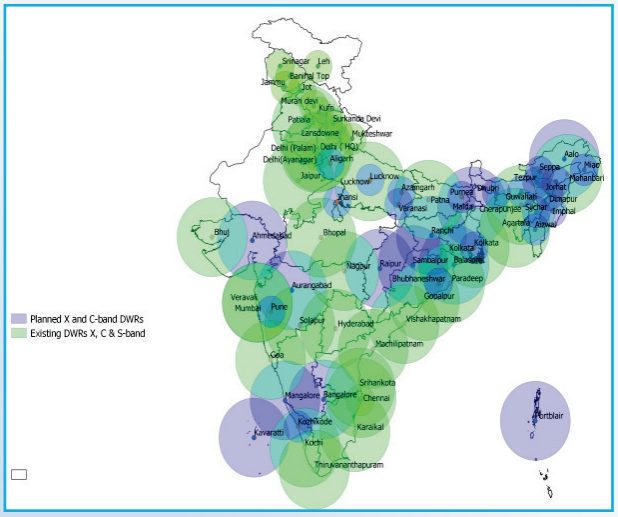


Fig. 27. Network of Proposed Radar

IMD has also planned the procurement of Wind profilers under MoU with ISRO, Bangalore. The information on wind profiles improves the weather prediction in the tropics. Therefore, wind profilers are planned to be installed at nine locations as presented in Fig. 28 given below.



Fig. 28. Proposed Wind profilers

4.5. Satellite Observations

IMD has established Multi-Mission Meteorological Data Receiving and Processing System (MMDRPS) for INSAT-3D, INSAT-3DR and INSAT-3DS satellites through an MoU with M/s Antrix Corporation Ltd., ISRO. Dedicated New Earth stations have been setup under MMDRPS Project, which have the

capability to receive the data from INSAT-3D, INSAT-3DR and upcoming INSAT-3DS satellite. MMDRPS systems consist of advance & latest state of art servers capable to process the complete set of data within 7 minutes after completion of scanning along with the storage capacity of order 2.0/2.0PB (Main/ Mirror) & 324TB SSD which will facilitate online sharing of processed data for all Indian meteorological satellites to the registered users. The Imager payload of INSAT-3D and INSAT-3DR is being used in staggered mode so that effectively 15 minutes temporal resolution is achieved. During extreme weather events, INSAT 3DR imager is used for RAPID scanning. Rapid scan has been conducted during major cyclonic events, i.e., MOCHA, BIPARJOY, TEJ, MICHAUNG. The imageries of rapid scan conducted during cyclonic events are being disseminated through dedicated web page (http://satellite.imd.gov.in/rapid/rapid_scan.htm).

The products derived from the satellite data include: Cloud images in the Visible, Short wave Infra-red, Mid Infra-red, Thermal Infra-red, Water Vapour Channels and special enhanced images, Atmospheric Motion Vectors (IR Wind, Water Vapour Winds, MIR and Visible Winds), Sea Surface temperature, Outgoing Long-wave radiation, Land Surface Temperature (LST), Insolation, Quantitative Precipitation Estimates, Night time Fog, Smoke, Fire, Snow Cover, Aerosol Optical Depth, Upper Tropospheric Humidity, Cloud top Temperature, Cloud top Pressure, Temperature & Humidity profiles, Total ozone, Total/Layer Precipitable Water Vapour, Stability Indices. In addition to these, IMD has also started generation of Wind derived products such as Vorticity (at 850mb, 700mb, 500mb, 200mb levels), Wind Shear, Mid-level Wind Shear, Shear Tendency, Low level Convergence and Upper Level Divergence using Imager Wind product and NCEP forecast file and Tphi gram at all district locations using Sounder data. All these images and products are disseminated in a real time basis through dedicated IMD website. IMD has set up a countrywide network of 25 nos. Global Navigation Satellite System (GNSS) stations for “Earth and Atmospheric studies” have been Installed and commissioned to drive integrated precipitable water vapor (IPWV). The IPWV data is being used for nowcasting and assimilated in NWP models to improve the weather forecasting. A dedicated website has been developed to access IPWV data of 25 GNSS site in real time. Graphical user Interface was also provided to visualize 15 min, hourly, daily, weekly and monthly IPW data along with Meteorological data and minimum and maximum value of IPW etc. IPWV data is being shared with NCMRWF in near real time basis for assimilation in NWP model. The satellite and lighting merged products are also operationalized at IMD website. The merged lightening & satellite cloud top temperature operational product is a joint collaboration of IMD, IITM & IAF (Fig. 29). Work is in progress to merge (all 3 types of instrument data) Satellite+RADAR and Lightning data for the weather forecast.

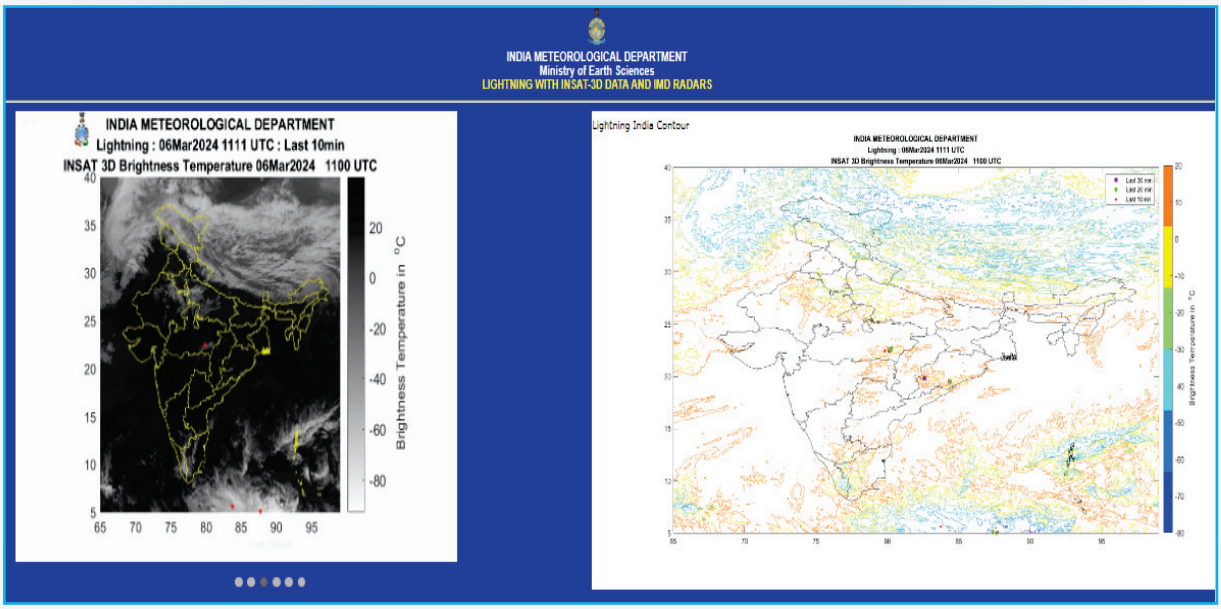


Fig. 29. The satellite and lighting merged products

The processed Satellite data (Digital, image, products) are being used by the operational weather forecasters, IAF, Indian Navy, Indian Coast Guard), Disaster management authorities, international meteorological agencies in a near real time basis for issuing the weather forecasts on a routine basis.The Imager payload of INSAT-3D and INSAT3DR is being used in staggered mode so that effectively 15 minutes temporal resolution is achieved. During extreme weather events, INSAT 3DR imager is used in RAPID scanning during severe weather/cyclonic events. Rapid scan was conducted during major cyclonic events notably during sever cyclonic storm, i.e., Tauktae, YAAS, GULAB, SHAHEEN, JAWAD, ASANI, MOCHA, BIPARJOY, TEJ and MICHAUNG. INSAT3D/3DR GSICS correction (TIR1/TIR2/MIR and WV) along with CAl VAL coefficients are being frequently implemented in MMDRPS.

1. Atmosphere and Climate Research, Observations, Science and Services (ACROSS)

Utilization of OCEANSAT-3 Scatterometer data

ISRO successfully launched EOS-06 in November 2022. Satellite Meteorology division, IMD had started receiving operational Scatterometer data from ISRO from May 2023 (Fig. 30). Satellite division, IMD, has indigenously devised a software module for operational handling of the scatterometer data. Data is fetched between dual swath mode in a day through file transfer protocol (FTP) and plotted by utilizing various Python libraries on a real time basis. The data output is currently generated in jpg format. The software code for this visualization has been indigenously developed at SATMET division for the forecasters and end users.

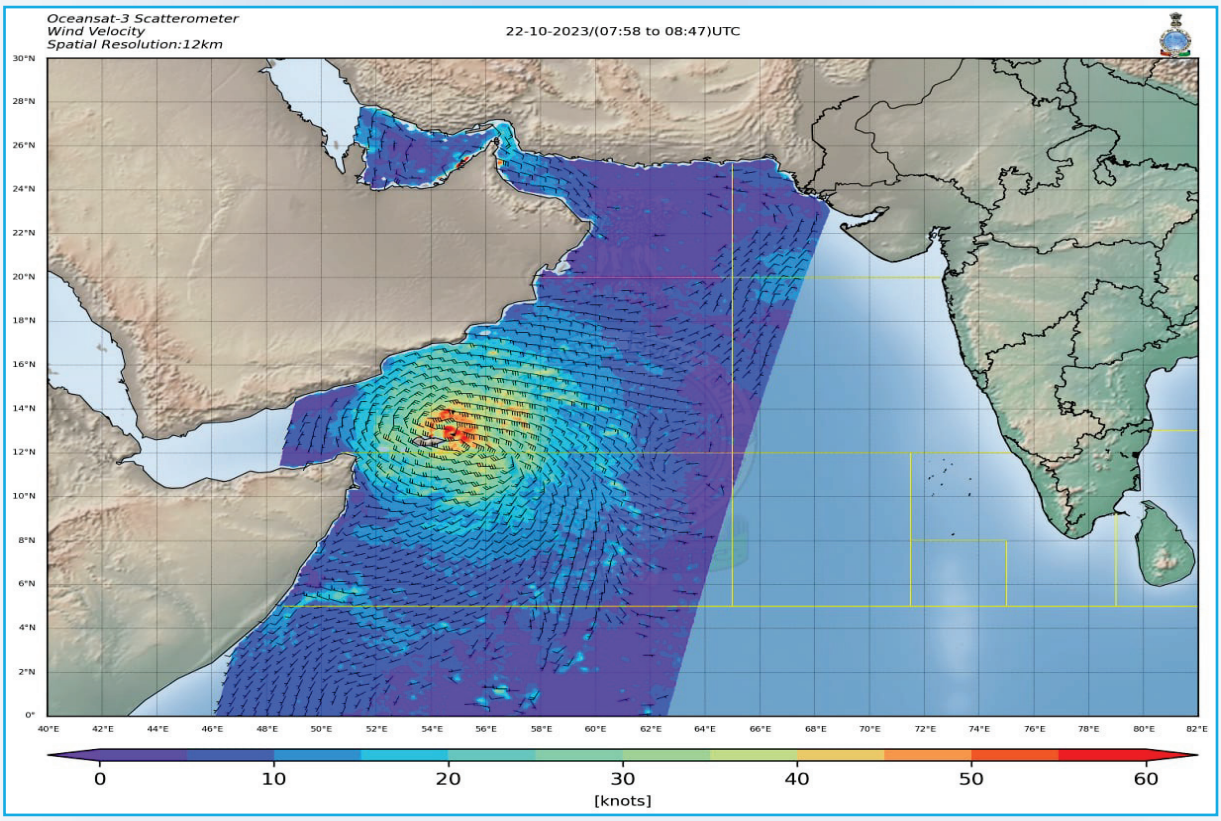


Fig. 30. Oceansat-3 image of Extremely Severe Cyclonic Storm-Tej during 22nd October, 2023

The imageries of rapid scan conducted during cyclonic events are being disseminated through dedicated web page (http://satmet.imd.gov.in/rapid/rapid_scan.htm).

S. No.	Name of cyclone	Duration	Total Number of Rapid Scans
1.	ESCS-Mocha	09-15th May 2023	1493
2.	ESCS- Biparjoy	06-19th June 2023	2880
3.	SCS Tej	20-24th October 2023	1152
4.	VSCS Hamoon	21-25th October 2023	1440
5.	SCS Michaung	01-06th December 2023	782

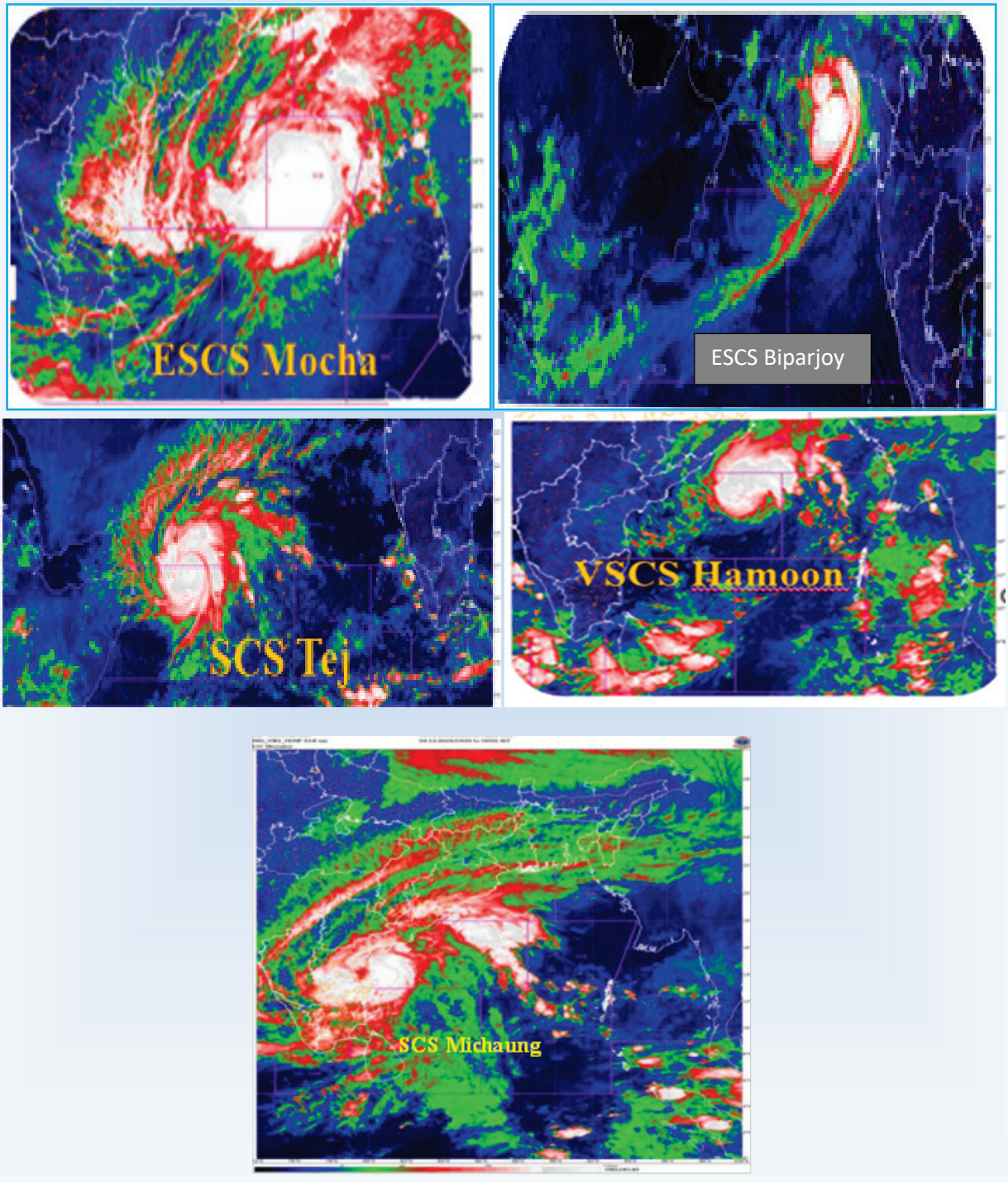


Fig. 31. NHC Curve during different cyclones

INSAT 3D Derived Land Surface Temperature (LST) over Delhi region

Satellite based Land Surface temperature product is currently generated on a pilot mode for Delhi-NCR region (Fig. 32). The region-specific land surface temperature values from INSAT 3D and 3DR are generated for improved understanding of the urban hotspots over the city. This module is also planned for other smart cities in near future. The software code for this visualization has also been exclusively made at SATMET division for the forecasters and end users.

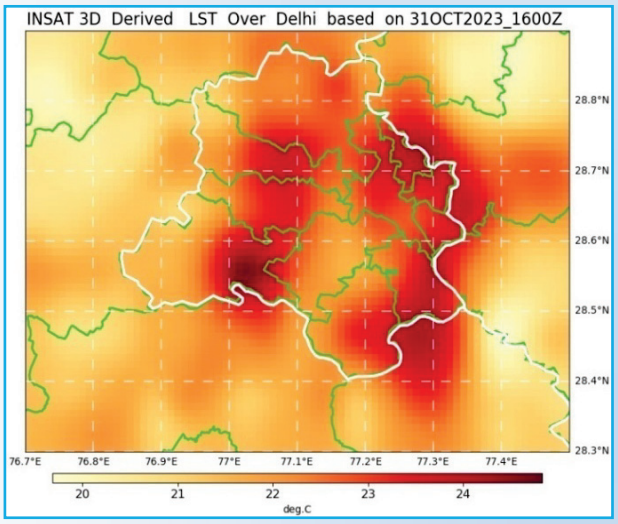


Fig. 32. Land Surface Temperature (LST)

4.6. FDP STORM Report – 2023

STORM Forecast Demonstration Project-2023

The STORM program was conceived as a multidisciplinary nationally coordinated research and development programme and has been carried out as a multi-year observational-cum modelling campaign with an objective to build appropriate operational early warning systems for highly damaging severe thunderstorms over various parts of India. In order to develop methods for improving the accuracy of nowcasting of Severe Thunderstorms, Hailstorms, Squalls & other associated phenomenon, India Meteorological Department conducts field experiments over entire country under STORM Forecast Demonstration Project (FDP STORM) during March to June every year. The programme was run as SAARC STORM project prior to 2017.

At the end of every FDP programme, an Annual STORM Report is compiled and published. It contains region wise detailed analysis of observed significant weather events, case studies, verification of Intensive Observation Periods (IOPs) issued during the FDP, as well as verification of 3 hourly Nowcasts issued round the clock throughout the season.

This year also STORM Fields Experiments covered the whole India. The monitoring period was uniform for entire country from 1 March to 30 June, 2023.

Under this project, FDP Bulletins were issued on daily basis with updated one in the evening, if required. The FDP Bulletin consists of four sections:

(i) Current Synoptic situations and satellite current & past 24 hrs observations over India,

(ii) NWP model Guidance from IMD GFS, IMD WRF and NCUM (NCMRWF) Models,

(iii) Radar & Realized Thunderstorm reports of the past 24 hours and

(iv) Intensive Observation Period (IOP) for thunderstorm and rainfall occurrence during next 24 hrs and 24-48 hrs for the meteorological subdivision and summary of the weather of the day.

A total of 122 FDP Bulletins were issued during the STORM Period-2023.

Nowcast Guidance Bulletins

In addition to FDP Bulletins during March to June - 2023, Nowcast Guidance Bulletins containing current Synoptic features and depicting potential areas for Severe Weather (Heavy Rainfall/ Thunderstorm & Associated Phenomenon/Fog) for next 24hours, in text as well as visual form based on 0830 IST observations were issued once a day (updated in the afternoon if needed) throughout the year. These bulletins provide significant guidance to the forecasters working at different RMCs/MCs, in keeping a watch over their areas of responsibility as mentioned in the Guidance Bulletins & issue Nowcast Bulletins accordingly.

Location Specific three hourly Thunderstorm (TS) Nowcast

Nowcasting of Severe Weather (thunderstorms, squalls and hailstorms, heavy rainfall etc.) has benefited from the recent improvement in monitoring & forecasting due to introduction of (i) digital and image information at 10 mins interval from a network of 39 Doppler Weather Radars, (ii) half hourly satellite observations from RAPID Satellite imagery, (iii) dense automatic weather station (AWS) network (iv) better analysis tools in synergy system at forecaster's workstation, (v) Ground based lightning network (vi) availability of mesoscale models and (vii) computational & communication capabilities.

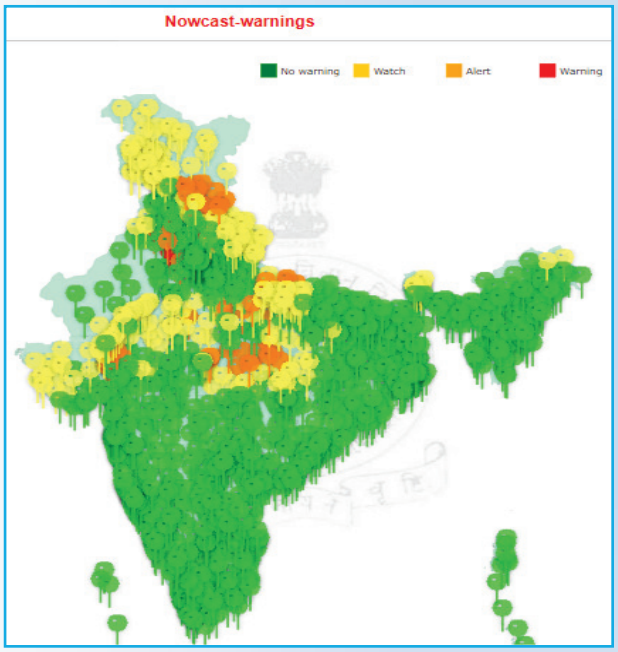


Fig. 33(a). Stationwise Nowcast Warning Page on IMD website Link: https://mausam.imd.gov.in/responsive/stationWiseNowcast.php

Thunderstorm nowcast of major towns is uploaded every 3 hourly interval utilizing Synoptic Data, Model outputs, Satellite products and finally various Radar outputs by the respective RMCs/MCs/ RWFCs under whose jurisdiction these stations are situated. During the year-2023, 34 new stations were added on All India Nowcast Warning page of IMD website for issuing three hourly thunderstorm nowcast, thereby, increasing the total number of nowcast stations to 1200 (till December, 2023) under 25 Nowcast Centers (RMC/RWFC/MC/CWC). Fig. 33(a) depicts the screen shot of Nowcast Warning Page on IMD website and Fig. 33(b) indicates the year-wise cumulative number of stations added on Nowcast Warning page for three hourly thunderstorm Nowcast. In addition to stationwise nowcasting, district level nowcast, which was started in July, 2019 was also issued for all the 735 districts of India [Fig. 33(c)]. Considering the importance and reliability of DWR and satellite based information for nowcast of severe weather, all district headquarters/major towns/ tourist places and specific locations within capital cities (under Urban Meteorology and Climate project) in India are to be included for nowcasting of severe weather.

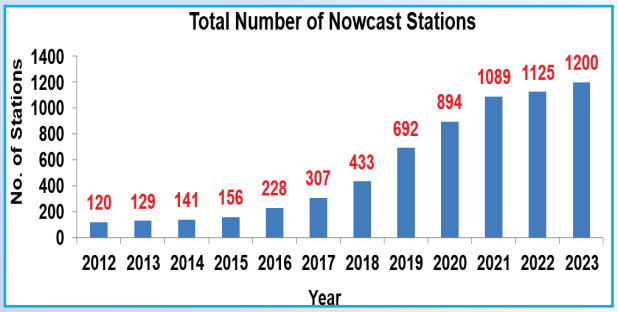


Fig. 33(b). Year-wise cumulative number of stations for three hourly thunderstorm Nowcast

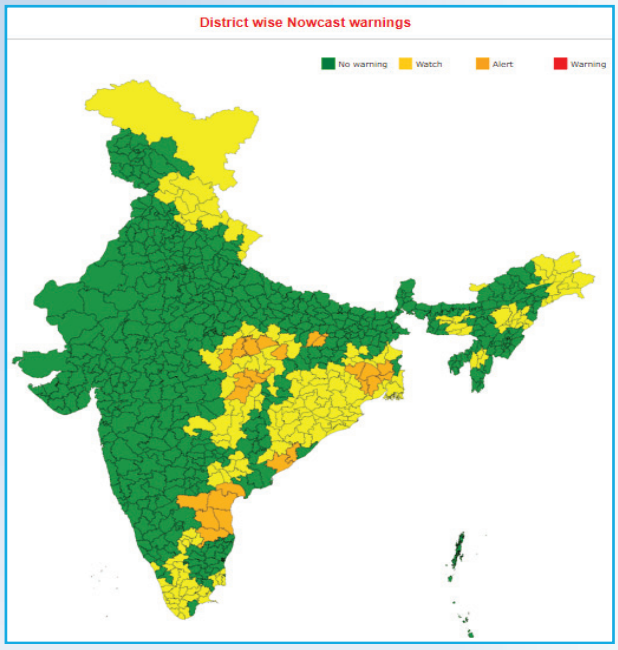


Fig. 33(c). Districtwise Nowcast Warning Web Page on IMD website Link: https://mausam.imd.gov.in/responsive/districtWiseNowcast.php

The Stationwise and district wise nowcast is issued for about nineteen categories [Fig. 33(d)] of

different kinds based on severity of weather for lightning, thunderstorms, dust storms, hail storms, squalls, rain and snow etc. This nowcast warning page is available on new as well as old IMD websites.

A new web based Thunderstorm Decision Support System (TDSS) portal has been developed by IMD in 2023 - **'Interactive System for Nowcast Services'** (Fig. 33e). All (i) observational data products including lightning data from IITM & ILDN networks, satellite & radar tools, (ii) mesoscale/ nowcast model products developed by IMD including newly developed nowcast models EWRF & HRRR, NCMRWF and (iii) climatological thermodynamic indices are integrated on this portal for monitoring of thunderstorms and associated phenomena. This integrated system guides a forecaster/nowcaster in generating impact based colour coded nowcast warnings in an effective way as well as their dissemination to various users and updating on IMD's Nowcast web Page.

i No weather
ii. Light rain: < 5 mm/hr
iii. Light snow < 5cm/hr
iv. Light Thunderstorms with maximum surface wind speed upto 40 kmph
v. Slight dust storm: If the wind speed is up to 40 kmph and visibility is less than 1,000 metres but more than 500 meters due to dust
vi Low cloud to ground Lightning probability (< 30% probability of lightning occurrence)
vii. Moderate rain: 5-15 mm/hr
viii. Moderate snow: 5-15 cm/hr
ix. Moderate Thunderstorms with maximum surface wind speed between 41 – 61 kmph (In gusts).
x. Moderate dust storm: If the wind speed is between 41- 61 kmph and visibility is between 200 and 500 metres due to dust
xi. Moderate cloud to ground Lightning probability (30 - 60% probability of lightning occurrence)
xii. Heavy rain: >15 mm/hr
xiii Heavy snow: >15 cm/hr
xiv. Severe Thunderstorms with maximum surface wind speed between 62 -87 kmph (In gusts).
xv. Very Severe Thunderstorms with maximum surface wind speed > 87 kmph (In gusts).
xvi. Thunderstorms with Hail
xvii. Severe dust storm: If surface wind speed (in gusts) exceeding 61 kmph and visibility is less than 200 metres due to dust
xviii. High cloud to ground Lightning probability (> 60% probability of lightning occurrence)
xix. Other warnings (to be filled by the user MC)

Fig. 33(d). Different categories of Nowcast Warnings

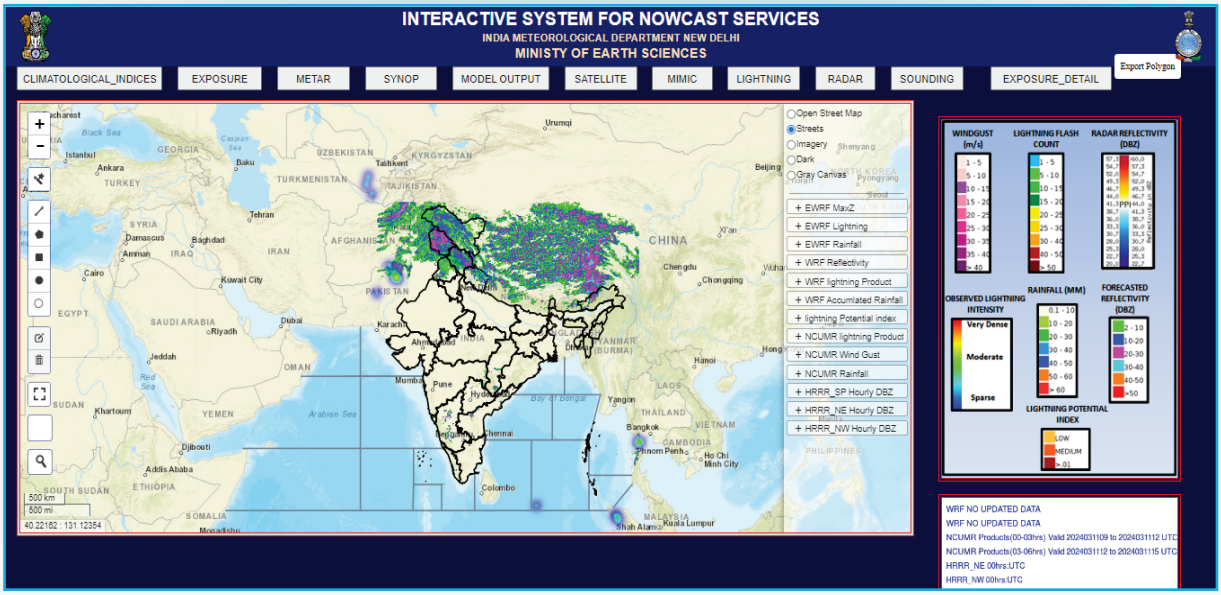


Fig. 33(e). New Portal-Interactive System for Nowcast Services
Link:http://103.215.208.18/dwr_img/GIS/nowcast.html

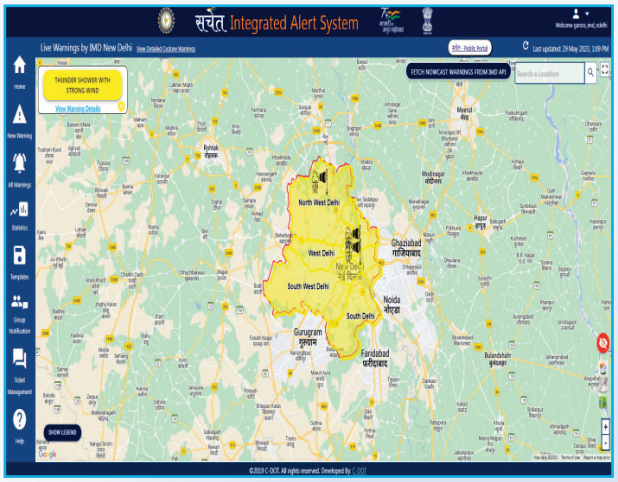


Fig. 33(f). Common Alert Protocol based warning issued through SACHET portal

There has simultaneously been a conscious thrust from all Meteorological centres to provide impact based dissemination of warnings of thunderstorms over the Indian region in line with the forecast Circular No. 1/2019 using Common Alert Protocol through SACHET portal [Fig. 33(f)]. Simultaneously, Automated generation of Nowcast Bulletin through the TDSS portal has allowed the penetration of IMD forecasts up to Tehsil level and more [Fig. 33(g)].

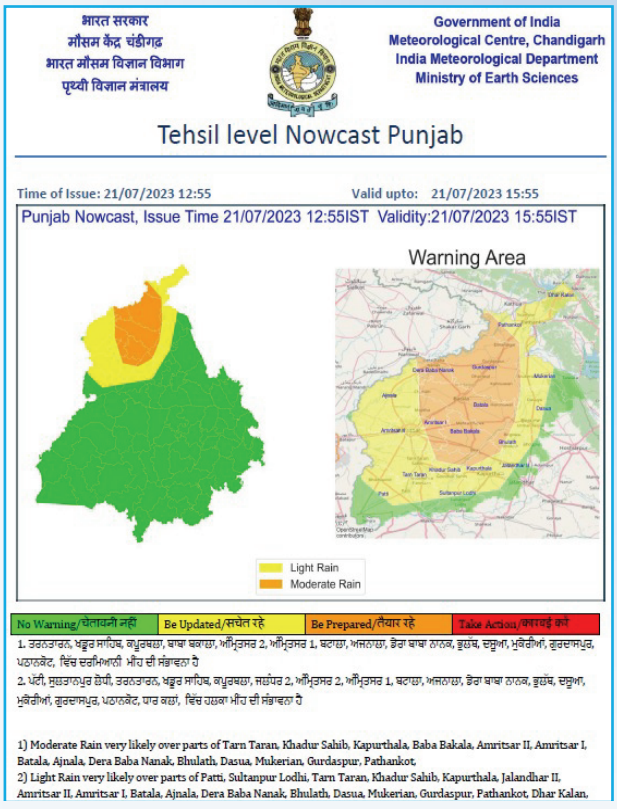


Fig. 33(g). Automatic Nowcast Bulletin generated and issued through TDSS portal

Verification of IOPs/TS Nowcast-2023

(i) FDP Bulletins

The thunderstorm forecasts issued for 24 hours during FDP STORM-2023 were verified with realised thunderstorm data. The monthwise evolution of forecast skill during 2023 as indicated by the verification results for thunderstorm forecast are shown in Table 2 and graphically by Fig. 33(h). Fig. 33(i) indicates the evolution of 24 hr Thunderstorm forecast IOP skill during FDP season of 2016 to 2023 which shows a significant improvement in all the scores.

TABLE 2

Skill sores for Thunderstorm verification for FDP STORM - 2023 (March to June)

Month	Ratio Score	POD	FAR	CSI	ETS	BIAS
March	0.81	0.88	0.32	0.62	0.44	0.81
April	0.80	0.86	0.28	0.64	0.43	0.80
May	0.76	0.89	0.30	0.65	0.34	0.76
June	0.63	0.80	0.35	0.56	0.12	0.63
FDP-2023	0.75	0.86	0.32	0.61	0.34	0.75

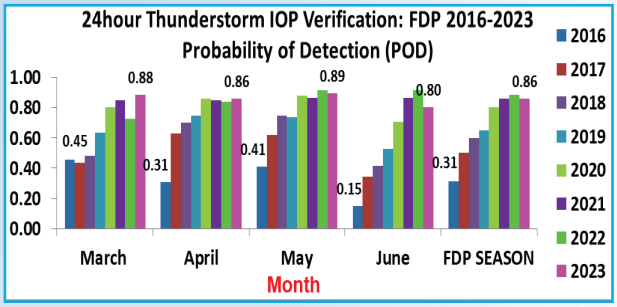


Fig. 33(h). Month wise evolution of the all India POD scores from March to June during the period of 2016 to 2023

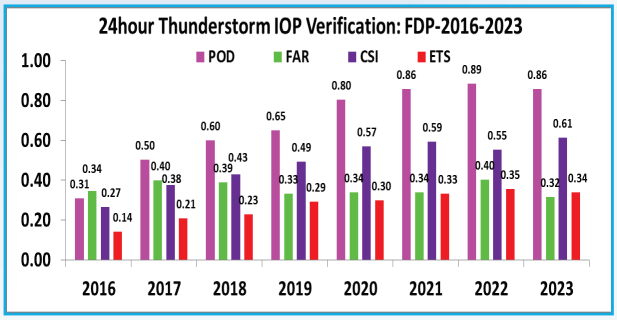


Fig. 33(i). 24 hour thunderstorm forecast verification result for the entire FDP season of 2016 to 2023

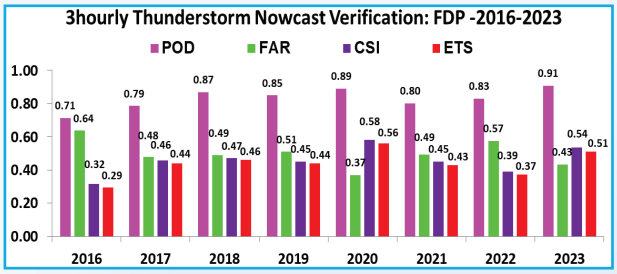


Fig. 33(j). Three hourly thunderstorm nowcast verification result for the entire FDP season of 2016-23

Fig. 33(j) indicate that this year the thunderstorms were detected more accurately in all the months of the season as compared to similar result for all previous STORM seasons.

(ii) Three Hourly TS Nowcast

Figs. 33(k-o) indicate respectively the Ratio Score, FAR, POD, CSI and ETS scores of three hourly TS Nowcasts issued by various RMCs/MCs during FDP STORM (March to June) for the year-2023 and Fig. 33(p) indicates All India Nowcast Verification Scores for the same.

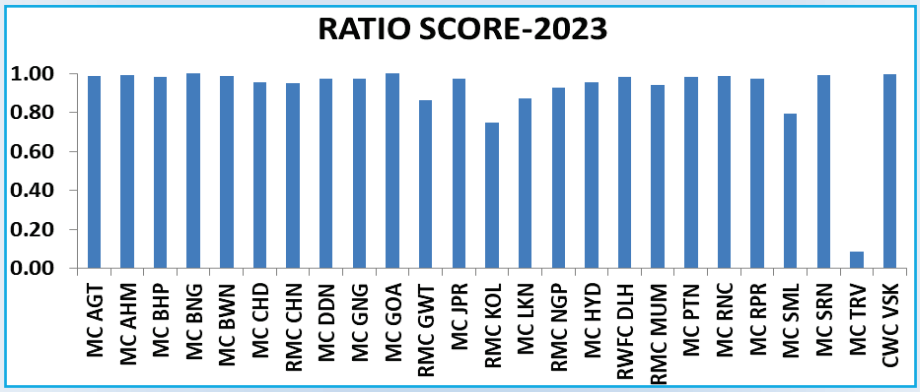


Fig. 33(k). MC-wise Ratio Score of Three Hourly TS Nowcast Verification during FDP STORM-2023

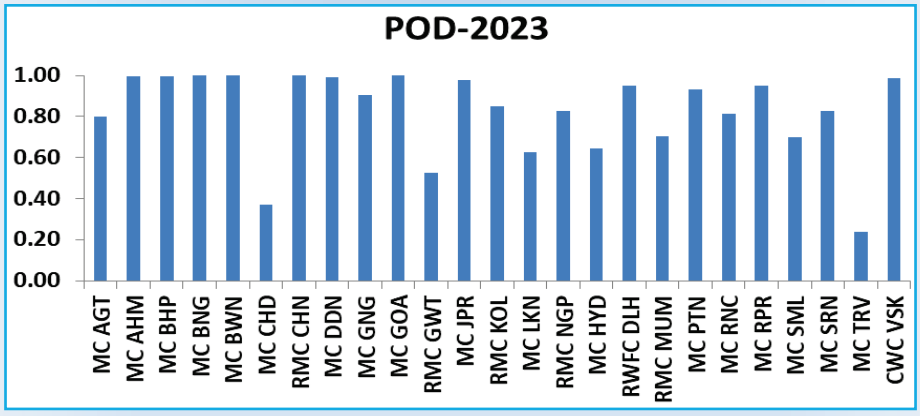


Fig. 33(l). MC-wise Probability of Detection (POD) of Three Hourly TS Nowcast Verification during FDP Periood-2023

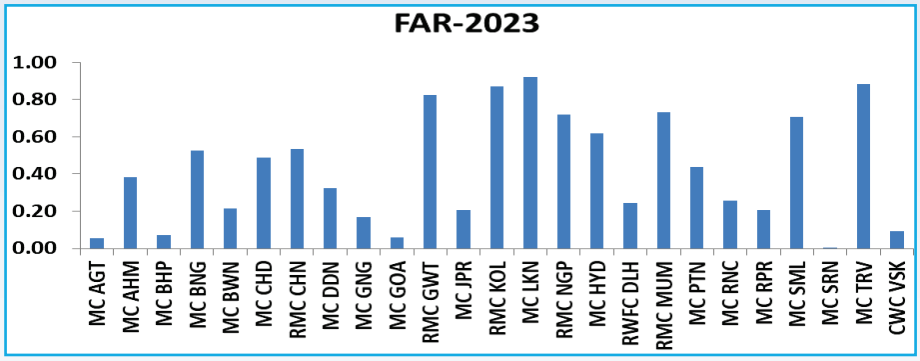


Fig. 33(m). MC-wise False Alarm Ratio (FAR) of Three Hourly TS Nowcast Verification during FDP Period-2023

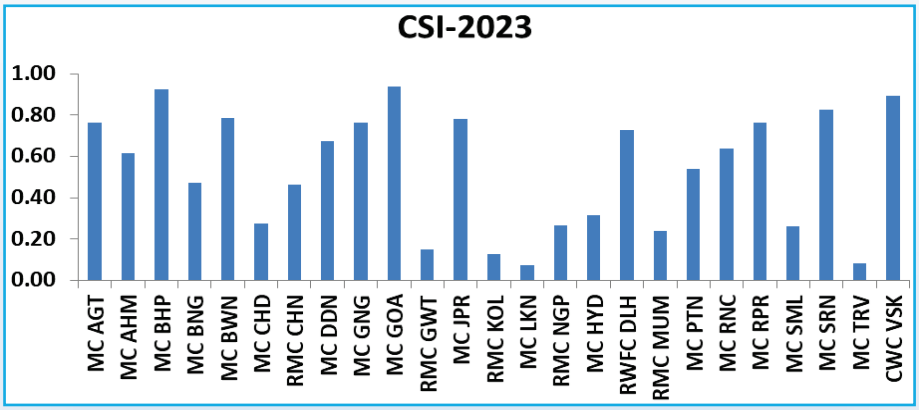


Fig. 33(n). MC-wise Critical Success Index (CSI) of three Hourly TS Nowcast Verification during FDP Period-2023

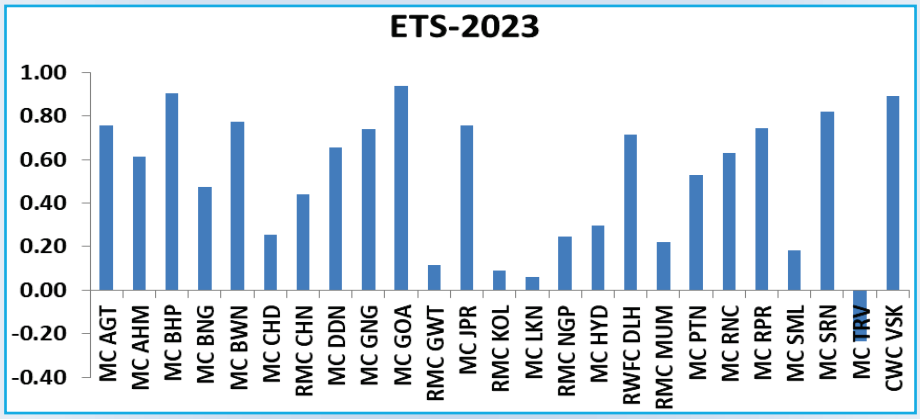


Fig. 33(o). MC-wise of Equitable Threat Score (ETS) of three Hourly TS Nowcast Verification during FDP Period-2023

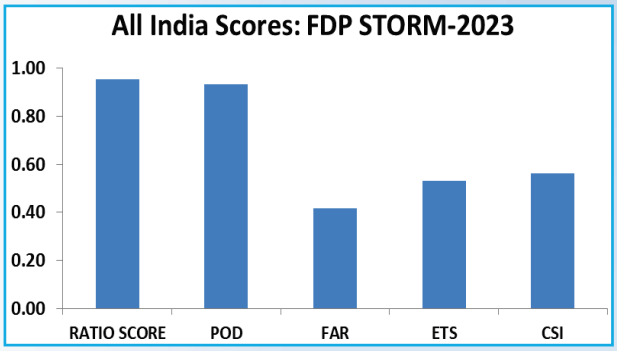


Fig. 33(p). All India 3 hourly TS Nowcast Verification Scores during FDP Period-2023

FDP STORM Report - 2023

A detailed STORM Report document, based on thunderstorm activities observed over India during March to June-2023, was prepared by Nowcast Division, NWFC. It contains information on daily weather situation, important weather charts, severe weather events all through the campaign period, case studies and the bulletins issued during the period. The report has been published during IMD foundation Day on 15th January, 2024. Figs. 33(q-w) represent some of the salient features of the FDP STORM Report-2023.

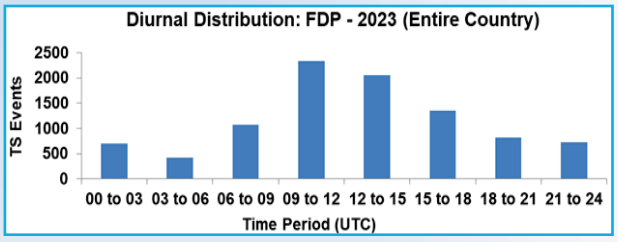


Fig. 33(q). Diurnal distribution of TS events over the country during FDP STORM -2023

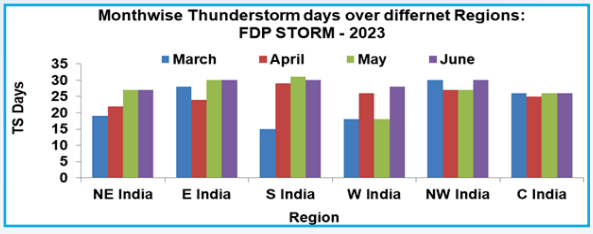


Fig. 33(r). Monthwise distribution of TS Days over different regions of India during FDP STORM-2023

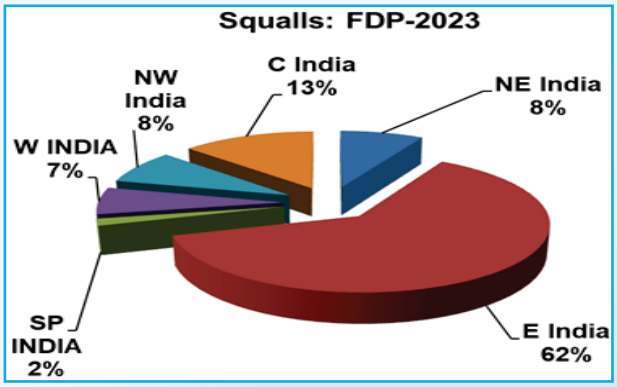


Fig. 33(s). Regionwise Distribution of squall events over the country during entire FDP STORM-2023

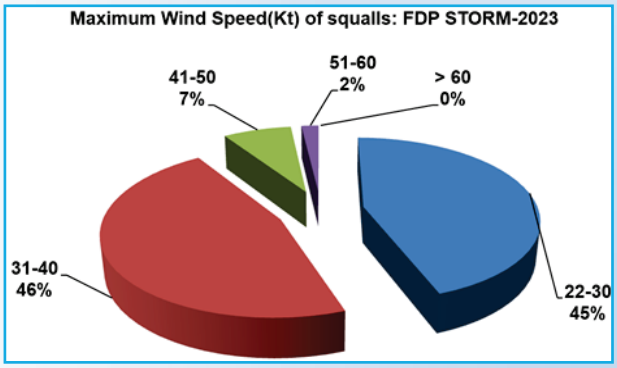


Fig. 33(t). Distribution of squalls over the country based upon max wind speed (Kt) during FDP STORM-2023

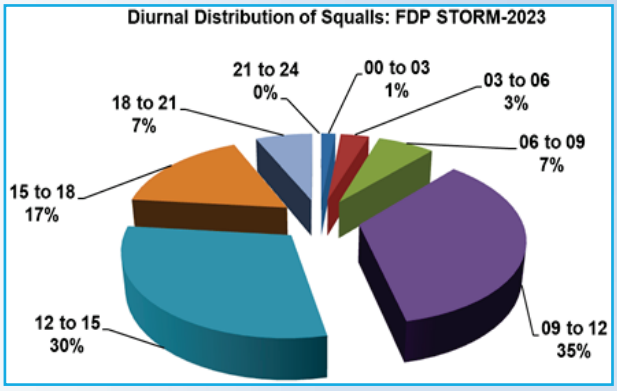


Fig. 33(u). Diurnal (time in UTC) distribution of thundersqualls during FDP STORM-2023

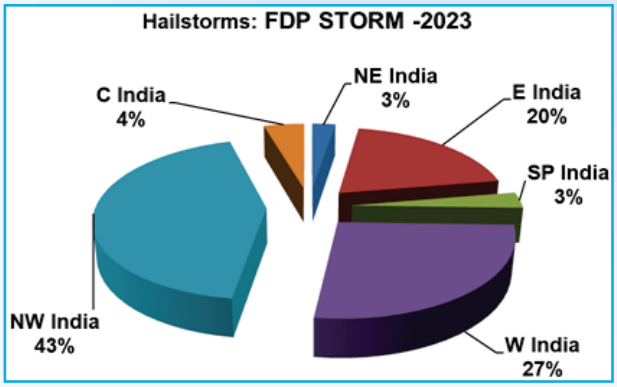


Fig. 33(v). Regionwise distribution of hailstorm events during FDP STORM-2023

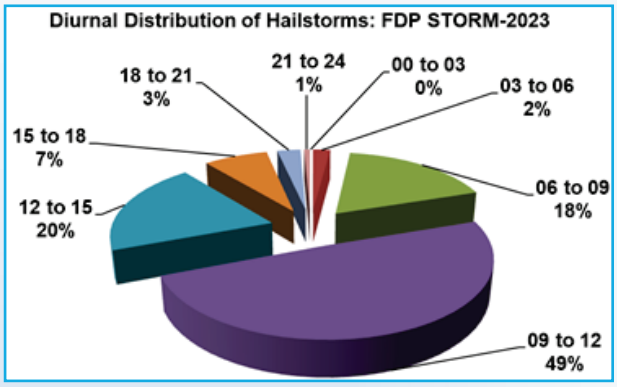


Fig. 33(w). Diurnal Distribution of Hailstorm Events over the Country during entire FDP STORM-2023

Short-range Warning of Intense Rainstorms in Localised Systems (SWIRLS)

SWIRLS is based on the extrapolation of radar echoes using the TREC (Tracking Radar Echoes by Correlation) technique. With a suitable choice of pixel array size on the radar reflectivity maps, the TREC vectors derived can be used to monitor and extrapolate echo motion right across the mesoscale spectrum, from individual convective cells, to supercells and clusters and to groups of rain bands or squall lines.

On the basis of TREC, quantitative precipitation forecast (QPF) algorithms have been developed to produce high resolution forecast rainfall distribution maps over the local area. These maps provide useful objective guidance for forecasters to assess the likely rain scenario in the next 30, 60 & 120 minutes along with analysis and to facilitate decision-making in operating the Rainstorm Warning System. The first SWIRLS was installed and made operational at Delhi in October, 2018. At present the SWIRLS software is operational at Delhi. Fig. 33(x) shows IMD SWIRLS forecast for Delhi.

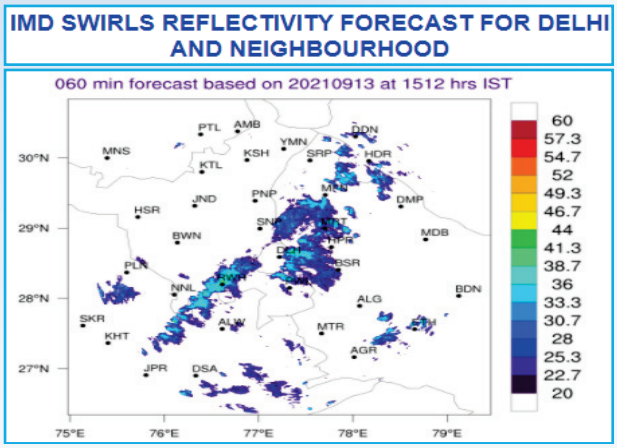


Fig. 33(x). SWIRLS Reflectivity Delhi Link : https://nwp.imd.gov.in/swirls.php

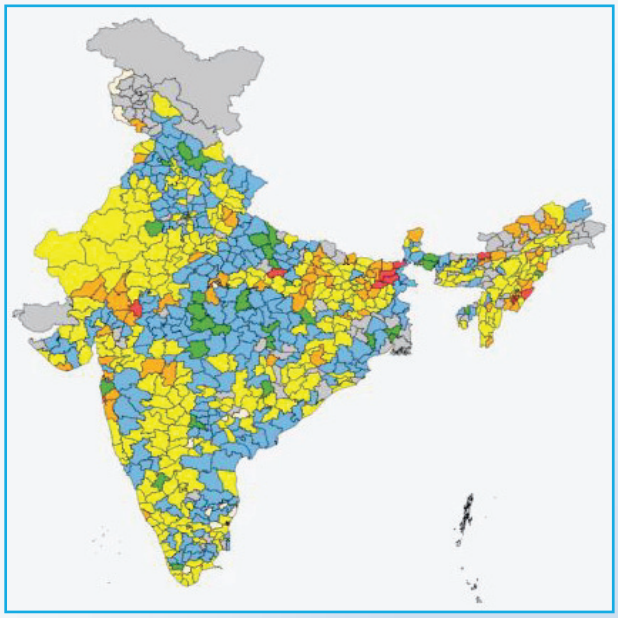


Fig. 33(y). Districtwise POD of 3 hourly district nowcast verification for FDP STORM Period-2023

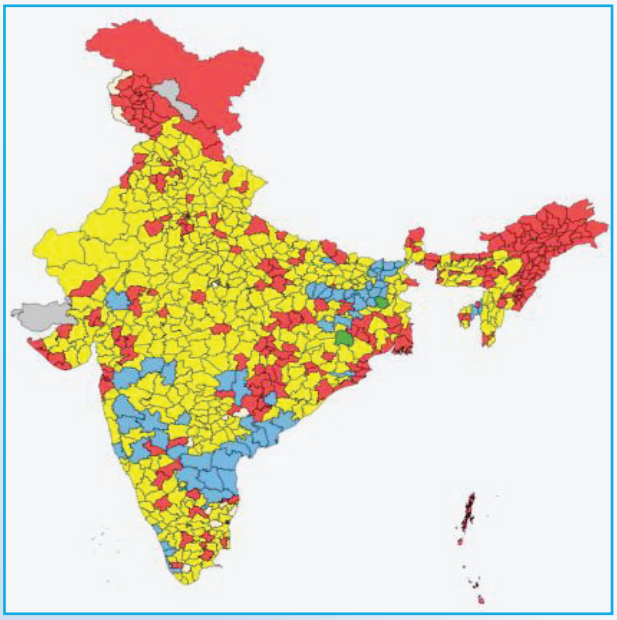


Fig. 33(z). Districtwise FAR of 3 hourly district nowcast verification for FDP STORM Period-2023

New Initiatives undertaken by Nowcast Unit

(i) Automation of district nowcast verification

IMD operationally issues district level nowcasts for severe weather for all districts of India round the clock at three hourly intervals since 2018. The phenomena for which nowcasts are issued include: (a) Thunderstorms and associated weather and (b) rainfall. All these nowcasts are updated every three hours on the IMD website (https://mausam.imd.gov.in/imd_latest/contents/districtwisewarnings.php). The data from the ground based lightning array network of the Indian Institute of Tropical Meteorology and Indian Air Force has been used for verification of the District level Nowcasts. This network currently has 83 sensors and provides spatial accuracy of about 500 m. The point data for lightning with lat-long coordinates is provided from the network in near realtime mode to IMD at 15 minute intervals for operational use. The point data is geolocated up to the district level using open source "Nominatim Server" software. For verification purposes, a yes-no criterion (2x2 configuration table) is applied for occurrence-non-occurrence of thunderstorms in each district. All the eleven categories of nowcasts for thunderstorms and associated weather are considered for verification. A minimum of 2 (two) incidences of lightning occurrence in a district within the validity period of a nowcast is considered occurrence of thunderstorm over that district. The two flashes may occur concurrently or subsequently in time in any part of the district within a period of three hours, i.e., during the validity time of the nowcast for the district. Based on both observation and nowcast for thunderstorms (any one of the eleven categories), the forecast skill scores have been calculated. Fig. 33(y-z, aa-bb) represent the district wise POD, FAR, CST and ETS scores of 3 hourly district nowcast verification for the FDP STORM Period-2023 (March to June).

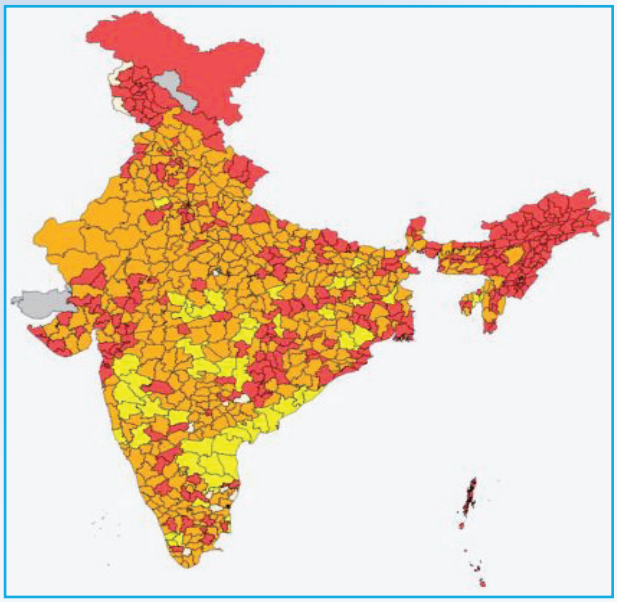


Fig. 33(aa). Districtwise CSI of 3 hourly district nowcast verification for FDP STORM Period-2023

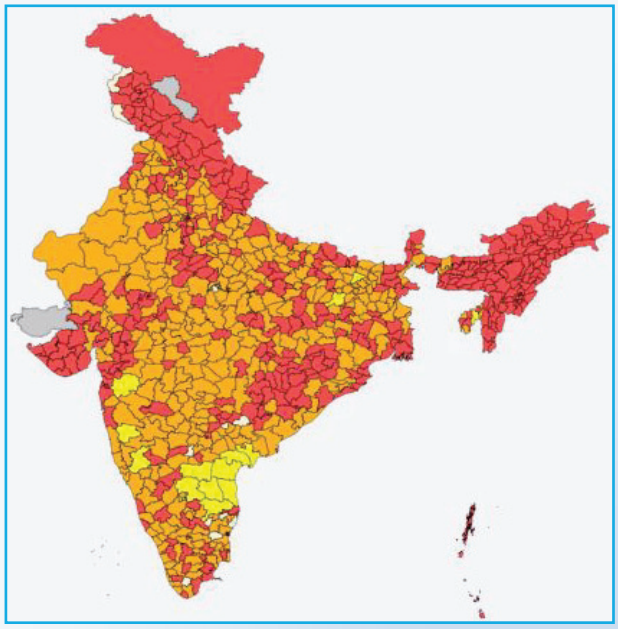


Fig. 33(bb). Districtwise ETS of 3 hourly district nowcast for FDP STORM Period -2023

(ii) Crowd sourcing

The term "crowdsourcing" was first coined in 2006 by American journalist Jeff Howe who defined it as "the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and general large) network of people in the form of an open call.

In recent years, with the improved understanding of the mesoscale nature of weather systems over Indian region, the constraints of the existing observatory network are sought to be supplemented by other sources of observations. This requirement has been partly met by remote sensed observations of weather by radar and satellite based instruments and the lightning detection network. However, in the absence of validation with ground data, the limitations of each instrument hamper the process of forming a clear picture of the weather occurred and its intensity and impact. The lack of clarity in observations causes uncertainty in forecasts of subsequent weather and its associated impact. With the widespread availability of smart phones, information regarding the state of the atmosphere can now be obtained from many non-traditional sources in text, audio and video form from sources such as citizen scientists (Wiggins and Crowston, 2011), amateur weather stations and sensors, smart devices and social-media/web 2.0 (Muller et al.).

Since 2021, IMD has started an online interface [Fig. 33(cc)] to collect the information of the weather that has occurred as well as the associated impact information for six weather events initially, viz., Rain. Hail, Duststorm, Wind Speed, Thunderstorm/Lightning & Fog. The target weather reporters are (a) Class II, Class III observatories (any observatory not covered under MMR) (b) AMFU, KVK observatories (c) Railways Station Masters (d) Power discom maintenance staff & (e) General Public. Further, the interface has following features: (i) The reporting interface is without login requirement. (ii) The time of submission will be automatically recorded. (iii) The user machine address and time is automatically recorded. (iv) The user has the facility to record the Location, State, District of observation. There is also the facility to add photo or video proof of the event.



Fig. 33(cc). Crowdsourcing weather reporting Interface Link: https://city.imd.gov.in/citywx/crowd/enter_th_datag.php

CHAPTER 5

WEATHER AND CLIMATE SERVICES OF IMD

5.1. Hydromet Services

Mandate of Hydromet Division

Hydro-meteorological Division is established to fulfill the following mandates with various services being provided to support all stakeholders, Central/State Govt. organizations and other agencies in sector specific applications (Fig. 1).

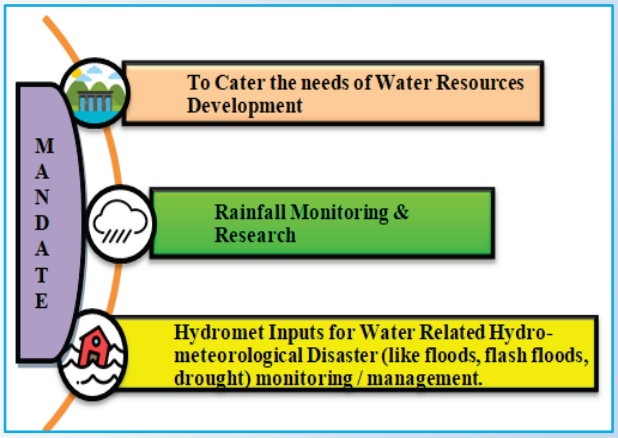


Fig. 1. Mandate of Hydromet Division

Overview of Hydro-meteorological Services of IMD

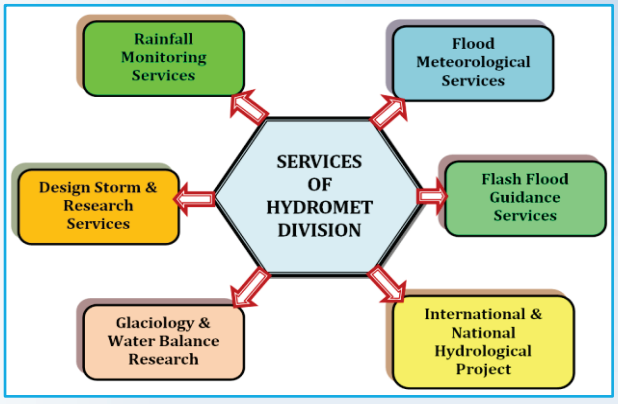


Fig. 2. Services of Hydromet Division

Flood Meteorological Services

During 2023, IMD achieved some significant improvement in Flood Meteorological Services by improving Quantitative Precipitation Forecasts (QPF). The accuracy within same category of river sub-basin-wise QPF has improved by 4% in Day-1, 3% in Day-2, Day-3 and Day-5, and 2% in Day-4 as compared to 2022. QPF Forecast increased from 5 days forecast to 7 days forecast. During this year, Number of Sub-basins increased from 153 to 156 all over India.

The sub-basin wise Quantitative Precipitation Forecasts (QPFs) were issued (daily on operational basis) by FMOs Agra, New Delhi, Asansol, Ahmedabad, Bhubaneswar, Guwahati, Jalpaiguri, Hyderabad, Lucknow, Patna, DVC Met Unit Kolkata, MC Srinagar, Chennai, Thiruvanantha-puram and Bengaluru during the monsoon season 2023 for their area of jurisdiction from 1st Jun to Oct, 2023. FMO Chennai, Thiruvananthapuram and Bengaluru continued to issue QPFs up to 31st Dec, 2023. These operational QPF were provided to the field offices of Central Water Commission for the use in their Flood Forecast Model.

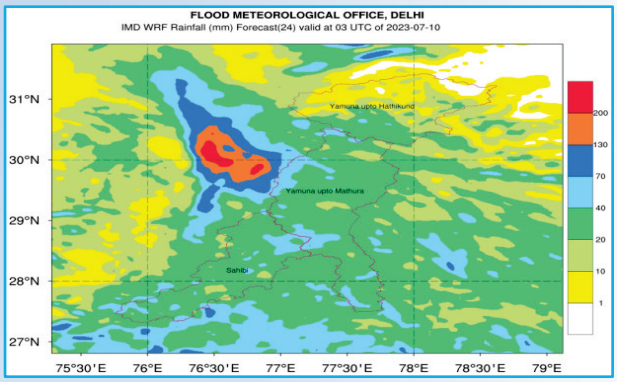


Fig. 3. IMD WRF Rainfall (mm) Forecast (24) valid at 0300 UTC of 07-10-2023

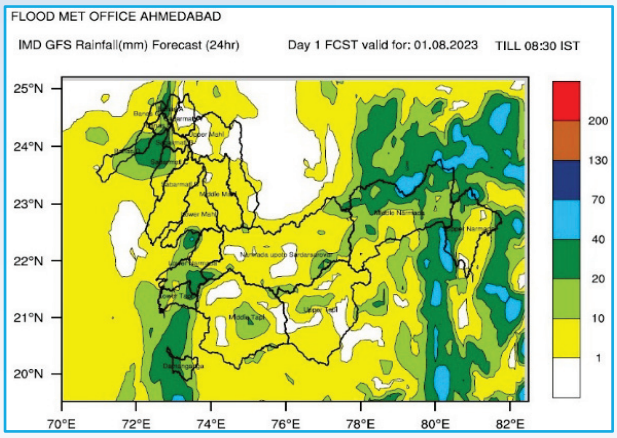


Fig. 4. IMD GFS Rainfall (mm) Forecast (24hr)

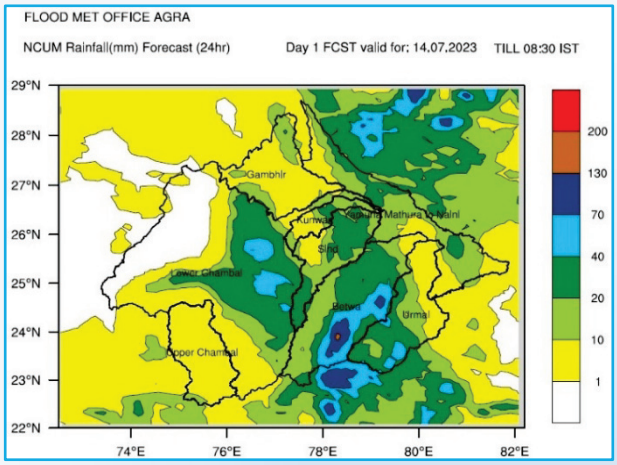


Fig. 5. NCUM Rainfall (mm) Forecast (24hr)

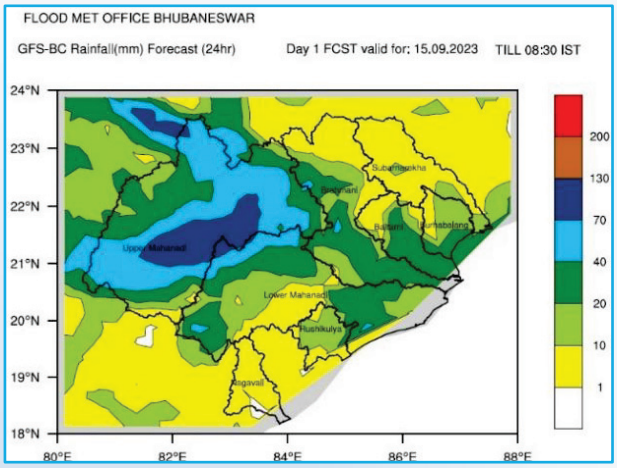


Fig. 6. GFS-BC Rainfall (mm) Forecast (24hr)

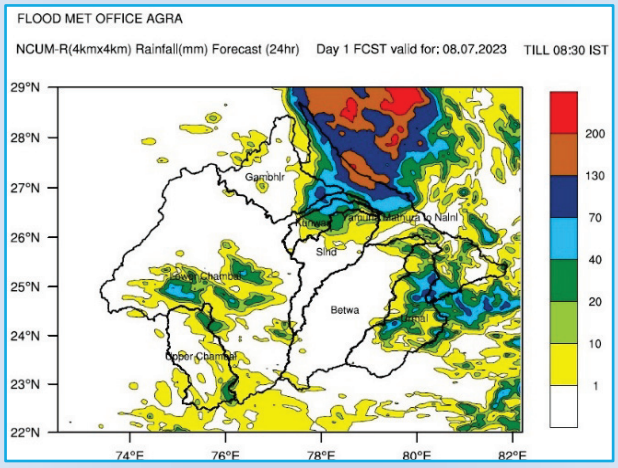
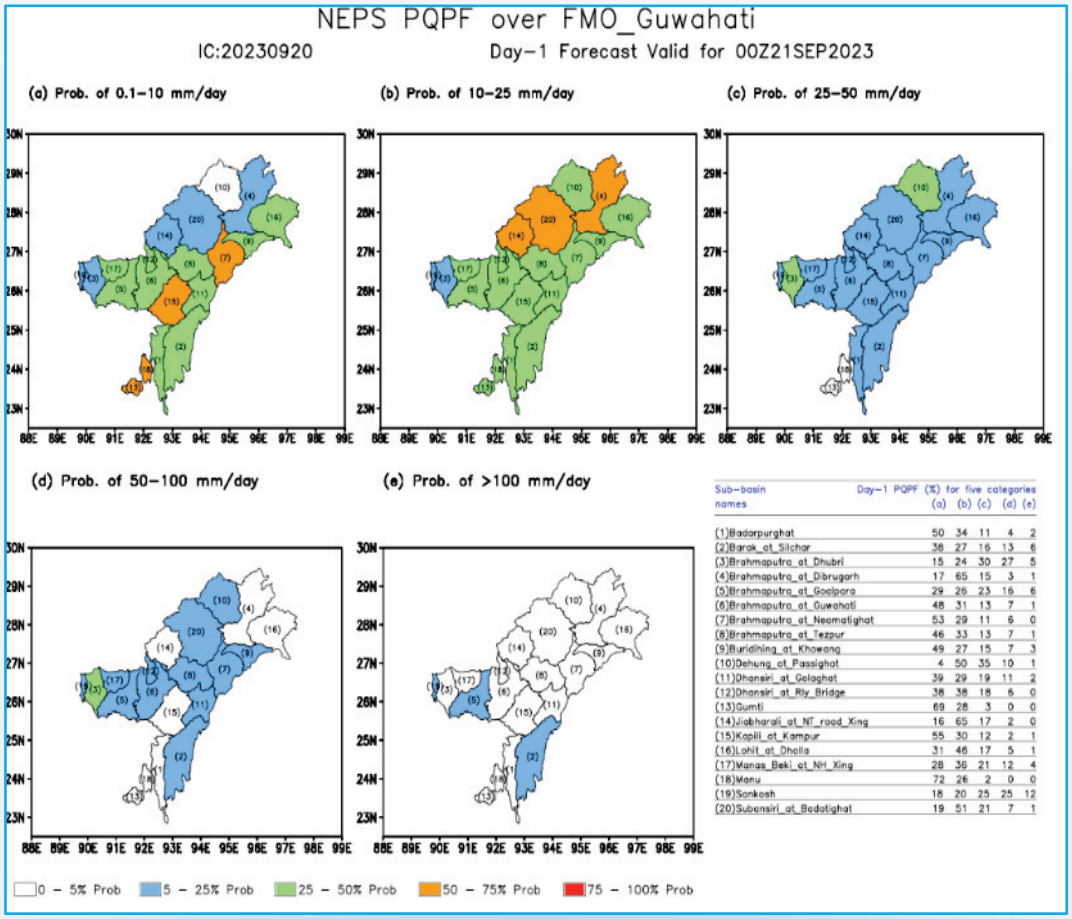


Fig. 7. NCUM-BC Rainfall (mm) Forecast (24hr)

IMD provided grided rainfall forecast data of the dynamical model operationally, viz., GFS (12km x 12km) and WRF (3km x 3km) to Central Water Commission for the use in Hydrological modelling.

River sub basin wise Probabilistic QPF based on dynamical model GEFS & NEPS were uploaded in the IMD website operationally.



Sub-basin names	Day-1 PQPF (%) for five categories (a)	(b)	(c)	(d)	(e)
(1)Badarpurghat	50	34	11	4	2
(2)Barak_at_Silchar	38	27	16	13	6
(3)Brahmaputra_at_Dhubri	15	24	30	27	5
(4)Brahmaputra_at_Dibrugarh	17	65	15	3	1
(5)Brahmaputra_at_Goalpara	29	26	23	16	6
(6)Brahmaputra_at_Guwahati	48	31	13	7	1
(7)Brahmaputra_at_Neamatighat	53	29	11	6	0
(8)Brahmaputra_at_Tezpur	46	33	13	7	1
(9)Buridihing_at_Khowang	49	27	15	7	3
(10)Dehung_at_Passighat	4	50	35	10	1
(11)Dhansiri_at_Golaghat	39	29	19	11	2
(12)Dhansiri_at_Rly_Bridge	38	38	18	6	0
(13)Gumti	69	28	3	0	0
(14)Jiabharali_at_NT_road_Xing	16	65	17	2	0
(15)Kapili_at_Kampur	55	30	12	2	1
(16)Lohit_at_Dhalla	31	46	17	5	1
(17)Manas_Beki_at_NH_Xing	28	36	21	12	4
(18)Manu	72	26	2	0	0
(19)Sankosh	18	20	25	25	12
(20)Subansiri_at_Badatighat	19	51	21	7	1

Fig. 8. NEPS PQPF over FMO Guwahati

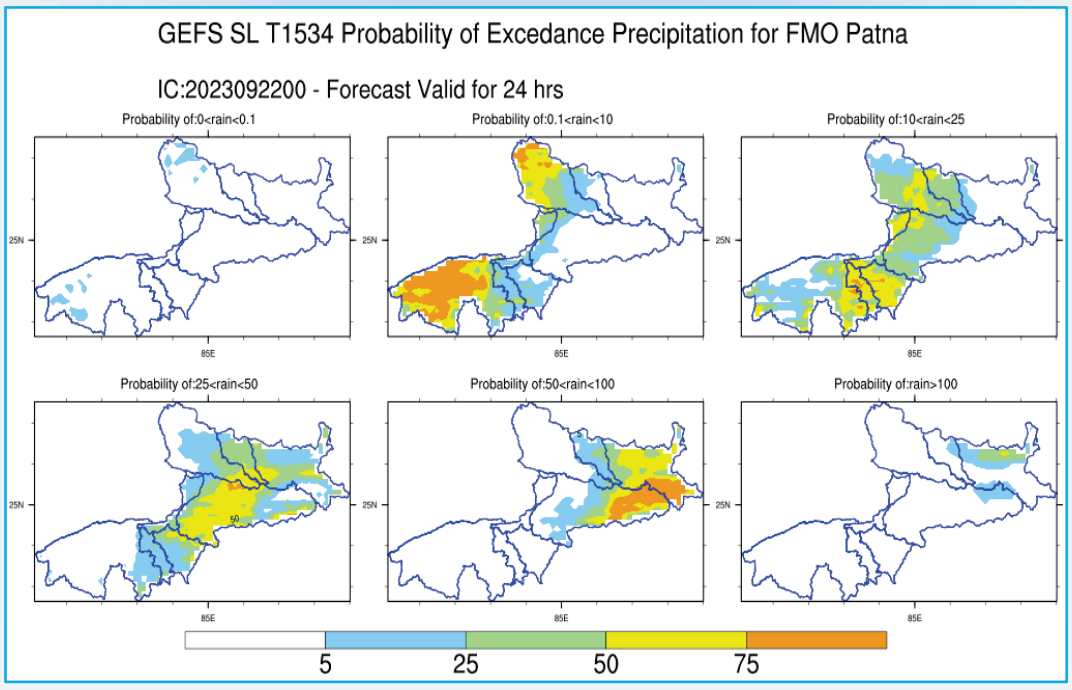


Fig. 9. GEFS SL T1534 Probability of Excedance precipitation for FMO Patna

Daily monitoring of river sub basin wise Severe Flood Situation & high QPF provided to Central Agencies.

Fl. No.	River/Sub-Basin/Basin	State	District	Rainfall Situation					Remarks/ Advisories
				Day 1	Day 2	Day 3	Day 4	Day 5	
1	Penganga/Middle Godavari/Godavari	Maharashtra	Yavatmal						
2	Wardha/Middle Godavari/Godavari	Maharashtra	Chandrapur						
3	Godavari/Middle Godavari/Godavari	Telangana	Adilabad Bhupalpally						
4	Sabari/Lower Godavari/Godavari	Andra Pradesh	Alluri Sitharama Raju						
5	Goadavari/Lower Godavari/Godavari	Andra Pradesh	Alluri Sitharama Raju						
6	Kosi/Kosi/Ganga	Bihar	Supaul						
7	Sabari/Lower Godavari/Godavari	Chhattisgarh	Sukma						
8	Indravathi /Lower Godavari/Godavari	Chhattisgarh	Bijapur						
9	Damanganga/Damanganga/West Flowing Rivers from Tapi to Tadri	Dadra and Nagar Haveli	Dadra and Nagar Haveli						
10	Purna/Purna/West Flowing Rivers from Tapi to Tadri	Gujarat	Surat						
11	Cauvery/Upper Cauvery/Cauvery	Karnataka	Chamarajanagar						
12	Tungabhadra /Upper Krishna/Krishna	Karnataka	Shimoga						
13	Kumudvati/Upper Krishna/Krishna	Karnataka	Haveri						
14	Varadha/Upper Krishna/Krishna	Karnataka	Haveri						
15	Bhavani/Middle Cauvery/Cauvery	Kerala	Palaghat						
16	Tapi/Middle Tapi/Tapi	Madhya Pradesh	Burhanpur						
17	Noyyal/Middle Cauvery/Cauvery	Tamil Nadu	Coimbatore						
18	Godavari/Middle Godavari/Godavari	Telangana	Mulugu Badradri						
19	Sarda/Ghaghara/Ganga	Uttar Pradesh	Kheri						

Fig. 10. Daily monitoring of river sub basin wise Severe Flood Situation &high QPF provided to Central Agencies

Dated: 04/09/2023

Sub-basin-wise Real Time Monitoring of Flood Situation and Quantitative Precipitation forecast (QPF) by IMD

Flood Monitoring Offices				Flood Level (CWC)		Quantitative Precipitation Forecast (QPF)																				
						Day-1 (04/09/23)*			Day-2 (05/09/23)*			Day-3 (06/09/23)*			Day-4 (07/09/23)*			Day-5 (08/09/23)*			Day-6 (09/09/23)*			Day-7 (10/09/23)*		
SNo	FMO	Basin	Sub-Basin	Severe Flood	Extreme Flood	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm
1	FMO Agra	Betwa	Betwa															✓			✓					
2	FMO Agra	Chambal	Sind																		✓					
3	FMO Agra	Ken	Ken															✓			✓					
4	FMO Bhubaneshwar	Baitarani	Baitarani			✓																				
5	FMO Bhubaneshwar	Brahmani	Lower Brahmani			✓																				
6	FMO Bhubaneshwar	Brahmani	Upper Brahmani			✓																				
7	FMO Bhubaneshwar	Mahanadi	Upper Mahanadi						✓																	
8	FMO Chennai	Pennar	Kunderu			✓																				
9	FMO Chennai	Pennar	Sagileru			✓																				
10	FMO Chennai	Pennar	Upper Pennar			✓																				
11	FMO Chennai	Pennar	Papagni			✓																				
12	FMO Chennai	Pennar	Cheyyeru			✓																				
13	FMO Guwahati	Brahamputra	Brahmaputra at Dhubri	✓																						
14	FMO Hyderabad	Godavari	Upper Godavari									✓									✓					

Highest Flood Level = HFL
Severe Flood : when the river water level is at or above Danger Level and below HFL.
Extreme Flood : when the river water level is at or above HFL
* Forecast and Warning for any day is valid from 0830 hours IST of day till 0830 hours IST of next day.

Fig. 11. Sub-basin wise Real Time Monitoring of Flood Situation and Quantative Precipitation forecast (QPF) by IMD

RAINFALL MONITORING SERVICES

Hydromet Division brings out real-time rainfall summary every week from Thursday to Wednesday and also for months. During Monsoon season, the same is prepared on daily basis for 717 Districts, 36 Met. Sub-divisions, 36 States including UTs, 4 Regions and for the country as a whole. Besides this, rainfall statistics is also prepared for 61 selected River basins of India and the maps are uploaded on IMD website. The Unit also brings out updated monthly, seasonal and annual rainfall statistics after incorporating the late receipt data. Rainfall Monitoring Unit also publishes Annual Rainfall Report.

The real time rainfall statistics was prepared for the October - 2023. The rainfall for the country as a whole, for the October -2023 has been recorded as 50.8 mm which is 67% of its Long Period Average (LPA) of 75.4 mm. In all, category wise, 05 Met sub-divisions in LARGE EXCESS, 02 Met sub-divisions in EXCESS, 08 Met sub-divisions in NORMAL, 10 in DEFICIENT, 11 in LARGE DEFICIENT and no any Met. Sub-divisions in NO RAIN category of rainfall.

The rainfall for the country as a whole, for the Winter season - 2023 has been recorded as 22.4 mm which is 56% of its Long Period Average (LPA) of 39.8 mm. In all, category wise, 02 Met sub-divisions in LARGEEXCESS, 01 in EXCESS, 02 Met sub-divisions in NORMAL, 09 in DEFICIENT, 19 in LARGE DEFICIENT and 03 Met. Sub-divisions in NO RAIN category of rainfall.

The rainfall for the country as a whole, for the Pre-Monsoon season -2023 has been recorded as 147.9 mm which is 87% of its Long Period Average (LPA) of 130.6 mm. In all, category wise, 17 Met sub-divisions in LARGE EXCESS,04 in EXCESS, 07 Met sub-divisions in NORMAL, 06 in DEFICIENT, 02 in LARGE DEFICIENT and no any Met. Sub-divisions in NO RAIN category of rainfall.

The rainfall for the country as a whole, for the Monsoon season - 2023 has been recorded as 820.0 mm which is 94% of its Long Period Average (LPA) of 868.6 mm. In all, category wise, 03 Met sub-divisions in EXCESS, 26 Met sub-divisions in NORMAL, 07 in DEFICIENT and no any Met. Sub-divisions in LARGE EXCESS, LARGE DEFICIENT, NO RAIN category of rainfall.

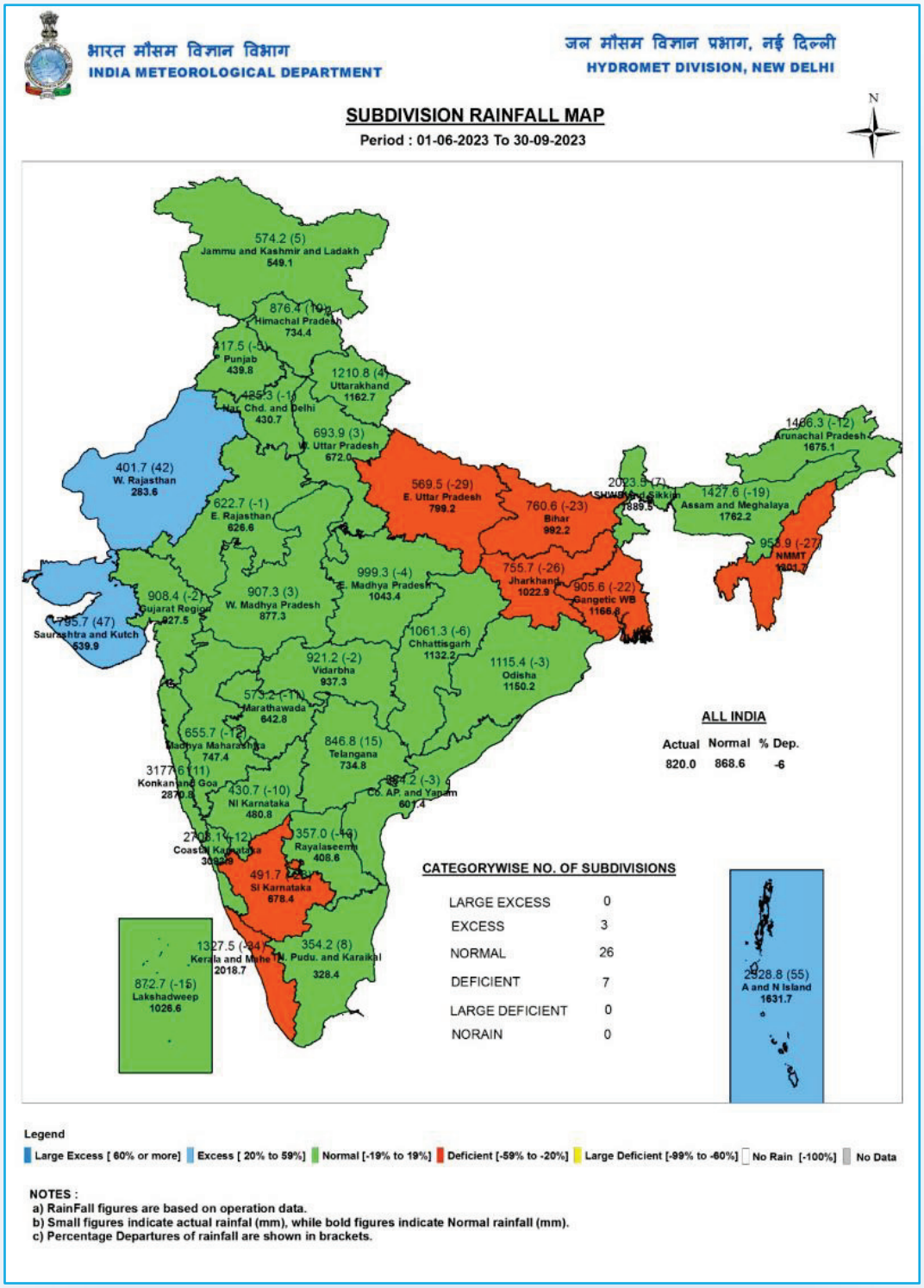


Fig. 12. Subdivisional Rainfall Map for the peiof 01-06-2023 to 30-09-2023

TABLE 1

SUBDIVISION-WISE RAINFALL (MM) DISTRIBUTION

S. NO.	METEOROLOGICAL SUBDIVISIONS	PERIOD: 01.06.2023 TO 30.09.2023			
		ACTUAL	NORMAL	% DEP.	CAT.
EAST & NORTH EAST INDIA		1115	1367.3	-18%	
1	ARUNACHAL PRADESH	1466.3	1675.1	-12%	N
2	ASSAM & MEGHALAYA	1427.6	1762.2	-19%	N
3	N M M T	953.9	1301.7	-27%	D
4	SHWB & SIKKIM	2023.5	1889.5	7%	N
5	GANGETIC WEST BENGAL	905.6	1166.8	-22%	D
6	JHARKHAND	755.7	1022.9	-26%	D
7	BIHAR	760.6	992.2	-23%	D
NORTH WEST INDIA		593	587.6	1%	
1	EAST U.P.	569.5	799.2	-29%	D
2	WEST U.P.	693.9	672	3%	N
3	UTTARAKHAND	1210.8	1162.7	4%	N
4	HAR. CHD & DELHI	425.3	430.7	-1%	N
5	PUNJAB	417.5	439.8	-5%	N
6	HIMACHAL PRADESH	876.4	734.4	19%	N
7	J & K AND LADAKH	574.2	549.1	5%	N
8	WEST RAJASTHAN	401.7	283.6	42%	E
9	EAST RAJASTHAN	622.7	626.6	-1%	N
CENTRAL INDIA		981.7	978	0%	
1	ODISHA	1115.4	1150.2	-3%	N
2	WEST MADHYA PRADESH	907.3	877.3	3%	N
3	EAST MADHYA PRADESH	999.3	1043.4	-4%	N
4	GUJARAT REGION	908.4	927.5	-2%	N
5	SAURASHTRA & KUTCH	795.7	539.9	47%	E
6	KONKAN & GOA	3177.6	2870.8	11%	N
7	MADHYA MAHARASHTRA	655.7	747.4	-12%	N
8	MARATHWADA	573.2	642.8	-11%	N
9	VIDARBHA	921.2	937.3	-2%	N
10	CHHATTISGARH	1061.3	1132.2	-6%	N
SOUTH PENINSULA		659	716.2	-8%	
1	A & N ISLAND	2528.8	1631.7	55%	E
2	COASTAL A. P.& YANAM	584.2	601.4	-3%	N
3	TELANGANA	846.8	734.8	15%	N
4	RAYALASEEMA	357	408.6	-13%	N
5	TAMIL., PUDU. & KARAIKAL	354.2	328.4	8%	N
6	COASTAL KARNATAKA	2708.1	3093.9	-12%	N
7	N. I. KARNATAKA	430.7	480.8	-10%	N
8	S. I. KARNATAKA	491.7	678.4	-28%	D
9	KERALA & MAHE	1327.5	2018.7	-34%	D
10	LAKSHADWEEP	872.7	1026.6	-15%	N
COUNTRY AS A WHOLE		820	868.6	-6%	

TABLE 2

CATEGORYWISE NO. OF SUBDIVISIONS & % AREA (SUBDIVISIONAL) OF THE COUNTRY

CATEGORY		PERIOD: 01.06.2023 TO 30.09.2023	
		NO. OF SUBDIVISIONS	SUBDIVISIONAL % AREA OF COUNTRY
LARGE EXCESS		0	0%
EXCESS		3	9%
NORMAL		26	73%
DEFICIENT		7	18%
LARGE DEFICIENT		0	0%
NO RAIN		0	0%

Design Storm Studies

1. Design Storm Studies are being conducted to evaluate design storm estimates (rainfall magnitude and time distribution) for various river catchments/ projects in the country, for use as main input for design engineers in estimating design flood for hydraulic structures, irrigation projects, dams etc. on various rivers. This estimation of design values is required for safe and optimum design of storage and spillway capacity. On the request of Central Govt./ State Govt., Private Agencies, design storm values (Standard Project Storm, Probable Maximum Precipitation along with Time Distribution, IDF Curve etc.) are being provided for users as main input. These studies are being carried out on payment basis. The detailed project reports are sent to the project authorities.

2. During the year 2023, design storm studies of Six (6) projects have been completed (till Nov). Revenue of Rs.13,83,531/- (Rupees Thirteen Lakh Eighty Three Thousand Five Hundred Thirty One only) was generated.

5.2. Agrometeorological Advisories Services

Agrometeorological Observatories & Data Management

Under the network of observatories related to agrometeorology, at present there are 224 Agromet observatories, 3 Evapotranspiration Stations, 9 Soil Moisture Stations and 17 Dew gauge stations in the country. In collaboration with these observatories, this division is exploring to develop a suitable National network of Agromet Observatories for effective use of real time agromet data in Agromet Advisory Services (AAS). Under this National network all the observatories will get access of agromet data of their own station in addition to other stations on line. This data will be of much use for preparation of district as well as block level agromet advisories. A web based system has already been developed in collaboration with National Informatics Centre (NIC), Pune for receipt, scrutiny and archival of weather data from agromet observatories of IMD using internet. Under the network of agromet observatories, there are 263 Agromet observatories. Every day observations are recorded at two different local timings.

Observing Systems and Field Campaigns under Gramin Krishi Mausam Seva (GKMS)

Inputs for “Crop Specific Weather Based Agromet Advisories” for the country have been prepared every Tuesday and Friday for telecasting through DD Kisan Channel, New Delhi and Regional Doordarshan Channel at state level.

694 bi-weekly District AAS bulletins and 3075 Block AAS Bulletins [1396 Block level Agromet Advisories by Agromet Field Units (AMFUs) and 1679 Block level Agromet Advisories by District Agromet Units (DAMUs)] have been prepared and uploaded in the website of Agrimet Division, Pune.

Impact based forecast (IBF) for Agriculture (Heavy Rainfall / Hailstorm / Heat Wave / Thunderstorm with Gusty winds / Cold Wave) and Agromet Advisories based on the IBF have been issued for different districts of various States and UTs across the country in coordination with NWFC, New Delhi, RMCs/MCs, AMFUs and DAMUs.

Heavy rainfall warning was issued by India Meteorological Department due to Cyclonic Storm "Mocha" over Bay of Bengal during 9 to 14 May 2023. During the period 1715493 SMSs have been sent to 760489 number of farmers in the States of Assam, Nagaland, Manipur, Mizoram and Tripura. Special Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division.

Heavy rainfall warning was issued by India Meteorological Department due to Cyclonic Storm "Biparjoy" over Arabian Sea during 6 to 19 June 2023. During the period 2,08,36,313 SMSs have been sent to the farmers in the states of Gujarat and Rajasthan. Special Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division.

Weather forecast and Agromet advisories have been integrated

Agriculture Information Management System (AIMS), Department of Agriculture & Farmers Welfare, Govt. of Kerala (https://www.aimsnew.kerala.gov.in/). About 40 lakhs farmers are accessing the block level weather forecast and Agromet Advisories from this platform.

Website of Directorate of Agriculture, Himachal Pradesh (https://agriculture.hp.gov.in/en/home-english/). About 33,727 farmers are accessing the block level weather forecast and Agromet Advisories from this platform.

5.3. Positional Astronomy Services

The Positional Astronomy Centre, located at Sector V, Saltlake, Kolkata, is the nodal office of the Govt. of India having the responsibility for preparation of data on positional astronomy for scientific purposes as well as National Calendar for civic purposes.

Since ancient times, late Indian astronomers like Aryabhata and Bhaskara have made significant contributions to the field of astronomy. The position of stars and planets governed the observance of religious events, festivals and rituals, making astronomy a part of daily life in India.

In today's world, almanacs and astronomical ephemeris facilitate the practical applications of astronomy. They help to foreshadow significant celestial events like eclipses of Sun and moon, unusual planetary configurations, phase of the moon and so on. In India, such almanacs, known popularly as Panchangs, were being prepared from historical times but the method of calculation followed by them differed widely.

Nearly 30 different Panchangs were in use during post-independence period of the country which reflected the rich and varied political, cultural and historical traditions of India. Each calendar system had its advantages and disadvantages. Therefore, there was a need to adopt a scientific approach and evolve a uniform calendar on the basis of the most accurate modern astronomical data for the entire country for the interest of national integrity. The Government appointed a seven-member Calendar Reform Committee in November, 1952 under the chairmanship of Prof. Meghnad Saha with Late N. C. Lahiri as member secretary, under CSIR with a view to develop a unified National Calendar on the basis of most accurate modern astronomical data for the interest of national integrity.

The committee recommended preparation of the Indian Ephemeris and Nautical Almanac calculated with most modern astronomical formulae, the National Calendar of India with timings of Tithis, Nakshatras, Yogas etc, and also festival dates. The era chosen for this calendar was the Saka Era.

Thus, the residual work of the Calendar Reform Committee and also the preparation of the Indian Ephemeris and Nautical Almanac along with Rashtriya Panchang were taken up by the India Meteorological Department from the Council of Scientific and Industrial Research on 1st December, 1955. The work was entrusted to a unit named 'Nautical Almanac Unit' under the administrative control of the then Director, Regional Meteorological Centre, Calcutta.

The unit undertook the preparation of “The Indian Ephemeris and Nautical Almanac” for 1958, which was the first issue published in March 1957. Simultaneously the first issue of Rashtriya Panchang was started from 1879 Saka Era (1957-58 A.D.). From 1979, the title of “The Indian Ephemeris and Nautical Almanac” was changed to “Indian Astronomical Ephemeris”.

In the year 1976 the Ramanna Committee, after examination of the working of the Nautical Almanac Unit, recommended its independent status and upgradation of the post of Officer-in Charge of the Unit to the level of Director. These recommendations were finally approved by the Council of Meteorology and Atmospheric Sciences (CMAS) of the Govt. of India and it was decided that the Nautical Almanac Unit would be completely separated from the administrative control of the Director, Regional Meteorological Centre, Calcutta and was made an independent centre with the name as "Positional Astronomy Centre" (P.A.C.) directly under the control of the Director General of Meteorology, New Delhi. The implementation of this decision has been made with effect from the 1st December, 1979 and the formal inauguration of the Positional Astronomy Centre took place on the 26th April, 1980.

Positional Astronomy Centre, Kolkata under IMD, is the only national agency dealing with work on publication of Ephemeris containing data on positional coordinates of celestial objects. The centre is also responsible to prepare the National Calendar for civil and religious purposes through publication of RashtriyaPanchang in 14 languages which serves as a standard panchang of the country and acts as a source of correct panchang data. The centre also fixes dates of all India festivals for all communities for declaration of holidays by the Central and State Governments Thus, the job performed by the centre is unique and no other organization in the country is performing this kind of work.

Present Activities

Publication of Indian Astronomical Ephemeris, Tables of Sunrise - Sunset, Moonrise - Moonset, Preparation of Indian National calendar.

Publication of Rashtriya Panchang in 14 languages namely, Hindi, English, Sanskrit, Urdu, Assamese, Bengali, Gujarati, Marathi, Punjabi, Tamil, Telugu, Kannada, Malayalam and Odia.

Supply data to meets up data requirements of a large number of users including Government organizations, non-Government organizations, astronomers, various panchang makers, general public etc.

Taking observation on special astronomical events from time to time with the help of its portable telescopes.

Activities during the Year 2023

The 2024 edition of the Indian Astronomical Ephemeris, an annual publication from the Positional Astronomy Centre, has been published in both hard copy and soft copy formats. This comprehensive resource provides positional data for the Sun, Moon, and planets in various astronomical coordinate systems. Additionally, it includes details such as the rising and setting times of the Sun and Moon; the mean and apparent positions of bright stars; a calendar of celestial events; information on eclipses and occultations; calendric data; explanatory text and other valuable insights into astronomy.

The Rashtriya Panchang for the 1945 Saka Era (2023-24 AD) has been released in 14 languages, both in hard copy and soft copy formats. These publications are vital resources provided by the Centre to meet the daily needs of almanac users, Panchang makers and others interested in this information. The Panchang includes essential details such as Tithi, Nakshatra, Yoga and Karana in Indian Standard Time (IST) calculated for the central point (82°30’ E, 23°11’ N). It follows the traditional luni-solar arrangement, with Lunar months beginning from the ending moment of the New Moon. Additionally, it provides Tables of Nirayana longitudes, the beginning of lagnas, transits of the Sun, Moon and planets in different rasis and nakshatras; details of All India fairs and festivals for all communities and tables of Sunrise-Sunset and Moonrise-Moonset.

Offprint copy for Sunrise-sunset, Moonrise-moonset Table for 2024 have been published during the year 2023.

The Centre continued its web-based service by developing electronic editions of '14 language versions of Rashtriya Panchang' and 'Indian Astronomical Ephemeris'. Users can access these versions through the PAC Kolkata website.

The monthly star charts and astronomical bulletins for all 12 months of 2023 have been prepared. These resources are designed to offer valuable guidance for observing celestial objects in the night sky. The bulletins comprise concise explanations of object positions in the sky, along with celestial diagrams suitable for practical demonstrations.

All India festivals for all communities have been prepared for the year 2024 in advance to facilitate the declaration of holidays by the Government of India and other State Governments. Additionally, calendar data for the Indian National Calendar and the Gregorian calendar for the year 2024-25 has been prepared in advance for the convenience of various stakeholders. Advance Panchang data has been prepared and supplied to different stakeholders. Observations has been taken of special events throughout the year.

5.4. Climate Research & Services

As a custodian of all meteorological data collected from different stations of the country, National Data Centre (NDC) processed and archived them in standard format from time to time. The total holding of meteorological data at the data centre as of date is 7,86,06,987 records.

During the year 2023, 1448 new users registered on Data Supply Portal. NDC received 3015 (including 6 foreign parties) queries and requests for data supply from various parties that include Government, private institutions, industries, research and operational users. On receipt of requests, the required data were retrieved from the computer archives, within short time and supplied to the users in the desired formats, following the usual formalities as per department policy. During the period 12,56,87,673 records were retrieved and supplied to different users.

(i) Operational Long Range Forecast and its Verification

Operational LRF System

IMD has implemented a new strategy for issuing monthly and seasonal operational forecasts for the rainfall and temperature over the country by modifying the existing two state forecasting strategy in 2021. The new strategy uses the existing statistical forecasting system to generate these forecasts along with a newly developed Multi-Model Ensemble (MME) forecasting system based on coupled global climate models (CGCMs) from different global climate prediction and research centers including IMD's Monsoon Mission CFS (MMCFS) model. The Performance operational forecast (1988-2023) is shown in Fig. 13. Table 3 shows various long-range forecasts issued during the year. Details of the various long-range forecasts issued by IMD and their verification are discussed in this report.

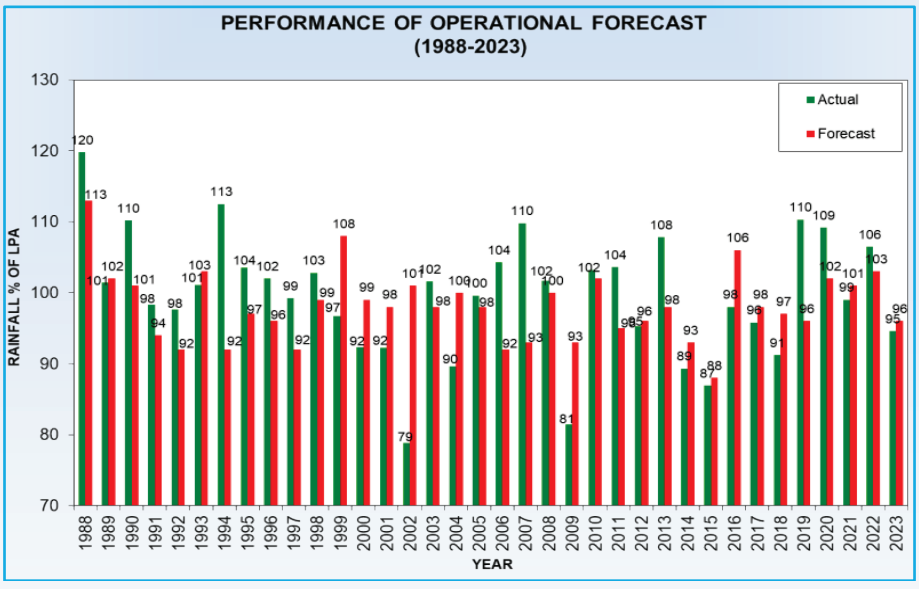


Fig. 13. Performance operational forecast (1988-2023)

TABLE 3

Details of the various long range forecasts issued by IMD

S. No.	Forecast for	Region for which forecast issued	Method/Model
1.	Monthly outlook for rainfall and temperatures during January 2023	North India	MME
2.	Monthly outlook for rainfall and temperatures during February 2023	North India	MME
3.	Seasonal (March-May) and Monthly (March) 2023 Outlook for the Rainfall and Temperatures	Country as a Whole	MME
4.	Long Range Forecast for the 2023 Southwest Monsoon Season Rainfall	Country as a Whole	Statistical & MME
5.	Monthly Outlook for the Temperature and Rainfall during May 2023	Country as a Whole	MME
6.	Forecast of the Onset Date of Southwest Monsoon - 2023 over Kerala	Over Kerala	Statistical
7.	Updated Long Range Forecast of Rainfall during Southwest Monsoon Season (June - September), 2023 and Monthly Outlook for Rainfall and Temperature during June 2023	Country as a Whole	Statistical & MME
8.	Forecast outlook for rainfall and temperatures during the month of July and July to September 2023 of Southwest monsoon season	Country as a Whole	MME
9.	Forecast outlook for rainfall and temperatures during the month of August and August-September 2023 of Southwest monsoon season.	Country as a Whole	MME
10.	Forecast outlook for rainfall and temperatures for the Month of September 2023	Country as a Whole	MME
11.	Forecast outlook for rainfall and temperatures for Post-monsoon Season (Oct-Dec) and October 2023	South Peninsular India	MME
12.	Long Range Forecast for rainfall and temperature for November 2023	Country as a Whole	MME
13.	Seasonal Outlook for Winter Temperatures and Rainfall and Temperature Forecast for December 2023	Country as a Whole	MME

Verification of Operational Long-Range Forecasts

Southwest Monsoon Season (June to September, 2023) Rainfall

The long range forecast for the 2023 southwest monsoon rainfall was issued in 2 stages. The first stage long range forecast issued on 11th April consisted of only forecast for season (June-September) rainfall over the country as a whole. In the second stage (26th May), along with the update for the April forecast, forecast for season rainfall over the four broad geographical regions (Northwest India, Central India, South Peninsula and Northeast India) and that for monthly rainfall over the country as a whole for the months of July, August and September were issued. In the 3rd stage (31st July), the forecast for the rainfall during the second half of the monsoon season over the country as a whole was issued.

The first stage forecast for the season (June-September) rainfall over the country as a whole issued in April was 96% of LPA with a model error of ± 5% of LPA. The update issued on 26th May for this forecast was (96% of LPA) with a model error of ± 4% of LPA. The actual season rainfall for the country as a whole was 94% of LPA. Thus, the both the forecasts were within forecast limits and therefore the forecast was correct.

Considering the four broad geographical regions of India, the forecasts issued in 26th May, the southwest monsoon seasonal rainfall was most likely to be below normal over Northwest India (<92% of LPA) and normal over other three broad homogeneous regions; central India (94-106% of LPA), North East India (94-106% of LPA) and South Peninsular India (94-106% of LPA). The southwest monsoon seasonal rainfall over the monsoon core zone consisting of most of the rainfed agriculture areas in the country was most likely to be Normal (94-106% of LPA. The actual rainfall departure over Northwest India, Central India, Northeast India, South Peninsula and Monsoon Core Zone were 1%, 0%, -18%, -9% and 1% of the LPA respectively. Thus, rainfall over northwest and northeast India were underestimated and overestimated respectively.

The forecasts for the monthly rainfall over the country as a whole for the months of June and August were below Normal (<92% of LPA) and (<94% of LPA) respectively and observed rainfall was 91% & 64% respectively. For the month of July, it was predicted that rainfall for the country as a whole would be on positive side of normal (94-106% of LPA) and September Normal (91-109% of LPA). Based on extended range forecast issued on 30 September, it was stated that there would be good rainfall in September. The observed rainfall in July and September was 113% of LPA each. The realized spatial rainfall pattern matched well for all the individual months except September. The second half of the monsoon season (August - September) rainfall was below normal against the prediction of rainfall in the negative side of the normal rainfall. Thus, the trend of rainfall in second half of monsoon season was well predicted. It was also predicted since April that the El Nino would have no impact in first half and could adversely impact in second half of the monsoon season, which is found to be correct.

The Table 4 below gives the summary of the verification of the long-range forecasts issued for the 2023 Southwest monsoon.

TABLE 4(a)

Performance of Long-Range Forecast of Southwest Monsoon 2023

FORECAST			OBSERVED
11 April, 2023 - 1st Stage for Season as a whole	26th May, 2023 - 2nd stage - Updated (For Season as whole)	31 July - 3rd Stage (For 2nd half of Monsoon 2023 (August-September)	
El Niño conditions are likely to develop during the monsoon season Positive IOD conditions are likely to develop during the southwest monsoon season. It was stated that Eurasia snow cover has been less during December to February 2022-2023, which will favour the Monsoon over India in spite of IOD conditions also will counter the adverse impact of El-Nino. Based on the above, it was predicted that in spite of El-Nino, the monsoon will not be affected severely and Quantitatively seasonal rainfall was predicted to be 96 % of Long Period Average (LPA) with a model error of ± 5%(Normal). It was also told that monsoon would get impacted "in the 2nd half of monsoon season and not likely in the 1st half of the season".	El Niño conditions during monsoon season. Development of positive IOD conditions over the Indian Ocean during monsoon season. Same rainfall forecast was reiterated in 2nd Stage LRF issued on 26th May 2023 96 ± 4%. It was also told that monsoon would get impacted "in the 2nd half of monsoon season and not likely in the 1st half of the season."	Weak El Niño conditions are prevailing over the equatorial Pacific region. The El Niño conditions are likely to intensity further and continue up to early next year. Neutral IOD conditions are prevailing over the Indian Ocean and the positive IOD conditions are likely to develop during remaining part of the monsoon season. Rainfall to be normal but on negative side of the normal (94 to 99% of LPA).	Weak El Niño conditions developed in July became moderate in Aug & Sept. IOD remained neutral till 3rd week of Aug and became positive thereafter. Rainfall is below normal (94% of LPA). 1st half of the monsoon season 2023 got more rainfall (10%, above normal). It was below normal during 2nd half the season (17% below normal)

TABLE 4(b)

Performance of monthly Rainfall Forecast during Monsoon 2023

Month	Forecast	Realized
Jun 2023	Rainfall to be below normal (<92 % of LPA)	91% of LPA
Jul 2023	Rainfall to be normal but on positive side of the normal (100-106 % of LPA)	113% of LPA
Aug 2023	Rainfall to be below normal (<91 % of LPA)	64% of LPA
Sep 2023	Rainfall to be normal (91-109 % of LPA). However extended range forecast indicated good rainfall in Sept. Also predicted formation of Low-Pressure Systems one after another to cause good rainfall over Central & South India	113% of LPA
Aug-Sep 2023	Rainfall to be normal but on negative side of the normal (94 to 99% of LPA	83% of LPA

Supporting WMO's Activities

Apart from severe weather guidance, India has been at the forefront in actively supporting WMO's effort in Global Framework of Climate Services (GFCS) in developing climate services at different levels. Numerical Modelling support through Global Forecast System (GFS), Regional Forecast System (RFS). Model forecast products for different level of forecasting (Nowcasting, short range forecasting, medium range forecasting and extended range forecasting are available globally through web-link: [https://mausam.imd.gov.in/].

Regional Climate Centre (RCC) Activities

The CRS office of IMD, Pune is also recognized as the WMO Regional Climate Center (RCC) for south Asia. Presently the MMCFS is used for the following the RCC long range forecasting activities.

Generate global monthly and seasonal (anomaly and probability) forecasts for the temperature and rainfall. This is updated every month.

Prepare Seasonal Climate Outlook for rainfall and temperatures over south Asia for the next 2 moving 3-month seasons (total 4 months) with monthly update.

Prepare ENSO & IOD bulletin every month providing statement on the global SST anomalies and probabilities forecast with emphasis on the ENSO and IOD conditions for the next 9 months prepared based with monthly update.

Take lead role in preparing consensus forecast outlook for the monsoon season rainfall, northeast monsoon rainfall and winter rainfall over South Asia.

Acting as Lead Centre in conducting South Asia Climate Forum Activities for RA II Region and Conducting South Asian Seasonal Climate Outlook Forum (SASCOF) for generating consensus outlook for South Asian region for Summer Monsoon, Northeast Monsoon and December to February (DJF) Season. During the year 2023, three such SASCOF events were organized (SASCOF 25, SASCOF 26, and SASCOF 27).

Summary of SASCOF25

Normal to below normal rainfall is likely during the 2023 southwest monsoon season (June – September) over most parts of the South Asia. Geographically, above-normal rainfall is likely over northern most parts and northwest of the region as well as parts of eastern and southern regions of

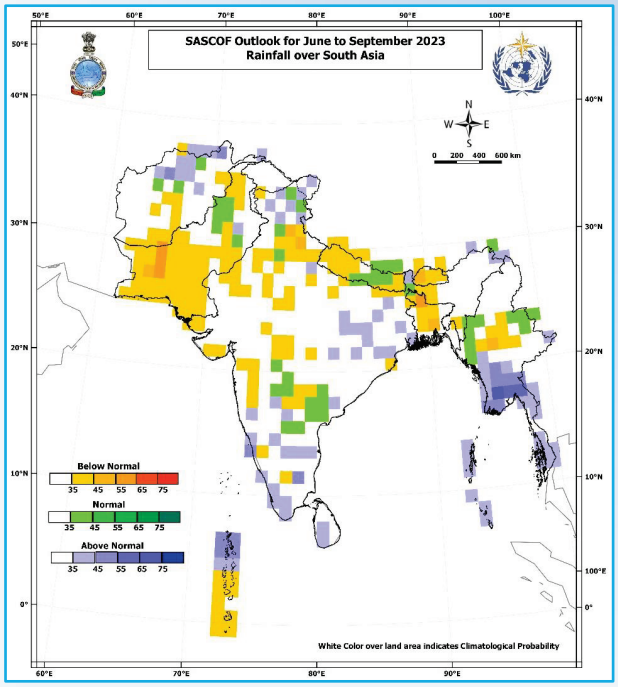


Fig. 14(a). Probability of the most likely category for the 2023 southwest monsoon rainfall over South Asia. (Tercile categories have equal climatological probabilities, of 33.33% each)

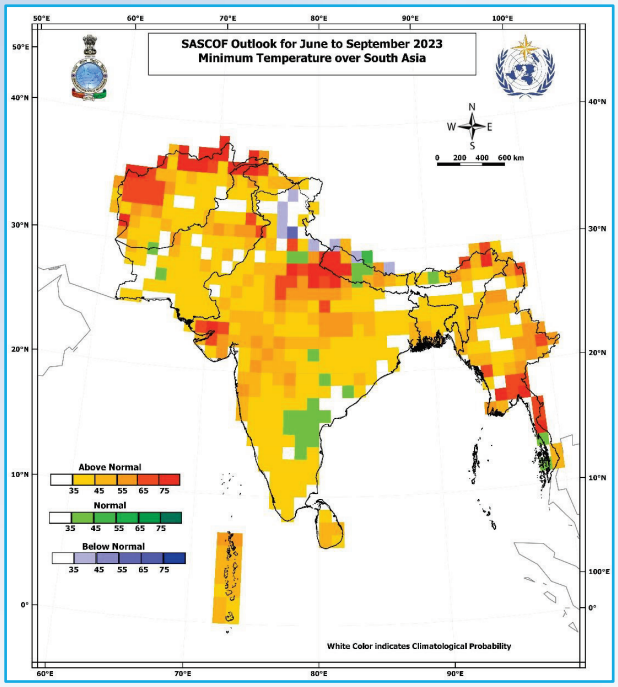


Fig. 14(b). Consensus outlook for the monsoon season (June to September, 2023) Minimum Temperature and over South Asia

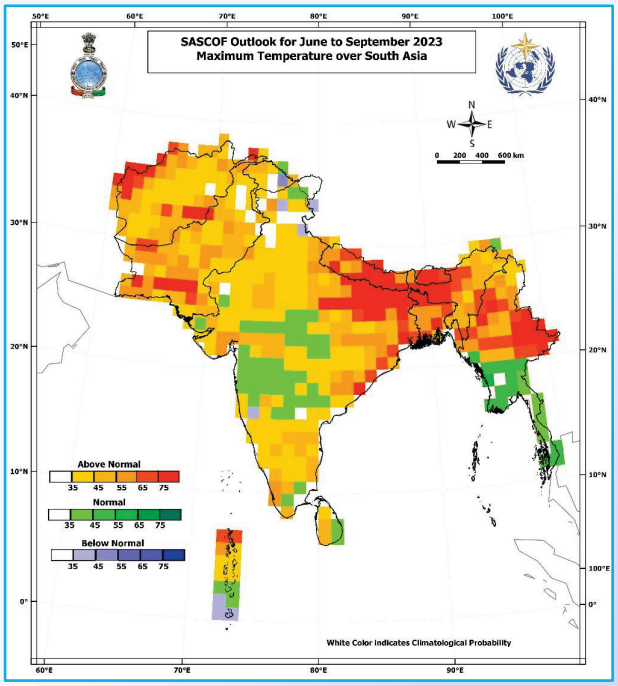


Fig. 14(c). Consensus outlook for the monsoon season (June to September, 2023) Maximum Temperature and over South Asia

South Asia. However, below normal rainfall is likely over some areas northwest, central and north-eastern parts of the region. The seasonal rainfall is likely to be normal or of climatological probabilities over the remaining areas of the region.

During the season, above normal minimum temperatures are likely over most parts of South Asia except parts of the foothills of Himalaya. The seasonal maximum temperatures are most likely to be above normal over most parts of the region except central and parts of the southern region of South Asia.

Summary of SASCOF26

Twenty-sixth Session of South Asian Climate Outlook Forum (SASCOF-26) and Climate Services User Forum (CSUF) conducted on 26th - 27th, September, 2023. The aim of SASCOF-26 was to prepare the Consensus Outlook for 2023 winter season covering the months from October to December. The Climate Services User Forum (CSUF) which conducted on the 3rd of October 2023 had focus on interface with users from the various application sectors to interpret seasonal climate information and understand their specific needs with a view to further customizing climate information.

Summary of SASCOF27

Above-normal precipitation is likely during the winter season (December 2023 to February 2024) over many regions of South Asia especially over parts of the north, northwest, along the foothills of the Himalayas and the north-eastern part of South Asia. Below normal precipitation is likely over the parts of the western region and some regions of the northeast and southern part of South Asia.

During the season, above normal minimum temperatures are likely over most areas of South Asia. Normal to Above normal maximum temperatures are most likely over many area of South Asia especially over north, northwest, south, northeast regions and along the Himalayas. Below normal maximum temperatures are likely over central part of the region and foothills of Himalaya.

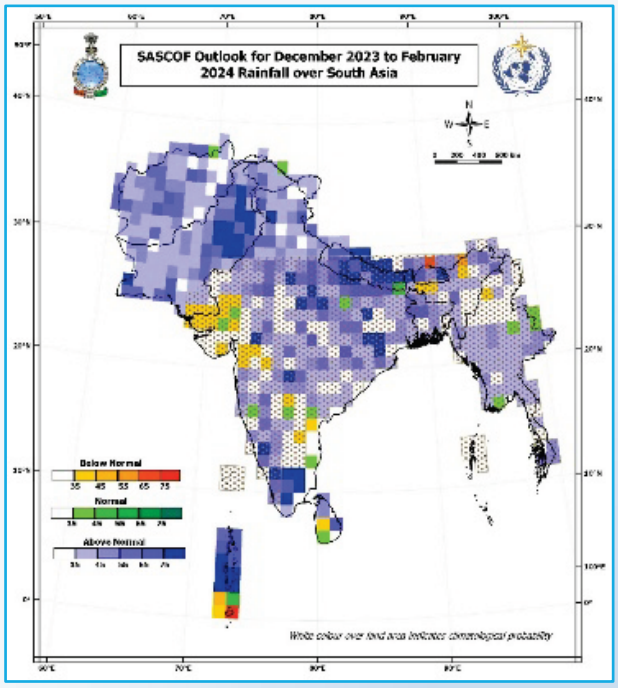


Fig. 15(a).Consensus outlook for the winter season (December 2023 to February 2024) precipitation over South Asia. The dotted area shown in the map climatologically receivesvery low rainfall and experiences dry weather during the DJF season. (Tercile categories have equal climatological probabilities, of 33.33% each)

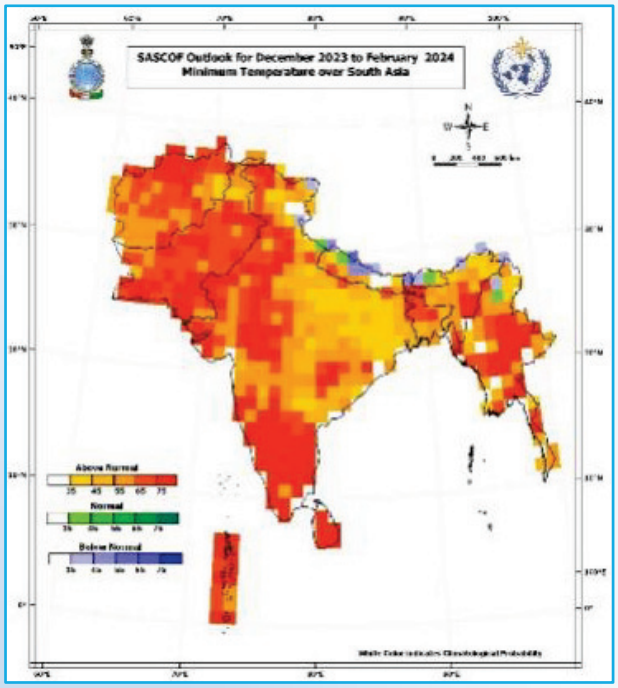


Fig. 15(b). Consensus outlook for the winter season (December 2023 to February 2024) Minimum Temperature over South Asia

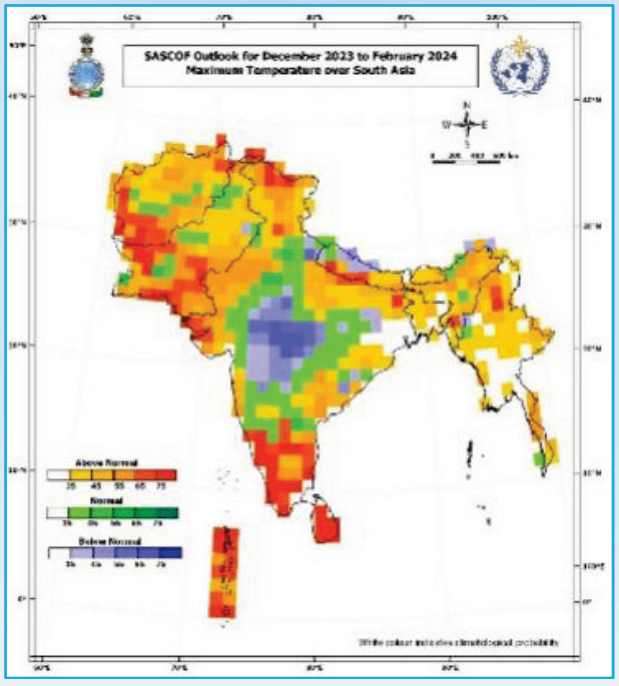


Fig. 15(c). Consensus outlook for the winter season (December 2023 to February 2024) Maximum Temperature over South Asia

Regional Climate Centre (RCC) Activities during January to March 2023

During January to March 2023, following RCC activities have been carried out as shown in Table 5.

TABLE 5

Details of various seasonal forecasts issued by RCC, IMD, Pune

S. No.	Issued Bulletin/Outlook	Month of Issue	Details of Forecast
1.	Climate Outlook for South Asia	Jan, Feb & Mar	Precipitation & Temperature forecast for next 2 seasons
2.	ENSO Bulletin	Jan, Feb & Mar	ENSO & IOD forecast for next 7 seasons

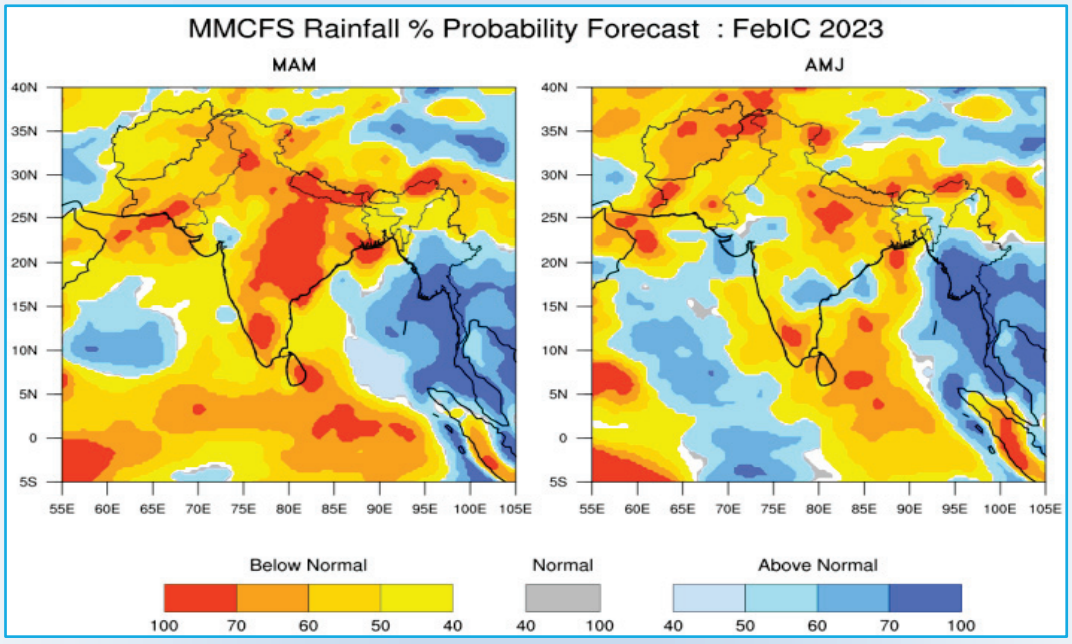


Fig. 16. Seasonal probability (%) forecasts of MAM & AMJ season for Precipitation based on Initial conditions of Feb 2023 for South Asia

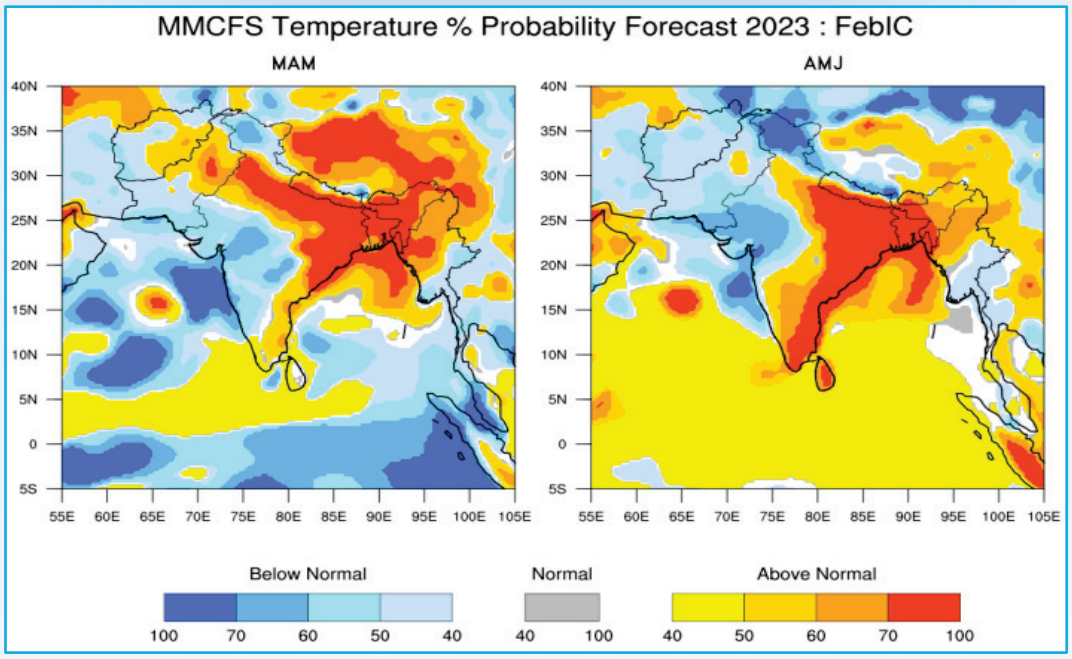


Fig. 17. Seasonal probability (%) forecasts of MAM & AMJ season for Temperature based on Initial conditions of Feb 2023 for South Asia

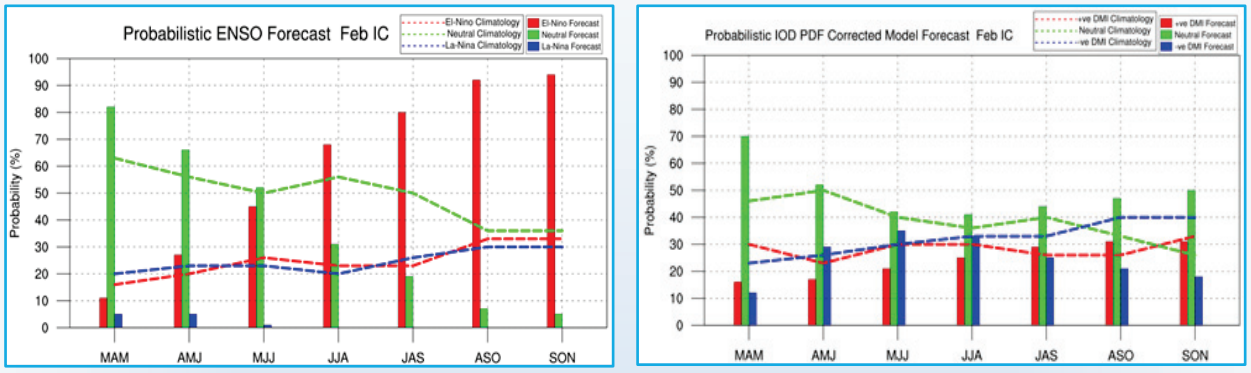


Fig. 18. Probabilistic forecast for ESNO (left) and IOD (right) prepared using MMCFS Feb I(c)

Regional Climate Centre (RCC) Activities, May to August 2023

For this quarter two Seasonal Climate Outlook for rainfall and temperatures over south Asia were prepared. The details are as follows.

Summary of Seasonal climate outlook for South Asia using April IC (May - August 2023)

- The probability forecast for precipitation for MJJ and JJA indicates that enhanced probability of below normal precipitation is likely over most parts of South Asia except over some parts of northwest, southeast, extreme south and northeast of peninsula where above normal precipitation is likely. (Fig. 19).

- Temperature probability forecast for MJJ season indicates that enhanced probability of below normal temperatures is likely over most parts of northwest and north along the plains of Himalayas and enhanced probability of above normal temperatures is likely over most parts of west, central, eastern and extreme southern parts of South Asia. Northeast and southern region of South Asia is likely to have climatological probability. The JJA season indicates that enhanced probability of above normal temperatures is likely over most parts of South Asia except over some parts of extreme northwest, north along the foothills of Himalayas and southeast region where enhanced probability of below normal temperatures is likely. (Fig. 20).

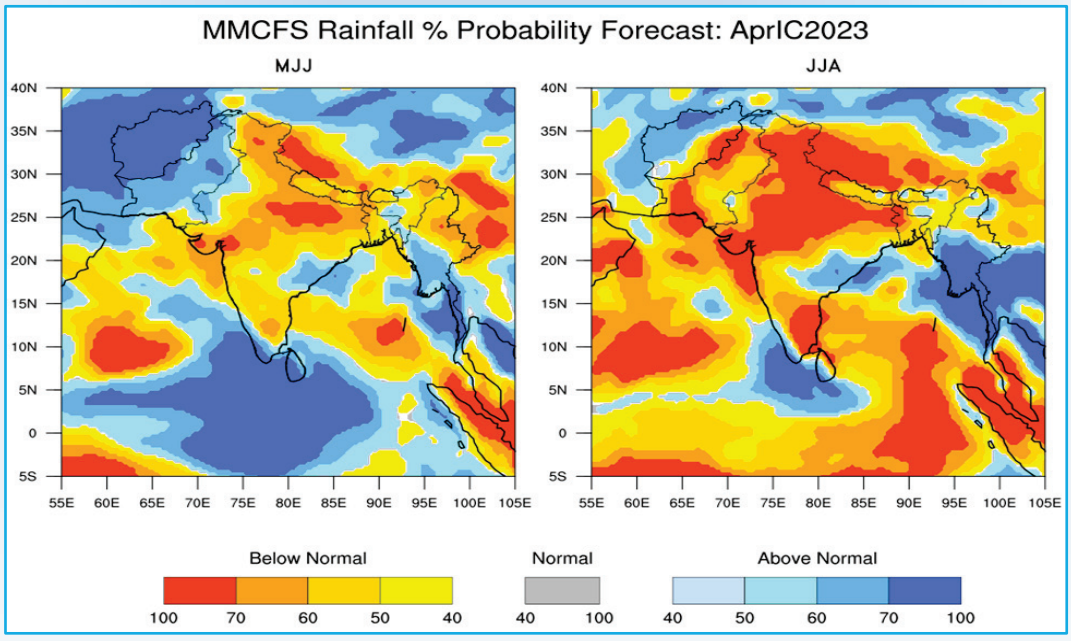


Fig. 19. Seasonal probability (%) forecasts of precipitation for (a) MJJ 2023 (left) and (b) JJA 2023 (right) based on initial conditions of April 2023

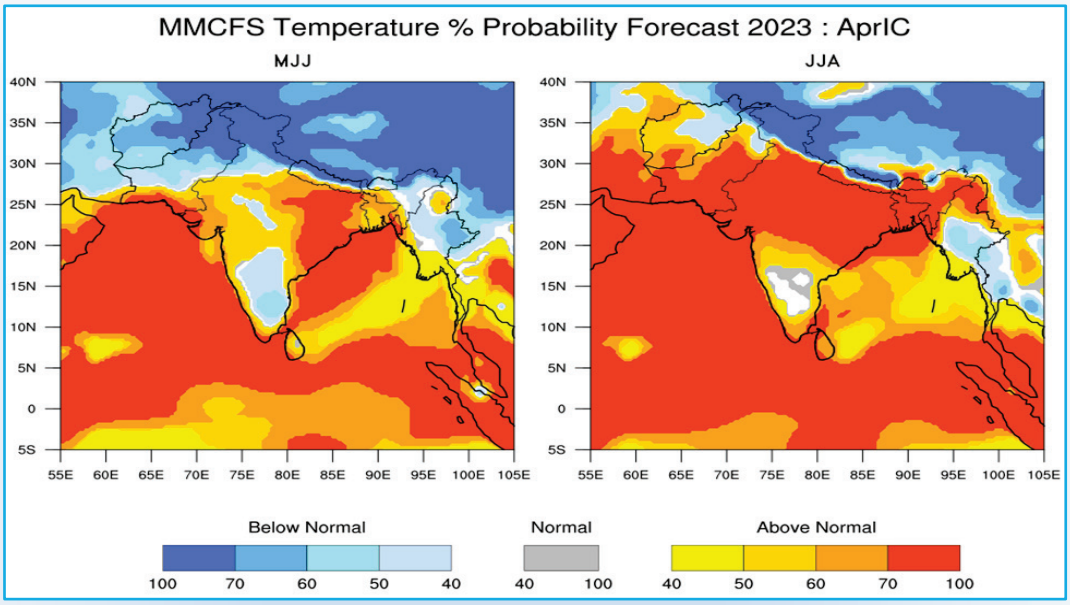


Fig. 20. Seasonal probability (%) forecasts of temperature for (a) MJJ 2023 (left) and (b) JJA 2023 (right) based on initial conditions of April 2023

Summary of Seasonal climate outlook for South Asia using May IC (Jun - Aug 2023)

- The probability forecast for precipitation for June – August (JJA) indicates that enhanced probability of below normal precipitation over some parts of northwest and most parts of west, north along the Himalayan plains, central, east, northeast, south peninsular region and extreme south of South Asia while enhanced probability of above normal precipitation is likely over most parts of northwest, north peninsular region and southeast of South Asia. The same for July - September (JAS) indicates that enhanced probability of below normal precipitation is likely over most parts of northwest, west, north along the Himalayan plains, central, east and extreme south of South Asia while enhanced probability of below normal precipitation is likely over most parts of peninsular region, northeast and southeast of South Asia (Fig. 21).

- Temperature probability forecast for JJA and JAS seasons indicates that enhanced probability of above normal temperatures is likely over most parts of northwest, west, central, east and northeast and southeast and southern most parts of south Asia and enhanced probability of below normal temperatures is likely over north along the plains of Himalayas (Fig. 22).

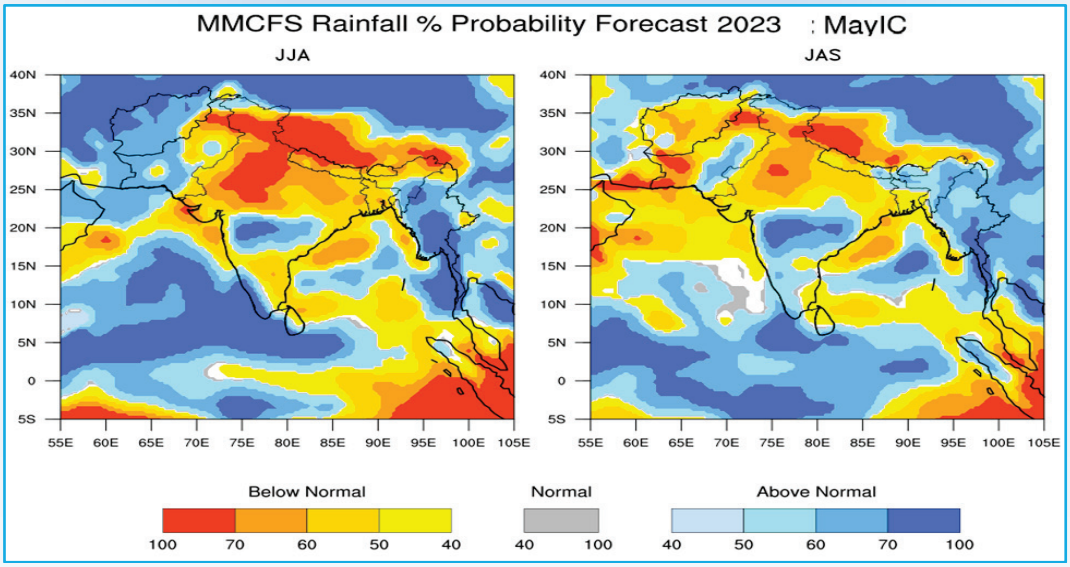


Fig. 21. Seasonal probability (%) forecasts of precipitation for (a) JJA 2023 (left) and (b) JAS 2023 (right) based on initial conditions of May 2023

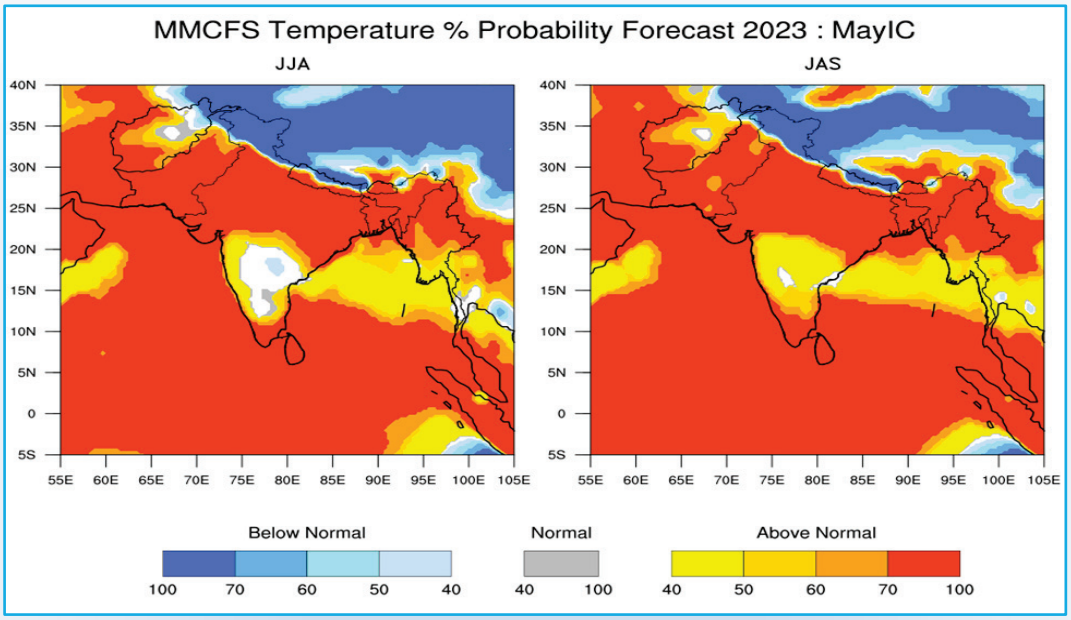


Fig. 22. Seasonal probability (%) forecasts of temperature for (a) JJA 2023 (left) and (b) JAS 2023 (right) based on initial conditions of May 2023

Prepare ENSO & IOD bulletin every month providing statement on the global SST anomalies and probabilities forecast with emphasis on the ENSO and IOD conditions for the next 9 months prepared based with monthly update.

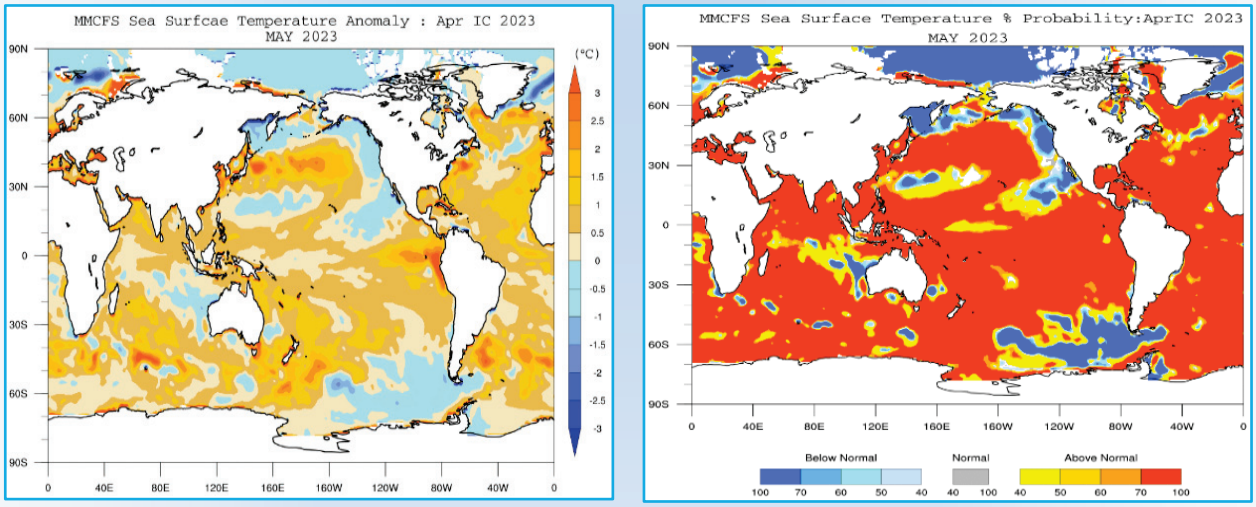


Fig. 23. Gives the Global sea surface temperature anomaly and probability forecast for the month of May 2023 using the April initial conditions

Summary

Normal to below normal rainfall is likely during the 2023 southwest monsoon season (June - September) over most parts of the South Asia. Geographically, above normal rainfall is likely over northern most parts and northwest of the region as well as parts of eastern and southern regions of South Asia. However, below normal rainfall is likely over some areas northwest, central and north-eastern parts of the region. The seasonal rainfall is likely to be normal or of climatological probabilities over the remaining areas of the region.

During the season, above normal minimum temperatures are likely over most parts of South Asia except parts of the foothills of Himalaya. The seasonal maximum temperatures are most likely to be above normal over most parts of the region except central and parts of the southern region of South Asia.

This regional climate outlook for the 2023 southwest monsoon season over South Asia has been collaboratively developed by all nine National Meteorological and Hydrological Services (NMHSs) of South Asia with the support from international experts at the 25th session of the South Asian Climate Outlook Forum (SASCOF-25) conducted online. The process involved an expert assessment of the prevailing global climate conditions and forecasts from different climate models from around the world.

The multi-year La Niña has ended around March 2023 and currently neutral conditions are prevailing over the tropical Pacific Ocean. Based on the global climate model forecasts, there is strong consensus among experts that the El Niño conditions are likely to develop during the southwest monsoon season. However, there is uncertainty in its strength and the time of its onset. It is recognized that the global climate model predictions prior to and during the spring season generally have noticeable uncertainty due to spring barrier in the seasonal predictability. It is also recognized that other regional and global factors as well as the intra-seasonal features of the region can also affect the seasonal climate patterns over the region.

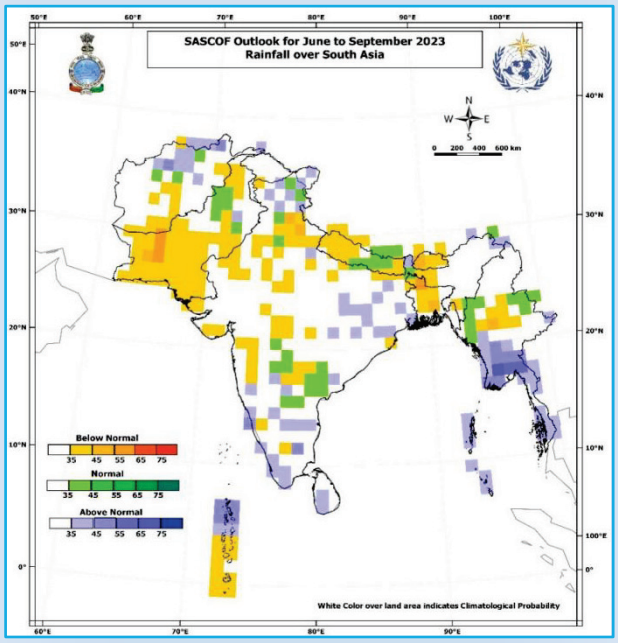


Fig. 24. Probability of the most likely category for the 2023 southwest monsoon rainfall over South Asia

a) Climate Research and Services (CRS), India Meteorological Department (IMD), Pune has brought out the "State-wise annual climate statement for the year 2022" in line with the annual climate statement prepared for the country. This work is output of the collaboration between IMD and state governments. The statement of climate is attempting to capture the regional climate variability of the state especially with reference to weather parameters like; temperature and rainfall which has huge impact on various sectors like agriculture, health, power, water Management and many other critical domains. This statement on climate of 2022 also includes the inputs like loss and damage data due to severe weather and other weather-related factors which are received from the respective state governments. This yearly update with climatological perspectives, will create more awareness among all the stakeholders in the state. In addition to extreme weather event data is very important to disaster management for future course of planning. The annual statements for all the states are available in the following link: https://www.imdpune.gov.in/Reports/Statewise%20annual%20climate/statewise_annual_climate.html

Regional Climate Centre (RCC) Activities during July - September 2023

Monthly and seasonal ENSO & IOD bulletins with monthly update are carried out under RCC, Pune. Fig. 25 shows ENSO & IOD forecast for next 7 seasons.

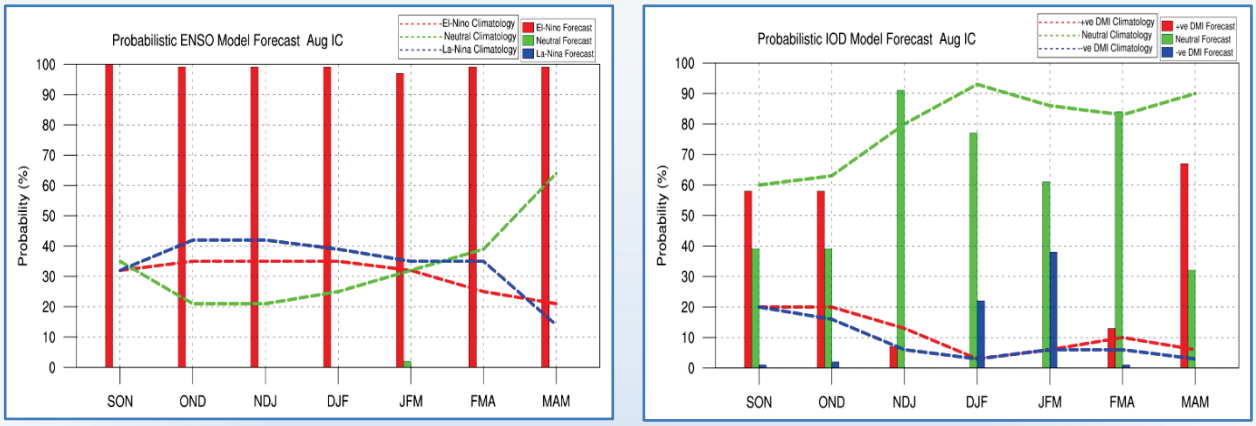


Fig. 25. Probabilistic forecast for ESNO (right) and IOD (left) prepared using MMCFS Aug I(c)

For this quarter two Seasonal Climate Outlook for rainfall and temperatures over South Asia were prepared. The details are as follows.

(i) Summary of Seasonal climate outlook for South Asia using July IC (August - November 2023)

The probability forecast for precipitation for August - October (ASO) and September - November (SON) indicates that enhanced probability of below normal precipitation is likely over most parts of South Asia except over some parts of northwest, southeast and Peninsular region where enhanced probability of above normal precipitation is likely (Fig. 26).

Temperature probability forecast for ASO and SON seasons indicates that enhanced probability of above normal temperatures is likely over most parts of South Asia except over some parts of north along the Himalayan Plains where probability of below normal temperature is likely (Fig. 27).

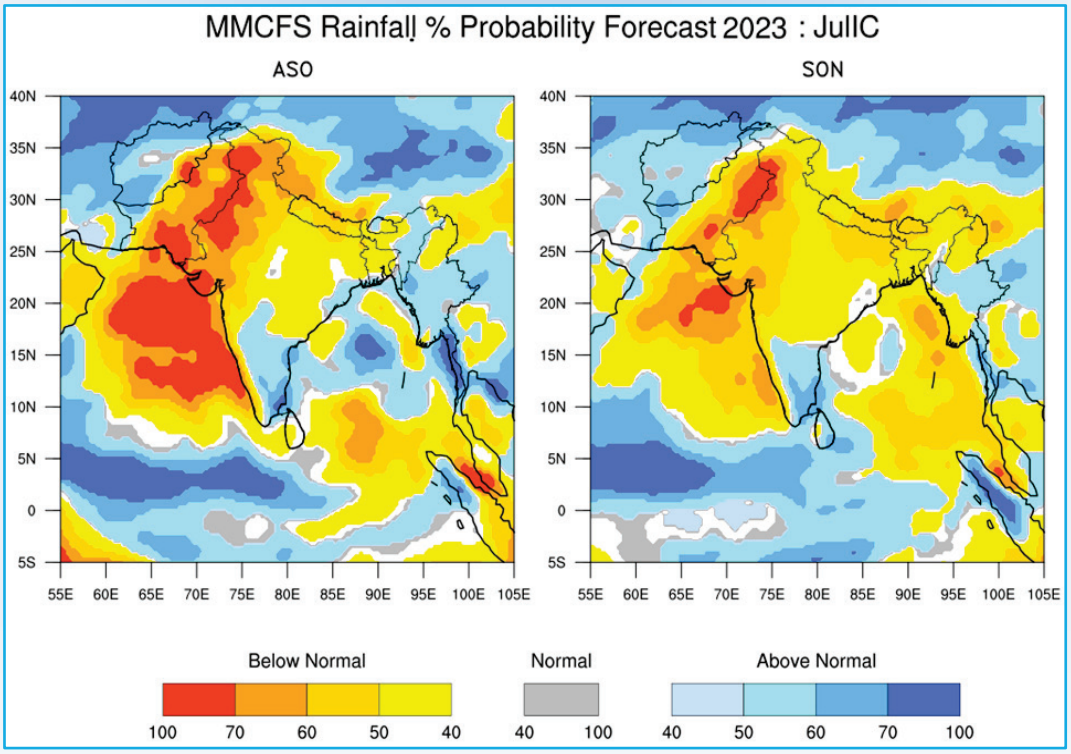


Fig. 26. Seasonal probability (%) forecasts of precipitation for (a) ASO 2023 (left) and (b) SON 2023 (right) based on initial conditions of July 2023. The white colour indicates climatological probability

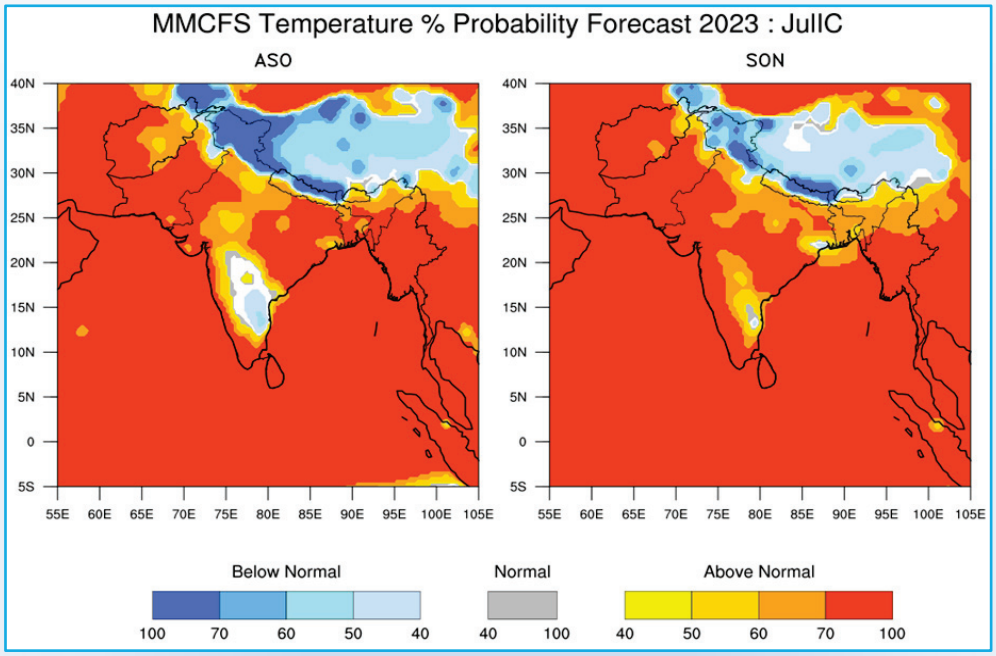


Fig. 27. Probability (%) forecast for the seasonal mean temperature for (a) ASO 2023 (left) and (b) SON 2023 (right) based on initial conditions of July 2023

(ii) Summary of Seasonal climate outlook for South Asia using August IC (September – December 2023)

The probability forecast for precipitation for September - November (SON) indicates enhanced probability of above normal precipitation in extreme northwest, northeast and south Peninsular regions and enhanced probability of below normal precipitation in north, west, central, east and north peninsular regions of South Asia. The same for October - December (OND) indicates that enhanced probability of above normal precipitation is likely over most parts of South Asia except over some parts of north Peninsular regions and central parts of South Asia where enhanced probability of below normal precipitation is likely (Fig. 28).

Temperature probability forecast for SON and OND seasons indicates that enhanced probability of above normal temperatures is likely over most parts of South Asia except over some parts of north along the Himalayan Plains where probability of below normal temperature is likely (Fig. 29).

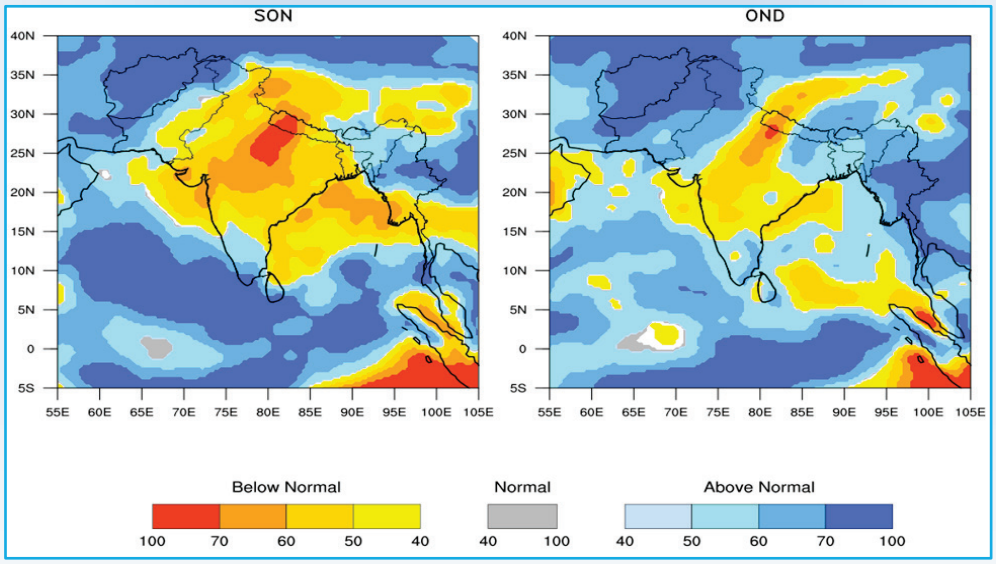


Fig. 28. Seasonal probability (%) forecasts of precipitation for (a) SON 2023 (left) and (b) OND 2023 (right) based on initial conditions of August 2023

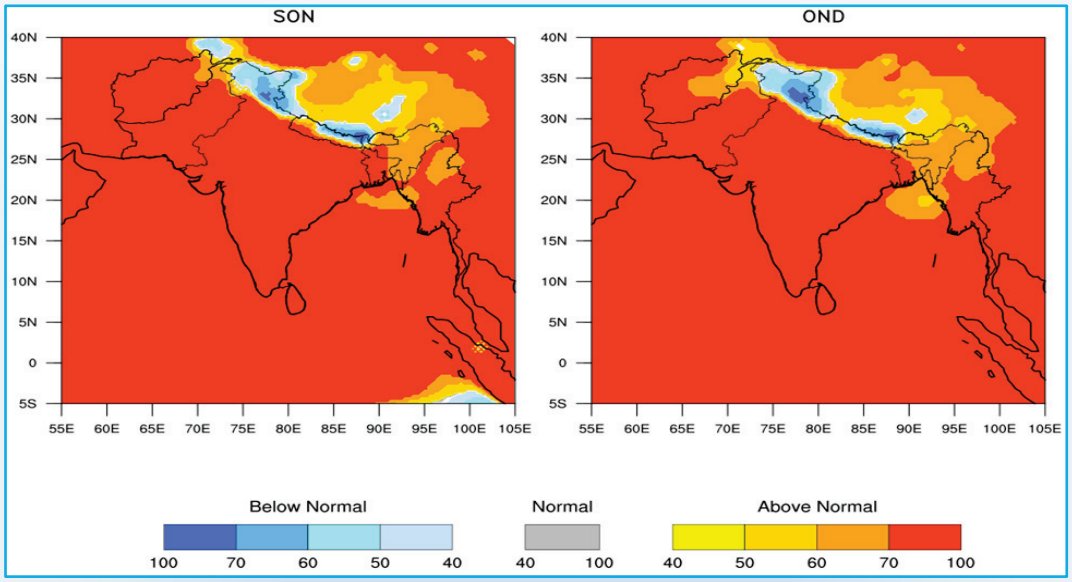


Fig. 29. Probability (%) forecast for the seasonal mean temperature for (a) SON 2023 (left) and (b) OND 2023 (right) based on initial conditions of August 2023

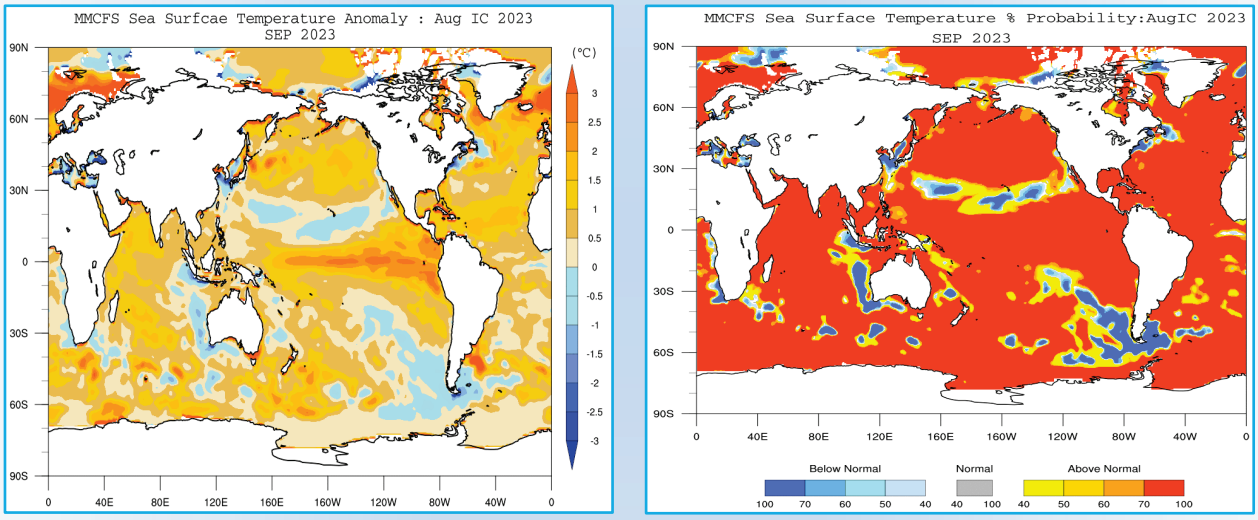


Fig. 30. Global Sea surface temperature anomaly and probability forecast for the month of September 2023 using the August 2023 initial conditions

(iii) Prepare ENSO & IOD bulletin every month providing statement on the global SST anomalies and probabilities forecast with emphasis on the ENSO and IOD conditions for the next 9 months prepared based with monthly update. Fig. 30 gives the Global sea surface temperature anomaly and probability forecast for the month of September 2023 using the August 2023 initial conditions.

(iv) Take lead role in preparing consensus forecast outlook for the monsoon season rainfall, northeast monsoon rainfall and winter rainfall over south Asia.

(v) Acting as Lead Centre in conducting South Asia Climate Forum Activities for RA II Region and Conducting SASCOF for generating consensus outlook for South Asian region for Summer Monsoon, Northeast Monsoon and December to February (DJF) Season.

5.5. Cyclone Monitoring & Prediction

5.5.1. Salient features of the cyclonic disturbances over the North Indian Ocean during 2023

The salient features of the cyclonic disturbances (CDs) over the north Indian Ocean (NIO) during the year 2022, the operational forecast performance of India Meteorological Department (IMD) and

new initiatives during the year are presented below:

1. Salient features of CDs over the NIO

Following CDs developed over the NIO during 2023:

2. Salient features of CDs over the NIO

(i) Depression over Southwest & adjoining Southeast Bay of Bengal : 30 January – 02 February
(ii) Extremely Severe Cyclonic Storm MOCHA over Bay of Bengal : 09 – 15 May
(iii) Extremely Severe Cyclonic Storm over Bay of Bengal BIPARJOY : 06 – 19 June
(iv) Deep Depression over the Northeast Bay of Bengal : 1 – 3 August
(v) Depression over Arabian Sea : 30 September – 01 October
(vi) Extremely Severe Cyclonic Storm TEJ over Arabian Sea : 20 – 24 October
(vii) Very Severe Cyclonic Storm HAMOON over Bay of Bengal : 21 – 25 October
(viii) Cyclonic Storm MIDHILI over Bay of Bengal: 15 - 18 November
(ix) Severe Cyclonic Storm MICHAUNG over Bay of Bengal : 01 - 06 December.

Observed tracks of the CDs during 2023 are presented in Fig. 31.

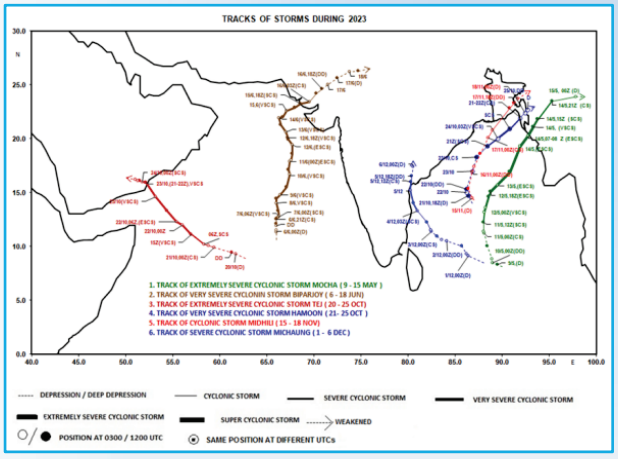


Fig. 31. Tracks of cyclonic disturbances over the North Indian Ocean during 2023

The salient features of the cyclonic disturbances (CDs) over the north Indian Ocean (NIO) during the year 2023, the operational forecast performance of India Meteorological Department (IMD) and new initiatives during the year are presented below:

Annual activity : 9 CDs (maximum sustained wind speed (MSW) ≥ 17 knots) developed over the NIO against the normal of 11.2 per year during 1965-2022. Thus, annual activity of formation of CDs was below normal during the year 2023.

Category-wise activity : There were 2 Depressions and 1 Deep Depressions (MSW : 17-33 knots) (Normal : 6.5 per year) (Less than Normal), 1 Cyclonic Storm (MSW : 34-47 knots) (Normal : 1.8 per year) (Less than Normal), 1 Severe Cyclonic Storm (MSW : 48-63 knots) (Normal : 2.9 per year) (Less than Normal), 1 Very Severe Cyclonic Storm (MSW : 64-89 knots) (Normal : 2.9 per year) (Less than Normal), and 3 Extremely Severe Cyclonic Storms (MSW : 90-119 knots) (Normal : 2.9 per year) (Above Normal) during the year 2023. A total of 6 cyclones (MSW≥ 34 knots) developed over the NIO during 2022 against normal of 4.7 per year. Overall, the frequency of formation of Disturbances over the region was less than normal except the Extremely Severe Cyclonic Storms category.

Basin-wise activity : There were 3 CDs over Arabian Sea (Normal: 2.3 per year) (Above Normal), 6 over Bay of Bengal (Normal : 7.8 per year) (Below Normal). Overall, Basin-wise activity wrt formation of CDs was above normal over Arabian Sea and below normal over Bay of Bengal.

Season-wise activity : There was 1 Depression during Winter Season (Jan-Feb) (Above Normal), 1 CD during pre-monsoon season (March-May) (Normal : 1.4 per year) (Below Normal), 3 CDs during monsoon season (Jun-Sep) (Normal : 4.9 per year) (Below Normal), 4 CDs during post-monsoon season (Oct-Dec) (Normal : 4.8 per year) (Below Normal). Overall activity was above normal only for the winter season. It was below normal all other seasons.

Unique features wrt lifetime of cyclones : Biparjoy has been one of the longest duration cyclones over the NIO including the Bay of Bengal (BoB) and the Arabian Sea (AS) with a total life period of 13 days and 3 hours (Depression to Depression). The average life period of the very severe cyclonic storm category during monsoon season over the

AS is 6 days and 3 hours based on the data during 1990-2013.

Tracks/Paths of cyclones (Straight/recurving) : All 6 cyclones had recurving tracks.

Landfall of cyclones : All 6 cyclones crossed the coast as cyclones (Normal : 3.2 per year). Overall frequency of landfalling cyclones was above normal.

(a). Extremely Severe Cyclonic Storm "MOCHA" over the BoB (9th - 15th May, 2023)

It developed from a low pressure area (LPA) that formed over southeast BoB and adjoining south Andaman Sea in the morning (0830 hrs IST) of 8th May 2023. It concentrated into a Depression in the same evening (1730 hrs IST) over Southeast BoB. It intensified into the Cyclonic Storm "Mocha" at 0530 hrs IST of May 11, 2023. It intensified into an extremely severe cyclonic storm (ESCS) on 1730 hrs IST of 12th May. It reached peak intensity of 110 knots over the eastcentralBoB on 2330 hrs IST of 13th May till 0530 hrs IST of 14th May. Eventually, the system weakened slightly and made landfall between Kyaukpyu (Myanmar) and Cox's Bazar (Bangladesh) as an Extremely Severe Cyclonic Storm on May 14, 2023. Thereafter, it moved west-northwestwards and rapidly weakened into a depression over northwest Myanmar in the morning (0530 hrs IST) of 15th May. Fig. 31.1 shows the observed track of the system.

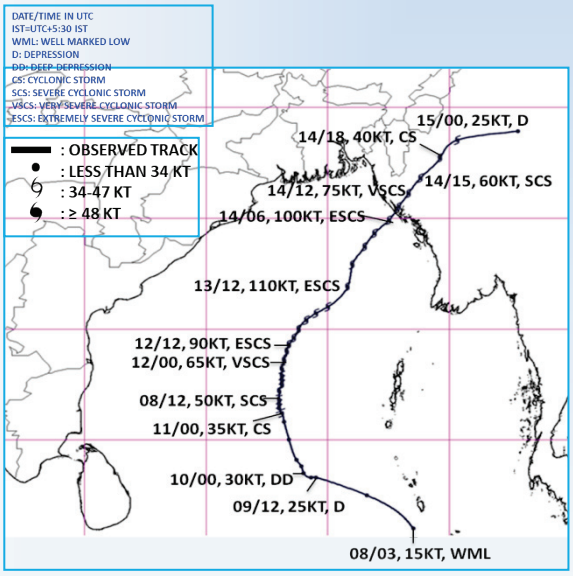


Fig. 31.1. Observed track of extremely severe cyclonic storm 'MOCHA" over the BoB during 9th-14th May, 2023

(a) 1.1. Forecast Performance

First information about likely cyclogenesis over southeast BoB and adjoining Andaman Sea around 9th May was issued in the extended range outlook issued on 27th April (about 12 days ahead of formation of depression).

On 4th May, it was indicated that the system would intensify into a cyclonic storm (about 7 days prior to formation of cyclonic storm "MOCHA" at 0530 hrs IST of 11th May), at a stage when even cyclonic circulation had not formed.

IMD issued first pre-genesis track forecast on 8th May on formation of low pressure area, indicating that the system would move initially north-northwestwards till 11th and thereafter recurve north-northeastwards towards Bangladesh-Myanmar coasts. The pre-genesis track forecast issued on 9th May indicated the movement of the system towards Myanmar (Fig. 31.2).

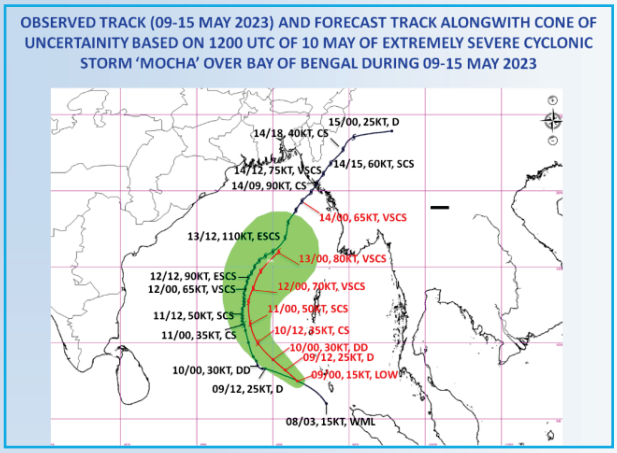


Fig. 31.2. Pre-genesis track and intensity forecast issued on 9th May morning at the stage of well-marked low pressure

Actually, low pressure area formed over southeast BoB& adjoining South Andaman Sea on 8th May, depression over southeast BoB on 9th May, CS over southeast BoB on 11th May and landfall occurred over Myanmar and adjoining Bangladesh coast on 14th May.

The first advisory issued on formation of depression indicated landfall over North Myanmar – Southeast Bangladesh coast around 14th May noon (about 90 hours prior to landfall). Typical track and intensity forecast issued on 11th May demonstrating the accuracy in track and landfall prediction is presented in Fig. 31.3.

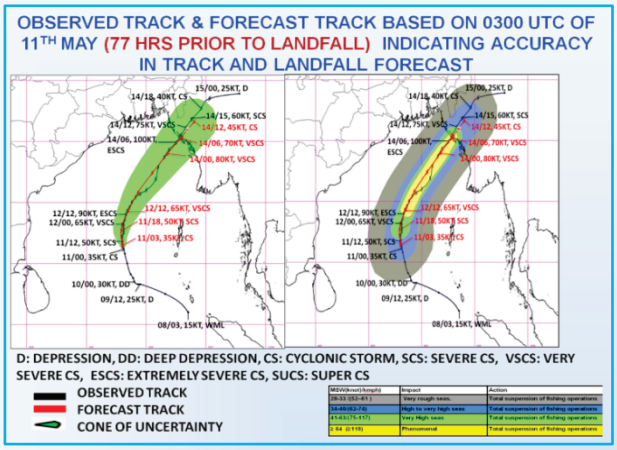
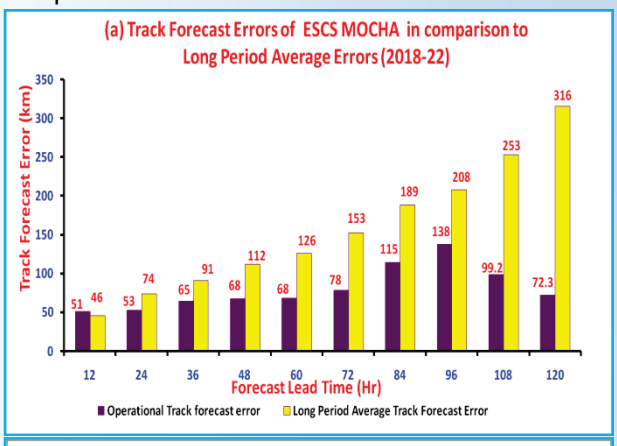
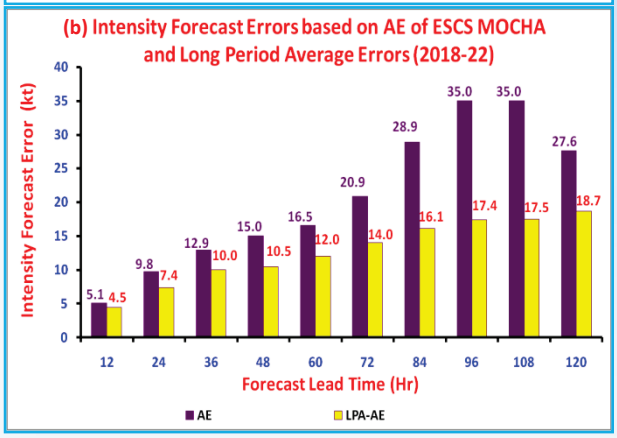


Fig. 31.3. Typical track and intensity forecast issued on 11th May morning demonstrating accuracy in track and landfall prediction (about 77 hours prior to landfall)

(a) 1.2. Operational Track, Intensity and Landfall Point & Time Forecast Errors

The track forecast errors for 24, 48 and 72 hrs lead period were 53, 68 and 78 km respectively against the long period average (LPA) errors (2018-22) of 74, 112 and 153 km respectively [Fig. 31.4(a)]. For all lead periods upto 120 hours, the operational track forecast errors were exceptionally less as compared to LPA errors.



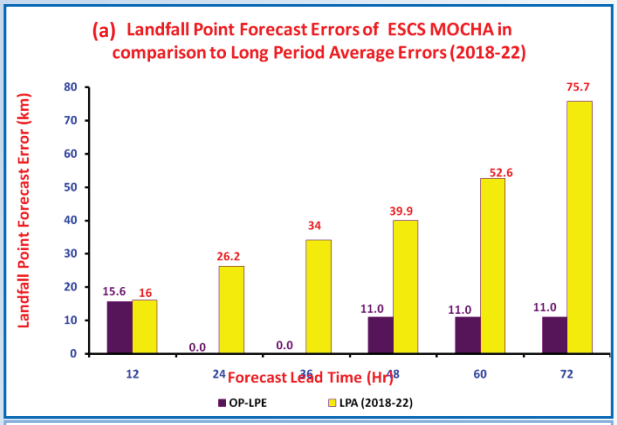


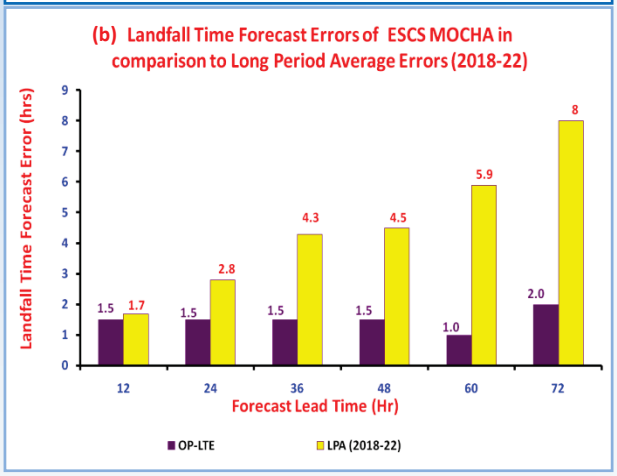
Figs. 31.4(a&b). Operational (a) track and (b) intensity forecast errors compared to long period average (LPA) during 2018-22

The absolute error (AE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 9.8, 15.0 and 20.9 knots against the LPA errors of 7.4, 10.5 and 14.0 knots during 2018-22 respectively [Fig. 31.4(b)]. The intensity forecast errors were higher than LPA as the impact of approaching trough in westerly that provided favourable environment for rapid intensification of the system could not be captured by the models.

The landfall point forecast errors for 24, 48 and 72 hrs lead period were zero, 11.0, 11.0 km respectively against the LPA errors (2018-22) of 26.2, 39.9 and 75.7 km during 2018-22 respectively [Fig. 31.5(a)]. There was almost zero error in landfall point forecast for all lead periods upto 96 hrs.

The landfall time forecast errors for 24, 48 and 72 hrs lead period were 1.5, 1.5 and 2.0 hours respectively against the LPA errors (2018-22) of 2.8, 4.5 and 8.0 hours during 2018-22 respectively [Fig. 31.5(b)]. For all lead periods upto 96 hrs, the landfall time errors were appreciably less than LPA errors.





Figs. 31.5(a&b). Operational landfall (a) point and (b) time forecast errors compared to long period average (LPA) during 2018-22

(b). Extremely Severe Cyclonic Storm "BIPARJOY" over the Arabian Sea (6th - 19th June, 2023)

It developed from an LPA over southeast AS in the evening (1730 hrs IST) of 5th June. It concentrated into a Depression in the early morning (0530 hrs IST) of 6th June over southeast AS. It moved nearly northwards and intensified into the Cyclonic Storm (CS) "BIPARJOY" pronounced as "BIPORJOY" over eastcentral and adjoining southeast AS in the evening (1730 hrs IST) of 6th June. Continuing to move further nearly northwards, it intensified into an Extremely Severe Cyclonic Storm (ESCS) over eastcentral AS in the early morning (0530 hrs IST) of 11th June and maintained its intensity till 2030 hrs IST of 12th June. Thereafter, it entered into an unfavourable environment and started weakening gradually from midnight (2330 hours IST) of 12th June, 2023. It crossed Saurashtra & Kutch and adjoining Pakistan coasts between Mandvi (Gujarat) and Karachi (Pakistan) close to Jakhau Port (Gujarat) near latitude 23.28°N and longitude 68.56°E between 2230 and 2330 hours IST of 15th June, 2023 as a VSCS with maximum sustained wind speed (MSW) of 115-125 kmph (65 knots) gusting to 140 kmph (75 knots). After landfall, it weakened gradually into a deep depression over South Rajasthan and adjoining North Gujarat in the midnight (2330 hours IST) of 16th June and into a WML over central parts of Northeast Rajasthan and neighbourhood in the morning (0830 hours IST) of 19th June. Observed track of ESCS Biparjoy is presented in Fig. 32.1.

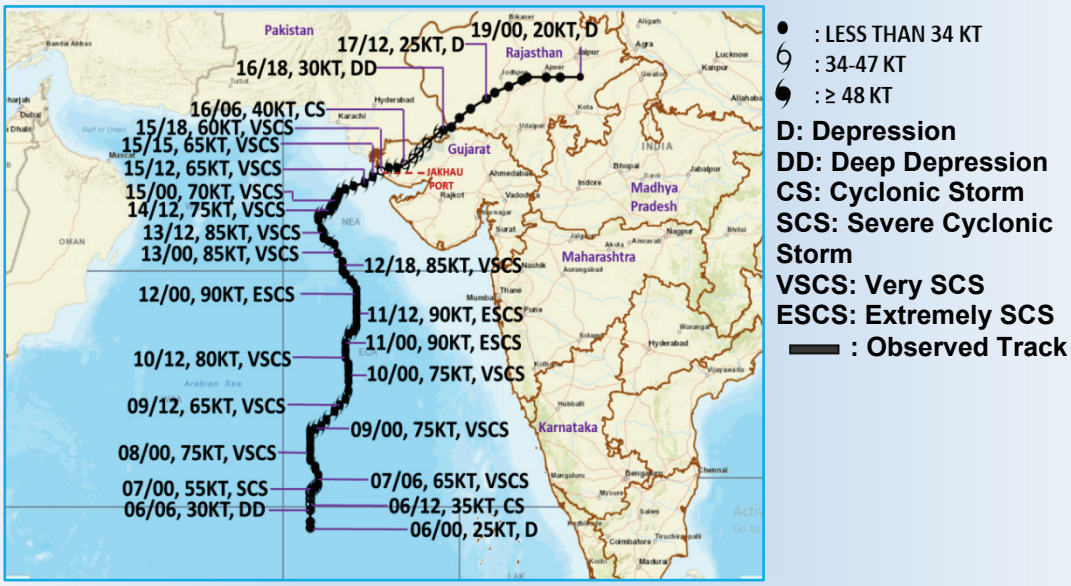


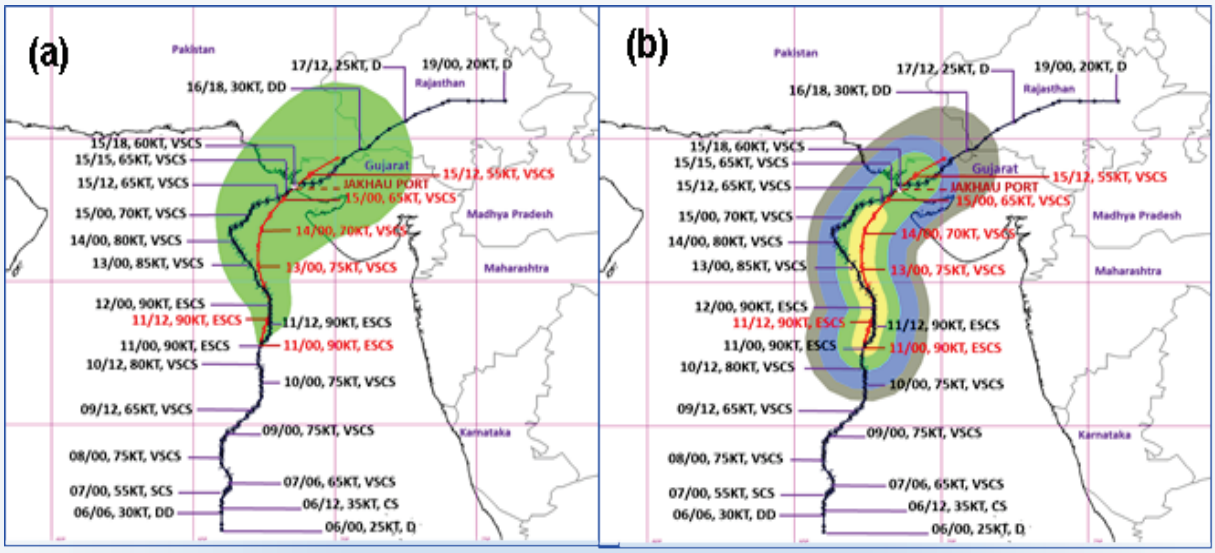
Fig. 32.1. Observed track of ESCS 'BIPARJOY" over the AS during 6th - 19th June, 2023

(b) 1.1. Forecast Performance

First information about likely cyclogenesis over southeast AS during the week (2nd - 8th June), around 6th June was issued in the extended range outlook issued on 1st June.

The first advisory issued by IMD based on 0530 hours IST observations of 6th June, on formation of depression, indicated movement of the system towards central Arabian Sea. It was also indicated that the system would intensify further upto very severe cyclonic storm stage. However, no landfall was indicated in this forecast as it was beyond five day forecast period. Subsequently, from 11th June (1130 hours IST) onwards landfall over Saurashtra & Kutch coast close to Jakhau airport was indicated. Typical track and intensity forecast issued on 11th June (about 110 hours prior to landfall) demonstrating the accuracy in track, intensity and landfall prediction is presented in Fig. 32.2.

Typical track & intensity forecast with cone of uncertainty and wind distribution based on 1730 hours IST of 9th June (about 6 days and 6 hours prior to landfall) and 0530 hours 12th June (3 days and 18 hours prior to landfall) are presented in Fig. 32.3.

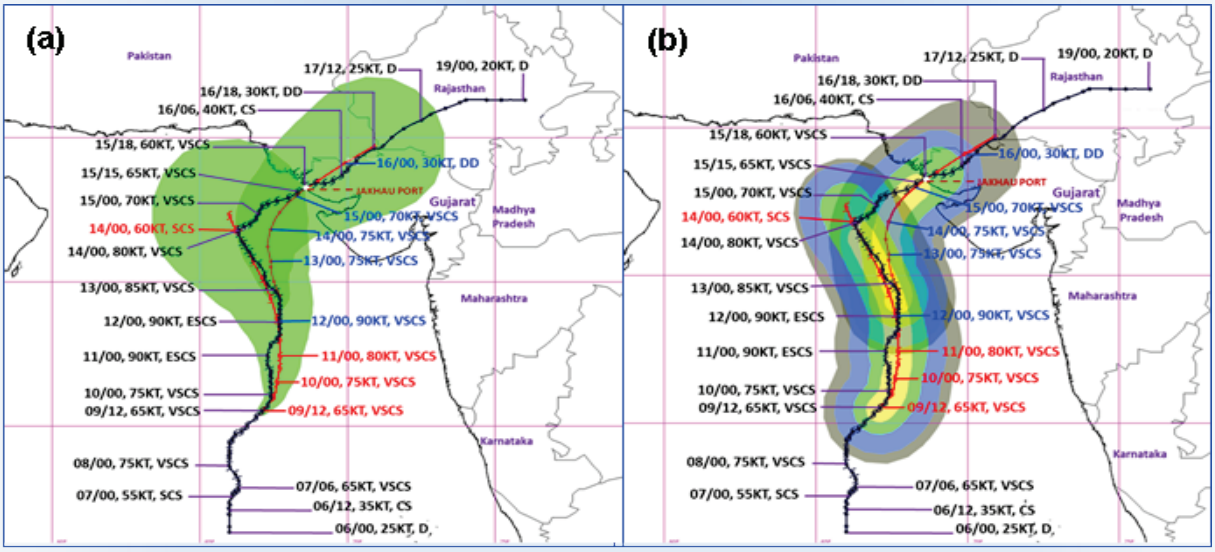


Figs. 32.2(a&b). Observed track and forecast track along with (a) cone of uncertainty in track forecast and (b) wind distribution issued on 11th June based on 0000 UTC (0530 IST) observations demonstrating accuracy in track, landfall point and intensity prediction (about 4 days 18 hrs prior to landfall)

D: DEPRESSION, DD: DEEP DEPRESSION, CS: CYCLONIC STORM, SCS: SEVERE CS, VSCS: VERY SEVERE CS, ESCS: EXTREMELY SEVERE CS, SUCS: SUPER CS

OBSERVED TRACK
FORECAST TRACK
CONE OF UNCERTAINTY

: LESS THAN 34 KT
: 34-47 KT
: ≥ 48 KT



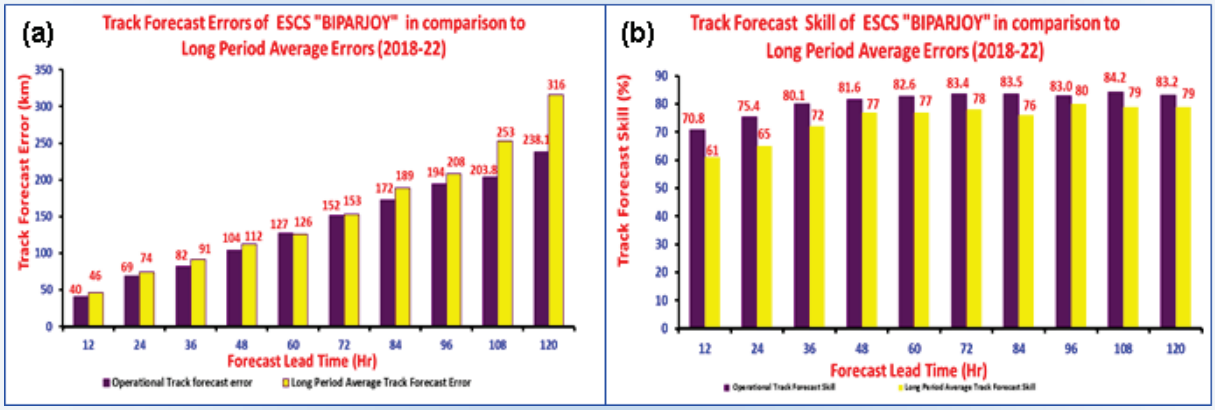
MSW(knot)/kmph)	Impact	Action
28-33 /(52–61)	Very rough seas.	Total suspension of fishing operations
34-40/(62-74)	High to very high seas	Total suspension of fishing operations
41-63/(75-117)	Very High seas	Total suspension of fishing operations
≥ 64 (≥118)	Phenomenal	Total suspension of fishing operations

Figs. 32.3(a&b). Typical track and intensity forecast along with (a) cone of uncertainty and (b) wind distribution issued on 9th June evening (1730 hrs IST) about 6 days and 6 hours prior to landfall and 12th June morning (0000 UTC/ 0530 hours IST) about 4 days and 18 hours prior to landfall demonstrating accuracy in track, intensity and landfall prediction

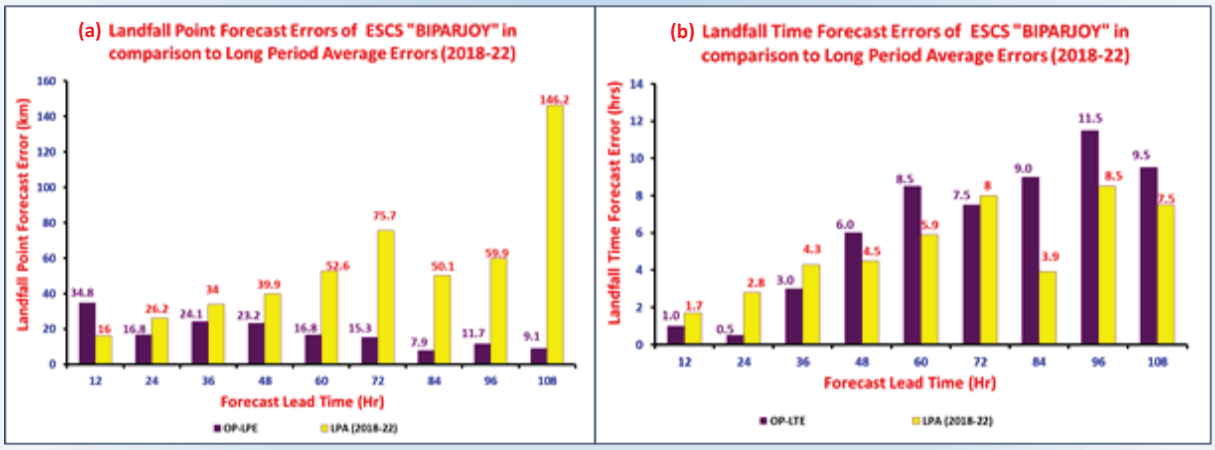
(b) 1.2. Operational Track, Intensity and Landfall Point & Time Forecast Errors

The track forecast accuracy for 24, 48, 72, 96 and 120 hrs lead period were 69, 104, 152, 194, 238 km respectively against the long period average (LPA) errors (2018-22) of 74, 112, 153, 208 and 316 km respectively [Fig. 32.4(a)]. For all lead periods upto 120 hours, the operational track forecast errors were less than LPA errors.

The track forecast skill for 24, 48 and 72 hrs lead period were 75, 82, 83, 83 and 83 % respectively against the LPA skill (2018-22) of 65, 77, 78, 80 and 79 % respectively [Fig. 32.4(b)]. For all lead periods upto 120 hours, the operational track forecast skill was more than the LPA skill.



Figs. 32.4(a&b). Operational (a) track forecast accuracy and (b) track forecast skill of cyclone Biparjoy compared to long period average (LPA) during 2018-22

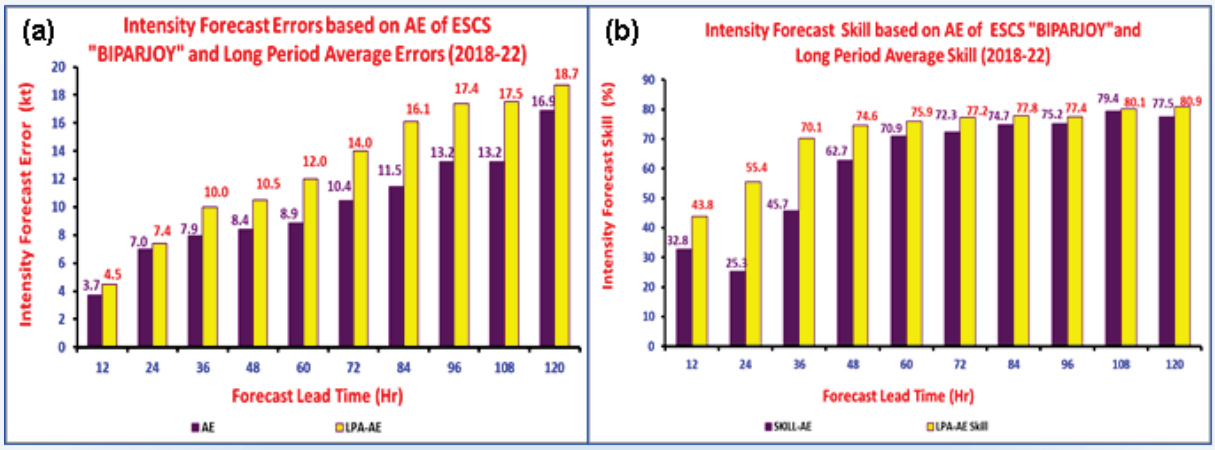


Figs. 32.5(a&b). Operational landfall (a) point and (b) time forecast accuracy of cyclone Biparjoy compared to long period average (LPA) during 2018-22

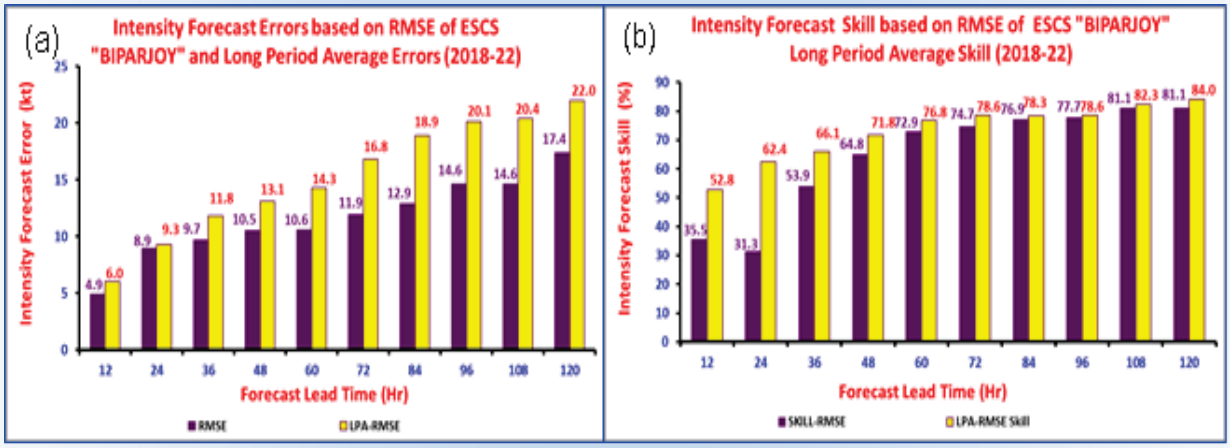
The accuracy in landfall point forecast for 24, 48, 72 and 96 hrs lead period was 16.8, 23.2, 15.3 and 11.7 km respectively against the LPA errors (2018-22) of 26.2, 39.9, 75.7 and 59.9 km during 2018-22 respectively [Fig. 32.5(a)]. For 24 to 96 hours lead period, the landfall point forecast accuracy varied between 10-23 km.

The landfall time forecast errors for 24, 48, 72 and 96 hrs lead period were 0.5, 6.0, 7.5 and 11.5 hours respectively against the LPA errors (2018-22) of 2.8, 4.5, 8.0 and 8.5 hours during 2018-22 respectively [Fig. 32.5(b)].

The absolute errors (AE) of intensity (wind) forecast for 24, 48, 72, 96 and 120 hrs lead period were 7.0, 8.4, 10.4, 13.2 and 16.9 knots against the LPA errors of 7.4, 10.5, 14.0, 17.4 and 18.7 knots during 2018-22 respectively [Fig. 32.6(a)]. For all lead periods upto 120 hours, the accuracy in



Figs. 32.6(a&b). Operational (a) Absolute errors (AE) and (b) skill in intensity forecast of cyclone Biparjoy compared to long period average (LPA) during 2018-22



Figs. 32.7(a&b). Operational (a) Root Mean Square Error (RMSE) and (b) skill in intensity forecast compared to long period average (LPA) during 2018-22

prediction of intensity was more than the LPA errors.

The skill in intensity forecast based on AE for 24, 48, 72, 96 and 120 hrs lead period was 25.3, 62.7, 72.3, 75.2 and 77.5 % against the LPA skill of 55.4, 74.6, 77.2, 77.4 and 80.9 % during 2018-22 respectively [Fig. 32.6(b)].

The root mean square error (RMSE) of intensity (wind) forecast for 24, 48, 72, 96 and 120 hrs lead period were 8.9, 10.5, 11.9, 14.6 and 17.4 knots against the LPA errors of 9.3, 13.1, 16.8, 20.1 and 22.0 knots during 2018-22 respectively [Fig. 32.7(a)]. For all lead periods upto 120 hours, the accuracy in prediction of intensity was more than the LPA errors. The skill in intensity forecast based on RMSE for 24, 48, 72, 96 and 120 hrs lead period was 31.3, 64.9, 74.7, 77.7 and 81.1 % against the LPA skill of 52.8, 71.8, 78.6, 78.6 and 84.0 % during 2018-22 respectively [Fig. 32.7(b)].

(c). Extremely Severe Cyclonic Storm "TEJ" over the Arabian Sea (20th - 24th October, 2023)

It developed from an LPA that formed over southeast and adjoining eastcentral AS in the early morning (0530 hrs IST) of 18th October, 2023. It concentrated into a Depression (D) over southwest AS in the morning (0530 hrs IST) of 20th October. It intensified into the Cyclonic Storm (CS) "TEJ" pronounced as "TEJ" in the early morning (0530 hrs IST) of 21st October 2023 over southwest AS and into a Very Severe Cyclonic Storm (VSCS) in the night (2030 hrs IST) of 21st October. Moving northwestwards, it intensified rapidly into an ESCS in the morning (0830 hrs IST) of 22nd October over

westcentral and adjoining southwest AS. It exhibited rapid intensification during midnight (2330 hours IST) of 21st to noon (1130 hours IST) of 22nd October, reaching its peak intensity of 95 knots in the morning (0830 hours IST) of 22nd October. It then maintained its intensity till early hours (0230 hours IST) of 24th October. Thereafter, it entered into an unfavourable environment and started weakening. It crossed Yemen coast close to South of Al Ghaidah in the early hours (between 0230 and 0330 hours IST) of 24th October as a VSCS with intensity of 65 knots gusting to 75 knots (120-130 kmph gusting to 140 kmph). Thereafter, it moved nearly westwards and weakened into a depression in the evening (1730 hours IST) and into a well marked low pressure area over Yemen in the night (2030 hours IST) of 24th October. Observed track of extremely severe cyclonic storm "TEJ" is presented in Fig. 33.1.

(c) 1.1. Forecast Performance

First information about likely cyclogenesis over south AS around 20th was issued in the extended range outlook issued on 12th October about 8 days prior to formation of depression on 20th October.

The forecast based on 0600 UTC (1130 IST) of 22nd indicated, crossing of cyclone over Yemen close to Al Ghaidah with MSW of 70 knots gusting to 80 knots around midnight 2330 hours IST of 23rd October-0230 hours IST of 24th October (about 2 days and 15 hours ahead of landfall).

Observed and forecast track & intensity issued based on 0600 UTC (1130 IST) observations of 22nd October about 2 days and 15 hours ahead of landfall are presented in Fig. 33.2.

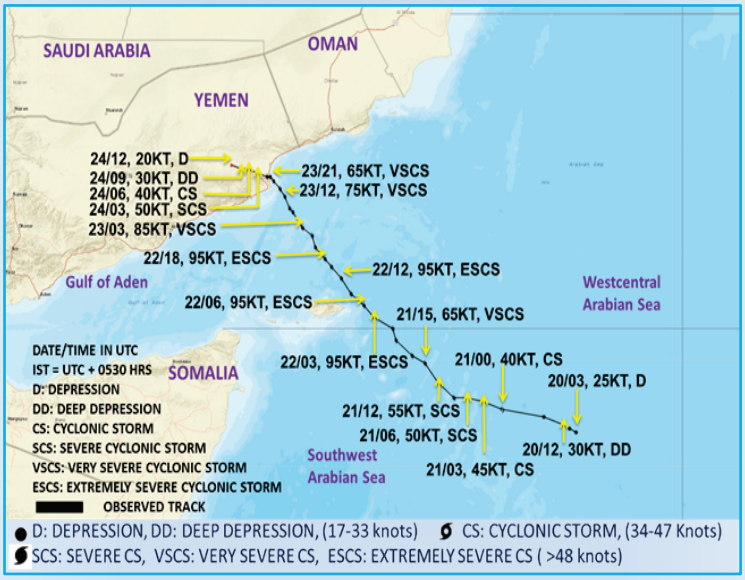


Fig. 33.1. Observed track of extremely severe cyclonic storm "TEJ" during 20-24 October, 2023

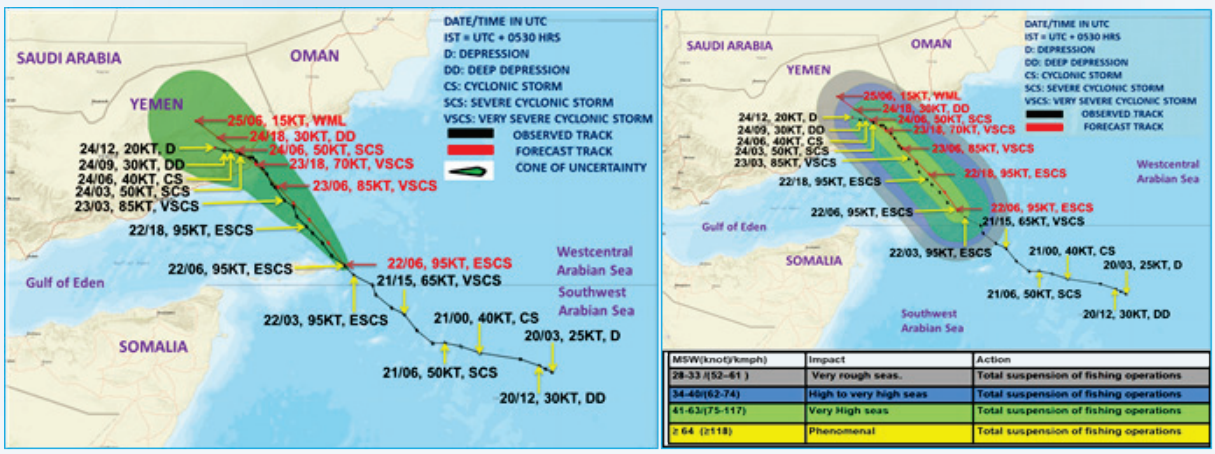
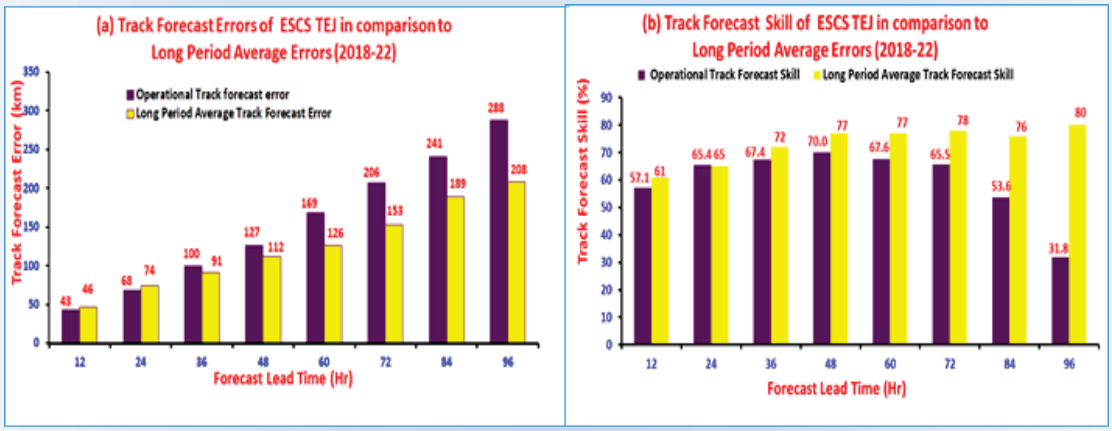


Fig. 33.2. Observed track and forecast track & intensity issued based on 1130 hours IST of 22nd October about 2 days and 15 hours ahead of landfall

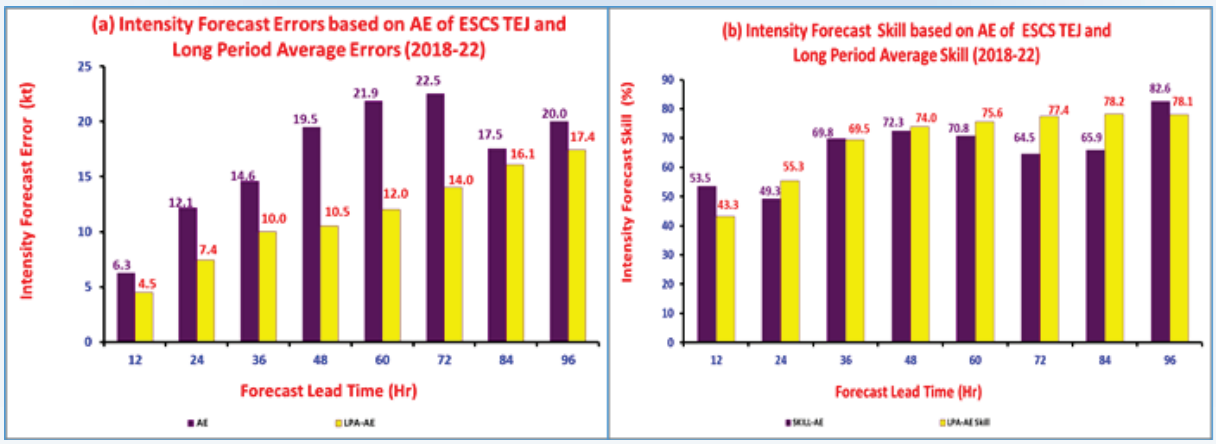
(c) 1.2. Operational Track, Intensity and Landfall Point & Time Forecast Errors

The track forecast errors for 12, 24, 48 and 72 hrs lead period were 43, 68, 127 and 206 km respectively against the long period average (LPA) errors (2018-22) of 46, 74, 112 and 153 km respectively [Fig. 33.3(a)]. For all lead periods upto 48 hours, the operational track forecast errors were comparable to LPA errors. The skill in track forecast [Fig. 33.4(b)] was comparable to LPA skill upto 48 hours lead period. The track forecast skill for 12, 24, 48 and 72 hrs lead period was 57, 65, 70 and 66% respectively against the long period average (LPA) errors (2018-22) of 61, 65, 77, and 78% respectively. The operational 48 hrs track forecast error was higher, as "TEJ" had a multiple recurvatures and rapid intensification. Both the situations adversely affect the forecast. Studies show that track & intensity are correlated. Increased error in track lead to increased error in intensity prediction and *vice-versa*. Similarly recurving tracks are difficult to predict compared to straight moving cyclones.

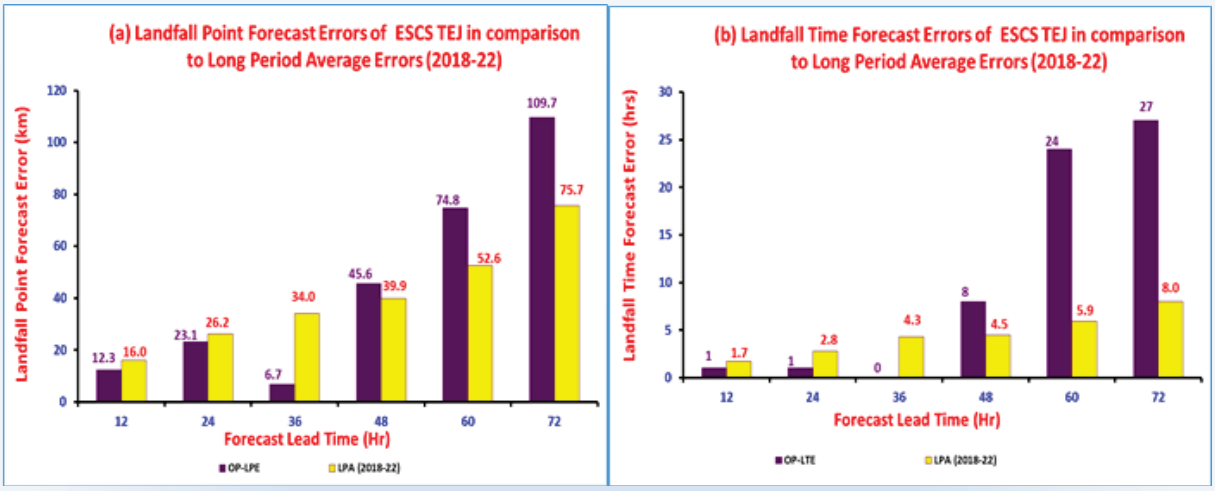


Figs. 33.3(a&b). (a) Track forecast errors and (b) track forecast skill against the long period average (LPA) errors (2018-22)

The absolute error (AE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 12.1, 19.5 and 22.5 knots against the LPA errors of 7.4, 10.5 and 14.0 knots during 2018-22 respectively [Fig. 33.4(a)]. The skill in intensity forecast based on AE for 24, 48 and 72 hrs lead period was 47, 72 and 65% against the LPA skill of 55, 74 and 77% during 2018-22 respectively [Fig. 33.4(b)]. The intensity forecast errors were higher than LPA as the impact of approaching trough in westerly that provided favourable environment for rapid intensification of the system could not be captured by the models. However, the errors for longer lead period (96 and 120 hrs) are comparable, as the weakening of the system prior to landfall was well captured based on environmental conditions and also by the models.



Figs. 33.4(a&b). (a) Absolute error (AE) in intensity forecast (b) intensity forecast skill based on AE against the long period average (LPA) errors (2018-22)



Figs. 33.5(a&b). (a) Landfall point and (b) time error against the long period average (LPA) errors (2018-22)

The landfall point forecast errors for 24, 48 and 72 hrs lead period were 23.1, 45.6, 109.7 km respectively against the LPA errors (2018-22) of 26.2, 39.9 and 75.7 km during 2018-22 respectively [Fig. 33.5(a)]. The landfall point forecast errors were less than the LPA upto a lead period of 36 hours, comparable for 48 hrs and higher than LPA error for 72 hrs lead period.

The landfall time forecast errors for 24, 36, 48 and 72 hrs lead period were 1.0, zero, 8 and 27 hours respectively against the LPA errors (2018-22) of 2.8,4.3, 4.5 and 8.0 hours during 2018-22 respectively [Fig. 33.5(b)]. For all lead periods less than 36 hours, the landfall time errors were appreciably less than LPA errors. For 36 hours lead period, there was zero error in landfall time prediction and error was higher for 72 hrs lead period.

(d). Very Severe Cyclonic Storm "HAMOON" over Westcentral Bay of Bengal (21-25 October)

It developed from an LPA that formed over southwest and adjoining southeast BoB in the early morning 0530 hrs IST of 20th October, 2023. It concentrated into a depression over westcentral BoB in the midnight (2330 hrs IST) of 21st October. It moved initially northwestwards for some time, then gradually recurved north-northeastwards and intensified into the Cyclonic Storm (CS) "HAMOON" (pronounced as "HAMOON") over westcentral & adjoining southwest BoB in the evening (1730 hrs IST) of 23rd October, 2023. It rapidly intensified into a VSCS over westcentral BoB in the same morning (0830 hrs IST) of 24th October. Thereafter, it entered into an area with high vertical wind shear, and it started weakening. It crossed Bangladesh coast to the south of Chittagong near (21.90 N/91.90 E) between 0130-0230 hours IST of 25th October as a CS with maximum sustained wind speed of 75-85 kmph gusting to 95 kmph. Continuing to move north-eastwards, it weakened into a depression over southwest Mizoram & adjoining Bangladesh & Myanmar in the noon (1130 hours IST) and into a well marked low pressure area over Mizoram and adjoining areas of Manipur and Myanmar the evening (1730 hours IST) of 25th October. Observed track of the system is presented in Fig. 34.1.

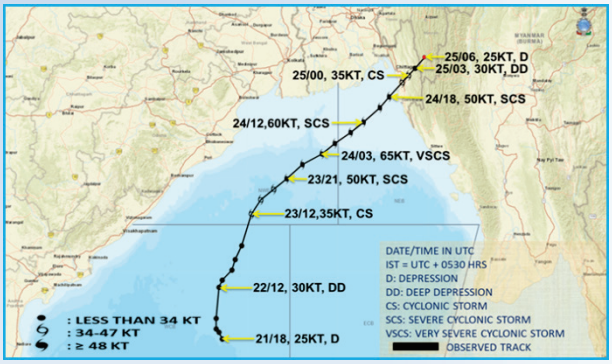


Fig.34.1. Observed track of very severe cyclonic storm "HAMOON" during 21-25 October, 2023

(d)1.1. Genesis Forecast

First information about likely cyclogenesis over southeast BoB during the week (20th - 26th Oct), around 21st was issued in the extended range outlook issued on 12th October about 9 days prior to formation of depression on 21st October, 2023.

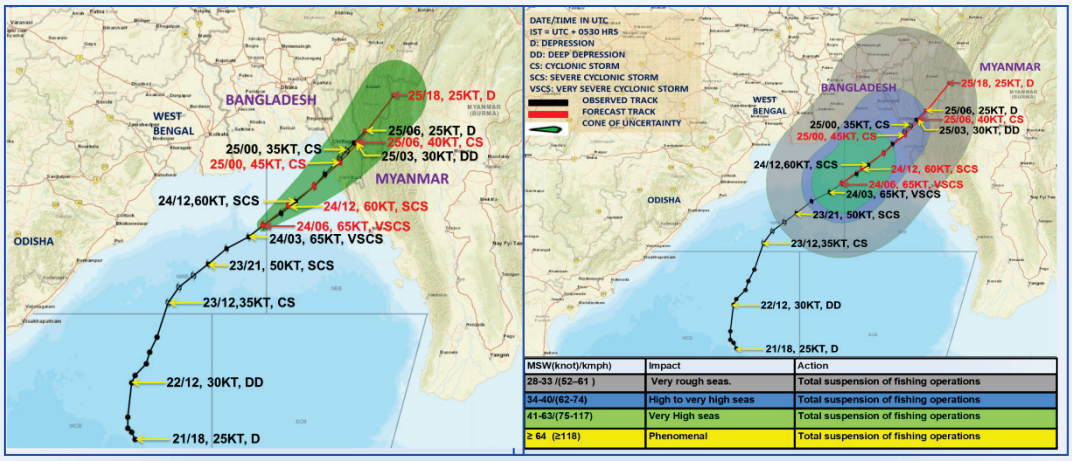
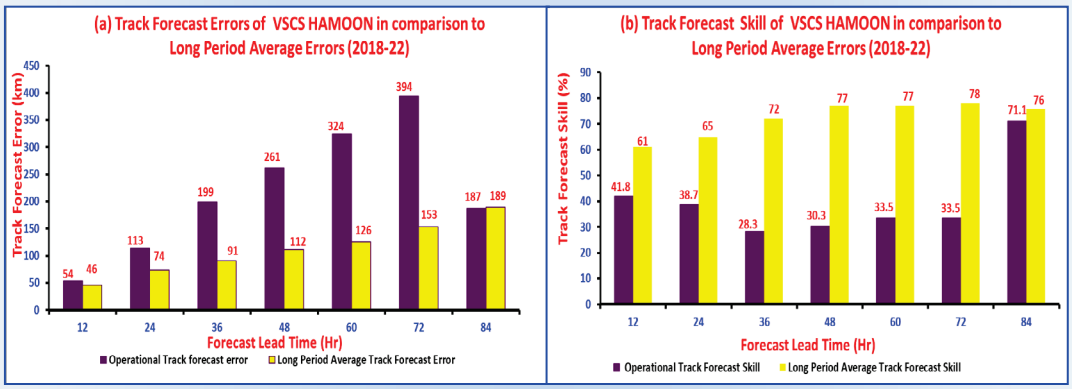


Fig. 34.2. Observed track and forecast track & intensity issued based on 0600 UTC Observation of 24th October about 14 hours ahead of landfall



Figs. 34.3(a&b). (a) Track forecast errors and (b) track forecast skill against the long period average (LPA) errors (2018-22)

The first advisory based on 2330 hours IST of 21st on formation of depression indicated initial northwest movement till 22nd / 1130 hours IST, followed by gradual north-northeastward recurvature towards Bangladesh-West Bengal coast.

Regular 6/3 hourly warnings were provided since then till the weakening of system into a well-marked low pressure area.

The forecast based on 1130 hours IST of 22nd indicated, crossing of cyclone over Bangladesh coast between Khepupara and Chittagong around 25th October evening as a deep depression (about 03 days ahead of landfall).

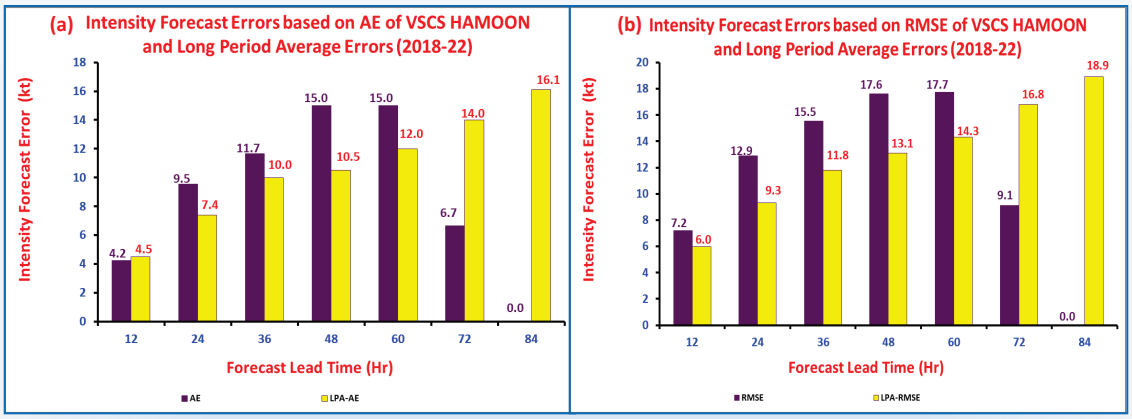
The warning was further updated and the bulletin issued at 0000 UTC (0530 IST) of 24th indicated the system to cross Bangladesh coast as a cyclonic storm around 1200 UTC of 25th October. The was further updated and the bulletin issued on 0600 UTC of 24th indicated the system to cross on Bangladesh coast around 2100 UTC of 24th Oct.

(c) 1.2. Track forecast error and skill

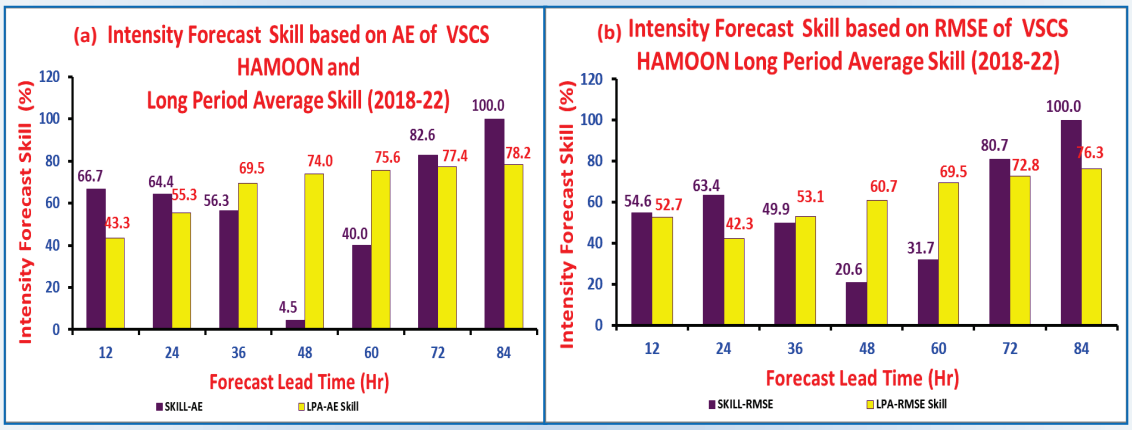
The track forecast errors for 12, 24, 48 and 72 hrs lead period were 54, 113, 261 and 394 km respectively against the long period average (LPA) errors (2018-22) of 46, 74, 112, and 153 km respectively [Fig. 34.3(a)]. The track forecast skill for 12, 24, 48 and 72 hrs lead period was 38, 38, 30 and 33% respectively against the long period average (LPA) errors (2018-22) of 61, 65, 77 and 78% respectively [Fig. 34.3(b)]. The operational track forecast errors were higher, as the system moved very fast prior to landfall.

(d) 1.3. Intensity forecast error and skill

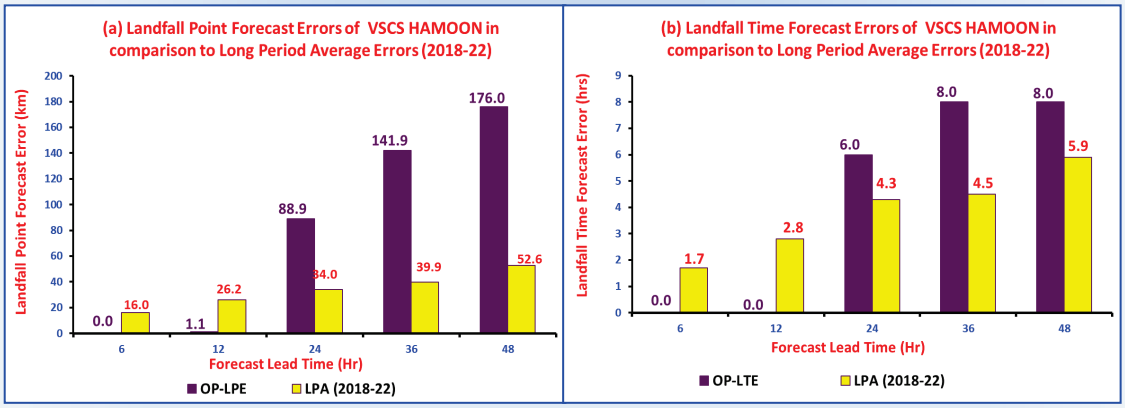
The absolute error (AE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 9.5, 15.0 and 6.7 knots against the LPA errors of 7.4, 10.5



Figs. 34.4(a&b). (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) in intensity forecast (winds in knots) of VSCS "HAMOON" as compared to long period average (2018-22)



Figs. 34.5(a&b). Skill (%) in intensity forecast based on (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) as compared to long period average (2018-22)



Figs. 34.6(a&b). (a) Landfall point and (b) time error against the long period average (LPA) errors (2018-22)

and 14.0 knots during 2018-22 respectively [Fig. 34.4(a)]. The root mean square error (RMSE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 12.9, 17.6 and 9.1 knots against the LPA errors of 9.3, 13.1 and 16.8 knots during 2018-22 respectively [Fig. 34.4(b)].

The skill in intensity forecast based on AE for 24, 48 and 72 hrs lead period was 64%, 4.6% and 82.6% against the LPA skill of 55, 74 and 77% during 2018-22 respectively [Fig. 34.5(a)]. The skill in intensity forecast based on RMSE for 24, 48 and 72 hrs lead period was 63, 21 and 81% against the

LPA skill of 42, 61 and 73% during 2018-22 respectively [Fig. 34.5(b)].

(d) 1.4. Landfall point and time errors

The landfall point forecast errors for 12, 24 and 48 hrs lead period were 1.1 km, 88.9 km, 176.0 km respectively against the LPA errors (2018-22) of 34, 52.6 km during 2018-22 respectively [Fig. 34.6(a)]. There was almost zero landfall time error upto 12 hrs lead period [Fig. 34.6(b)].

(e). Cyclonic Storm MIDHILI over Bay of Bengal : 15 November - 18 November

It developed from a low pressure area that formed over southeast BoB and adjoining Andaman & Nicobar Islands in the early morning (0530 hours IST) of 14th November. It concentrated into a Depression over westcentral BoB in the morning (0830 hours IST) of 15th November, 2023. It moved nearly northwards till the midnight (2330 hours IST) of 15th November & thereafter gradually recurved north-northeastwards and intensified into the Cyclonic Storm "Midhili" (pronounced as "Midhili") over Northwest BoB in the early morning (0530 hours IST) of 17th November, 2023. It crossed Bangladesh coast near Khepupara during afternoon (1430-1530 hrs IST) of 17th November and moved across the Islands of Bangladesh as a cyclonic storm with maximum sustained wind speed of 70-80 kmph gusting to 90 kmph. Thereafter, it moved northeastwards and weakened gradually into a depression over Tripura and adjoining Bangladesh & Mizoram in the early morning (0530 hours IST) of 18th November.

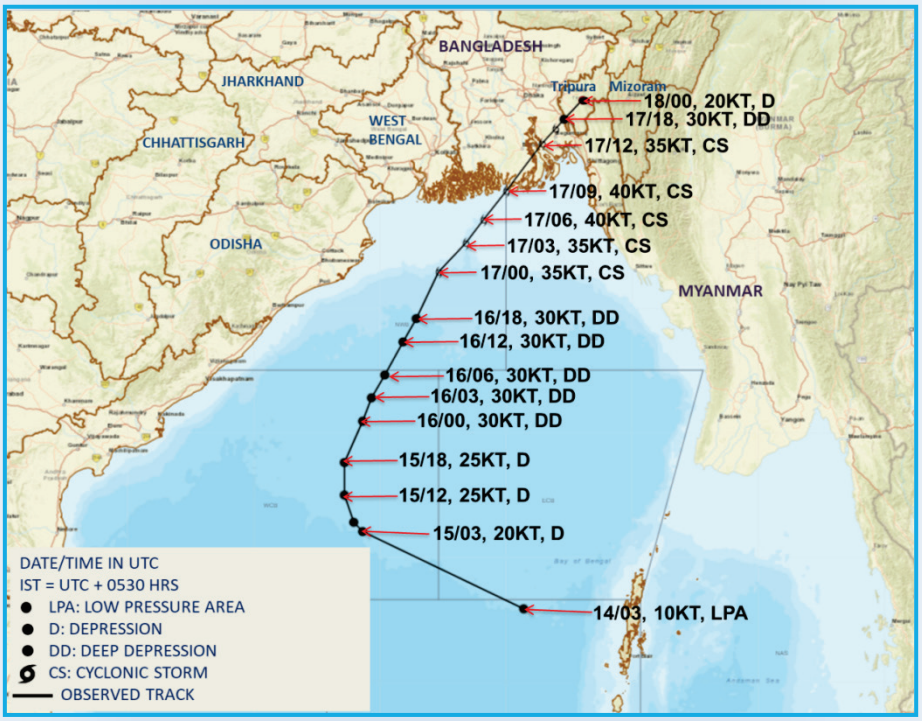


Fig. 35.1. Observed track of severe cyclonic storm 'MIDHILI" over Bay of Bengal during 14th - 18th November, 2023

(e)1.1. Genesis Forecast

First information about likely cyclogenesis over southwest & adjoining westcentral BoB during the week (17th - 23rd Nov), around 17th was issued in the extended range outlook issued on 9th Nov about 6 days prior to formation of depression on 15th November.

The tropical Weather Outlook issued on 13th Nov. indicated likely formation of an upper air cyclonic circulation around 13th, low pressure area around 14th and depression around 15th with low probability. Since then, the Daily Tropical Weather Outlooks issued indicated formation of depression over BoB around 15th.

Actually, a cyclonic circulation from Gulf of Thailand emerged into South Andaman Sea on 13th November; a low pressure area formed over southeast Bay of Bengal (BoB) and adjoining

Andaman & Nicobar on 14th November, 2023 and depression over westcentral BoB on 15th November, 2023. The cyclogenesis (formation of depression) was predicted 6 days ahead.

(e)1.2. Track, intensity and landfall forecast errors and skill

The track forecast errors for 12, 24 and 48 hrs lead period were 87, 172 and 366 km respectively against the long period average (LPA) errors (2018-22) of 46, 74 and 112 respectively (Fig. 35.2).

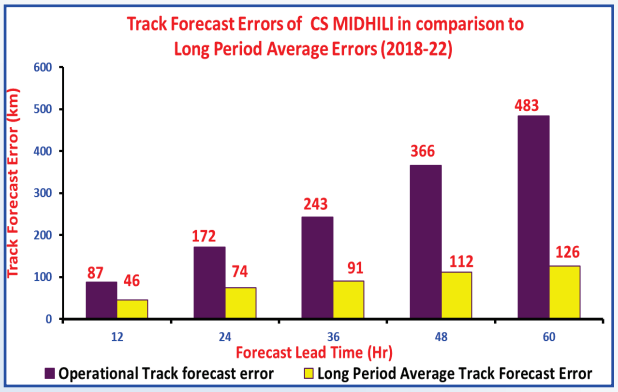
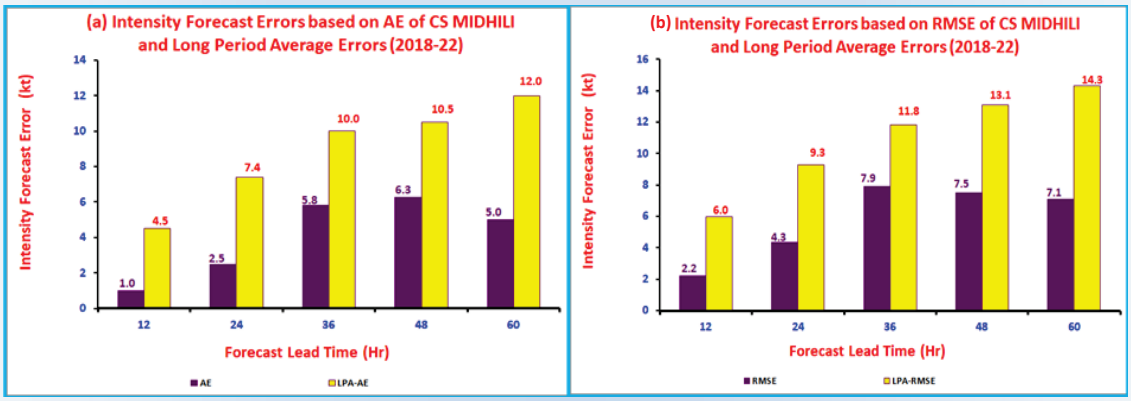
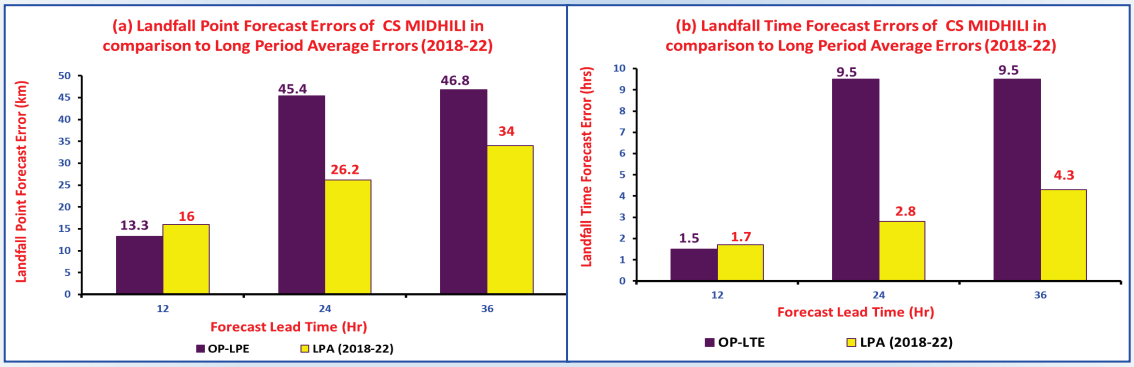


Fig. 35.2. Track forecast errors against the long period average (LPA) errors (2018-22)



Figs. 35.3(a&b). (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) in intensity forecast (winds in knots) of CS "MIDHILI" as compared to long period average (2018-22)



Figs. 35.4(a&b). (a) Landfall point and (b) time error against the long period average (LPA) errors (2018-22)

(e) 1.3. Intensity forecast error and skill

The absolute error (AE) of intensity (wind) forecast for 24 and 48 hrs lead period were 2.5 and 6.3 knots against the LPA errors of 7.4 and 10.5 knots during 2018-22 respectively [Fig. 35.3(a)]. The root mean square error (RMSE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 4.3 and 7.5 knots against the LPA errors of 9.3 and 13.1 knots during 2018-22 respectively [Fig. 35.3(b)].

(e) 1.4. Landfall point and time errors

The landfall point forecast errors for 12, 24 and 36 hrs lead period were 13.3, 45.4 and 46.8 km respectively against the LPA errors (2018-22) of 16, 26.2 and 34 km during 2018-22 respectively [Fig. 35.4(a)]. The landfall time forecast errors for 12, 24 and 36 hrs lead period were 1.5, 9.5 and 9.5 hours respectively against the LPA errors (2018-22) of 1.7, 2.8 and 4.3 hours during 2018-22 respectively [Fig. 35.4(b)].

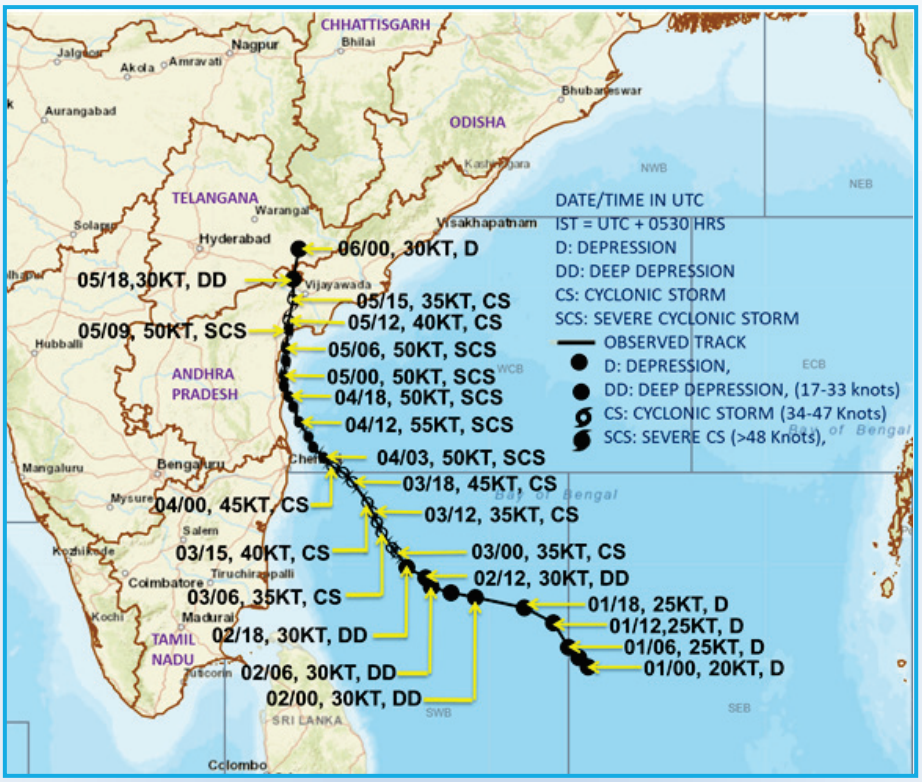


Fig. 36.1. Observed track of severe cyclonic storm "Michaung" over the Bay of Bengal during 1st - 6th December

(f). Severe Cyclonic Storm MICHAUNG over Bay of Bengal : 01-06 December

It developed from an LPA over South Andaman Sea & adjoining Malacca Strait in the early morning (0530 hours IST) of the 27th November. Moving westwards, it concentrated into a Depression over Southeast & adjoining Southwest Bay of Bengal in the early morning (0530 hours IST) of the 1st December, 2023. It moved west-northwestwards and intensified into the Cyclonic Storm "MICHAUNG" (pronounced as MIGJAUM) over the southwest BoB in the early morning (0530 hours IST) of the 3rd December, 2023. Thereafter, it moved nearly northwards almost parallel and close to south Andhra Pradesh coast and crossed south Andhra Pradesh coast between Nellore and Machilipatnam, close to south of Bapatla during 1230 to 1430 hours IST of the 5th December, 2023 as a Severe Cyclonic Storm with maximum sustained wind speed of 90-100 kmph gusting to 110 kmph. After the landfall, it continued to moved nearly northward and weakened into a Cyclonic Storm and lay centred at 2030 hrs IST of 5th December over south coastal Andhra Pradesh, about 15 km west of Bapatla. It then moved north-northeastwards and weakened into a Depression over northeast Telangana and neighbourhood in the early morning (0530 IST) of 6th December. It weakened into a WML over the same region in the forenoon (0830 IST) of 6th December.

(f) 1.1. Genesis Forecast

India Meteorological Department (IMD) maintained round the clock watch over the north Indian Ocean and the cyclone was monitored since 16th November, about 15 days prior to formation of depression on 1st December and 19 days prior to the landfall of system over Andhra Pradesh coast. The information about the system was first released in the weekly extended range outlook issued by IMD on 16th November indicating formation of depression over southeast BoB around 30th November during the week 2 (24-30 November).

Further, the extended range outlook issued on 23rd November, 2023 indicated formation of depression over southwest BoB around 30th November and it's movement towards Andhra Pradesh coast with high confidence (76-100%) (about 8 days ahead of formation of depression and 12 days ahead of landfall over Andhra Pradesh).

(f) 1.2. Pre-genesis track & intensity and structure forecast

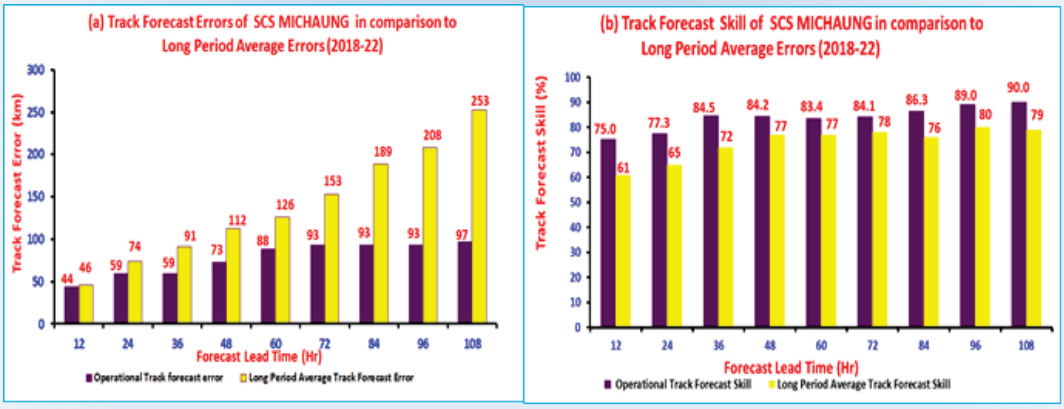
On formation of low pressure area over South Andaman Sea on 27th November, pre-genesis track & intensity forecast was issued indicating movement of depression towards westcentral BoB on 1st December (about 4 days ahead of formation of depression). It was also indicated on 27th November itself that the system will intensify into a cyclonic storm.

On formation of depression in the early morning of 1st December, the track and intensity forecast issued at 1000 hrs IST of 1st December (about 4 days ahead of landfall on 5th December), indicated the system to move very close to South Andhra Pradesh coast since 4th December evening (1730 hours IST) and system to cross coast between Nellore and Machilipatnam, close to Bapatla around noon (during 1230-1330 hours IST) of 5th December as a cyclonic storm with wind speed of 70-80 kmph gusting to 90 kmph. The forecast issued at 1130 hours IST of 3rd December indicated the system to cross coast near Bapatla as a severe cyclonic storm with wind speed of 90-100 kmph gusting 110 kmph (Fig. 36.1).

Actually, a low pressure area lay over South Andaman Sea on 27th November. It moved west-northwestwards and intensified into a depression over southeast BoB in the early morning (0530 hours IST) of 1st December, into a deep depression in the early morning (0530 hours IST) of 2nd December, into the cyclonic storm "Michaung" in the early morning (0530 hours IST) of 3rd December and into a severe cyclonic storm in the noon (1130 hours IST) of 4th December. It crossed Andhra Pradesh coast between Nellore and Machilipatnam, close to south of Bapatla during 1230-1430 hours IST, as a severe cyclonic storm with wind speed of 90-100 kmph gusting 110 kmph.

(f) 1.3. Track forecast error and skill

The track forecast errors for 12, 24, 48, 72 and 96 hrs lead period were 44, 59, 73, 73 and 93 km respectively against the long period average (LPA) errors (2018-22) of 46, 74, 112, 153 and 208 km respectively [Fig. 36.2(a)]. The track forecast skill for 12, 24, 48, 72 and 96 hrs lead period was 75, 77, 84, 84 and 89 km respectively against the long period average (LPA) errors (2018-22) of 61, 65, 77, 78, and 80 % respectively [Fig. 36.2(b)]. The operational track forecast errors were less than the LPA errors for all lead periods and the operational track forecast skill was better than the LPA skill for all lead periods.

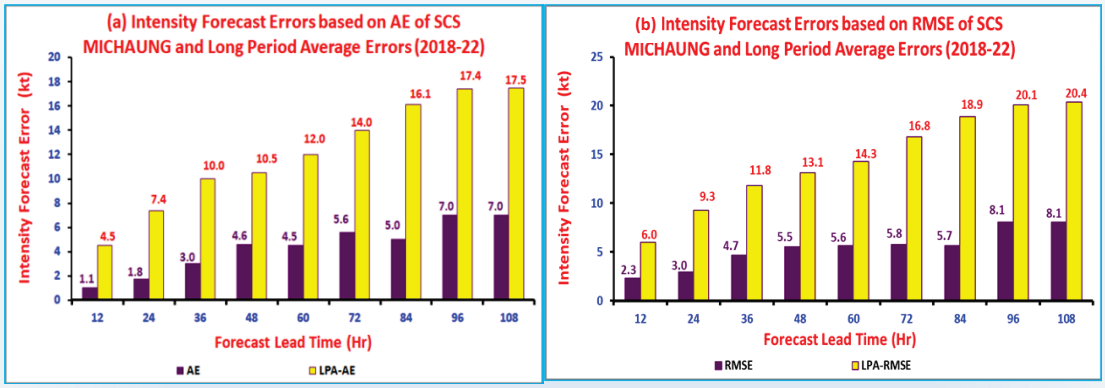


Figs. 36.2(a&b). (a) Track forecast errors and (b) skill against the long period average (LPA) errors (2018-22)

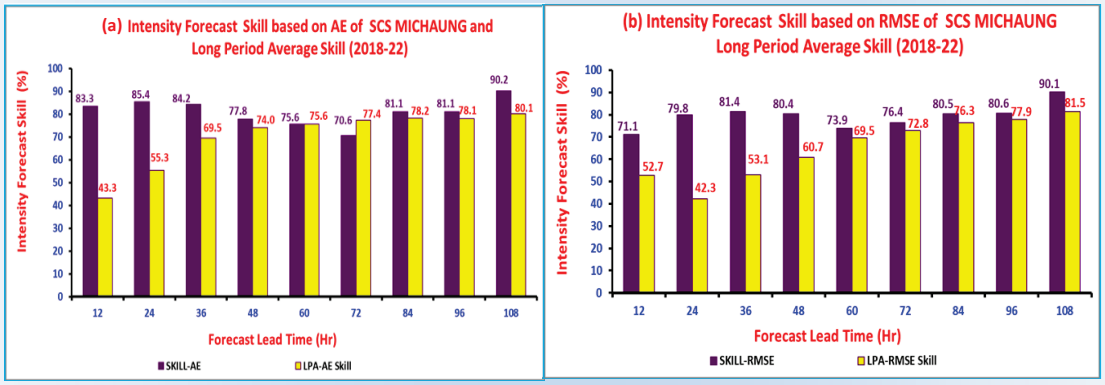
(f) 1.4. Intensity forecast error and skill

The absolute error (AE) of intensity (wind) forecast for 12, 24, 48 and 72 hrs lead period were 1.1, 1.8, 4.6 and 5.6 knots against the LPA errors of 4.5, 7.4, 10.5 and 14.0 knots during 2018-22 respectively [Fig. 36.3(a)]. The root mean square error (RMSE) of intensity (wind) forecast for 12, 24, 48 and 72 hrs lead period were 2.3, 3.0, 5.5 and 5.8 knots against the LPA errors of 6.0, 9.3, 13.1 and 16.8 knots during 2018-22 respectively [Fig. 36.3(b)].

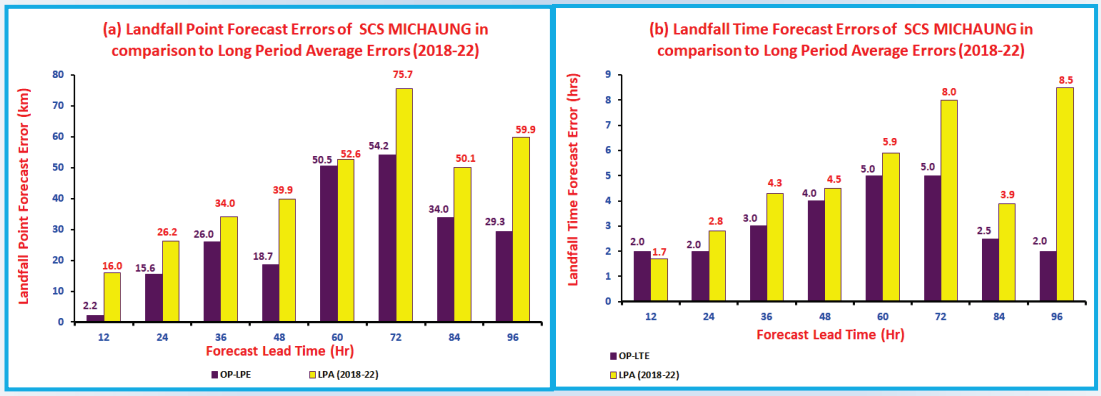
The skill in intensity forecast based on AE for 12, 24, 48 and 72 hrs lead period was 83, 85, 78 and



Figs. 36.3(a&b). (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) in intensity forecast (winds in knots) as compared to long period average (2018-22)



Figs. 36.4(a&b). Skill (%) in intensity forecast based on (a) Absolute errors (AE) and (b) Root Mean Square errors (RMSE) as compared to long period average (2018-22)



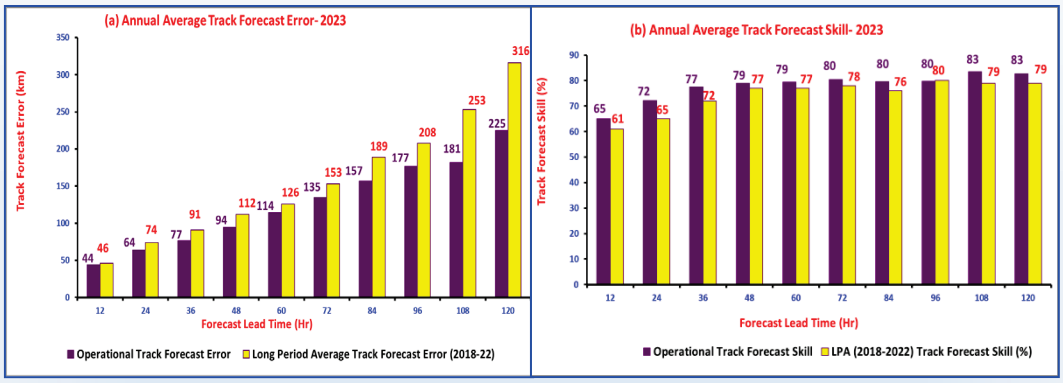
Figs. 36.5(a&b). (a) Landfall point and (b) time error against the long period average (LPA) errors (2018-22)

71% against the LPA skill of 43, 55, 74 and 77% during 2018-22 respectively [Fig. 36.4(a)]. For all lead periods, the operational intensity forecast errors and skill were better than the LPA. The skill in intensity forecast based on RMSE for 12, 24, 48 and 72 hrs lead period was 71, 80, 80 and 76% against the LPA skill of 53, 42, 61 and 73% during 2018-22 respectively [Fig. 36.4(b)].

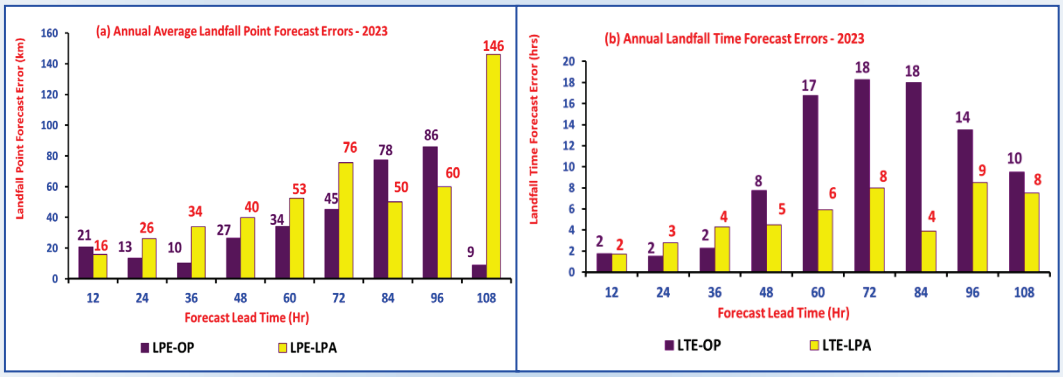
(f) 1.5. Landfall point and time errors

The landfall point forecast errors for 24, 48, 72 and 96 hrs lead period were 15.6, 18.7, 54.2 and 29.3 km respectively against the LPA errors (2018-22) of 26.2, 39.9, 75.7 and 59.9 km during 2018-22 respectively [Fig. 36.5(a)]. Considering the eye diameter to be about 50 km, there was almost zero landfall point forecast errors for all lead periods.

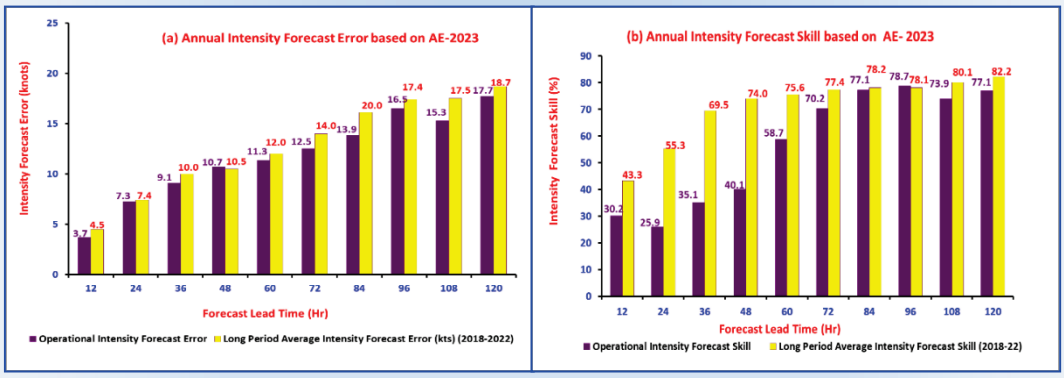
The landfall time forecast errors for 24, 48, 72 and 96 hrs lead period were 2.0, 4.0, 5.0 and 2.0 hours respectively against the LPA errors (2018-22) of 2.8, 4.5, 8.0 and 8.5 hours during 2018-22 respectively [Fig. 36.5(b)]. For all lead periods, the landfall time errors were appreciably less than LPA errors.



Figs. 37.1(a&b). Annual average (a) track forecast error (km) and (b) track forecast skill against the climatology and persistence forecast during 2023 as compared to that during 2018-2022



Figs. 37.2(a&b). Annual average (a) landfall points forecast error (km) and (b) landfall time forecast errors as compared to long period average errors during 2018-2022



Figs. 37.3(a&b). Annual average (a) absolute error (AE) in kts and (b) skill in % during 2023 as compared to that during 2018-2022

(g) Annual Performance of cyclone landfall, track and intensity forecast

(g) 1.1. Track Forecast

The annual average track forecast errors in 2023 have been 64 km, 94 km and 135 km, respectively for 24, 48 and 72 hrs against the past five-years average error of 74, 112 and 153 km based on data of 2018-2022. The errors have been less than the long period average (LPA) (2018-22) for all lead period. The track forecast skills compared to climatology and persistence forecast have been 72%, 79% and 80% respectively for the 24, 48 and 72 hrs lead period which was more than long period average of 2018-2022 (65%, 77% & 78% respectively). The annual average track forecast errors and skill during 2023 are presented in Fig. 37.1(a&b).

(g) 1.2. Landfall Forecast

The annual average landfall forecast errors for the year 2023 have been 13 km, 27 km and 45 km for 24, 48 and 72 hrs lead period against the past five years average errors of 26 km, 40 km and 76 km during 2018-2022. The landfall time forecast errors have been 1.5, 7.8 and 18.3 hrs for 24, 48 and 72 hrs lead period during 2022 against the average of past five years of 2.8, 4.5 and 8 hrs during 2018-2022. The annual average landfall points and time forecast errors are presented in Fig. 37.2 (a&b).

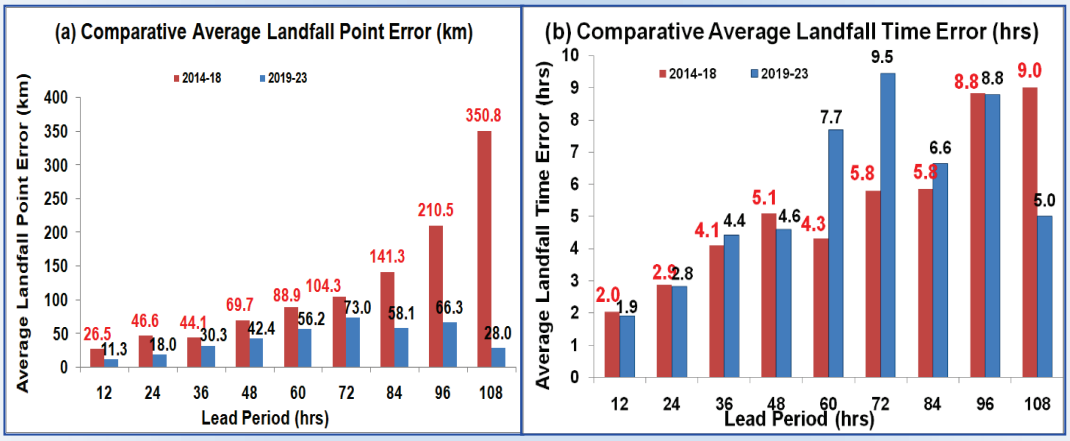
(g) 1.3. Intensity Forecast

The annual average absolute error (AE) in intensity forecast [Fig. 7.3(a&b)] has been 7.3 knots, 10.7 knots and 12.5 knots respectively for 24, 48 and 72 hrs lead period of forecast against the past five-year average of 7.4, 10.5 and 14.0 knots. The skill in terms of AE compared to persistence forecast was 26%, 40% and 70% as compared to long period average (2018-22) of 55%, 74% and 77% for 24, 48 and 72 hours period.

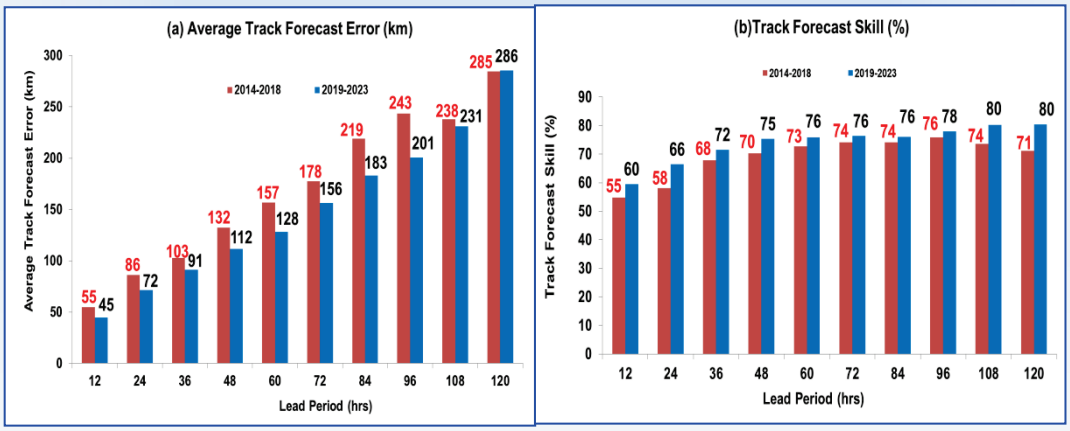
(h). Comparative analysis of forecast accuracy in recent five years (2019-23) as compared to previous five years (2014-18)

(h) 1.1. Landfall Forecast Error

Comparative analysis of landfall point error (LPE) and landfall time error (LTE) during 2019-23 vis-à-vis 2014-18 is presented in Fig. 38.1 (a&b). The LPE for 24, 48 and 72 hrs lead period during 2019-23 were 18.0 km, 42.4 km and 73 km against 46.6 km, 69.7 km and 104.3 km respectively during 2014-18 which shows an improvement of 61%, 39% and 30% respectively. The LTEs for 24, 48 and 72 hrs lead period during 2019-23 were 2.8 hrs, 4.6 hrs& 9.5hrs against 2.9hrs, 5.1hrs & 5.8hrs respectively during 2014-18 registering an improvement of 1.6% and 9.6% for 24 and 48 hours lead period respectively.



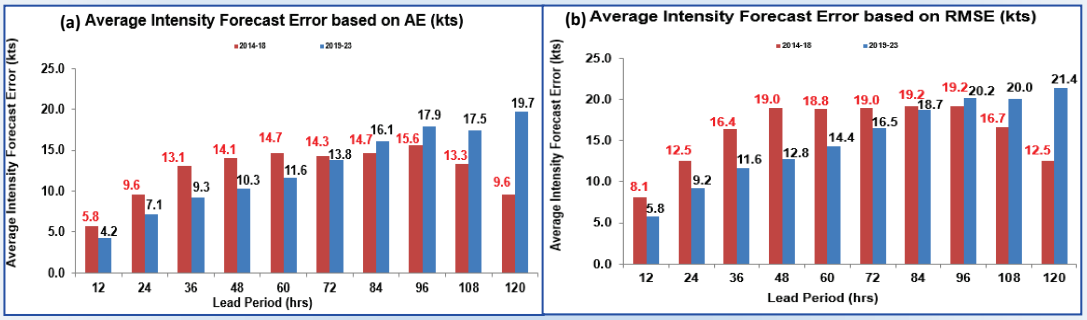
Figs. 38.1(a&b). Comparative average landfall (a) point and (b) time forecast errors during 2019-23 vis-à-Vis 2014-18



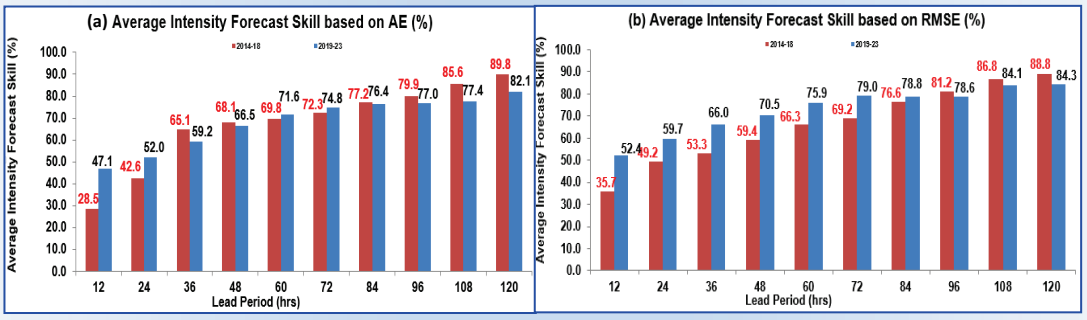
Figs. 38.2(a&b). Comparative Average track forecast (a) error and (b) skill during 2019-23 vis-à-vis 2014-18

(h) 1.2. Track forecast error and skill

The comparative analysis of average track forecast error and skill during 2019-23 and 2014-18 is presented in Fig. 38.2. The average track forecast errors during 2019-23 were 72 km, 112 km & 156 km against 86 km, 132 km & 178 km during 2014-18 for 24, 48 and 72 hrs lead period respectively. There has been an improvement of 17%, 16% & 12% in track forecast errors for 24, 48 and 72 hours lead period during 2019-23 with respect to 2014-2018. The 24, 48 and 72 hr average track forecast skill during 2019-23 were 66%, 75% and 76% against 58%, 70% and 74% respectively during 2014-18 with an improvement of 8%, 5% and 2% for 24, 48 and 72 hours lead period.



Figs. 38.3(a&b). Comparative Average Intensity forecast errors (kts) based on (a) absolute error and (b) root mean square errors during 2019-23 vis-à-vis 2014-18



Figs. 38.4(a&b). Comparative Average Intensity forecast skill (%) based on (a) absolute error and (b) root mean square errors during 2019-23 versus 2014-18

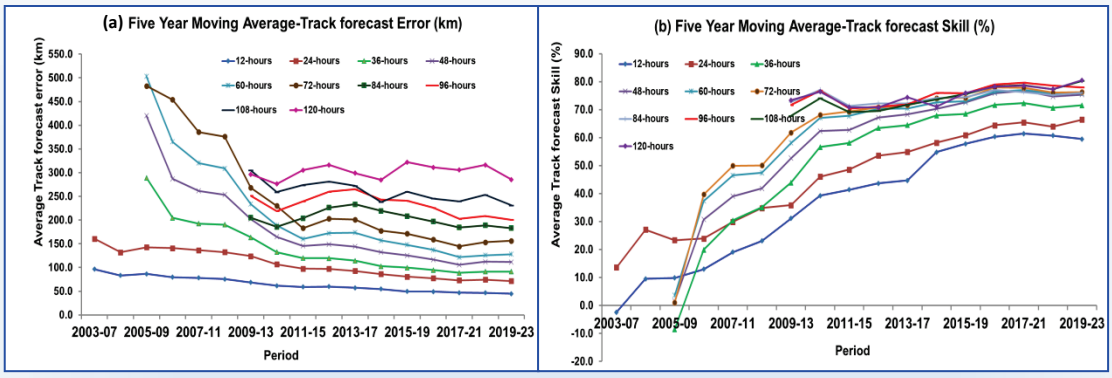
(h) 1.3. Intensity forecast error and skill

The comparative analysis of average intensity forecast error and skill based on AE and RMSE during 2019-23 and 2014-18 are presented in Fig. 8.3 and 8.4 respectively. The average intensity forecast error based on AE for 24hrs, 48hrs and 72hrs are 7.1 knots, 10.3 knots and 13.8 knots during 2019-23 against 9.6 knots, 14.1 knots and 14.3 knots during 2014-18. Based on RMSE the intensity forecast errors were 9.2 knots, 12.8 knots and 16.5 knots during 2019-23 against 12.5 knots, 19.0 knots, and 19.0 knots during 2014-18. It can be seen that there has been marginal improvement in intensity forecast during recent five years (2018-22) as compared to previous five years (2013-17).

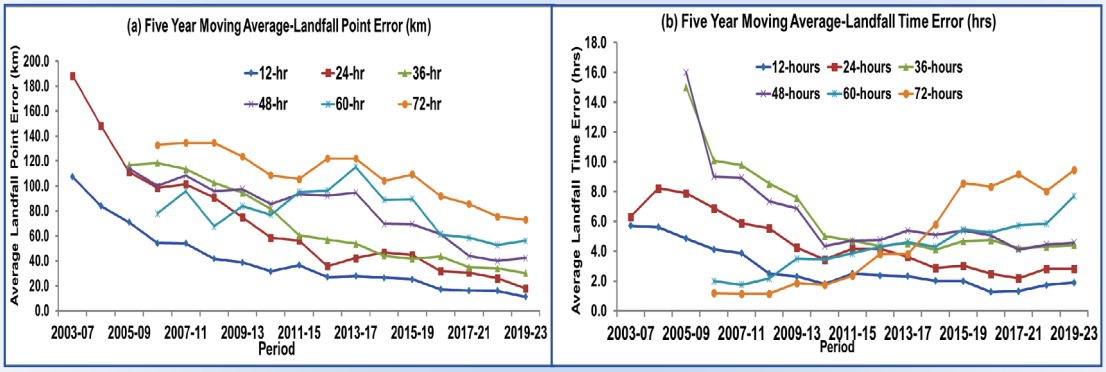
The average intensity forecast skill based on AE for 24hrs, 48hrs and 72hrs are 52%, 66.5% and 74.8% during 2019-23 against 42.6%, 68.1% and 72.3% during 2014-18. Based on RMSE the intensity forecast skill score was 59.7%, 70.5% and 79.0% during 2019-23 against 49.2%, 59.4% and 69.2% during 2014-18. It can be seen that there has been marginal improvement in intensity forecast during recent five years (2019-23) as compared to previous five years (2014-18).

(i). Five Year Moving Average errors and skill over north Indian Ocean

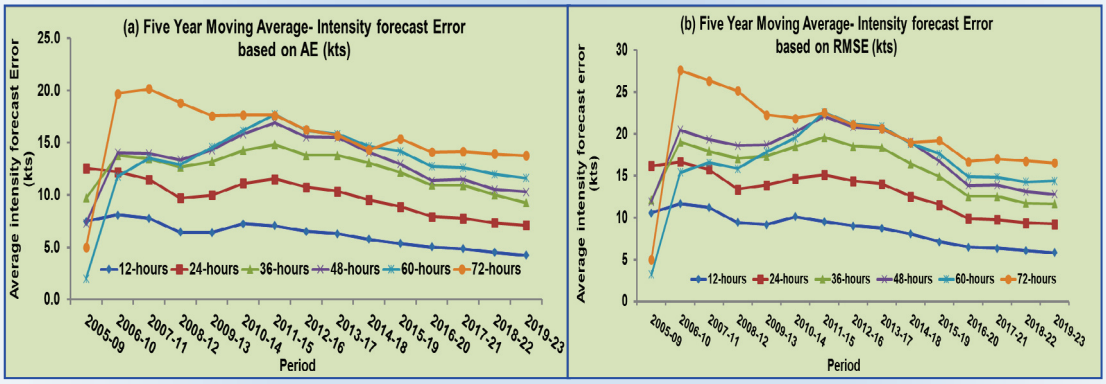
Five year moving average track forecast errors and corresponding skill, absolute errors in intensity forecast errors based on AE and landfall point &



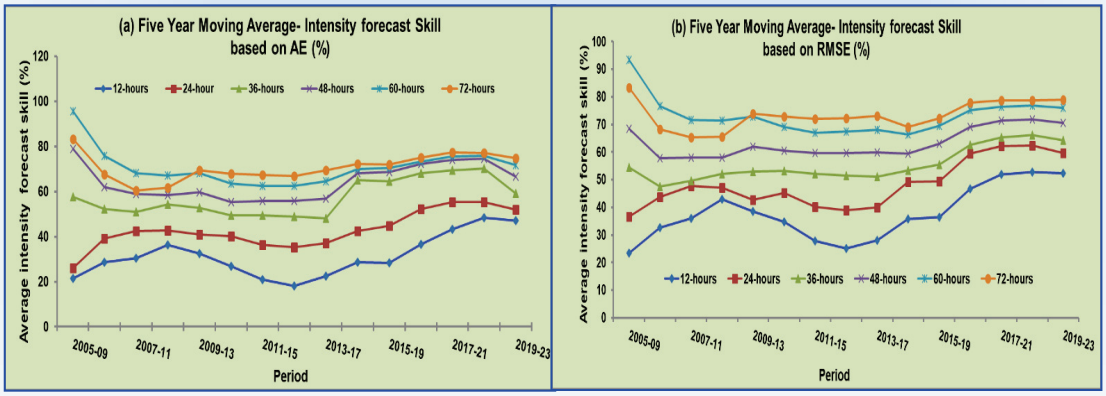
Figs. 39.1(a&b). Five Year Moving Average (a) Errors in Track Forecast (km) and (b) skill of RSMC, New Delhi over north Indian Ocean



Figs. 39.2(a&b). Five Year Moving Average Errors in (a) Landfall Point (km) and (b) Landfall Time (hrs) of RSMC, New Delhi over north Indian Ocean



Figs. 39.3(a&b). Five Years Moving Average Intensity Forecast (a) Absolute Error (kts) and (b) Root Mean Square Error (kts) of RSMC, New Delhi over the NIO



Figs. 39.4(a&b). Five Year Moving Average Intensity Forecast skill based on (a) AE and (b) RMSE of RSMC, New Delhi over North Indian Ocean

time. The Figs. 39.1-39.4 indicate improvement in recast accuracy.

(j). Major initiatives in various components of early warning system for Tropical Cyclones during 2023

(j) 1.1. Forecasting Services

(i) Extension of lead period for probabilistic cyclogenesis to next 7 days in daily Tropical Weather Outlook.

(ii) Operationalisation of Web based Dynamic Composite Risk Atlas (Web-DCRA) Tool for generating dynamic impact based forecast and loss to exposure before disaster from cyclone Biparjoy in June, 2023. The sample for wind hazard and flood hazard map for extremely severe cyclonic storm is presented in Fig. C.1.

(iii) Decision support system for rainfall, winds and storm surge on GIS platform indigenously for forecasters.

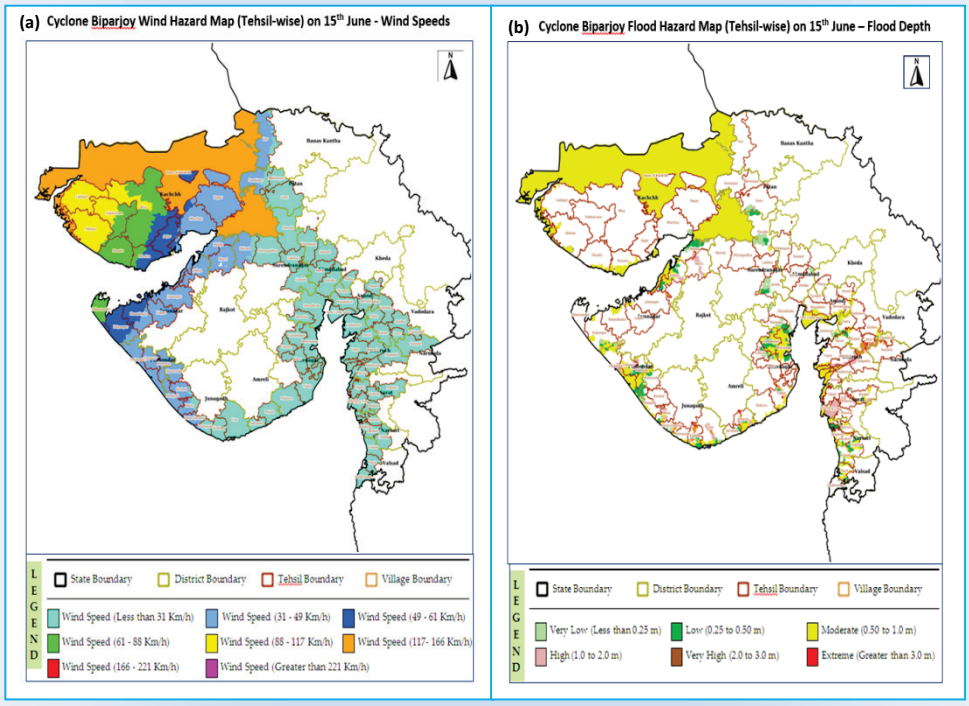


Fig. C.1. (a) Wind hazard map for extremely severe cyclone Biparjoy using Web-DCRA (b) Flood hazard map for extremely severe cyclone Biparjoy using Web-DCRA

(iv) Customized location specific bulletins for offshore & onshore industries.

(v) Marine bulletins in textual, graphical and interactive GIS platform for users for easy decision making.

(vi) Introduction of services for Search & Rescue Operations & Oil Spill experimentally as RSMC for Marine Emergency Response and Search & Rescue (MER-SAR) jointly with INCOIS.

(vii) Introduction of risk guidance for heavy rainfall, strong winds (>17 knots, >34 knots) for 98 sub-divisions under Severe Weather Forecast covering 9 member countries and oceanic area above 10° South. RSMC New Delhi provides severe weather guidance on rainfall, winds, waves, cyclonic disturbances to 9 countries including Thailand, Myanmar, Bangladesh, Bhutan, Nepal, India, Sri Lanka, Maldives, Pakistan under WMO's Severe Weather Forecasting Programme. RSMC New Delhi introduced impact-based forecast of Severe Weather from 1st September, 2023 for 96 subdivisions under its area of jurisdiction for next 5 days. The severe weather guidance product during cyclone Michaung is presented in Fig. C.2. The impact-based forecast for heavy rainfall and strong winds is presented in Fig. C.3(a) and C.3 (b).

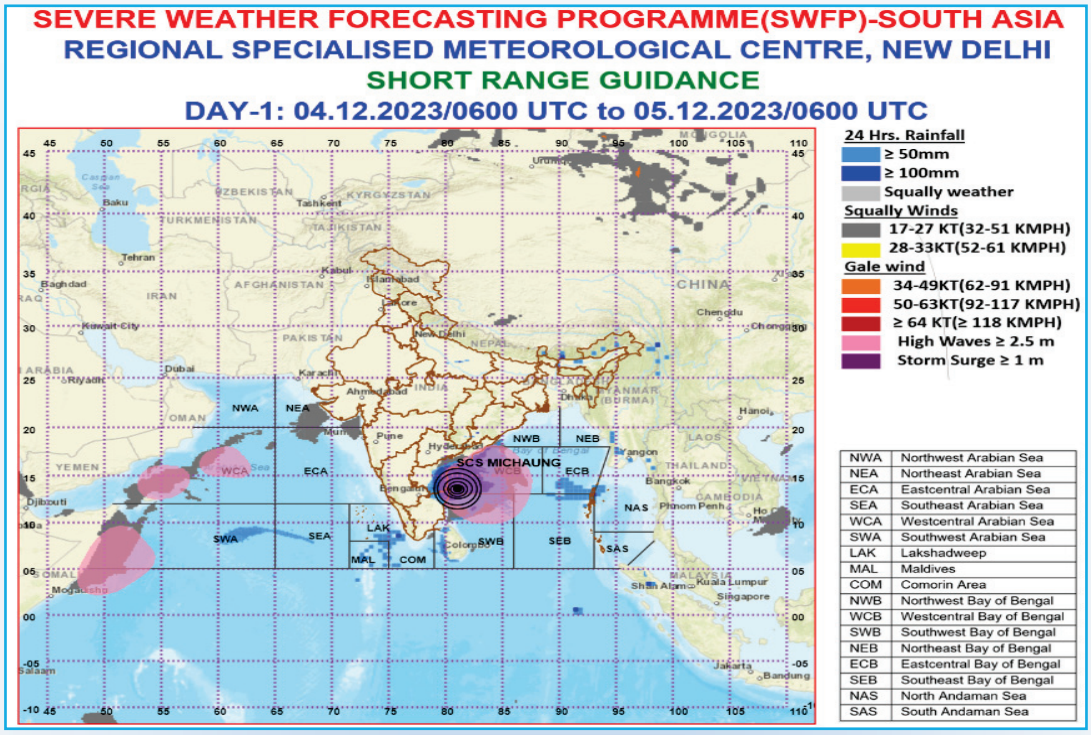


Fig. C.2. Severe weather guidance product during cyclone Michaung

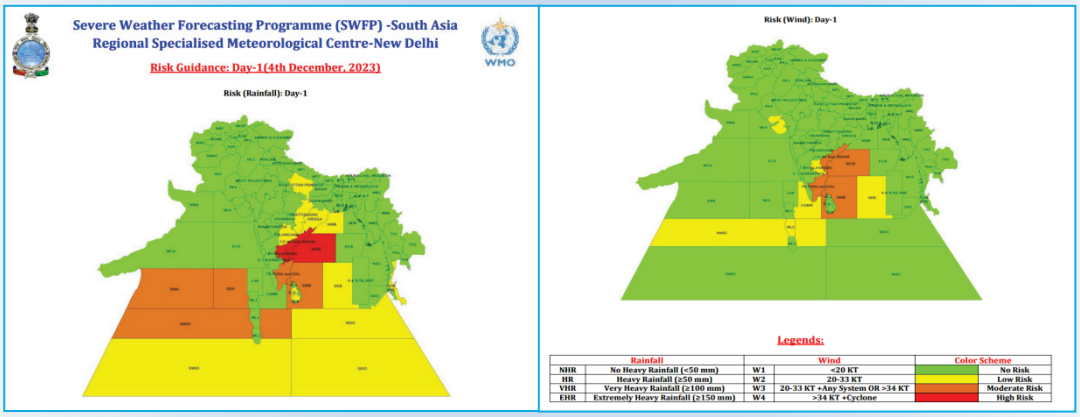


Fig. C.3. (a) Impact based forecast for heavy rainfall (b) Impact based forecast for strong winds

TABLE 4: CYCLONIC DISTURBANCE FORECAST FOR IOCL COASTAL LOCATIONS IN BAY OF BENGAL REGION BASED ON 2330 hrs IST of 4th December,2023

SI	DESCRIPTION OF SITE NAME(LAT°N /LON°E)	LOCATION		CURRENT LOCATION FROM CENTRE OF CYCLONIC DISTURABANCE		FORECAST PARAMETERS WHEN THE SITE WOULD BE NEAREST TO THE CYCLONE PATH							
		LAT (°N)	LON (°E)	DISTANCE (NM)	DIRECTION	DATE/ TIME(IST) OF OCCURRENCE	DISTANCE OF SITE FROM PATH	DIRECTION OF SITE FROM PATH	UNCERTAINITY IN DISTANCE OVER PATH(NM)	MSW OVER SITE(KTS)	UNCERTAINITY IN MSW OVER SITE(KT)	SIGNIFICANT WAVE HEIGHT	STATE OF SEA
Marketing - Lubes													
37.	Kolkatta LBP (22.54,88.3)	14.5	80.3	663	NE	06.12.23/1130	491	NE	55	<27	5	<4	Rough
38.	Budge Budge LBP (22.49,88.18)	14.5	80.3	657	NE	06.12.23/1130	485	NE	55	<27	5	<4	Rough
39.	Vijaywada (16.47,80.59)	14.5	80.3	119	N	05.12.23/2030	5	NW	40	63	15	10-14	Very High
40.	Chennai	14.5	80.3	81	S	04.12.23/2330	81	S	10	33	5	4-6	Very
	LBP (13.14,80.28)												Rough
Refineries													
41.	Paradip Refinery (20.15,86.35)	14.5	80.3	485	NE	06.12.23/1130	320	ENE	55	<27	5	<4	Rough
42.	Haldia Refinery (22.05,88.11)	14.5	80.3	635	NE	06.12.23/1130	466	NE	55	<27	5	<4	Rough
43.	CPCL (13.16,80.28)	14.5	80.3	80	S	04.12.23/2330	80	S	10	33	5	4-6	Very Rough

Fig. C.4 (a). Sample customized bulletin issued to Indian Oil Corporation

TABLE 4: CYCLONIC DISTURBANCE FORECAST FOR INDIAN AIR FORCE BASES BASED ON 2330 hrs IST of 4th December,2023													
SI	DESCRIPTION OF SITE NAME(LAT°N /LON°E)	LOCATION		CURRENT LOCATION FROM CENTRE OF CYCLONIC DISTURABANCE		FORECAST PARAMETERS WHEN THE SITE WOULD BE NEAREST TO THE CYCLONE PATH							
		LAT (°N)	LON (°E)	DISTANCE (NM)	DIRECTION	DATE/ TIME(IST) OF OCCURRENCE	DISTANCE OF SITE FROM PATH	DIRECTION OF SITE FROM PATH	UNCERTAINITY IN DISTANCE OVER PATH(NM)	MSW OVER SITE(KTS)	UNCERTAINITY IN MSW OVER SITE(KT)	SIGNIFICANT WAVE HEIGHT	STATE OF SEA
BAY OF BENGAL REGION													
1.	Kumbhigram (24.92,92.98)	14.5	80.3	951	NE	06.12.23/1130	785	NE	55	<27	5	<4	Rough
2.	Kalaikunda (22.37,87.22)	14.5	80.3	615	NE	06.12.23/1130	440	NE	55	<27	5	<4	Rough
3.	Suryalanka (15.83,80.5)	14.5	80.3	81	N	05.12.23/1430	9	SE	30	63	15	10-14	Very High
4.	Tambaram (12.92,80.12)	14.5	80.3	95	S	04.12.23/2330	95	S	10	33	5	4-6	Very Rough

Fig. C.4 (b). Sample customized bulletin issued to Indian Air Force

(viiii). Extension of customized services to Indian Oil Corporation (IOC) and Indian Air Force (IAF) in October, 2023 Offshore and onshore locations of Indian Oil Corporation are 92 and Indian Air Force Stations 9 for Bay of Bengal and Arabian Sea.

Introduction of Marine & Oceanographic guidance jointly by IMD and INCOIS for Marine Emergency Response (MER) & Search and Rescue (SAR) in November, 2023.

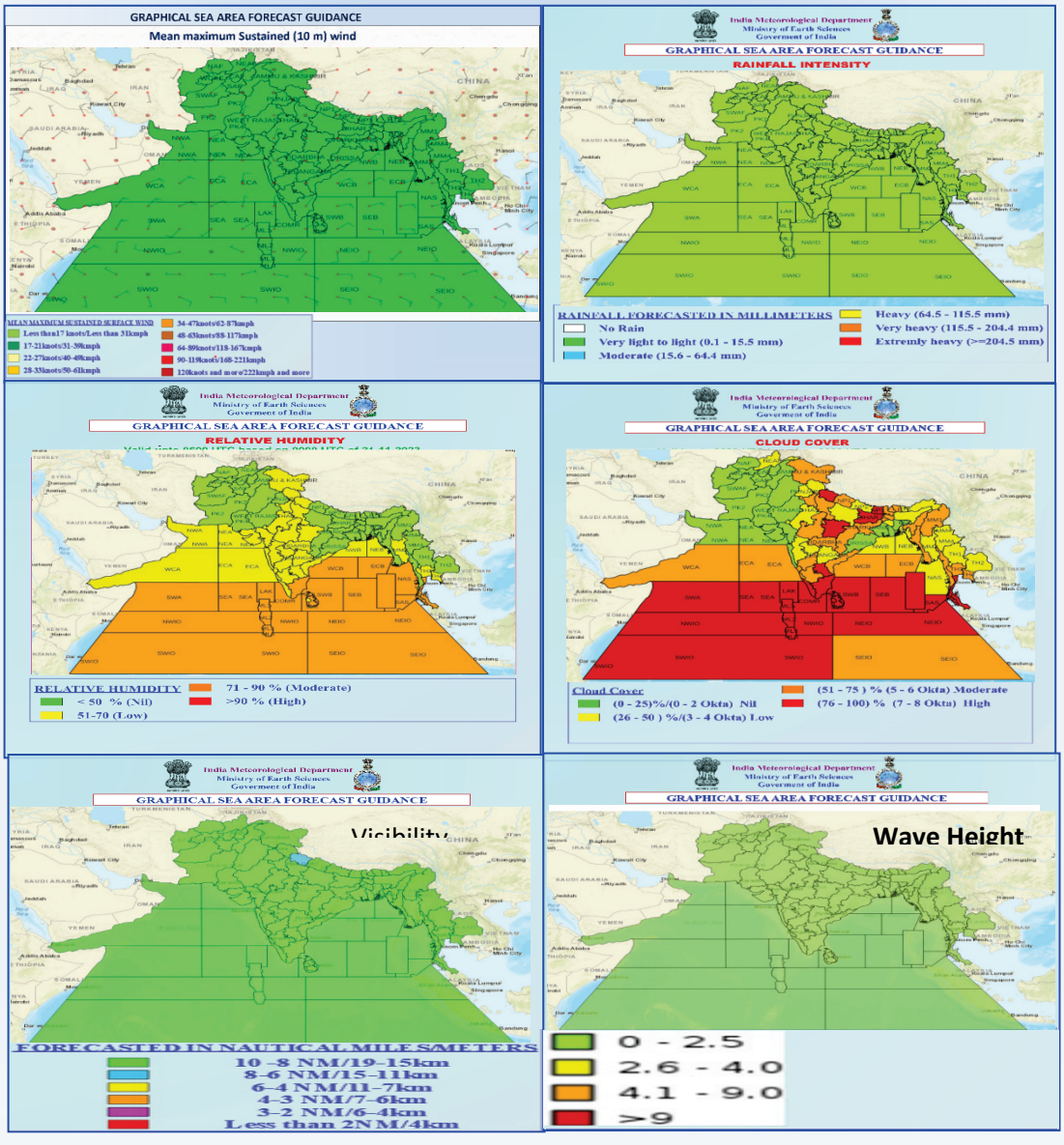


Fig. C.5. Multi Model Ensemble based Graphical Forecast for Weather State Parameters

(j) 1.2. Dissemination

RSMC utilizes all means of communication for transmission including email, FAX, websites, social networking platforms (facebook, tweeter, whatsapp to national & international users), SMS etc., Application Programming Interface (API), crowd sourcing, Common Alert Protocol (CAP) (38 crores messages during Biparjoy and 16 crores during Michaung), Global Multi-hazard Alert System (GMAS).

All these measures enabled the disaster managers and general public in reducing the loss of life to double digit during the year not only in India, but also in 13 PTC member countries. It also helped in building confidence among disaster managers, media & general public and earned appreciation for IMD and RSMC New Delhi.

(j) 1.3. 50 years of establishment of PTC and RSMC New Delhi:

(i) WMO, ESCAP, RSMC New Delhi and Panel on Tropical Cyclones (PTC) member countries jointly initiated various activities to commemorate 50 years of foundation of PTC and RSMC New Delhi. RSMC New Delhi organised a lecture series with expert speakers as eminent scientists and Permanent Representatives of various member countries during August-November.

(ii) RSMC New Delhi also organised a Technical Session on Challenges and New Initiatives in Tropical Cyclone Monitoring & Forecasting at Bahrain.

(iii) A new logo commemorating 50 years of formation of PTC was released during 50th Session of PTC.

150 years of establishment of IMD: IMD will commemorate 150 years of its establishment with 15th January, 2024 as the curtain raiser. In this regard, new logo commemorating 150 years of formation of IMD has been released.

(j) 1.4. Major publications released during 2023 by RSMC New Delhi

(i) Report on cyclonic disturbances over North Indian Ocean during 2022, (ii) Tropical Cyclone Operation Plan (TCP-21) (Edition 2022), (iii) Forecast Demonstration Project during 2022: A Report, (iv) Preliminary Reports on cyclonic disturbances during 2023, (v) Best track data of all cyclonic disturbances during 2023, (vi) Updation of various articles on climatology on RSMC website, (vii) Archival of all bulletins and annual reports on RSMC website since 2011.

(j) 1.5. Major achievements

WMO appreciated RSMC New Delhi for support to WMO Coordination Mechanism System during cyclone MOCHA.

During cyclone Biparjoy, zero death toll could be achieved with accurate prediction from IMD and proactive response actions of disaster management agencies in India.

India got elected to host PTC Secretariat for the period 2024-28.

The WMO/ESCAP Panel on Tropical Cyclones in it's 50th Session at Bahrain, elected RSMC New Delhi, India Meteorological Department to host PTC Secretariat for period 2024-27 in December, 2023.

5.6. Drought Monitoring & Prediction

Drought Monitoring and Prediction is being done using different indices like SPI (Standardized Precipitation Index), AAI (Aridity Anomaly Index) and SPEI Drought monitoring using Aridity Anomaly Index (AAI). The SPI maps are being generated every week as well as every month to identify the regions with prevailing or beginning/ ending of the extremely/ severely/ moderately dry/ wet conditions. The detailed statistics of the SPI computed for the entire SW monsoon period helps the various state government agencies for initiating drought management. Weekly SPI maps and values are being sent to all the state authorities as demanded by them according to new Drought manual of Ministry of Agriculture.

The Drought Indicator assessment has been done for 30 states and 11 union territories (718 districts) for the month of September 2023 and the period June to September 2023 using the drought monitoring indices, viz., Standardized Precipitation Index (SPI), Standardized Precipitation Evapotranspiration Index (SPEI) and Aridity Anomaly Index (AAI).

220 districts are in deficient/large deficient category for the period June to September 2023 whereas 258 districts are in deficient/large deficient category for the month of September 2023 based on rainfall percentage departure from normal (Figs. 40-43).

For the month of September 2023, 74 districts are in moderately/severely/extremely dry condition or moderately/severely Arid condition in any two of three drought indices (SPI, SPEI, AAI) and 25 districts are in aforementioned dry condition in all the three drought indices.

For the period June to September 2023, 58 districts (6.9% area of the country) are in moderately Arid condition and 14 districts (0.9% area of the country) are in severely Arid condition.

For the period June to September 2023, 125 districts (14.8% area of the country) are in moderately/severely/extremely dry condition or moderately/severely Arid condition in any two of three drought indices (SPI, SPEI, AAI) and 48 districts (5.9% area of the country) are in aforementioned dry condition in all the three drought indices.

Maximum number of districts in dry/arid condition as per the three drought indices are in Bihar and Uttar Pradesh states for the period June to September 2023.

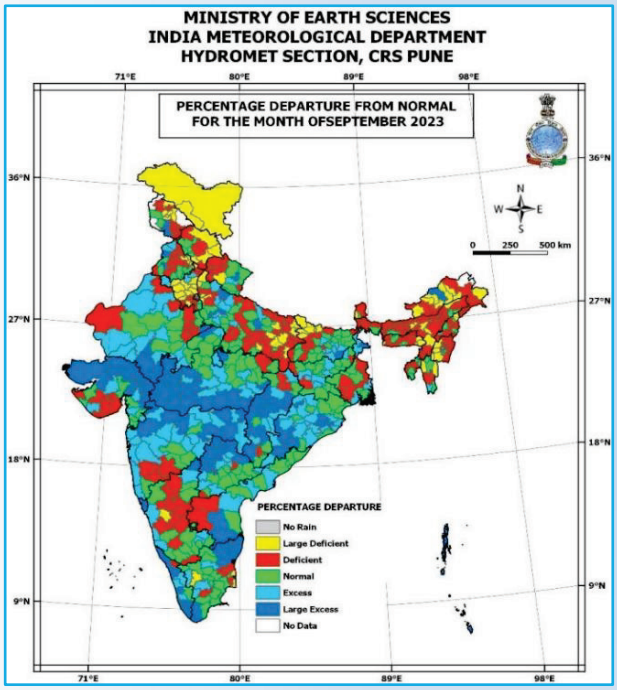


Fig. 40. Rainfall Percentage departure from Normal for the month of September 2023

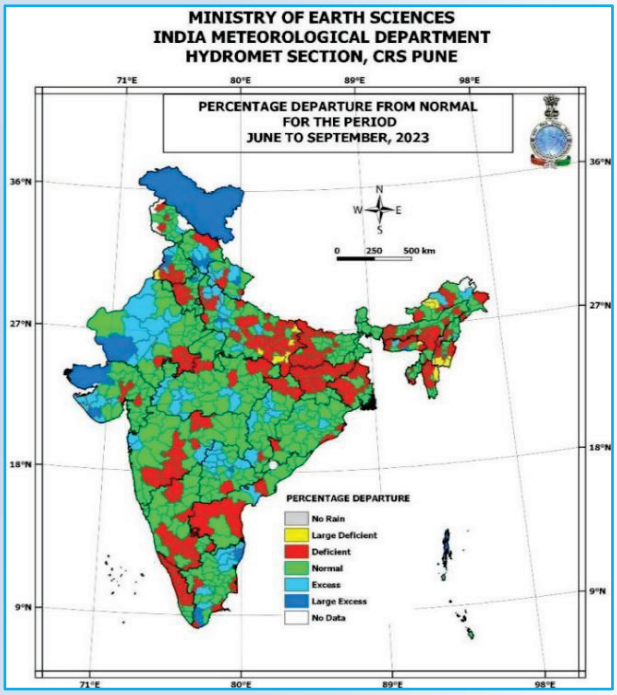


Fig. 41. Rainfall Percentage departure from Normal for the period June to September 2023

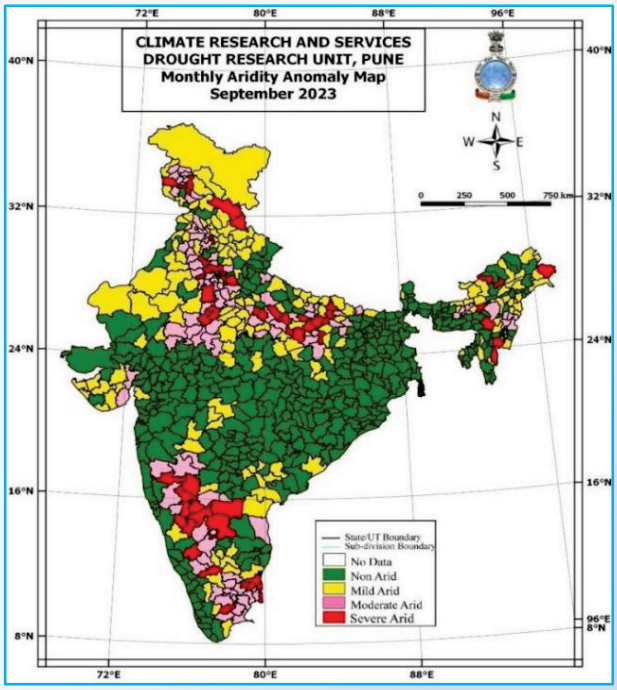


Fig. 42. Map based on Aridity Anomaly Index (AAI) for September 2023

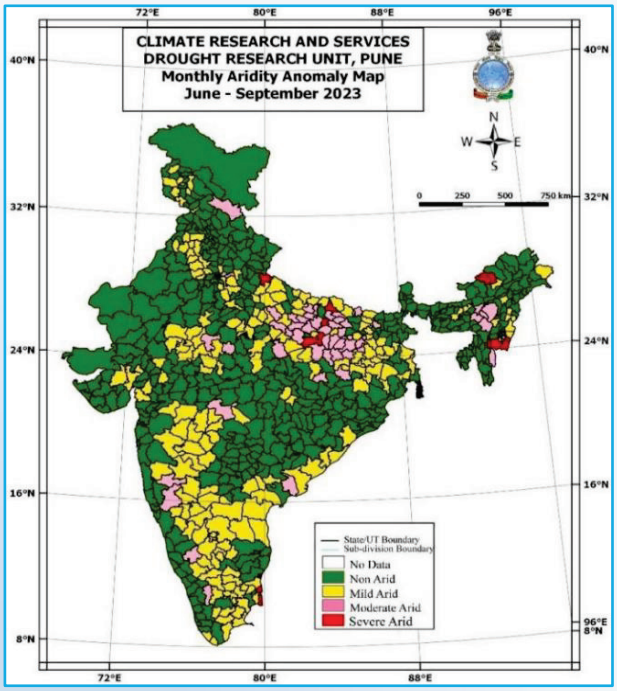


Fig. 43. Map based on Aridity Anomaly Index for the period June to September 2023

CHAPTER 6

CAPACITY BUILDING, PUBLIC AWARENESS & OUTREACH PROGRAMME

6.1. Important Events

148TH FOUNDATION DAY OF INDIA METEOROLOGICAL DEPARTMENT (IMD)

India Meteorological Department (IMD) celebrated its 148th Foundation day on 15th January, 2023 at Vrishti Sabhagaar of IMD. **Dr. Jitendra Singh**, Hon'ble Minister of State (IC), Ministry of Earth Sciences graced the occasion as the Chief Guest. **Shri Pushkar Singh Dhami**, Hon'ble Chief Minister, Uttrakhand, **Shri Sukhvinder Singh Sukhu**, Hon'ble Chief Minister, Himachal Pradesh and **Shri Manoj Sinha**, Hon'ble Lieutenant Governor, Jammu & Kashmir participated remotely as Guests of Honour. **Dr. M Ravichandran**, Secretary MoES presided over the function. **Dr. Mrutyunjay Mohapatra**, DG, IMD delivered welcome address and presented the achievements of IMD during the year and the future plans (Figs.1 &2). The celebrations were screened live (available at https://www.youtube.com/watch?reload=9&v=S7AxTOcMSSs&feature=youtu.be).



Fig.1. Dr. Jitendra Singh, Hon'ble Minister, Dr. M. Ravichandran, Secretary MoES, Dr. Mrutyunjay Mohapatra, DG IMD and Shri S. C. Bhan, Sc. 'G' during ceremonial lighting of lamp & Hon'ble Minister during his address

THE MAIN ACTIVITIES OF THE PROGRAMME

Honorable minister expressed his obligation towards the vision of Honorable Prime Minister, **Shri Narender Modi** that under his leadership India has made progress in the terms of Radar stations which will enhance the efficiency of IMD. **Dr. Mrutyunjay Mohapatra**, DG IMD during his welcome address, highlighted IMD's vision, "**No weather Hazard should go undetected and unpredicted**". Honorable minister also presented the certificates of Merit, Best employee awards, to IMD employees and Best office award and distributed awards and prizes to the winning school students of various competitions.

Inauguration of observational instruments including radars and Agro-AWS (a) Four (4) Doppler Weather Radars at Banihal in Kashmir, Murari Devi & Jot in Himachal Pradesh and Surkanda Devi in Uttarakhand and (b) Two Hundred (200) no's. Agrometeorological Automatic Weather Stations (Agro-AWS) were dedicated to the nation.

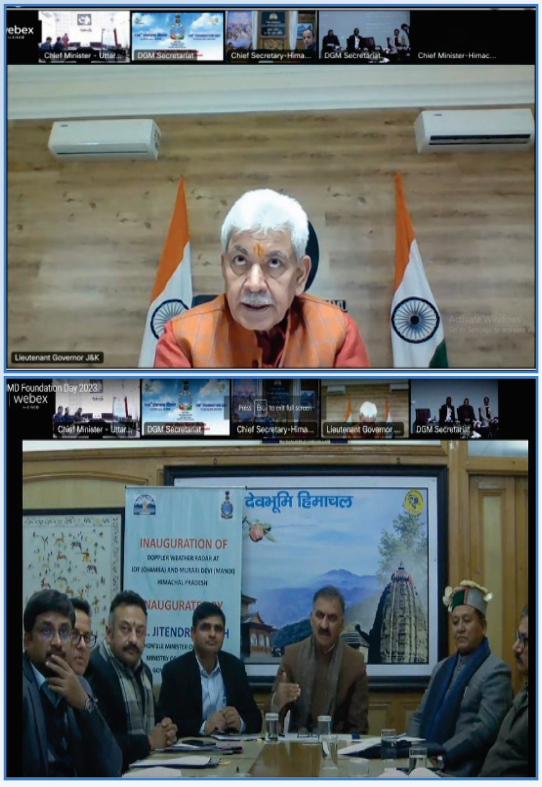


Fig. 2. Shri Manoj Sinha, Hon'ble Lt. Governor of J&K & Shri Sukhvinder Singh Sukhu, Hon'ble Chief Minister of H. P. during 148th IMD Foundation Day

India Meteorological Department celebrated the **74th Republic Day** ceremony on 26th January, 2023 (Fig. 3). On this occasion **Dr. Mrutyunjay Mohapatra**, DG IMD unfurled the National Flag. On this occasion DGM IMD addressed all the colleagues countrywide through VC.



Fig. 3. Dr. Mrutyunjay Mohapatra, DG, IMD unfurling the National Flag

India Meteorological Department signed memorandum of understanding with IIT Patna to enhance collaborative research between IMD and IIT Patna. **Dr. Mrutyunjay Mohapatra**, DG IMD signed the MOU with Director IIT Patna on 28th January, 2023 (Fig. 4). During last year, IMD has signed about 40 such MoUs with various research institutes and universities for improving collaborative research in the field of meteorology.



Fig. 4. IMD signed memorandum of understanding with IIT Patna

India Meteorological Department (IMD) signed Memorandum of Understanding (MoU) with Telangana State Load Dispatch Centre (TSSLDC) to ensure streamlined and strategic management of power through customized weather forecast on 1st February, 2023.

IMD signed MoU with Chitkara University, Chandigarh with an objective to promote research activities between the two institutions on 4th February, 2023. **Dr. Mrutyunjay Mohapatra**, DG IMD graced the occasion as the Chief Guest at the Annual Excellence Awards organized by Chitkara University, Chandigarh (Fig. 5).



Fig. 5. IMD signed MoU with Chitkara University

India Meteorological Department (IMD) & NIGERIAN METEOROLOGICAL AGENCY (NiMet), Nigeria signed a Memorandum of Understanding (MoU) on 2nd March, 2023 in the WMO Headquarters at Geneva (Fig. 6) for collaboration between the two agencies for the mutual benefit of cooperation in the conduct of Scientific & Technical Research and the development of practical skills that benefit the International Community.



Fig. 6. Senator Hadi Sirika, Hon'ble Minister of Aviation, Federal Republic of Nigeria; Dr. Mrutyunjay Mohapatra, Permanant Representative (PR) of India with WMO: Professor Mansur Bako Matazu, PR of Nigeria with WMO & Ms. Barkha Tamrakar, First Secretary , Permanent Mission of India, Geneva

The IMD & NiMet will work together to provide WMO standard services in the field of Numerical Weather Prediction Capability, Meteorological Sensor Designing, Satellite Meteorology, Scientific research on meteorology and its applications in various sectors, Nowcasting, Early warning capabilities and Capacity building activities.

A letter of Agreement is signed between IIT Bombay, Mumbai and India Meteorological Department (CR&S Pune) for joint studies and Projects related to climate.

India Meteorological Department (IMD) celebrated **International Women's Day** on 9th March, 2023 at IMD H.Q. and sub-offices of IMD. At headquarters, various competitions were organized to encourage women employees in the organization and awards were distributed to the winners. In addition, special lectures were also organized on physical & mental fitness issues.

WORLD METEOROLOGICAL DAY 2023

IMD and Indian Meteorological Society (IMS) jointly celebrated **World Meteorological Day** on 23rd March, 2023 addressing the theme "**The future of weather, climate and water across generations**". On this occasion, **Dr. Anshu Sharma**, Co-Founder of Sustainable Environment and Ecological Development Society (SEEDS) delivered the keynote talk and **Dr. Mrutyunjay Mohapatra**, DG, IMD delivered the thematic talk. Following publications were released during the function:

- **Special Issue of MAUSAM** (Vol. 74, No. 2, 2023) containing the proceedings of 7th WMO International Workshop on Monsoon (IWM-7).
- IMD Met Monograph: Northeast Monsoon of South Asia
- IMD Annual Report 2022
- The event was telecast live on Youtube and is available at following link: https://youtube.com/live/ce1GYlbw_6U?feature=share

IMD signed Letter of Agreement with Green Alerts Web Portal to provide weather forecast and farm based weather advisories to farmers at block level on 29th March. It would help the farmers prepare and execute strategies to save crops from adverse weather situations.

Shri Kiren Rijiju taken charge as Minister of Earth Sciences at New Delhi



Fig. 7. Hon'ble Union Minister, MoES, Shri Kiren Rijiju



Fig. 8. Hon'ble Union Minister, MoES, Shri Kiren Rijiju, chaired a meeting with the Secretary, MoES, Dr. M. Ravichandran, Dr. M. Mohapatra, DG IMD and Senior Officials of MoES, at Prithvi Bhawan in New Delhi on 19th May, 2023

Today on 19th May, 2023 **Honourable Minister of Earth SciencesShri Kiren Rijiju** took charge of the Ministry of Earth Sciences (Figs. 7 & 8). During the occasion **Dr. M. Mohapatra**, DG IMD made presentation on **Organizational Structure and Activities** of India Meteorological Department. During the presentation Dr. Mohapatra briefly discussed about organizational structure of IMD, its forecasting systems, various NWP models being used in IMD, Observational networks, Information and Communication Technology, Meteorological services to various sectors, performances of forecasts, dissemination mechanism and finally he presented organizational structure of IMD in NE Region, present observational networks and

forecasting services provided by IMD to various stakeholders of NE Region and future plan to expand observational network and forecasting services over NE Region.

The Nineteenth World Meteorological Congress (Cg-19) at CICG

The World Meteorological Congress, the supreme body of World Meteorological Organization (WMO), organized its 19th session from 22nd May to 2nd June, 2023at the International Conference Centre of Geneva (CICG). It assembles all 193 Member States and Territories of the WMO. On 1st of June, 2023 voting was held for various positions of Cg-19. **Dr. Mrutyunjay Mohapatra**, DG IMD was elected **Third Vice President of WMO** (Fig. 9)

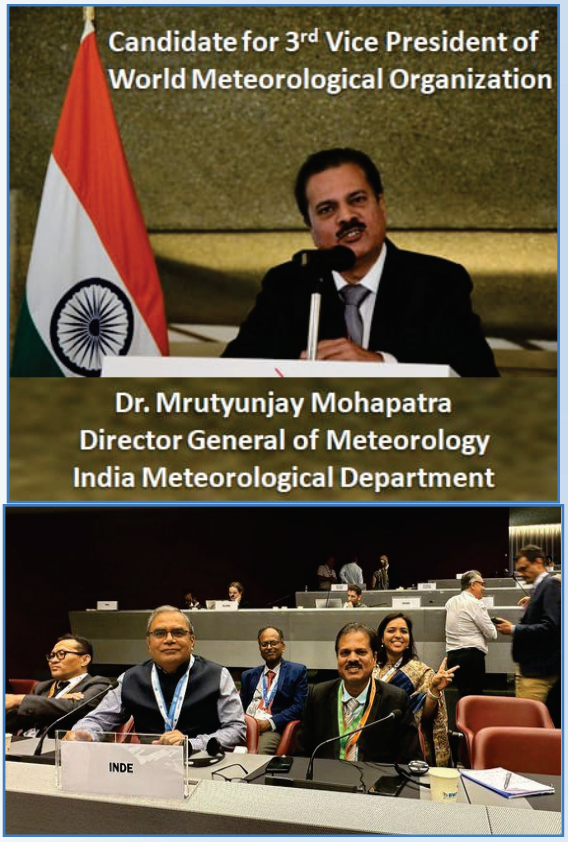


Fig. 9. Dr. Mrutyunjay Mohapatra, DG IMD elected "Third Vice President of World Meteorological Organisation"

First Project Management Committee (PMC) for implementation of Global FFGS

Mr. Rahul Saxena, Sc. 'F' & Focal Point (SA) attended first Project Management Committee (PMC) forimplementation of Global FFGS (Fig. 10) on 16th May, 2023 at Skopje, North Macedonia and was elected as first Chair for PMC for the duration of four years (Fig. 11). About 17 Regional Centers representing 70 countries participated in this election.



Fig. 10. First Project Management Committee (PMC) for implementation of Global FFGS

The news was shared in the official handle of MoES and appreciated by **Hon'ble Minister of Earth Sciences, Shri Kiren Rijiju Sir**.



Fig. 11. Mr. Rahul Saxena, Sc. 'F' & Focal Point (SA)elected as first Chair for PMC for the duration of four years

Achievements of India Meteorological Department as Regional Specialized Meteorological Centre

On 30th May, 2023 WMO organized a meeting to highlight the achievements of India Meteorological Department (IMD) as Regional Specialized Meteorological Centre (RSMC) for Tropical cyclones providing support to countries in Bay of Bengal and Arabian Sea region. During the meeting, WMO specially highlighted forecast and advisory services provided by IMD to Bangladesh and Myanmar during cyclone **MOCHA** (pronounced as MOKHA) helping these countries to take response action to minimize loss of life and property. WMO and UNHCR appreciated IMD for its services during cyclone MOCHA.

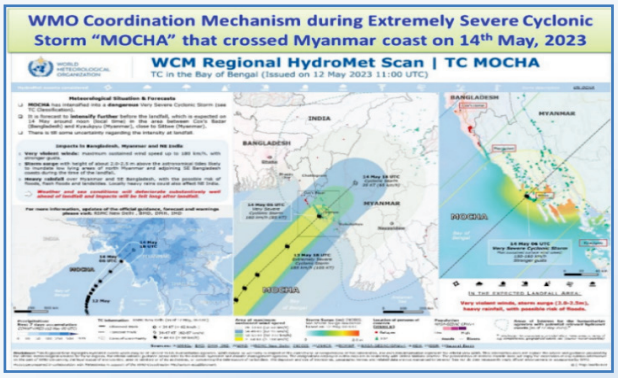


Fig. 12. WMO specially highlighted forecast and advisory services provided by IMD to Bangladesh and Myanmar during cyclone MOCHA



Fig. 13. Dr. Mrutyunjay Mohapatra discussing the early warnings provided by RSMC New Delhi

Dr. M. Mohapatra, DG IMD participated in the 77th Session of World Meteorological Organisation, Executive Council during 5- 6 June, 2023 as the 3rd Vice President of WMO (Fig. 14).



Fig. 14. Dr. M. Mohapatra, DG IMD participated in the 77th Session of WMO

Hon'ble Minister for MoES, **Shri Kiren Rijiju** and **Dr. M. Ravichandran**, Secretary, MoES visited X BAND Radar facility at NIOT campus Chennai on 8th June, 2023 (Fig. 15). During the visit of the Hon'ble Minister for MoES**, Shri Kiren Rijiju** and **Dr. M. Ravichandran**, Secretary, MoES for participation in the World Oceans Day programme at NIOT Chennai **Dr. S. Balachandran**, Sc. 'G', **Shri B. A. M. Kannan**, Sc. 'F' and **Shri P. S. Kannan**, Sc. 'E' participated in the programme at NIOT Chennai on 8th June, 2023.



Fig. 15. World Oceans Day programme at NIOT Chennai

Dr. M. Mohapatra, DG IMD led the delegation from India to participate in the 19th Session of World Meteorological Congress (Cg-19). During the Congress, **Dr. Mohapatra** actively participated in the deliberations & discussions and made several interventions which were accepted as recommendation by the Congress.



Fig. 16. Some interactive meetings with the heads of other countries during Cg-19 at Geneva

Dr. M. Mohapatra, DG IMD made a statement on India's commitment to support implementation of WMO's initiatives on Global Basic Observation Network (GBON) and Systematic Observations Financing Facility (SOFF). He also reiterated India's support from India towards implementation of SOFF for the benefit of least developed countries and island nations.

During the Cg-19, a video film on **"Cyclone Warning and Management in India : An End to End System"** developed by India Meteorological Department was screened by WMO during. The film showcased the multi-institutional mechanism in India to manage cyclones with case studies of cyclone **Tauktae** (2021) and **Mocha** (2023) discussed therein.

Long Term Plan of World Weather Research Program: Dr. M. Mohapatra, DG IMD highlighted the contribution of India to polar research and seasonal to sub seasonal forecast to different countries in the region as a regional climate centre. He also expressed willingness to act as Regional Climate Centre for Third Pole (The Himalayas) region.



Fig. 17. Participation in the Nineteenth World Meteorological Congress (Cg-19) at Geneva

Google team headed by its Vice President held a meeting with Indian delegation led by **Dr. M. Mohapatra**, DG IMD in Geneva on 25th May, 2023 in the sidelines of WMO Congress for possible extension of cooperation between Google and India Meteorological Department for extension of weather services in the region. It is needless to mention that Google works with IMD for sharing the cyclone advisory services in the region and is also working for development of nowcast techniques for prediction of location specific rainfall.



Fig. 18. Google team headed by its Vice President held a meeting with Indian delegation led by Dr. M. Mohapatra, DG IMD

During the session **"Early Warning for all (EW4All)"** on 26th May, 2023 (Fig. 19), **Dr. M. Mohapatra**, DG IMD informed the house about India's support for early warning for all initiatives by WMO and UN. He made a statement that India will act as Peer Advisor for implementation of systematic observation and forecasting facility (SOFF) in least developing countries and small island states for augmentation of meteorological observation network. He further stressed the need for regional and national committees for regular review and implementation of early warning for all initiative in the globe.



Fig. 19. Dr. M. Mohapatra, DG IMD during the session "Early Warning for all (EW4All)" on 26th May, 2023

Dr. M Mohapatra, DG IMD interacted with **President WMO, Secretary General of WMO** and **Permanent Representatives of different countries** to the UN Missions in Geneva, Permanent Representative of different countries to WMO during his visit and highlighted India's contribution and commitment towards implementation of various initiatives of WMO. **Prof. Pettari Taalas**, Secretary General of WMO appreciated the role of INDIA (Fig.20)especially India Meteorological Department in improving weather and climate services for the region and contributing to the world for betterment of services through observational infrastructure, modelling infrastructure, capacity building through various regional platforms like Regional Specialised Meteorological Centres for Tropical Cyclones, Severe Weather Guidance, Flash flood, Mountain Weather for Himalayan region among others. Dr. Adrian President of WMO appreciated INDIA for its services to different countries on weather and climate while addressing the gathering. Both the President and Secretary General of WMO highlighted and appreciated especially the contribution of **Dr. M. Mohapatra**, DG IMD as members of the Executive Council of WMO.



Fig. 20. Dr. M. Mohapatra, Prof. Petteri Taalas, Secretary General, WMO and Dr. Adrian, President WMO during the interactive meeting at Cg-19

Visit of Shri Kiran Rijiju, Hon'ble Minister of Earth Sciences to India Meteorological Department (IMD)

Shri Kiran Rijiju, Hon'ble Minister of Earth Sciences visited the India Meteorological Department (IMD) one 26th July, 2023. **Dr. M. Ravichandran,** Secretary Ministry of Earth Sciences and **Dr. M. Mohapatra**, DG IMD led the team of experts from IMD to explain the **Hon'ble Minister** about various activities and services provided to the country and the region (Fig. 21). **The Hon'ble Minister appreciated IMD** for the progress made in recent years in terms of forecast accuracy, service delivery, sectoral applications, impact-based forecast and risk based warnings.



Fig. 21. Meteorological data communication system of IMD being explained to Hon'ble Minister

The Hon'ble Minister addressed the Press and Electronic Media and appreciated the achievements of IMD especially w.r.t. the early warning services provided for Biparjoy cyclone, which helped the disaster managers and public to ensure zero loss of life over Gujarat. The Hon'ble Minister specifically appreciated the services provided by IMD to farmers, fishermen and other stake holders.



Fig. 22. DG IMD explaining about activities including indigenous decision support system for weather forecasting of IMD to Hon'ble Minister

During the G20 event held at Bharat Mandapam, IMD ensured timely provision of Weather Services and distributed weather updates across a range of platforms, including Twitter, Facebook and WhatsApp. The weather information was made also available througha dedicated webpage (https://mausam.imd.gov.in/g20), this en-compassed the delivery of both real-time nowcasts and detailed weather forecasts for the Bharat Mandapam area during the event (Figs. 23 & 24).



Fig. 23. IMD Nowcast & Weather Forecast



Fig. 24. Hon'ble Minister of Earth Sciences Shri Kiran Rijiju addressing the Press during G20 Event

Inauguration of Meteorological Centre at Port Blair, Imphal, Kohima and Aizawl : Hon'ble Minister of Earth Sciences Shri Kiren Rijiju Ji inaugurated four Meteorological Centres at Port Blair, Imphal, Kohima and Aizawl on the occasion of 17th Foundation Day of Ministry of Earth Sciences on 27th July, 2023 (Fig. 25).



Fig.25.Hon'ble Minister of Earth Sciences Shri Kiren Rijiju Ji virtually inaugurated the Meteorological Centres. Left to Right : Shri D. Senthil, Dr. M. Ravichandran, Hon'ble Minister Shri Kiren Rijiju Ji, Dr. M. Mohapatra and Shri Vishvajit Sahay

Dr. M. Mohapatra, DG IMD hoisted National Flag of India at IMD on the occasion of 77th Independence Day on 15th August, 2023. IMD Officials alongwith their families participated in the event. DG IMD addressed all the participants on this occasion.



Fig. 26. Dr. M. Mohapatra, DG IMD hoisted National Flag on the occasion of 77th Independence Day on 15th August, 2023

Shri Bikram Singh, Sc. 'F' briefed the **Hon'ble Governor of Uttarakhand Lt. Gen. (Retd) Gurmeet Singh** about the ongoing monsoon activities and the services being provided by Meteorological Centre Dehradun on 17th August, 2023 at Raj Bhawan, Dehradun.



Fig. 27. Shri Bikram Singh, Sc. 'F' briefed the Hon'ble Governor of Uttarakhand Lt. Gen. (Retd.) Gurmeet Singh

The Hon'ble Governor of Uttarakhand praised the Officers and Staff of Meteorological Centre Dehradun for accurate and timely weather forecast and warnings services given for Uttarakhand state (Fig. 27).

IMD hosted the 2nd Meeting of WMO's Advisory Group on Severe Weather Forecasting (AG-SWF) Programme at New Delhi during 19-21 September, 2023 (Fig. 28) with experts from WMO and various severe weather forecasting centres across the globe. The meeting was inaugurated by **Dr. M. Ravichandran,** Secretary, MoES in presence of **Dr. M. Mohapatra,** DG IMD and released the

(1) Upgraded website of "**Severe Weather Forecasting Programme (SWFP) - South Asia**" and (2) a Souvenir on "**Severe Weather Forecasting Programme - South Asia**". Mrs. Monica Sharma, Sc. 'D' participated in the meeting as Co-Chair of the AG-SWF programme.



Fig. 28. 2nd Meeting of WMO's Advisory Group on Severe Weather Forecasting (AG-SWF)

Under the Severe Weather Forecasting Programme (SWFP), the Regional Specialized Meteorological Centre (RSMC), New Delhi provides guidance and forecast every day valid for next five days to nine

member countries in South Asian region **(Thailand, Myanmar, Bangladesh, Nepal, Bhutan, India, Sri Lanka, Maldives and Pakistan)** since 2016.

IMD conducted Pre-cyclone exercise and preparedness Meeting for the cyclone season (April-June) on 29th September, 2023 (Fig. 29) under the chairmanship of **Dr. M. Mohapatra**, DG IMD. The meeting was held through hybrid mode. **Mr. Harsh Gupta**, Project Director NCRMP participated in the meeting. The objective of the meeting was to share various achievements of IMD, its initiatives and to take stock of its preparedness for the ensuing cyclone season and most importantly to develop an effective liasioning with various stake holders. There were about 280 participants from different organisations including central level disaster management agencies, state level disaster management (DM) agencies, various Ministries & Departments, IMD's sister organisations and research institutes.



Fig. 29. Pre-cyclone exercise and preparedness Meeting for the cyclone season

Under directions of **Dr. M. Mohapatra**, DG IMD with guidance of **Mr. K. S. Hosalikar**, Sc. 'G' and with planning by **Shri Anjit Anjan**, Sc. 'E' a dedicated team of three members, including **Shri B. Sudarsan Patro**, Sc. 'D', **Shri Manoj Gujar**, Met. 'A' and **Shri Parsottam**, S. A. successfully installed an Automatic Weather Station (Fig. 30) in proximity to the G20 event on 4th September, 2023. This station, named **PRAGATI_MAIDAN_G20_SUMMIT**, provided real-time weather updates at 15-minute intervals, with live data dissemination to websites. The system performed satisfactorily and reported rainfall on 9-10 September, 2023. The unwavering support provided by **Dr. V. K. Soni,** Sc. 'F', **Dr. Manish Ranalkar,** Sc. 'F', **Dr. Sanjay Bist,** Sc. 'E' and their dedicated team in Delhi.



Fig. 30. SID CRS Pune Team installing AWS for G20 event at Delhi

To commemorate the 150 years of foundation of IMD, the Hon'ble Minister of Earth Sciences (HMOES) **Shri Kiren Rijiju Ji** graced the occasion as the Chief Guest and released the logo 150 years of service to the nation on 26th December, 2023 (Figs. 31 & 32). **Dr. M. Ravichandran**, Secretary, Ministry of Earth Sciences (MoES), **Dr. Mrutyunjay Mohapatra**, DG IMD, **Dr. S. Pandian**, Joint Secretary MoES, **Shri Vivek Sinha**, Sc. 'G', IMD and Co-Chair Local Organising Committee and **Mrs. Ranju Madan,** DDG (Administration), IMD & Co-Chair LOC also graced the occasion. The logo release ceremony was also attended by various sister organisations of IMD, central and state Govt. agencies and print and electronic media, in person and online mode. Detailed Press Release issued in this regard is availableat the link: https://internal.imd.gov.in/press_release/20231226_pr_2716.pdf.
Logo release video is available at the link: https://youtu.be/Q9aGatf7b9c



Fig. 31. Hon'ble Minister of Earth Sciences (HMoES) Shri Kiren Rijiju Ji released the IMD logo 150 years of service to the nation on 26th December, 2023



Fig. 32. Logo released to commemorate 150 years of IMD to the Service of Nation Shri Kiren Rijiju Ji, Hon'ble Union Minister of Earth Sciences and other Dignitaries during Logo released

Dr. Mrutyunjay Mohapatra, DG IMD, PR of India to WMO and 3rd Vice President of WMO participated as Guest of Honour and led the Indian delegation to the 50th session of World Meteorological Organisation/Economic and Social Commission for Asia and the Pacific (WMO/ESCAP) Panel on Tropical Cyclones (PTC) in Bahrain during 19th - 23rd December, 2023. **Dr. D. R. Pattanaik,** Sc. 'G' and **Mrs. Monica Sharma** Sc.-D were part of the team. In his speech, Dr. Mohapatra highlighted (Figs. 33 &34) the role of India in building the Tropical Cyclone Forecasting System over the region. During the 50th Session of PTC, India got elected to host PTC Secretariat during 2024-2028.



Fig. 33. Dr. M. Mohapatra addressing during Inaugural of 50th Session of PTC



Fig. 34. Group Photograph after election of India to host WMO/ESCAP Panel on PTC Secretariat during 2024-2028

IMD organised a Technical Conference on "**Advancements of Cyclone Warning services through WMO/ESCAP Panel on Tropical Cyclones**" on 19th December, 2023 prior to the 50th PTC Session and also made presentations during the 50th Session of PTC. **Dr. D. R. Pattanaik**, Sc. 'G' made a presentation on (i) **Activities to commemorate 50 years of establishment of PTC**, (ii) **Tropical Cyclone Impact based forecast and Risk Assessment through Web based Dynamic Composite Risk Atlas**. **Mrs. Monica Sharma**, Sc. 'D' made a presentation on (i) **Gaps and Challenges in Tropical Cyclones monitoring and forecasting over North Indian Ocean**, (ii) **Review of cyclone season 2022 and 2023 during PTC-50 Meeting on 20th December, 2023** and (iii) **Tropical Cyclone Operation Plan (TCP-21) (Edition 2023)** as Rapporteur during PTC-50 meeting. **The WMO/ESCAP PTC appreciated the tropical cyclone** advisory services and other supports provided by IMD. WMO/ESCAP PTC also appreciated IMD for providing tropical cyclone forecasters training to WMO/ESCAP Panel countries in 2023.

Delegation from Ghana, visited India Meteorological Department on 23rd November, 2023 to have an overview of the forecasting techniques and practices at India Meteorological Department on 23rd November, 2023. The team visited National Weather Forecasting Centre in IMD.

Hon'ble Union Minister of Earth Sciences, Shri Kiren Rijiju chaired a Review Meeting on 26th December, 2023. DG, IMD along with other senior officers of IMD attended the meeting. A presentation was made by IMD on "**Field trial on the AWS using a Direct Methanol Fuel Cell along with a Solar panel**".

Memorandum of Understanding

IMD signed Letter of Agreement with **Bhabha Atomic Research Centre** on 14th April, 2023 with an objective to enhance collaboration between the two agencies for establishment of environmental radiation network in IMD observatories by BARC.

Dr. M. Mohapatra, DG IMD, deliver an invited talk on **"Climate Change and You"** at DAE Convention Centre at Mumbai on 14th April, 2023.

Dr. M. Mohapatra, DG IMD signed an MoU with **Prof. Petteri Taalas, Secretary General World**

Meteorological Organization for the hosting of WMO Regional Training Centre with IMD as coordinator.

IMD signed a Memorandum of Understanding with World Food Programme on 1st May, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' and **Smt. Sangita Sil**, Deputy General Manger (Electrical), DVC signed an agreement of MOU on 20th June, 2023 (Fig. 35).



Dr. Sanjib Bandyopadhyay, Head RMC Kolkata (IMD) and Smt. Sangita Sil, Dy. General Manger (Electrical), DVC signing agreement of MOU with Damodar Valley Corporation on 20.06.23

Fig. 35. Dr. S. Bandyopadhyay, Sc. 'G' and Smt. Sangita Sil, Deputy General Manger (Electrical)

IMD signed a Memorandum of Understanding with United Nations Development Programme (UNDP) to enhance India's climate resilience by using weather data to strengthen climate adaptation efforts on 22nd June, 2023. With this collaboration, the community needs will be strengthened upto Gram Panchayat level.



Fig. 36. IMD signed a Memorandum with UNDP

India Meteorological Department signed a MoU with **Indian Institute of Science Education and Research Pune (IISER)**, Pune on 4th August, 2023 to promote research and development between the two organisations. **Dr. Mrutyunjay Mohapatra**, DG IMD presented a public lecture on Climate Change and Our Role at the IISER Pune institute on 4th August, 2023 (Fig. 37).



Fig. 37. Dr. M. Mohapatra, DG IMD & Prof. Sunil S. Bhagwat (Director, IISER Pune) with Dr. K. S. Hosalikar

IMD signed an MoU with Shiksha 'O' Anusandhan Deemed to be University, Bhubaneswar on 12th August, 2023 to promote research and development between the two institutes (Fig.38).



Fig. 38. MoU Signing ceremony

6.2. MEETINGS

Shri Vivek Sinha, Sc. 'G', **Shri Anand Shankar**, Sc. 'C' participated in the meeting of technical committee to finalize PFP for installation of 52 AWS in the State of Bihar by Department of planning & Statistics on dated 3rd January, 2023.

Dr. H. R. Biswas, Sc. 'F' attended the meeting on status of Doppler Weather Radar (DWR) stations at Balasore & Sambalpur under the chairmanship of Additional State Relief Commissioner at Conference hall of State Relief Commissioner office, held on 6th January, 2023.

Dr. S. Dwivedi, Sc. 'C' and **S. Patra**, S. A. attended online Webex meeting in view of "**Technical Demonstration on use of CSC Kiosk for dissemination of Advisory and Weather Forecast**" organized by Agromet Service Cell, New Delhi on 9th January, 2023.

Dr. (Smt.) Manorama Mohanty, Sc. 'E' virtually attended Post monsoon Inter State meeting on Flood Management & Preparedness for Monsoon 2022 for Lower Narmada, Tapi and Damanganga Basins through VC on 10th January, 2023 organized by CWC Gandhinagar.

Shri Vivek Sinha, Sc. 'G' along with **Shri Anand Shankar**, Sc. 'C' and **Shri Ashish Kumar**, Sc. 'C' has participated in the virtual meeting with Bihar Status Pollution Control Board regarding Air Quality early warning system on 10th January, 2023.

A meeting has been conducted with **Mr. Subha Dutta**, marketing engineer, Cellcom solution Ltd. On 13th January, 2023 in presence of Head RMC Guwahati **Sh. K. N. Mohan**, Sc. 'G', **Dr. S. O' Shaw,** Sc. 'F' regarding problem facing by all the AWS/ARG station under NE Region.

Dr. Kripan Ghosh, Sc. 'F', **Dr. Ashutosh Kumar Misra**, Sc. 'D' and **Dr. Asha Latwal,** Sc. 'C' attended online meeting to plan activities for celebration of 150 years of IMD addressed and chaired by **Dr. M. Mohapatr**a, DG IMD, New Delhi on 23rd January, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' participated in the 161 Quarterly Meeting of HQ Official Language Implementation Committee through Virtual Mode on 25th January, 2023.

Dr. H. R. Biswas, Sc. 'F' attended the 59th meeting of the SLCCCI (State Level Co-ordination Committee on Crop Insurance) on 25th January, 2023 in Conference Hall of Lok Seva Bhawan, Bhubaneswar under the Chairmanship of the Development Commissioner-cum ACS, Odisha.

A meeting **with AAI, Patna and IIT, Patna** has been conducted in the presence of DGM, IMD on 28th January, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the **WCSSP Executive Council Meeting** through webex on 2nd, 9th February, 2023.

Shri H. S. Sawhney, Sc. 'E' attended a meeting on 3rd February, 2023 organised by Central Electricity Authority under the Chairmanship of Chairperson, CEA to deliberate the requirement of weather data to arrive at possible solutions for improving RE forecasting for better scheduling.

Dr. Mrutyunjay Mohapatra, DG IMD had a meeting with **Prof. Amit Tandon**, USA on 8th February, 2023 about **EKAMSAT project** over Arabian Sea and role of IMD.

Dr. Mrutyunjay Mohapatra, DG IMD had a meeting with winning team of Smart India Hackethon-Non-Residential built up deduction on 8th February, 2023.

Dr. O. P. Sreejith, Sc. 'E' attended WMO online meeting "**Authors' Meeting: State of the Climate in Asia 2022**" on 9th February, 2023.

Dr. Ashok Kumar Das, Sc. 'E' attended the 1st meeting of PRSG of "**Autonomous Bathymetric Survey Vessel for Advanced Glacier Lake Profiling by CDAC-Thiruvananthapuram**" on 10th February, 2023 at Sikkim State Council of Science and Technology (SSCST), Gangtok,.

Dr. Sankar Nath, Sc. 'F' attended the 2nd Meeting of RA II Expert Team virtually on 15th February, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the EU-India brokerage event on "Essential Ocean Variables (EOVs) at MoES on 18th February, 2023.

Dr. Kripan Ghosh, Sc. 'F', attended an online meeting of WMO on 21st February, 2023 to discuss "**Work plan for RA II Operating Plan 2021-2024, RA II Implementing Plan 2021-2023 and preparation of the upcoming RA II RECO**".

A meeting was held with the representative of office of Principal Scientific Advisor, Government of India on 22 Feb, 2023 regarding the **"Manthan"-Digital Platform for Research and Innovation.**

Dr. Mrutyunjay Mohapatra, DG, IMD participated in the briefing meeting for Regional Association II, Regional Conference (RECO) through VC on 23rd February, 2023.

Dr. Sankar Nath, Sc. 'F' attended the 42nd meeting of the Financial Advisory Committee (FINAC-42) virtually on 23rd February, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD and team of scientists from IMD participated in the meeting with senior delegates from Nuclear Power Corporation of India Ltd. (NPCIL) in virtual mode to discuss about sharing of customized weather forecast with NPCIL for effective management of various power plants during severe weather conditions on 23rd February, 2023.

Dr. Kripan Ghosh, Sc. 'F' attended online meeting on "**FDP Storm and Heat Wave Preparedness-2023**" **chaired byDr. M. Mohapatra**, DG IMD, New Delhi on 24th February, 2023.

Dr. H. R. Biswas, Sc. 'F', **Shri Umasankar Das**, Sc. 'C' & **Dr. S. Dwivedi**, Sc. 'C', M.C. Bhubaneswar, attended the Webex meeting on FDP Storm and Heat Wave Preparedness Meeting 2023 on 24th February, 2023.

Dr. G. N. Raha, Sc. 'E' and other officials of M. C. Gangtok has attended Cisco Webex meeting to discuss preparedness of various participating organizations for the ensuing FDP STORM & Heat Wave Seasons on 24th February, 2023.

Dr. G. N. Raha, Sc. 'E' attended Post budget interaction meet headed by **Smt. Nirmala Sitharaman, Hon'ble Union Minister of Finance & Corporate Affairs** at Chintan Bhawan, Gangtok, Sikkim on 27th February, 2023.

Dr. Kuldeep Srivastava Sc. 'F' participated in 9th Meeting of Geospatial Information Sectional Committee of BIS on 1st March, 2023 in Hybrid Mode.

Shri Asok Raja S. K., Sc. 'C' and **Ms. Hemlata Bharwani**, Sc. 'C' attended International virtual meeting with WMO Hydrology Team on 1st March, 2023 to discuss the training activities, support other regions through capacity building, enhance FFGS Moodle platform and prepare new simulator cases.

Dr. Mrutyunjay Mohapatra, DG IMD led Indian to Geneva to attend the 76th Session of WMO's Executive Council during 26th February to 3rd March, 2023.

Dr. Ashok Kumar Das, Sc. 'E' attended the CWC's First meeting of the Project steering Committee for **Assessment of Water Resources Potentialof India** at Sewa Bhawan, CWC on 6th March, 2023.

Shri S. C. Bhan, Sc. 'G' and **Dr. Ashok Kumar Das,** Sc. 'E' attended the Project Review Committee (PMC) meeting on 7th March, 2023 under the Chairmanship Secretary, MoES.

Shri Radheshyam Sharma, Sc. 'C' participated in the Third Disaster Risk Reduction NDPRR meeting organized by NDMA on 10-11 March, 2023 at New Delhi from MC Jaipur.

Shri Anand Shankar, Sc. 'C' and **Shri Ashish Kumar**, Sc. 'C' attended the meeting with Chief Secretary and Disaster Secretary on 14th March, 2023 for the preparation of Heat wave in coming season.

Dr. (Smt.) Manorama Mohanty, Sc. 'E' had attended the meeting with Chief Secretary regarding Heat Wave Forecast for summer on 14th March, 2023 and meeting with Collector of all the districts of Gujarat chaired by Commissioner of Relief on 16th March, 2023.

Dr. G. N. Raha, Sc. 'E' has attended Online Quarterly review meeting for AWS & ARG Maintenance with RMC Mumbai/RMC Kolkata/RMC Chennai Region on 14th March, 2023.

Dr. Ashok Kumar Das, Sc. 'E' attended the 5th project monitoring committee meeting of early warning system for flood prediction in the river basins of India under national super- computing mission C-DAC Innovation Park, Pune held on 15th March, 2023.

Shri S. C. Bhan, Sc. 'G' and Shri **H. S. Sawhney**, Sc. 'E' attended the first preliminary meeting for creating an Integrated Digital Platform for One Health on 16th March, 2023 under the chairmanship of **Shri Lav Agrawal, Additional Secretary (Health)**, Ministry of Health and Family Welfare.

Dr. G. N. Raha, Sc. 'E' has attended a meeting on **Weather based Crop Insurance scheme for Large Cardamom** on 17th March, 2023 at Krishi Bhavan Conference hall organized by Spices Board, Gangtok.

Dr. Ashok Kumar Das, Sc. 'E' **and Shri Asok Raja S. K.,** Sc. 'C' attended 9th quarterly inter-ministerial virtual meeting regarding the Brahmaputra Real-Time Monitoring System (BRTMS) on 17th March, 2023.

Dr. M. Mohapatra, DG IMD participated in a review meeting under the chairmanship of Principal Secretary to PM on Review of weather conditions and crop situation on 24th March.

Shri. Asok Raja S. K., Sc. 'C' and **Ms. Hemlata Bharwani,** Sc. 'C' attended in the International virtual meeting with WMO & USAID Training Team on 24 & 30 March, 2023 to discuss and draft the new Training Stream of Operational forecasters and allied WMO training activities to support other regions for sustainability of the Global flash Flood Guidance Project (Fig. 39).



Fig. 39. Meeting with WMO Hydrology Team

Dr. M. Mohapatra, DG IMD participated in the first working group meeting of G-20 on Disaster Risk Reduction held on 30th March at Gandhi Nagar.

Shri K. Santhosh, Sc. 'F', had a meeting with Additional Chief Secretary, Revenue & Disaster Management Department, Government of Kerala on 29th March, 2023 in connection with issuing Possession Certificate of land belonging to IMD at Kozhikode.

Dr. Ashok Kumar Das, Sc. 'E' attended a virtual meeting on 30th March, 2023 with Ranjit Sagar Dam authority & NWP Division regarding the requirement of weather forecast data in reference to flood forecasting.

Dr. H. R. Biswas, Sc. 'F' attended heat wave preparedness meeting on 9th April, 2023 at Lok Seva Bhawan under chairmanship of **Hon'ble minister, Smt. Pramila Mallik,** Revenue and Disaster Management, Government of Odisha.

Shri Vivek Sinha, Sc. 'G' attended the meeting with Chief Minister, Govt. of Bihar and given presentation about Heat Wave and long range forecast on 10th April, 2023.

Dr. S. Dwivedi, Sc. 'C' attended State Level Technical Committee Meeting for implementation of PMFBY at Krushi Bhawan, Bhubaneswar under the chairmanship of DAFP, Govt. of Odisha on 11th April, 2023.

Dr. S. Dwivedi, Sc. 'C' attended State Level Technical Committee Meeting for implementation of PMFBY at Krushi Bhawan, Bhubaneswar under the chairmanship of DAFP, Govt. of Odisha on 11th April, 2023.

Dr. H. R. Biswas, Sc. 'F' attended review meeting on "**Seed Reserve Policy to discuss the status of monsoon for 2023**" at Krushi Bhawan, Bhubaneswar under the chairmanship of DAFP, Govt. of Odisha on 12 April, 2023.

Dr. Kripan Ghosh, Sc. 'F', Agrimet Division, Pune attended the "**13th meeting of Project Monitoring and Advisory Committee (PMAC) of IMD**" to monitor the periodic progress of the projects under ACROSS-IMD and to suggest suitable remedial measures for successful implementation of the activities on 13th April, 2023.

Shri Abhimanyu Chauhan, Sc. 'C' & **Shri N. S. Darji**, Met. 'A' attended Monsoon 2023 preparedness meeting at Collector office Ahmedabad on 13th April, 2023.

Shri S. C. Bhan, Sc. 'G' and **Dr. Ashok Kumar Das**, Sc. 'E' attended the 13th '**Project Monitoring and Advisory Committee (PMAC)**' held through VC on 13th April, 2023 and **Dr. Ashok Kumar Das**, Sc. 'E' made a presentation on the status of the project '**Upgradation of Hydromet Services**'.

Shri Abhimanyu Chauhan, Sc. 'C' and **Shri N. S. Darji**, Met. 'A' attended meeting on use of Satellite images in Crop Plantation at Director of Agriculture, Gandhinagar on 15th April, 2023.

Dr. S. Bandyopadhyay, Sc. 'G', attended a meeting along with officers of NCCR on the subject of Implementation of Iflows chaired by Municipality Commissioner, Kolkata Municipal Corporation on 17th April, 2023.

Pre-cyclone exercise and preparedness Meeting on 17th April, 2023 : IMD conducted Pre-cyclone exercise and preparedness Meeting for the cyclone season (April-June) on 17th April, 2023.

Dr. (Smt.) Manorama Mohanty, Sc. 'E' took a lecture on "**Heat Wave early warning & Forecast of the current year**" on 18th April, 2023.

Dr. Rajib Chattopadhya, Sc. 'E', **Dr. Divya Surendran**, Sc. 'C', **Dr. Ananya Karmakar**, Sc. 'C' and **Ms. Lekshmi**, JRF had attended a meeting with the District collector of Pune for discussing latest forecast issued for the South West monsoon 2023 and the overall activities of the CR&S office on 19th April, 2023.

Dr. S. Bandyopadhyay, Sc. 'G', attended meeting with officials of Environment Department, Government of West Bengal on 20th April, 2023.

Pre-Cyclone meet 2023 was chaired by **Dr. S. Bandyopadhyay**, Sc. 'G' on 20th April, 2023 at RMC Kolkata.

Shri G. S. Nagrale, Sc. 'E' attended a meeting of Flood Crisis Management Team (FMCT) under Chairmanship of the Chief Engineer, Monitoring (Central) Organisation, CWC, Nagpur will be held on 23rd April, 2023.

A meeting was organised under the **Chairmanship of Secretary MoES** to discuss the various issues faced by IMD Officers. The meeting was held at O/o CRS, Pune on 25th April, 2023 and attended by DGM, Joint Secretary MoES, other senior officers of MoES and Heads of RMCs, MCs and senior officers.

Dr. G. N. Raha, Sc. 'E' attended a meeting on Monsoon Preparedness and Updating of Disaster Management Plan 2023 in Jalpaiguri on 27th April, 2023.

Sri S. Adhikary, Sc. 'E' attended AP044/23(MET) - Twelfth Meeting of Meteorological Requirements Working Group (MET/R WG/12) and Seminar on Meteorology and Air Traffic Management (MET/ATM Seminar), held at Bankok, Thailand from 1- 5 May, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting under Chairmanship of **Shri Amit Khare**, Advisor to PM on"**Smart India Hackathon (SIH)**"through VC on 2nd May, 2023.

Dr. M. Mohapatra, DG IMD and **Dr. V. K. Soni**, Sc. 'F' participated in the meeting of the National Steering Committee (NSC) for Review and Finalization of India's Third National Communication (TNC) to UNFCCC at Teestha Conference Hall, Indira Paryavaran Bhawan, Jor Bagh, New Delhi on 2nd May, 2023.

Dr. M. Mohapatra, DG IMD participated in the 41st Annual General Meeting of National Institute of Hydrology Society, Roorkee through VC on 2nd May, 2023.

Dr. G. N. Raha, Sc. 'E', attended the Video Conference meeting "**Conduct of State Level Mock Exercise on Earthquake disaster in Sikkim**" on 2nd May, 2023.

Dr. H. R. Biswas, Sc. 'F', attended a review meeting with Hon'ble Chief minister of Odisha on preparedness for possible Summer Cyclone in Bay of Bengal in the 3rd floor Conference Hall of Lok Seva Bhawan on 2nd May, 2023.

Dr. M. Mohapatra, DG IMD participated in the 9th Meeting of the Executive Committee on Climate Change (ECCC) under Chairmanship of Principal Secretary to PM on 3rd May, 2023.

Dr. Sathi Devi, Sc. 'F', **Dr. R. K. Jenamani**, Sc. 'G' , **Dr. D. S. Pai**, Sc. 'G' and **Dr. Soma Senroy**, Sc. 'F' also participated in the meeting on 9th May, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting under the Chairmanship of **Ms. Leena Nandan**, Secretary (Environment, Forest and Climate Change) as a follow-up meeting of the meeting chaired by **Principal Secretary to Hon'ble PM** on 9th May, 2023.

Dr. Suprit Kumar, Sc. 'E' attended cyclone preparedness review meeting with Chief Secretary, A & N Island Government on 10th May, 2023.

Dr. Rajib Chattopadhyay, Sc. 'E', **Dr. Divya Surendran**, Sc. 'C' and **Dr. Ananya Karmakar**, Sc. 'C' had attended online KJSIT - IMD Collaborative Research Product Launch Event on 10th May, 2023 conducted by K. J. Somaiya Institute of Technology (KJSIT), Sion, Mumbai.

Dr. G. N. Raha, Sc. 'E' and **Shri Himanshu Gupta**, SA attended the Video Conference Meeting Table Top Exercise (TTEx) on 10th May, 2023 conducted by Sikkim State Disaster Management Authority (SSDMA).

Mr. David Puig, Ambassador of Dominican Republic made a Courtesy call to the office of **Dr. M. Mohapatra**, DG IMD on 11th May, 2023. **Mr. Alan Ramírez**, Technical Director of the National

Council for Climate Change and Clean Development Mechanism of the Dominican Republic, met with **Dr. Mrutyunjay Mohapatra**, DG, IMD. Together, they discussed areas of cooperation in this field (Fig. 40).



Fig. 40. Mr. David Puig, Ambassador of Dominican Republic With Dr. M. Mohapatra, DG IMD

Dr. G. N. Raha, Sc. 'E', attended the meeting in connection with Flood Preparedness related to ensuing Monsoon at the Office of the Chief Engineer, Irrigation & Waterways, Jalpaiguri on 15th May, 2023.

Mr. Sourav Adhikary, Sc. 'E' and **Dr. Anwesa Bhattacharya**, Sc. 'C' attended a meeting on "**The matter on acquiring India's Radar data for Hong Kong Observatory Regional Sig-Met coordination platform**" on 15th May, 2023.

Hydromet Division of IMD in collaboration with World Meteorological Organization organized a one-day Steering Committee Meeting for South Asia Flash Flood Guidance System (SAsiaFFGS) with member countries on 16th May, 2023, **Dr. M. Mohapatra**, DG, IMD & PR of India, **Dr. Hwirin Kim**, Head (HWR), WMO, **Shri S. C. Bhan**, Sc. 'G', PR's and Hydrological Advisors of Nepal, Bangladesh, Srilanka participated in this meeting held at New Delhi.



Fig. 41. Steering Committee Meeting for South Asia Flash Flood Guidance System (SAsiaFFGS)

Dr. (Smt) Manorama Mohanty, Sc. 'E', attended state level Pre-Monsoon Meeting under the chairmanship of chief secretary for disaster preparedness on 17th May, 2023 at Gandhinagar.

Shri Himanshu Gupta, S.A. attended the Meeting "**Development & Implementation of Unified Mobile App for IMD**" conducted by DGM New Delhi on 19th May, 2023.

Dr. Sankar Nath, Sc. 'F', attended a meeting between ICG, BEL & IMD scheduled on 17th May, 2023 at Bengaluru to discuss the sharing of weather data through coastguard Radar station with IMD.

Dr. Satyaban B. Ratna, Sc. 'E', attended the 19th World Meteorological Congress, Geneva, Switzerland online from 22nd May to 2nd June, 2023.

WMO 19th Session of Congress and FINAC-43 meeting & Cg-19, virtual as well as hybrid mode participated by **Shri K. C. Sai Krishnan**, Sc. 'G', **Dr. Kuldeep Srivastava,** Sc. 'F' and **Dr. Sankar Nath**, Sc. 'F' and **Shri Sunny Chug**, Sc. 'C' on 22 May-02 June, 2023, 29 May-02 June, 2023, 19-20 May, 2023 and 22 May-02 June, 2023 respectively.

Shri K. S. Hosalikar, Sc. 'G' and **Dr. O. P. Sreejith**, Sc. 'E' attended **Kharif Hangam 2023** meeting organized by Agriculture Ministry of Maharashtra Government on 24th May, 2023 at Mumbai.

Dr. Kripan Ghosh, Sc. 'F', participated in the meeting **'Joint AGRESCO 2023'** and presented on "**Southwest monsoon 2022 and activities under GKMS in Maharashtra**" at Central Campus, MPKV, Rahuri on 25th May, 2023.

Dr. Sankar Nath, Sc. 'F', attended second meeting of RA II WG-I Expert Team on WMO-IATA Collaborative AMDAR Programme (WICAP) (ET-WICAP) through online mode on 26 May, 2023.

Shri Vigin Lal F, Sc. 'C' and **Shri N. V. Patel**, Met. 'A' attended **Pre-Monsoon Inter State meeting on Flood Management & Preparedness for Monsoon 2023** for Lower Narmada, Tapi and Damanganga Basins at CWC Gandhinagar on 30th May, 2023.

Dr. G. N. Raha, Sc. 'E' attended a meeting regarding 80th Meeting of Brahmaputra Board at Mayfair, Gangtok, Sikkim on 30th May, 2023.

Shri Sanjoy Bhowal, Met. 'A', M. C. Gangtok attended "**Pre-Monsoon Preparedness Meeting"** of State Departments/Central Organizations, on 30th May, 2023 conducted by Sikkim State Disaster Management Authority (SSDMA) Gangtok Sikkim.

Dr. H. R. Biswas, Sc. 'F' attended the flag off ceremony of the maiden direct flight service to Bangkok from BPI Airport on 3rd June, 2023 at B.P.I. Airport, Bhubaneswar.

Dr. (Smt.) Manorama Mohanty, Sc. 'E', attended the Weather Watch Group Meeting with State govt. officials headed by the Relief Commissioner, Govt. of Gujarat at State Emergency Operation Centre, Gandhinagar on 5th ,7th , 20th and 27th June, 2023.

Shri H. S. Sawhney, Sc. 'E', attended NPCCHH National Review Meeting on 8th June, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting on Shri Amarnath Ji Yatra chaired by Union Home minister on 9th June, 2023.

Dr. (Smt) Manorama Mohanty, Sc. 'E', attended Cyclone meeting on 9th June, 2023 and on 11th June, 2023 at Sachivalaya, Gandhinagar under the Chairmanship of Chief Minister (Fig. 42).



Fig. 42. Meeting with Shri Bhupendra Rajnikant Patel Hon'ble Chief Minister of Gujarat

Dr. (Smt.) Manorama Mohanty, Sc. 'E', attended Cyclone meeting under the Chairmanship of Hon'ble Chief Minister of Gujarat on 12-16 June, 2023 at Sachivalaya, Gandhinagar.

Shri S. C. Bhan, Sc. 'G' attended meeting of Hon'ble Home Minister with the Ministries of the State/UTs holding the portfolio of disaster management on 13th June, 2023.

Dr. (Smt.) Manorama Mohanty, Sc. 'E', attended the Cyclone meeting (Online Mode) under the Chairmanship of Hon'ble Union Home Minister on 17th June, 2023 at Gandhinagar (Fig. 43).



Fig. 43. Shri Amit Shah, Hon'ble Union Home Minister on 17th June, 2023 at Gandhinagarduring cyclone review meeting

Dr. M. Mohapatra, DG IMD participated virtually in the 105th Governing Council Meeting of IITM, Pune on 17th June, 2023.

Dr. G. N. Raha, Sc. 'E', attended the Meeting "**Current status of RSRW & PB system and Procurement of balloon and has through GeM**" conduct by DGM New Delhi on 19th June, 2023, through online mode.

Dr. H. R. Biswas, Sc. 'F', attended the "**Crop Weather Watch Group Committee Meeting (CWWGCM) for Kharif-2023**" under the chairmanship of Agriculture Production Commissioner, Govt. of Odisha, on virtual mode through Microsoft Teams on 19th and 26th June, 2023.

Dr. S. Bandyopadhyay, Sc. 'G', attended a meeting for integration of GKMS services with State Agricultural Services on 22nd June, 2023.

Dr. M. Mohapatra, DG IMD participated in the South Asia Hydromet Forum (SAHF): Executive Council Preparatory Meeting on 22nd June, 2023.

Shri Umasankar Das, Sc. 'C' and **Dr. S. Dwivedi**, Sc. 'C' attended Virtual Interface meeting for Agricultural Contingencies during Kharif-2023 organised by Directorate of Agriculture & Food Production, Odisha, Bhubaneswar on 27th June, 2023.

Dr. M. Mohapatra, DG IMD participated in the Online meeting with Principal Secretary, West Bengal under Chairmanship of Shri Kamal Kishore, Member/Secretary, NDMA on 28th June, 2023 on implementation of Common Alert Protocol.

Dr. M. Mohapatra, DG IMD participated in the online meeting of the Indian National Decade Coordination Committee at INCOIS on 6th July, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting of the Joint Hindi Advisory Committee of Ministries of Science & Technology and Earth Sciences, in Delhi on 7th July, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting of the National Coordination Committee for Polar Science Program (NCPP) under the Chairmanship of Secretary, MoES at Prithvi Bhavan, New Delhi on 10th July, 2023.

Dr. Kripan Ghosh, Sc. 'F', attended the "**14th meeting of Project Monitoring and Advisory Committee (PMAC) of IMD**" to monitor the periodic progress of the projects under ACROSS-IMD and to suggest suitable remedial measures for successful implementation of the activities on 11th July, 2023.

Dr. R. K. Jenamani, Sc. 'G', attended the coordination meeting on 13th July, 2023 called by Delhi Disaster Management Authority (DDMA) and chaired by **Hon'ble LG of Delhi, Shri V. K. Saxena**, to "**Review the flood situation in Delhi**" and presented "**Heavy rainfall of 8-9 July, 2023 and forecast for Delhi**". And also attended the coordination meeting on 14th July, 2023 called by Ministry of Home and chaired by Home secretary and presented on "**Extremely Heavy rainfall Event over WesternHimalayan region and adjoining plains of northwest India including over HP and Delhi during 8-13 July, 2023 and forecast for 14-18 July, 2023**". It was attended by CWC and other central and state authority.

Shri Abhimanyu Chauhan, Sc. 'C', attended a meeting on discussion of Project RFP, document condition bids eligibility evaluation criteria & Project Implementation Procedure for use of satellite images in agriculture at Sachivalay, Gandhinagar on 15th July, 2023.

IMD officers **Shri Thangjalal Lhouvum**, Sc. 'D' and **Shri Arun Kumar V. H.**, Sc. 'C' attended the one day "**Consultation Meeting on Early Warning Dissemination**" with participation from SDMA officers and DDMOs of all districts in Meghalaya along with Agriculture and Health officers on 14th July, 2023. The officers presented about IMD observational and forecasting activities and briefing about routine, special and impact based (IBF) bulletins issued for Meghalaya and Shillong city.

Dr. M. Mohapatra, DG IMD participated in the Weather and Climate Science for Service Partnership (WCSSP) India Executive Committee (EC) Meeting through VC on 18th July, 2023.

Dr. (Smt.) Manorama Mohanty, Sc. 'E' attended the Weather Watch Group Meeting with State govt. officials headed by the Relief Commissioner, Govt. of Gujarat at State Emergency Operation Centre, Gandhinagar on 4th, 18th& 25th July, 2023.

Dr. A. Sandeep, Sc. 'C 'was on tour to Itanagar to attend the meeting with Director-In - Charge of CEHS, AAI, SDMA and to participate in Farmer awareness programe during the period 12-17 July, 2023.

Shri Abhimanyu Chauhan, Sc. 'C' attended a meeting (Online Mode) with Delhi HQ on Urban Meteorological Services Phase IV headed by **V. K. Soni,** Sc. 'F' **(UMS)** on 14th July, 2023.

Dr. Kuldeep srivastava, Sc. 'F', **Dr. Sankar Nath**, Sc-F Sc. 'F' and **Dr. A. K. Mitra**, Sc. 'F' attended SATCOM Stakeholders "**Open House**" on 17th July, 2023 organized by Telecommunication Engineering Centre (TEC), Dept. of Telecommunications at Janpath, New Delhi. The agenda was Mobile Satellite Services (MSS), Low bit rate Satellite Communications, Terrestrial & Non Terrestrial Network Integration.

WMO/ESCAP Panel on Tropical Cyclones is celebrating its 50th Anniversary. To commemorate the event first meeting with experts from WMO, ESCAP and PTC Members was held under the chairmanship of **Dr. M. Mohapatra**, DG IMD on 20th July, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting regarding concept paper on cloud burst

prediction, observation system strengthening and possibility of Doppler radar alarms along major river basins at the Chamber of Hon'ble MoES on 24th July, 2023.

Dr. Sanjeev Dwivedi, Sc. 'C', attended the meeting of State level Advisory Committee (STAC) under PMFBY under the chairmanship of the Principal Secretary to Govt. Agriculture & FE Deptt. Odisha dated 24th July, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting with SAC Ahmedabad regarding Nowcast on 28th July, 2023.

Dr. D. S. Pai, Sc. 'G' and **Dr. D. R. Pattanaik**, Sc. 'F' attended the NWP review meeting held on 26th July, 2023 at MoES, New Delhi, chaired by **Dr. M. Ravichandran**, Secretary, MoES.

Dr. Sanjeev Dwivedi, Sc. 'C', attended the meeting of Crop watch group for drought management (CWWGDM) under the chairmanship of Joint Secretary (Drought Management) Deptt. of Agriculture & Farmers Welfare, Govt. of India dated 27th July, 2023.

Dr. H. R. Biswas, Sc. 'F' attended 32nd Regional Coordination Committee (R.C.C.) meeting of Deltaic Regional Centre, Kakinada on 3rd August, 2023 at Indian Institute of Water Management (IIWM), Bhubaneswar, Odisha conducted by National Institute of Hydrology, Roorkee.

Dr. Kuldeep Srivastava, Sc. 'F' attended meeting of Geospatial Information Sectional Committee, LITD through online mode on 9th August, 2023.

A meeting to discuss the latest progress made on the **MoU singed between IMD and Grid Controller of India Ltd**. was held under the chairmanship of DGM on 10th August, 2023. A presentation on Load forecasting of Northern Region, which employs Recurrent Neural Networks (RNN) as a soft computing technique for forecasting load was delivered.

Shri Bikram Singh, Sc. 'F' attended a meeting on 16th August, 2023 under the chairmanship of Secretary, Department of Civil Aviation, Govt. of Uttarakhand regarding Aviation Met. Services at Heliport at Kedarnath Ji valley.The MoU regarding providing the Aviation Met. Services at Kedarnath Ji valley heliport is under process between IMD & the UCADA, Govt. of Uttarakhand.

Shri Umashankar Das, Sc. 'C' attended the Meeting of Crop Weather Watch Group for Drought Management (CWWGDM) held on 16th August, 2023 under the Chairmanship of Additional Secretary and CDRC, Department of Agriculture and Farmers Welfare, Govt. of India through video conference (Webex).

Dr. M. Mohapatra, DG IMD chaired the meeting of the Task Group to review Meteorological payloads of INSAT-4th Generation through VC on 19th August, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting under the chairmanship of Hon'ble Minister of Earth Sciences regarding research action plans of each institution of MoES on 21st August, 2023.

Dr. H. R. Biswas, Sc. 'F' attended Crop Weather Watch Group meeting for Drought Management (CWWGDM) CWWG held on 24th August, 2023 (Thursday) under the Chairmanship of Additional Secretary and CDRC, Department of Agriculture and Farmers Welfare, Govt. of India through video conference (Webex).

Dr. Ashok Kr. Das, Sc. 'E' attended 6th RA II Hydrological Advisories Forum meeting through VC on 24th August, 2023.

Dr. M. Mohapatra, DG IMD had meeting with **Shri G. S. Naveen Kumar**, Relief Commissioner, Disaster Management, UP regarding installation of RADAR at UP on 25th August, 2023.

National framework of Climate Services (NFCS) Pre-preparatory meeting at Christ University, Lavasa on 25th August, 2023, was attended by **Dr. Satyaban B. Ratna**, Sc. 'E', **Ms. Arti Bandgar**, Sc. 'D', **Dr. Sudeep Kumar**, Sc. 'C', **Mr. Jose Samuel**, Met. 'B' and **Mr. Sanjay Raskar**, Met. 'A'.

Shri S. C. Bhan, Sc 'G', IMD participated in the meeting to review prospects of Kharif Production under the Chairmanship of Secretary, Department of Agriculture and Farmers Welfare (DA&FW) at Krishi Bhawan on 28th August, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting with **Ms. Swati Pandey**, Vice Chairman & Managing Director, Maharashtra Airport Development Company Limited (MADC) on 29th August, 2023.

Mr. Uday K. Shende, Sc. ' E' has attended an online meeting as an external member of the expert committee for discussion of faulty sensor's repairing/replacement cited in 72 m tower lab at IITM, ART Bhopal on 29th August, 2023.

Dr. M. Mohapatra, DG IMD and **Mr. Gajendra Kumar**, Sc. 'F' participated in the meeting with **Dr. Bhagwat Kishanrao Karad**, **Hon'ble MoS for Finance** on 30th August, 2023 in connection with installation of radar in Aurangabad.

Dr. M. Mohapatra, DG IMD and **Dr. Soma Senroy**, Sc. 'F', **Dr. Trisanu Banik**, Sc. 'C' participated in the scientific brainstorming meeting to assess the performance of the Lightning Location Network (LLN) installed by the Indian Institute of Tropical Meteorology (IITM) Pune at MoES on 30th August, 2023.

Dr. M. Mohapatra, DG IMD had meeting with the delegation from Malawi, Africa on 30th August, 2023. The team also visited various workstations of IMD.

Dr. M. Mohapatra, DG IMD was felicitated during 11th Meeting of the IMS National Council at DGM's Conference Hall on 31st August, 2023.

Mr. Uday K. Shende, Sc. 'E' has attended an online meeting as a chairman of the DWR Radar installation committee to finalize the site selection at Durga Tekdi, Pune on 31st August, 2023.

Dr. S.O' Shaw, Sc. 'F', visited Itanagar on 4th September, 2023 to attend 81st meeting of Brahmaputra Board.

Dr. Ashok Kumar Das, Sc. 'E', Member and **Shri Swapan Kumar Manik**, Sc. 'D', Alternate Member attended the First Meeting of the Committee for Joint Flood Management study of river Yamuna for its reach between Hathinikund and Okhla barrage on 4th September, 2023 in the Chairman Committee Room, Central Water Commission, Sewa Bhawan, R. K. Puram, New Delhi.

Dr. D. R. Pattanaik, Sc. 'F' and **Mrs. Monica Sharma**, Sc. 'D' had an online meeting with **Shri Harsh Gupta**, JS NDMA to demonstrate the modeling capabilities of IMD on 5th September, 2023.

Dr. M. Mohapatra and senior scientists of IMD had meeting with DG, Solar Energy Society of India for forecast extension to solar energy industries and implementation of solar energy in IMD on 12th September, 2023.

Team from RMSI, NDMA and IMD had a meeting on transfer of technological know-how of the Web DCRA System under NCRMP Project of NDMA on 12th September, 2023.

A meeting was organised with **Solar Energy Society of India (SESI)** under the chairmanship of DGM on 12th September, 2023 to discuss the collaborative efforts in the field of solar energy.

Dr. Ashok Kumar Das, Sc. 'E' attended the 4th Project Steering Committee meeting of Central Water Commission for assessment of Water Resources Potential of India on 12th September, 2023 on hybrid mode.

Dr. Kuldeep Srivastava, Sc. 'F' (ISSD) attended meeting with delegation of Regional Integrated Multi-hazard Early Warning Systems for Africa and Asia (RIMES) during the period of 12-15 September, 2023.

Shri S. C. Bhan, Sc. 'G', Head Hydromet and **Shri S. K. Manik**, Sc. 'D' attended the "**International Conference on Dam Safety**" from 14-15 September, 2023 at Jaipur, Rajasthan.

Dr. G. N. Raha, Sc. 'E' attended the "**Inter-face meeting on State level Climate Information Services on 18th September, 2023**" conducted by SEEDS Technical service Ltd. & UNDP at Chintan Bhawan Gangtok, Sikkim.

Shri Vivek Sinha, Sc. 'G' attended 19th Meeting of CGPB Committee-XI (Geoinformatics and Data Management) on 15th September, 2023 through online mode.

Mr. Uday K. Shende, Sc. 'E' has attended an online meeting as a SAT committee member visited

helipad stations cited in Naharlgun and Kohima from 17- 24 September, 2023.

Dr. M. Mohapatra, DG IMD had meeting regarding collaboration with Startups for the development of various Met. sensors, application products on 20-21 September, 2023.

Dr. Praveen Kumar, Sc. 'C' attended the meeting on 23rd September, 2023 with **Deputy CM of Maharashtra**, Nagpur Municipal Commissioner, Collector of Nagpur and other officers from different department for briefing the Intense spell of rainfall over Nagpur.

Shri M. L. Sahu, Sc. 'F' and **Dr. Praveen Kumar**, Sc. 'C', attended the meeting with Nagpur's Collector and Agriculture officers of the district for weather briefing on 25th September, 2023.

Dr. M. Mohapatra participated as external examiner for Ph. D Viva Voce Examination of **Mr. Ashutosh Kumar Sinha** organised by the Department of Environmental Science. Central University of South Bihar on 27th September, 2023.

Dr. M. Mohapatra, DG IMD had a meeting regarding Harvard Climate Platform Collaboration Exploratoration Call through Webex on 27th September, 2023.

Dr. Ashok Kumar Das, Sc. 'E' attended the 5th Project Steering Committee meeting of Central Water Commission for assessment of Water Resources Potential of India on 27th September, 2023 on hybrid mode.

Dr. M. Mohapatra, DG IMD participated in the 19th Formation Day of NDMA on the theme : A Vision for Disaster Mitigation on 28th September, 2023.

Dr. M. Mohapatra, DG IMD participated in the Climate Services User Forum Session of South Asian Climate Forum -26 through VC on 3rd October, 2023.

Dr. Kripan Ghosh , Sc. 'G' and **Dr. Ashutosh Kumar Misra,** Sc. 'D' attended "**Climate Services User Forum (CSUF)**" through virtual mode conducted by CR&S, IMD, Pune in collaboration with RIMES and UK Met office on 3rd October, 2023.

Dr. M. Mohapatra, DG IMD participated in the Online meeting with Mr. Abdulla Al Mandous, President, WMO on 5th October, 2023.

Dr. M. Mohapatra, DG IMD participated in the Meeting of the National Crisis Management Committee under the Chairmanship of Cabinet Secretary to review the status of Sikkim Flash Flood incident at Committee Room, Cabinet Secretariat on 9th October, 2023.

Dr. M. Mohapatra, DG IMD participated in the WMO's Joint WMO-IOC Collaborative Board Meeting as Co-chair on 10th October, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting with **Dr. M. R. Ravi**, IAS, Managing Director and Brig. **D. M. Purvimath**, Technical Advisor, KSIIDC, Bangalore regarding meteorological services of Vijayapura and Hassan Airports in Karnataka and draft Memorandum of Understanding on 10th October, 2023.

Dr. M. Mohapatra participated in the meeting of the Sir Gilbert Walker Gold Medal Committee at the chamber of Secretary, MoES on 11th October, 2023.

Dr. M. Mohapatra, DG IMD participated in the Virtual Meeting on Indian Lightning Detection Network (ILDAN) under the Chairmanship of Secretary MoES on 12th October, 2023.

Dr. M. Mohapatra, DG IMD participated in the 4th SRMC Meeting of Monsoon Mission at IITM, Pune in person during 12th & 13 October, 2023.

Shri K. C. Sai Krishnan, Sc. 'G', attended the virtual meeting on 20th October, 2023 regarding economic and technology cooperation chapter of ETCA between India and Sri Lanka.

Dr. O. P. Sreejith, Sc. 'E', attended the online Climate Service Expert Team meeting of WMO RA II Region on 23rd October, 2023.

Dr. M. Mohapatra, DG IMD participated as an Expert Speaker in the Show Perspective on "National Framework for Climate Services" at Sansad Television on 25th October, 2023.

Dr. Kripan Ghosh, Sc. 'G', attended online meeting to discuss the proposal on "S2S hydroclimate

forecast application and services" with Professor Sankar Arumugam, North Carolina State University, Raleigh, USA and senior officials from IMD, IITM and MoES on 27th October, 2023.

Dr. Satyaban B. Ratna, Sc. 'E', attended a meeting between IMD and Fathom (UK) regarding the global flood maps on 27th October, 2023.

Dr. Ashutosh Kumar Misra, Sc. 'D', attended online meetings of "**State Level Technical Advisory Committee (STAC) for PMFBY Kharif-2023**" for following districts under the chairmanship of Additional Chief Secretary (Agriculture) organized by Agriculture Commissioner Office, Govt. of Maharashtra.

- Nandurbar district on 31st October, 2023.
- Dhule, Nashik and Ahmednagar districts on 10th November, 2023.
- Pune district on 17th November, 2023.
- Solapur, Jalgaon, Satara and Hingoli districts on 30th November, 2023.

A meeting was held **between IMD and SAC, ISRO** on dated 3rd November, 2023 regarding the navigation issues of INSA3D/3R.

Dr. Satyaban B Ratna, Sc. 'E', attended online the 5th meeting of the Task Team on WMO-accredited ENSO information (TT ENSO) on 13th November, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting of Sub-Committee of National Executive Committee (SC-NEC) to consider the proposals of Urban Flood Risk Management Programme (UFRMP) of NDRF in respect of the states of Bengaluru and Ahmedabad on 15th November, 2023.

Dr. Satyaban B Ratna, Sc. 'E', attended an online meeting with the University of Southampton (UK) and IIT Roorkee to discuss IMD's collaboration on the proposed project "Understanding Geohazard Processes and their Impacts Across India" on 17th November, 2023.

Dr. D.S. Pai, Sc. 'G', attended the Standing Committee on Energy (2023-24)-Examination of the subject- Prospects of Thermal Power Plants in the light of enhanced Renewable Energy Target, held on 22 November, 2023 at Main committee room at Parliament.

Dr. O. P. Sreejith, Sc. 'E', participated the online meeting organized by WMO the preparation process of the "**WMO State of the Climate in Asia 2023**" on 23rd November, 2023.

Dr. M. Mohapatra, DG IMD participated online in the third South Asia Hydromet Forum (SAHF) Executive Council Meeting convened by Regional Integrated Multi-hazard Early Warning System (RIMES) through hybrid mode on 30th November, 2023.

Dr. M. Mohapatra, DG IMD participated in 15th Regional Integrated Multi-hazard Early Warning System for Asia & Africa (RIMES) Council Meeting through hybrid mode on 1st December, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting of the National Crisis Management Committee Meeting on 1st December, 2023 in association with cyclone Michaung over the Bay of Bengal.

Dr. M. Mohapatra, DG IMD participated in the National Crisis Management Committee meeting chaired by Cabinet Secretary on 1st and 3rd December, 2023 in connection with cyclone, Michaung and made presentation on current status, forecast and early warning, impact expected and actions to be taken due to the cyclone.

Dr. M. Mohapatra, DG IMD attended the inaugural session of training programme seasonal forecast training for Department of Meteorology, Sri Lanka on 4th December, 2023.

Dr. M. Mohapatra, DG IMD participated in the WCSSP Executive Committee Meeting on 4th December, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting of the Peer Advisors for Mauritius through on 6th December, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting with **Shri Sanjeev Kumar**, Chairman, Airport Authority of India at Rajiv Gandhi Bhavan on 7th December, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting with **Shri Subramanyam Pulipaka**, CEO, National Solar Energy Federation of India on 8th December, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting with **Dr. Siksha Swaroopa Kar**, Principal Scientist, CSIR on 9th December, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting with **Shri Dibyanshu Prasad Das**, Program Director alongwith team of SARM regarding Agri Vision 2024 on 11th December, 2023.

Dr. M. Mohapatra, DG IMD attended the roundtable discussion on "**Fostering spatial thinking in Young Minds**" organised by Geospatial Association on 11th December, 2023 at Tamarind Hall, India Habitat Centre, New Delhi on 11th December, 2023.

Sh. Bikram Singh, Sc. 'F' and **Shri Ankit Sharma**, Met. 'A' attended a meeting with the Secretary, Vidhan Sabha, Govt. of Uttarakhand regarding providing of NOC for installation of AWS in Uttarakhand at New Vidhan Sabha, Gairsainon 11th December, 2023.

Dr. M. Mohapatra, DG IMD participated as a Panelist in the 9th CII Water Innovation Summit on 12th December, 2023.

Dr. M. Mohapatra, DG IMD participated in the courtesy meeting with Delegates-Meisei Japan on 12th December, 2023.

Dr. M. Mohapatra, DG IMD addressed the gathering in the 3rd Meeting of the BIMSTEC Centre for Weather & Climate (BCWC) Governing Body (GB) on 13th and BCWC Scientific Advisory Committee (SAC) on 14th December, 2023.

Dr. M. Mohapatra, DG IMD Chaired the Joint Collaborative Board (JCB) Meeting of Intergovernmental Oceanic Commission (IOC) and World Meteorological Organisation (WMO) through VC on 15th December, 2023.

Dr. (Smt.) Manorama Mohanty, Sc. 'E' attended onlinepost monsoon**Inter State Meeting on Flood Forecasting arrangements (Monsoon-2023) for Tapi, Lower Narmada & Daman Ganga Basin** at CWC Surat on 15th December, 2023 organized by CWC Gandhinagar.

6.3. CONFERENCE/PRESENTATIONS

Dr. Mrutyunjay Mohapatra, DG, IMD participated as Chief Guest in the inaugural function of the National Conference on "**Land-Atmosphere Interactions Controlling Weather & Climate: Applications of Numerical Models and Observations**" organized by Department of Earth and Atmospheric Sciences, NIT Rourkela on 9th January, 2023.

Dr. G. N. Raha, Sc. 'E' attended a presentation on the scope of "**Climatological Normals of RSRW 1991-2020**" on 10th January, 2023 arranged by CRS Pune. The meeting had been chaired by the DGM, Mausam Bhawan, New Delhi.

Dr. S. D. Attri, Sc. 'G' participated in the 14th High Level Monitoring Committee Meeting with **National Innovations in Climate Resilient Agriculture** chaired by the Secretary DARE and DG, ICAR on 13th January, 2023.

Dr. M. Mohapatra, DG IMD participated as Guest of Honour during the first networking event of C-20 on "**Towards Sustainability & Resilience - Dialogues on Climate, Environment & Net Zero Targets**" on 30th January organised by Amrita Vishwa Vidyapeetham, Kerala.

Dr. Ashok Kumar Das, Sc. 'E' and **Shri Asok Raja S. K.**, Sc. 'C' delivered presentations in the Brain-storming Session on **Urban Flood Management** at IISc Bangalore on 3 February, 2023.

Shri K. C. Sai Krishnan, Sc. 'G', **Dr. Kuldeep Srivastava**, Sc. 'F',**Dr. Sankar Nath**, Sc. 'F', **Dr. Iyyappan M,** Sc. 'D' and **Shri Sunny Chug** Sc. 'C' attended a presentation on **Cloud Server** which was given by Hewlett Packard Enterprises (HPE) on 7th February, 2023.

A VC meeting convened by CAMD on 08th February, 2023 regarding raising the Airport-wise GST invoices at MWOs/AMOs/AMSs towards the Aviation Meteorological services rendered at all AAI Airports.

Dr. Mrutyunjay Mohapatra, DG IMD participated as Chief Guest in the one day international Conference on "**Global Food Security**" on 11th February, 2023 organised by GB Pant University of Agriculture and Technology, Pant Nagar, Uttarakhand.

Dr. Kuldeep Srivastava, Sc. 'F', **Dr. Iyyappan M**, Sc. 'D', **Shri Avnish Varshney**, Sc. 'D', **Ms. Suman Gurjar**, Sc. 'D' and **Shri S. K. Manik,** Sc. 'C' attended conference on "**Geospatial Policy for National Development"** at Dr. Ambedkar International Center, Janpath, New Delhi on 21-22 February, 2023 to deliberate on the strategies for the implementation of the National Geo-spatial Policy-2022.

Dr. Mrutyunjay Mohapatra, DG IMD participated as Guest of Honour in the National Seminar on "**Recent Trends in Physical Science**" at Department of Physics, Bhadrak Autonomous College, Bhadrak, Odisha and addressed the students and other invitees on weather and climate services on 24th February, 2023.

Shri Radhesyma Sharma, Sc. 'C' presented a paper on "**A methodology for district wise heavy rainfall impact score for Rajasthan**" in WCSSP workshop at NCMRWF, Noida during 28th February-4th March, 2023.

Shri Sukumar Roy, Met. 'A', gave demonstration of the met. instruments to the visitors of 30th West Bengal State Science & Technology Congress held on 28th February & 1st March, 2023 at Science City Kolkata.

Shri Anand Shankar, Sc. 'C', presented a research work on the title Assessment of Flood Risk and Enhanced Resilience for Frequent Floods Impacted by High River Discharges in the Upper Catchments and Associated Heavy Rainfall in North Bihar, India at the 4th WCSSP (Weather and Climate Science for Service Partnership India) organized at New Delhi /Noida on dated 1st March, 2023.

Dr. Ananya Karmakar, Sc. 'C', presented an oral presentation on 1st March, 2023 in scientific presentation of Women's day week celebration entitled "**Indian summer monsoon rainfall 2022 patterns; special emphasis on AGRO-CLIMATIC zones of Northern India**".

Shri S. K. Manik, Sc. 'C', attended the 9th meeting of Geospatial Information Sectional Committee virtually on 1st March, 2023.

Dr. M. Mohapatra, DG IMD participated in the 3rd Session of National Platform of Disaster Risk Reduction (NPDRR) and made a presentation on lightning management in India on 11th March, 2023 at Vigyan Bhawan, New Delhi.



Fig. 44. Dr. M. Mohapatra, DG IMD in the 3rd Session of NPDRR at Vigyan Bhawan, New Delhi

Dr. M. Mohapatra, DG IMD led the delegation from India to Abu Dhabi to attend Regional Conference (RECO) of Asian countries on the theme "**Early Warning for all initiative of United Nations Organisation (UNO) and World Meteorological Organisation (WMO)**". During 13-16 March, 2023. **Dr. Mohapatra** held discussion with **Prof. Petteri Taalas**, Secretary General of WMO regarding capacity building in the region for further improvement of weather and climate services, especially for improvement of impact based forecast and early warnings. While participating as a panellist and chairing another panel discussion, he highlighted the important challenges and gap areas in the region, short term or immediate actions required for implementation of the initiative early warning for all. He also presented the guidelines to leverage the global initiatives for local actions to implement the early warning for all enabling early action for disaster risk reduction (Fig. 45).



Fig. 45. Dr. M. Mohapatra, DG IMD in Abu Dhabi at Regional Conference (RECO) of Asian countries

Dr. M. Mohapatra, DG IMD made an online presentation on Cyclone Warning System in India

in the working group meeting of NPDRR held in Bhubaneswar on 13th March, 2023.

Dr. K. Sathi Devi, Sc. 'F' attended WMO Regional Conference (REC) in Regional Association-II (RA-II) held in Abu Dhabi from 13-16 March, 2023.

Dr. Ananya Karmakar, Sc. 'C' presented an oral presentation in the National Symposium of IMSP 2023 entitled "**Indian Extreme Rainfall Events frequency and its effect in the health aspect during last Century**" on 30th March, 2023.

Dr. M. Mohapatra, DG IMD participated in the UN-WMO initiative on **development of Systematic Observations and Forecasting Facilities (SOFF)** Peer Advisors Virtual meeting on 3rd April, 2023 through VC.

Dr. M. Mohapatra, DG IMD participated as a Panelist in the session "**Improving Infrastructure Risk Management: Early Warning, Regulations and Local Action**" during International Conference on Disaster Resilient Infrastructure (ICDRI) 2023 on 4th April, 2023.

Dr. O. P. Sreejith, Sc. 'E', participated and gave presentation on "**Characteristic of Monsoon Circulation over the RSMC region**" on 11th April, 2023 during 19th Tropical Cyclones and Storm Surge Forecasters Training (Online) conducted by RSMC, New Delhi.

Dr. M. Mohapatra, DG IMD had been on Ex-India deputation Singapore to participate in the High Level Regional forum of the Open Consultative Platform in WMO Regional Associations II and V during 18-19 April, 2023.

Dr. M. Mohapatra, DG IMD participated in the WMO briefing to Permanent Representatives and Missions in Geneva prior to the Nineteenth Session of WMO Congress through VC on 24th April, 2023.

Ms. Lekshmi S., JRF participated and presented a paper on "**Propagation of Mid-Latitudinal Rossby waves along the Jet stream wave guides and their Role in Summer Temperature Intraseasonal Oscillations and Extremes over the Indian Region**" in the European Geophysical Union (EGU) General Assembly in online mode on 24th April, 2023.

Shri M. L. Sahu, Sc. 'F' attended and gave presentation, **Shri G. S. Nagrale**, Sc. 'E' and **Shri P. S. Chinchole,** Met. 'B'attended Pre Kharif season meeting by Departmental Agriculture Co-Ordinator Nagpur at 27th April, 2023.

Dr. M. Mohapatra, DG IMD participated in the conference to review **Pre-Monsoon/Monsoon situation for South-West Monsoon** under the Chairmanship of **Shri Kamal Kishore**, Member and Secretary, NDMA on 3rd May, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' attended 2nd International Conference on "**Geospatial Science and Technology for Earth Observation (GSTEO 2023)**" on 12th May, 2023 and delivered a lecture on "**Weather and Climatic Services**" at Adamas University Organized by the Department of Geography, School of Basic and Applied Sciences, Adamas University, Kolkata.

Twenty fifth (25th) Session of South Asian Climate Outlook Forum (SASCOF-25) and Climate Services User Forum (CSUF) conducted online in collaboration with World Meteorological Organization (WMO) and RIMES, Bangkok from 27-29 April, 2023 to issue outlook for Rainfall and Consensus Statement on the Seasonal Climate Outlook over South Asia for the 2023 Southwest Monsoon Season (June- September). **Dr. O. P. Sreejith**, Sc. 'E', gave presentation on "**Pre-Consensus outlook for SASCOF-25**" on 27th April, 2023 and **SASCOF-25 outlook** for Rainfall and Temperature over South Asia Region during Southwest Monsoon Season 2023 on 28-29 April, 2023 during Climate Services User Forum of SASCOF-25. Also, **Dr. Satyaban B. Ratna**, Sc. 'E', presented a talk on "**Seasonal climate outlook of South Asia for JJAS 2023 Global and Regional Perspectives**". **Dr. Ashutosh Kumar Misra**, Sc. 'D' and **Dr. Divya Surendran**, Sc. 'E' attended the same.

Shri H. S. Sawhney, Sc. 'E', attended a conference on "**Climate change and health - Climate Proofing Indian Health System : Pathways for Enhancing Health Sector Resilience and Sustainability**" on 2nd June, 2023 organised by the World Bank at New Delhi.

Dr. O. P. Sreejith, Sc. 'E', gave presentation on "**Updated SASCOF-25 outlook for Rainfall and Temperature over South Asia Region during Southwest Monsoon Season 2023**" on 14th June, 2023 during update session of SASCOF-25.

Dr. M. Mohapatra, DG IMD participated and presented the status & forecast of '**Biparjoy**' cyclone in the following High Level Committee Meetings: (i) National Emergency Response Committee (NERC) headed by Home Secretary, Govt. Of India was organised on 11th June, 2023 (ii) National Crisis Management Committee Meeting on impending Cyclone Scenario in Arabian Sea under the Chairmanship of Home Secretary, on 12th June, 2023. (iii) Hon'ble Prime Minister reviewed the preparedness in a high level meeting on 12th June, 2023. (iv) Hon'ble Home Minister reviewed the preparedness in a high level meeting on 13th June. (v) Hon'ble Home Minister reviewed the preparedness in a high level meeting on 17th June, 2023.

A presentation of Integration of **Biometric Attendance System** with METNET was given to Head of the Section of Delhi Offices by **Shri Parmod Kumar**, Sc. 'C' on 5th July, 2023 in the presence of DGM and DDGA.

Dr. Ashok Kr. Das, Sc. 'E' attended the 14th PMAC meeting through VC on 11th July, 2023 and made a presentation on the status of the project '**Upgradation of Hydromet Services**'.

Dr. M. Mohapatra, DG IMD participated in the Farmers' Awareness Programme on "**Self Reliant Farmers : Empowering farmers through Agrometeorological Advisory Services in Changing Climate**" jointly organized by MoES, India Meteorological Department, Association of Agrometeorologists, State Agriculture Department and Centre for Earth Sciences & Himalayan Studies, Department of Science & Technology, and Krishi Vigyan Kendra, Papumpare at Itanagar during 13-14 July, 2023.

Shri S. C. Bhan, Sc. 'G' attended the Launch event of "**India Climate & Energy Dashboard (ICED)**" and "**India Energy Security Scenarios (IESS) 2047**" organised by Niti Aayog on 20th July, 2023 at Akashvani Bhawan, New Delhi.

Dr. M. Mohapatra, DG IMD participated in the Launch of the Weather Information Network Data Systems (WINDS) Portal at Shangri-La Eros, 19, Ashoka Road, New Delhi on 21st July, 2023. The meeting was presided by **Hon'ble Minister of Agriculture & Farmers Welfare**.

Shri Raja Acharya, Met. 'B', participated virtually in the webinar "**Militarization of Space and its implications**" on 22nd July, 2023 organised by the Astronautical Society of India, Department of Space Govt of India as a part of Azadi ka Amrit Mahotsab celebrations.

Shri Raja Acharya, Met. 'B', participated in the webinar "**DERCON training-Springer and Nature Journals**" on 8th August, 2023 organised by the DGM Office New Delhi (IS & KRDD/Publication).

Shri H. S. Sawhney, Sc. 'E' attended a talk on "**Power Enhancement in Renewable Energy Sources through Power Electronic Interfaces**" organised by the Indian Science Technology and Engineering facilities Map (I-STEM) on 17th August, 2023.

Dr. Suprit Kumar, Sc. 'E', MO Port Blair gave a presentation on a Seminar on "**Climate Change and Sustainable development (an event to commemorate India's G20 presidency)**" organized by Prasar Bharti/Akashvani at DBRAIT, Port Blair on 22nd August, 2023.

Dr. M. Mohapatra, DG IMD participated in the Inaugural Session of the 8th National Conference of the **Ocean Society of India** at INCOIS, Hyderabad on 23rd August, 2023 through VC in connection with inauguration of WMO Regional Specialised Meteorological Centre (RSMC) for global and regional ocean modeling at INCOIS.



Fig. 46. Student and other visitors visiting MoES Stall during 26th National Science Exhibition from 24 -27 August, 2023

On behalf of MoES, the officers and staff members of RMC Kolkata participated in "**26th National Science Exhibition on the theme of 'Contribution**

to make advances, powerful and great India" from 24-27 August, 2023 at Central Park Maidan, Kolkata organized by Central Calcutta Science and Culture Organisation for Youth, '**Ananda Bhaban**'. Various meteorological instruments, charts, MoES flexes were displayed, briefed about meteorological observation and its importance for weather forecasting (Fig. 46).

Dr. A. K. Mitra, Sc. 'F' to participate in the First Discussion Meeting scheduled online on 29th September, 2023 in Bangalore regarding the **Satellite mission for simultaneous measurements of cloud and precipitation profiling**. In this regard, he had given a talk pertaining to satellite-based information regarding the cloud and precipitation profile on IMD's behalf.

Sh. S. C. Bhan Sc. 'G' chaired the launching of GKMS Sarpanches of Bhiwani block, Haryana held on 20th October, 2023.

Dr. M. Mohapatra, DG IMD participated in the "**1st Indian Arctic Winter Expedition Launching Function**" on 18th December, 2023 chaired by HMoES.

Dr. M. Mohapatra, DG IMD participated in the recording by Ms. Jessica, Doordarshanon 27th December, 2023 on 150th year of IMD.

6.4. TRAINING

Shri Kanwar Ajay Singh, Met. 'A', **Ms. Divya** S.A. and **Ms. Komal Srivastava** S.A. had provided Online e-Office training on e-File to all RMCs/MCs/CRS Pune/Offices of IMD during 9- 17 January, 2023.

Shri Sunny Chug, Sc. 'C' attended 5 days training deep-dive training under Cyber Surakshit Bharat initiative of MeitY as Deputy Chief Information Security Officers (CISO) during 16 -20 January, 2023 at Haryana Institute of Public Administration, Gurugram.

Training on installation & maintenance of AWS/AWOS PWD-22 (for RBR) instruments & others, held at RMC Guwahati w.e.f 23-24 January, 2023 with participation on 12 no's of Met. Officials from different field station are under RMC Guwahati.

Dr. G. K. Das, Sc. 'E' attended the training programme for Early Warning System for Village Disaster Response Force (VDRF) members in Gosaba Block during 29-31 January, 2023.

Shri Avnish Varshney, Sc. 'D' and **Ms. Suman Gurjar**, Sc. 'D' attended CDAC training on Artificial Intelligence for Government official in batch-10 in virtual mode during 01- 14 February, 2023.

One day on-line **"Refresher Training Course in Aviation Meteorology"** with special emphasis on Aviation Meteorological Observations & Reports and Aviation Forecast and Warning related issues was arranged by CAMD and inaugurated by DGM, IMD on 7th February, 2023 to all MWOs/AMOs/AMSs including DGCA officials.

Dr. Kripan Ghosh, Sc. 'F' delivered an invited lecture on "Management of Agricultural Risks using Climate Information" during training programme on "Climate smart viticultural technologies for sustainable quality grape production" conducted by ICAR - National Centre for Grapes (NRCG) Pune from 8-10 February, 2023.

WMO engaged expertise trainers from South Asia **Mr. Asok Raja Subbarayan Kumarasamy** and **Ms. Hemlata Bharwani** to nurture, operationally train and enhance the capacity building of SAOFFGS forecasters, hydro meteorologists. These 20 trained officials from PAGASA (Philippines), BMKG (Indonesia), MMD (Malaysia), BDMD (Brunei), and PNGNWS (Papua New Guinea) will now operationally work with their stakeholders to build an effective response system by fully leveraging the Flash Flood Guidance System's potential to avoid major losses and to save livelihoods in the South East Oceania region. "Together we learn to make a disaster resilient region in this climate change era" (Fig. 47).



Fig. 47. Southeastern Asia-Oceania Flash Flood Guidance System (SAOFFGS) Step 5 Refresher Training Cebu, Philipines (16-17 February 2023)

Dr. G. N. Raha, Sc. 'E' has attended one day Farmers' Awareness Programme on 13th March, 2023 at Chopra-KVK, Uttar Dinajpur under "Gramin Krishi Mousam Sewa" organised by AMFU-Pundibari.

METNET Team have imparted training to trainees Advance Training in Meteorological Instrumentation and Information System, Batch No.11 from 13- 15 March, 2023.

A Joint IMD-WMO group fellowship Training on "Numerical Weather Prediction" "Hands on Practical aspects of NWP" commenced from 27th March and will continue till 7th April, 2023 at Meteorological Training Institute.



Fig. 48. Participant of International Training for Cyclone Forecasters

International Training for Cyclone Forecasters (03-13, April-2023 : India Meteorological Department (IMD) conducted 19th WMO's Tropical Cyclones Forecaster Training during 3-13 April, 2023 through WebEx. IMD acts as one of the six Regional Specialised Meteorological Centres (RSMCs) in the world recognised by WMO under a global system for issue of warnings and advisories in association with cyclonic disturbances over north Indian Ocean. IMD started conducting tropical cyclones forecasters training for WMO sponsored participants from ESCAP Panel member countries since 2005. This year there were 106 participants including 26 International participants from Thailand, Myanmar, Bangladesh, SriLanka, Maldives, Pakistan, Iran, Oman, United Arab Emirate & Saudi Arabia, and 80 participants from various sub-offices of IMD. The training was aimed at building capacity of the TC forecasters in the region by understanding the latest developments in observations, monitoring, modelling, prediction and early warning services of TCs over the Bay of Bengal and the Arabian Sea and carrying out the case studies as practical examples in these aspects. The training included resource persons from UN-ESCAP, RSMC Tokyo, IMD, National Centre for Medium Range Weather Forecasting (NCMRWF), Indian National Centre for Ocean Information Services (INCOIS) and IIT Delhi. During the training special sessions were organised for storm surge & ocean state forecasts and monsoon circulations. Dr. T. Peng, WMO appreciated the role of IMD for providing the tropical cyclone advisories and the capacity building efforts. **Dr. Srivastava**, UN-ESCAP also highlighted the contributions of IMD and RSMC for capacity building in the region and the services provided by IMD for management of the cyclones. On the last day of training on 13th April, internal assessment of participants was carried out followed by the ceremonial Valedictory Ceremony and distribution of certificates (Fig. 48).

Nowcast Unit (NWFC) organized Demonstration Programme on the Nowcast Portal on 4th April, 2023 and Thunderstorm Monitoring and Training Workshop during 18-22 April, 2023.

Dr. S. Dwivedi, Sc. 'C' attended session on Climate & weather variability and seasonal forecast for Ganjam during the training of master trainers at Swosti Plam Resort, Gopalpur 18th April, 2023.

Training workshop on Thunderstorm monitoring and Forecasting (Online) is held on 19th April, 2023 and **Shri B. A. M. Kannan**, Sc. 'F', DWR Chennai given lecture on "**Radar Meteorology for Nowcasting of Thunderstorms**" to the trainees from IMD.

Shri S. K. Mallick, Met. 'B', DWR Paradeep attended the "**SAGARMITRAs' 2023-24 training**" on skill up gradation and awareness programme at BWTC Campus Paradeep on 1st May, 2023 & 4th May, 2023 organized by Principal Brackish Water Training Centre (BWTC).

Monsoon Preparedness Training workshop was organised through VC by NWP division, O/o DGM during 16-20 May, 2023. Officers from RMCs, MCs and O/o CRS, Pune attended the workshop.

Dr. M. Mohapatra, DG & PR of India and **Shri S. C. Bhan**, Sc. 'G' flagged off the three days Joint Refresher training workshop for SAsiaFFGS, BSMEFFGS and SEEFFGS conducted in New Delhi,

India. About 60 participants from Bangladesh, India, Sri Lanka, Nepal, Jordan, Turkey, Moldova and World Meteorological Organization attended this workshop. **Shri Rahul Saxena**, Sc. 'F' & Focal Point (SASIAFFGS), **Dr. Ashok Kumar Das**, Sc. 'E', **Shri Asok Raja S. K.**, Sc. 'C' and **Ms. Hemlata Bharwani**, Sc. 'C' conducted the Step 5 & Joint Refresher FFGS Training Workshop in collaboration with WMO New Delhi during 17-19 May, 2023.



Fig. 49. Joint Refresher FFGS Training Workshop, New Delhi

Dr. K. Naga Ratna, Sc. 'E' participated and presented a talk on "**Heavy Rainfall for the District, Block & Location level: Decision Making**" in Monsoon Preparedness Training Workshop (16-20 May, 2023) on 20th May, 2023.

M. C. Bhubaneswar conducted three training programme workshops in collaboration with Odisha State Disaster Management Authority on understanding Weather Forecasting at Meteorological Centre, IMD, Bhubaneswar on 17th May, 2023, 24th May, 2023 & 31st May, 2023. District Emergency Officers, District Project Officers and DRR Consultant attended the meeting. Dr. Gyana Das, IAS, Managing Director OSDMA, Odisha attended the meeting on 31st May, 2023.

Four Met. 'A' from M.C. Ranchi completed short term refresher course on Solar Radiation Instruments (instead of DATABASE MANAGEMENT) held in M.C. Ranchi from 22-26 May, 2023.

Dr. H. R. Biswas, Sc. 'F' Chaired in 3 days duration training workshops in collaboration with Odisha State Disaster Management Authority on understanding Weather Forecasting at Meteorological Centre, IMD, Bhubaneswar, dated 17th May, 2023, 24th May, 2023 & 31st May, 2023**. Shri Umasankar Das**, Sc. 'C' and **Dr. S. Dwivedi**, Sc. 'C, delivered lectures on understanding Weather Forecasting.

Shri Y. D. Bijani, Met. 'B' and **Shri Indra Jeet Jakhar**, S.A. was attended the short term refresher course on 'Solar Radiation Instruments' during 22-26 May, 2023.

AWS Software Training conducted in AWS Lab CRS, Pune during 1st week of June 2023(Fig.50).



Fig. 50. AWS Software Training (400) at CRS, Pune

50 Students and 2 Faculty Members from **Delhi Paramedical & Management Institute (DPMI**), New Ashok Nagar, New Delhi visited **Sat. Met. Division** on dated 13th June, 2023 for briefing and scientific understanding of the satellite-based products for improved weather forecasting.

12 MBBS Students and 2 Faculty Members from **All India Institute of Medical Sciences (AIIMS),** New Delhi visited **Sat. Met. Division** on dated 23rd June, 2023. They were briefed regarding the current operational infrastructure of Satmet division and also about the utilization of various satellite products with respect to different weather systems.

The following training courses are imparted to IMD officials and also to Officers from other departments on regular basis under Capacity Building.

- Advanced Meteorological Training Course (AMTC)
- Forecasters' Training Course (FTC)
- Integrated Met Training Course (IMTC)
- Direct Recruited Scientists Training Course (DRSTC)
- Modular Training Course (MTC)

Six (06) officers attended refresher course on "**Upper Air Instruments and Radars**" from 17-21 July, 2023 organised by ICITC, ISSD, New Delhi.

12 officers attended refresher course on "**Airport Meteorological Instruments**" from 21-25 August, 2023 organised by ICITC, ISSD, New Delhi.

One day training on use of Gravimetric Equipment was organized at Regional Meteorological Centre Guwahati on 4th August, 2023.

Shri Raja Acharya, Met-B, participatedin the webinar "**DERCON Training - Elsevier Training on Scopus and Science Direct**" on 24th August, 2023 organised by the DGM Office New Delhi (IS & KRDD/Publication).

HRC has conducted an online e-learning course entitled, "**FFGS System Administration**" on 25th August, 2023, **Mr. Rahul Saxena,** Sc. 'F', **Dr. Ashok Kumar Das**, Sc. 'E', **Madhu latha Akkisetti**, Sc. 'D', **Davinder Sharma**, Met. 'A', **Yashika Garg**, Met. 'A', **Rajeev Ranjan**, Met. 'A' attended this course.

Four-weeks **summer placement course** organized by Agrimet Division, IMD, Pune for B.Tech (Agril. Engineering) students during 4-28 September, 2023 (Fig. 51).



Fig.51. B.Tech (Agril. Engineering) students

Mr. Asok Raja Subbarayan Kumarasamy, Sc. 'D' trained and nurtured the SeAFFGS forecasters, and hydrologists of NMHS of Lao PDR during 4-6 Oct 2023 and the SeAFFGS forecasters, and hydrologists of NMHS of Cambodia during 9-11 October 2023 under the support of WMO to build an effective response system by fully leveraging the Flash Flood Guidance System's potential to avoid major losses and to save livelihoods in the South East Asia region (Figs. 52&53).



Fig. 52. Southeast Asia Flash Flood Guidance System (SeAFFGS) Refresher TrainingVientianne, Lao PDR



Fig. 53. Southeast Asia Flash Flood Guidance System (SeAFFGS) Refresher TrainingPnompenh, Cambodia (9-11 October 2023)

Integrated Meteorological training Course : This course is conducted for a period of four months. This is an introduction course for the fresh entrants and also for recording real time observations, current weather and other related subjects. January to December, 2023 MIT, Pune has conducted 2 batches and trained 117 personnel.

Forecaster Training Course : This course comprises of 2 months E-learning and 4 Months class room learning along with On Job training. This course is offered to the senior employees who are likely to be promoted to the Group A posts where forecasting for various users is the primary requirement. FOUR batches were called for training during the year 2023-24. This unit has imparted training for 69 candidates during this period and 40 names have been nominated for the batch from 9th October, 2023 onwards.

Dr. Ashutosh Kumar Misra, Sc. 'D' attended "**Common Alerting Protocol (CAP) Implementation Workshop and Training-2023**" through virtual mode conducted by the United

States Agency for International Development (USAID) and Alert-Hub.Org CIC from 10 - 12 October, 2023.

An online refresher training course in Aviation Meteorology - (part 2) held on 7th November, 2023 for all the officials of IMD.

An online training on implementation of Integrated Aviation Message submission and Report Generation System at airports was held on November 09, 2023 for all the AMOs and AMSs.

Shri Thangjalal Lhouvum, Sc. 'D' attended a virtual WMO Energy training course on 17- 20 November, 2023.

Dr. M Mohapatra, DG IMD addressed the participant in the inaugural ceremony of on Job Training program organized by MWO Palam on 6th December, 2023 (Fig. 53).

CRS Pune, conducted capacity building training programme on Seasonal Prediction to Operational Services in South Asia during 4-8 December 2023 for officials of the Department of Meteorology, Sri Lanka.



Fig. 54. Capacity building training programme for officials of the Department of Meteorology, Sri Lanka

Dr. (Smt) Manorama Mohanty, Sc. 'E' M.C Ahmedabad, **Shri Ramashray Yadav**, Sc. 'D', **Shri Abhimanyu Chauhan**, Sc. 'C', **Shri Y. D. Bijani**, Met. 'B', **Smt. S. N. Bhat**, Met. 'B', **Shri A. R. Khlas**, Met. 'A' and **Shri N. S. Darji,** Met. 'A' participated in online training on Cyclone & Marine Services (Bulletin & Products) organised by RSMC during 13-16 December, 2023.

Agrimet Division, IMD, Pune was actively involved in organizing a five-day training on "**Improvement of Agricultural Meteorological services using the latest remote sensing tools"** jointly organized by CR&S, IMD, Pune and Department of Meteorology (DoM), Sri Lanka for officials of the DoM, Sri Lanka at CR&S, IMD, Pune from 11-15 December, 2023 (Fig. 55).



Fig. 55. Capacity building training programme for officials of the Department of Meteorology, Sri Lankaat CR&S, IMD, Pune

A **"Customized Tailor-Made Meteorological Training"** programme commenced on 20th November to 15th December, 2023 for 5 Met. Trainees from Bhutan.

Fifteen IAF personnel who have been deployed to Myanmar for the installation of Meteorological Instruments were imparted training in the **'Installation, Operation and maintenance of Aviation Meteorological Instruments'** from 6-8 December, 2023.

CWD conducted a Refresher Training Course on marine Weather Forecasting and Cyclone Warning: Standard Operation Procedure during 13-16 December, 2023.

Officers (13) of RMC Nagpur attended refresher course on "**Networking**" from 20- 24 November, 2023 organised by ICITC, ISSD, New Delhi.

Officers (10) of RMC Nagpur attended refresher course on "Database Management" from 18- 22nd December, 2023 organised by ICITC, ISSD, New Delhi.

6.5. LECTURE

Dr. Partha Roy Sc. 'C' invited to deliver lecture on "**Early warning importance and Meteorological Service of MC Agartala**" at Central Training Institute on 3rd January, 2023.

Dr. S. Bandyopadhyay, Sc. 'G', delivered a lecture on "**cyclone and disaster management**" in a workshop at Vivekananda University, Belurmath on 6th January, 2023.

Shri Raja Acharya, Met. 'A' participated in the webinar "**Looking ahead: New technology for the Ocean Decade**" organized by the Global Ocean Observing System (GOOS), Marine Technology Society (MTS), and the National Oceanic and Atmospheric Administration (NOAA), on 11th January, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' delivered a lecture in a Training Program on '**Early Warning System'** in Gosaba Block of Sunderbans, West Bengal on 30th .January, 2023.

Mrs. Monica Sharma, Sc. 'D', CWD delivered a lecture on "**Cyclogenesis and Cyclone Forecasting Systems**" during the 18th training course on "S**pace Enabled Geo Information for Disaster Management**" conducted by NRSC-ISRO on 1st February and participated in the meeting of Expert Team on Operational Weather Forecasting System (ET-OWFS), World Meteorological Organization during 31st January to 2nd February. She presented on the subject "Support to Severe Weather Forecasting Programme (SWFP)" on 1st February as Vice Chair of Advisory Group on Severe Weather Forecasting (AG-SWF) and a talk on "Improved TC Science for better Decision making" during the 4th WCSSP India Annual Science Workshop on 28th February, 2023.

IMD and Indian Meteorological Society (IMS) hosted the talk on two types of critical transitions to monsoon: Universal definition of local monsoon onset by Prof. Elena Surovyatkina at DGM's Conference Room, IMD New Delhi on 7th February, 2023.

Shri Radheshyam Sharma, Sc. 'C' delivered an invited lecture on "Weather Observational Network and Early Warning System in Rajasthan" in a workshop "Industry-Academia Connect in Atmospheric Science" at Central University of Rajasthan, Kishangarh during 10-11 February, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the 15th Foundation Day of IIT Bhubaneswar as Chief Guest on 12th February, 2023 and delivered the Foundation Day lecture on Role of science and technology in combating climate change.

Shri Vivek Sinha, Head M.C. Patna along with **Shri. Ashish Kuma**r, Sc. 'C' & **Shri Anand Shankar**, Sc. 'C', visited Bihar Animal and Science University and delivered the lecture on 15th February, 2023.

Dr. A. K. Mitra, Sc. 'F' delivered Guest Lecture at Air Force Academy, Dundigal, Hyderabad on 17th February, 2023 on the topic "**Utilization of Satellite Products in Weather Forecasting**".

Dr. S.O' Shaw, Sc. 'F' attended pre event of 3rd session of National Platform for Disaster Risk reduction (NPDRR) 2023 and delivered a lecture at Administrative Staff College Khanapara Guwahati on 18th February, 2023.

Dr. Anwesa Bhattacharya, Sc. 'C' delivered a lecture on "**Recent Climate Change**" at Krishnachandrapur High School, Mathurapur on 27th February, 2023.

Dr. K. Sathi Devi, Sc. 'F' participated in National Meet on "**Disaster Management- Trends and Technologies**" during 27-28 February, 2023 at Hyderabad International Convention Center, Hyderabad and delivered a talk on "**Cyclogenesis and Cyclone Forecasting**".

Dr. H. R. Biswas, Sc. 'F', attended National Science Day Program to deliver a talk, related to the theme "**Global Science for Global well -being**" at Sri University Cuttack on 28th February, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' delivered a lecture on Hazards and Disaster Management to the Participants in the Department of Geology, University of Calcutta on 1st March, 2023.

Dr. S.O' Shaw, Sc. 'F' delivered invited lecture at NESAC (north east space Application centre) on 14th March, 2023.

Ms. Suman Gurjar, Sc. 'D', **Shri Parmod Kumar**, Sc. 'C' and **Shri Sunny Chug**, Sc. 'C' delivered lectures for Short Term Refresher Course on Topic - **CYBER SECURITY** during 20-24 March, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' delivered a lecture during celebration of WMO day by School of Agriculture and Allied Sciences, Neotia University on 22nd March, 2023.

Dr. Kripan Ghosh, Sc. 'F' delivered an invited lecture on "**Management of Agricultural Risks using Climate Information**" as a Distinguished Speaker on the occasion of WMO Day at University of Agricultural Sciences (UAS), Dharwad, Karnataka on 23rd March, 2023.

Dr. (Smt.) Manorama Mohanty, Sc. 'E' had attended the lecture at Space Applications Centre (SAC) organized by IMSA on 24th March, 2023 in view of World Meteorological Day, 2023 celebration.

Mr. Radheshyam Sharma, Sc. 'C' and **Mr. Himanshu Sharma**, Sc. 'C' delivered a lecture in a workshop on "**Climate change and human health**" on 29th March, 2023 at Health Department, Rajasthan govt.

Dr. H. R. Biswas, Sc. 'F' delivered lecture on "**Weather Forecasting & Warning Service-IMD**" for the training program of DEOC officials on "**Management of emergency operation centre**" on 13th April, 2023 at Gopabandhu Academy of Administration, Bhubaneswar.

Dr. Kripan Ghosh, Sc. 'F', delivered a lead lecture on "**Integration of Weather and Climate information for management of Agricultural Risks**" at College of Agriculture, Tripura during National Seminar on "**Climate Resilient Millet Production Technologies for Sustainable Agriculture (CRMPTSA)**" on 28th April, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' delivered a lecture on the occasion of World Environment Day, 2023 organized by Diamond Harbour Women's University, Diamond Harbour on 5th May, 2023.

Shri P. S. Kannan, Sc. 'E' delivered a lecture on Hydromet and Agromet services rendered by Regional Meteorological Centre, Chennai to the participants of International workshop on Hydromet Service for Coastal, Agricultural, and Urban Resilience held at Chennai on 7th May, 2023.

Dr. V. K. Mini, Sc. 'F' gave an interactive talk to educate nearly 200 fishermen in a Community Interactive Programme (CIP) organized by Headquarters, No. 4 Coast Guard District (Kerala & Mahe at Marianad Fish Landing Centre, Puthukurichi, Thiruvananthapuram on 20th May, 2023 in coordination with AD, Fisheries, Vizhinjam, Thiruvananthapuram.

Shri M. L. Sahu, Sc. 'F', RMC Nagpur delivered lecture to students of SBJITM, Nagpur on 26th May, 2023.

Dr. H. R. Biswas, Sc. 'F', attended & delivered lecture in State Level Consultation Workshop on "**preparation of Drought Management Plan**" for Odisha, 29th May, 2023, Convention Centre, Lok Seva Bhawan, Bhubaneswar.

Dr. S. Bandyopadhyay, Sc., 'G', delivered a lecture on the occasion of World Environment Day, 2023 organized by Diamond Harbour Women's University, Diamond Harbour on 5th June, 2023.

Dr. G. N. Raha, **Dr. G. N. Raha**, Sc. 'F', gave a Lecture on "**Plastic and Climate Change Connection**" On occasion of World Environment Day conducted by DGM New Delhi on 5th June, 2023 through online mode.

Dr. S. Bandyopadhyay, Sc. 'G' delivered a talk to Agriculture officers from government of West Bengal during GKMS familiarization Programme on 27th June, 2023.

Shri Abhishek Anand, Sc. 'C' delivered a lecture on "**Role of GIS in Disaster Management**", as a Guest lecturer in St. Xaviers College Ranchi on 27th June, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' delivered a lecture during a training program on Earth Observation Data Analytics for Disaster Management focusing on flood and drought at Indian Statistical Institute, Kolkata on 11th July, 2023.

Dr. H. R. Biswas, Sc. 'F' delivered lecture on **heat risk faced by Bhubaneswar**, **planned and ongoing strategies for heat adaptation in the city** held on 2nd August, 2023 conducted by School of Environment and Sustainability at IIHS.

Dr. S. Bandyopadhyay, Sc. 'G' delivered a talk at Calcutta Electric Supply Corporation on 3rd August, 2023.

Dr. M. Mohapatra, DG IMD delivered a recorded speech as an invited Speaker during the Plenary Session of the launch event of CEEW's report on "**Strengthening India's Disaster preparedness with Technology : A Case for Effective Early Warning Systems**" at India Habitat Centre, New Delhi on 13th July, 2023.

Dr. Kripan Ghosh, Sc. 'F', **Dr. Ashutosh Kumar Misra**, Sc. 'D' and **Dr. Asha Latwal**, Sc. 'C' attended an online talk on "**Evolution of cyclone monitoring and forecasting over the North Indian Ocean**" by **Dr. M. Mohapatra**, DG, IMD, New Delhi "**Commemorating 50th year of WMO/ESCAP Panel on Tropical Cyclones**" on 7th August, 2023.

Dr. Kripan Ghosh, Head Agrimet Division, delivered an invited lecture on "**Weather and climate services for the agriculture sector**" through virtual mode on 21st August, 2023 in the training programme on "**Sustainable Agricultural Water Management Options Under Changing Climate**" organised by ICAR-Indian Institute of Water Management, Bhubaneswar in collaboration with National Institute of Agricultural Extension Management, Hyderabad.

Dr. Asha Latwal, Sc. 'C' delivered an invited lecture on "**Climate Change: Causes, Adaptation and Mitigation**" through virtual mode on 22nd August, 2023 in the training programme on "**Sustainable Agricultural Water Management Options Under Changing Climate**" organised by ICAR-Indian Institute of Water Management, Bhubaneswar in collaboration with National Institute of Agricultural Extension Management, Hyderabad.

Dr. S. Bandyopadhyay, Sc. 'G', delivered lecture in the workshop on "**Unleashing Earth Observation Insights for Flood and Drought Management: Data to Build Resilience**" at ISI, Kolkata on 15th September, 2009.

Dr. (Smt) Manorama Mohanty, Sc. 'E' delivered a lecture on "**Heat Wave Forecasting and Weather Services**" at Indian Institute of Public Health (IIPH), Gandhinagar on 31st August, 2023 and on '**Climate Change: Crisis on Infinite Earth**' at Junagarh Agriculture University on 22nd September, 2023.

Dr. M. Mohapatra, DG IMD presented a Memorial Lecture in the Webinar on Late Professor G. P. Sinha Memorial on "**Climate Change : It's Impact & Solutions**" on 1st September, 2023.

Dr. H. R. Biswas, Sc. 'F' attended as Chief Guest and delivered lecture in the community training programme for fishermen organised by "**SPANDAN**" Puri, Odisha on 1st September, 2023.

Four-weeks summer placement course has been organized by Agrimet Division, IMD, Pune during 4-28 September, 2023. B.Tech (Agril. Engineering) students from various universities of Maharashtra has participated in the said course. Scientists of the division delivered lectures on following topics during the course:

'**Agromet Advisory services**' - by **Dr. Kripan Ghosh**, Sc. 'G' and Dr. Asha Latwal, Sc. 'C'.

'**Introduction to Agricultural Meteorology**', '**Crop weather relationship**', '**Application of Weather forecasting to Agriculture**' and '**Basics of Crop weather modelling**' - by **Dr. Ashutosh Kumar Misra**, Sc. 'D'.

'**Evaporation and Evapotranspiration**' and '**Basics of Remote Sensing and its applications in Agriculture**' - by Dr. Asha Latwal, Sc. 'C'.

Dr. H. R. Biswas, Sc. 'F' delivered lecture on "**Cyclone Early Warning system**" on 8th September, 2023 for Odisha Administrative Services probationer's 2020 batch at Gopabandhu Academy of Administration (GAA) Bhubaneswar.

Dr. M. Mohapatra, DG IMD delivered '**Dr. M. K. Rout Memorial Lecture**' at Bhubaneswar which was organized by State Pollution Control Board, Odisha on 12th September, 2023.

Dr. Ashutosh Kumar Misra, Sc. 'D' delivered a lecture on "**IMD services for the farming community of the country**" to the M.Sc. (Agri.) students and faculty members of Anand Agricultural University, Gujarat on 12th September, 2023.

Special lecture was delivered by **Dr. Taiichi Hayashi**, Professor in the Centre for South East Asian Studies, Network division, Kyoto University Japan on the topic of "**Why we are interested in heavy rainfall in the north Eastern India?**" at RMC Guwahati office on 12th September, 2023.

Special lecture was delivered by **Dr. Toru Terao**, Professor, Faculty of Education in Kagawa University, Japan on the topic of "**Summer Monsoon Onset and Lower Tropospheric High Moist Static Energy Airmass"** at RMC Guwahati office on 22nd September, 2023.

India Meteorological Department organized a series of lectures with **Permanent Representatives and Eminent Scientists from various WMO/ESCAP Panel on Tropical Cyclones** member countries during August-November, 2023. Special wrap up Session of the series was organized on 20th November, 2023**. Mrs. Monica Sharma**, Sc. 'D' made a presentation on the activities initiated by IMD to commemorate 50th year of formation of WMO/ESCAP Panel on Tropical Cyclones. The session was chaired by **Dr. M. Mohapatra**, DG, IMD. During his concluding remarks he highlighted the importance of regional association in minimizing death and damage due to tropical cyclones in the region.

Dr. Rajib Chattoapadhyay, Sc. 'E' and **Dr. Divya Surendran**, Sc. 'D' attended the Stakeholder Consultation Workshop for Development of National Framework for Climate Services in India (NFCS-India) from 5-6 October 2023 at Christ University, Lavasa, Pune organised by O/o CRS, IMD, Pune.

Dr. Divya Surendran, Sc. 'D' attended online and presented a poster on "**An overview of the climate indices related to health sector over Kerala State, India**" in the WCRP open Science conference on 9th October 2023.

Dr. (Smt.) K. Naga Ratna Sc. 'E' delivered a lecture on "**Climate forecasting for effective service delivery**" on 9th October, 2023 during ASCI-GIZ Training Program on "**Climate Resilient Urban Management & Service Delivery**" at Administrative Staff College of India (ASCI), Hyderabad.

Dr. S. Balachandran, Sc. 'G' delivered a lecture in the Regional Level Webinar on "Fighting inequality for a Resilient Future" organized by Tamilnadu Open University, Chennai on 12th October, 2023.

Dr. Ananya Karmakar, Sc. 'D' presented poster and short oral presentation in WCRP OSC 2023 on 11th October 2023 entitled "**Indian Extreme Rainfall Events Frequency in different climatological epochs**".

Smt. Arati Bandgar, Sc. 'D', delivered invited talk on "**Importance of Disease Data Analysis and use of disease data in understanding disease spread and prediction (special focus on Dengue and Chikungunya)**" during Workshop on Vector Borne Diseases for Field Workers by Pune Knowledge Cluster held on 26th October 2023 at Primary Health Centre, Wagholi, Pune.

Dr. Rajib Chattoapadhyay, Sc. 'E' attended Stakeholder Meeting on 31st October, 2023 at CDAC, Pune on "**Environment & Climate Data Infrastructure : Need, Challenges and Opportunities**".

Dr. (Smt.) K. Naga Ratna, Sc. 'E' presented "**Role of India Meteorological Department on Fore Warning and Advisories with regard to Climate Related Extreme Event**" on 20th November, 2023 at MANAGE, Hyderabad in a Training & Exposure Visit Program on "**Climate Change in Agriculture for Senior Officials of Department of Agriculture, Odisha**".

Dr. Sabeerali C. T., Sc. 'C' delivered a talk in TROPMET-2023 held at Jaipur from 22-24 November, 2023.

Dr. M. Mohapatra, DG IMD delivered lecture (online) on "**Meteorological Science: Recent Advances in NIAS-DST**" Training Programme on "**Science & Technology : Global Developments and Perspectives**" organized by NIAS, Bengaluru on 24th November, 2023.

Dr. M. Mohapatra, DG IMD participated as Chief Guest in the Panel Discussion: on **"Strategies for Building Geo Resilience in the Face of Disaster"** in the Geo Resilience Symposium organized by Association of Geospatial Industries (AGI) on 28th November, 2023.

Dr. Satyaban B Ratna, Sc. 'E' delivered a talk on "**Influence of Large scale Climate Drivers on Rainfall over South Asia**" in the Capacity Building Training Programme on Seasonal Prediction to Operational Services in South Asia at CRS, Pune on 4th December, 2023.

Dr. Kripan Ghosh, Sc. 'G' Pune delivered an Invited Lecture on "**Integration of climate information and crop simulation models for risk management in agriculture**" in National Training Programme on "**Concept of Agrometeorology and Crop Weather models**" organised by Centre of Advanced faculty Training in Agril. Meteorology (CAFT), College of Agriculture, Pune on 7th December, 2023.

A customized training programme has been prepared for 8 trainees from Met. Bhutan scheduled from 20th November to 15th December, 2023.

Shri Thangjalal Lhouvum, Sc. 'D'visited Department of Geography, Synod College, Shillong on 7th November, 2023 for a one day special lecture on "**Understanding IMD forecast and its application in daily life**" .

C. S. Patil, Sc. 'E' delivered a talk on aviation meteorology for the faculty and students of Koshys Institute of Management, Bengaluru on 7th December, 2023.

Scientists from Agrimet division, IMD, Pune delivered the following lectures during the training programme on "**Improvement of Agricultural Meteorological services using the latest remote sensing tools" on** 11- 15 December, 2023.

Dr. Kripan Ghosh, Sc. 'G' delivered the lectures on "**Concept of Operational Agromet Advisory Services and existing system in India**" and "Analysis and management of climatic risks in Agriculture using crop simulation model (CSM)" - by.

Dr. Ashutosh Kumar Misra, Sc. 'D' delivered the lectures on "**Impact based Forecast (IBF) for Agriculture**", "**Outreach and Dissemination of AAS**", "**Introduction to CSM**" and "**Water budgeting and scheduling of irrigation**".

Dr. Ashutosh Kumar Misra Sc. 'D' and **Dr. Jaya Dhami Parihar,** Sc. 'D' delivered the lectures on "**Use of decision support systems in preparation of Agromet Advisories**".

Dr. Asha Latwal, Sc. 'C' delivered the lectures on "**Various agromet products and their applications for appropriate decision making in Agricultural operations**", "**Basics of Remote Sensing and its Applications in Agriculture**" and "**Crop Weather Calendar, Pest Weather Calendar, Feedback on AAS & Impact Analysis**".

Sh. Shibin Balakrishnan, Sc. 'D' imparted two online lectures on the "**Analysis of Tropical Cyclones using satellite observations and derived products giving specific examples of applications in real-time forecasting**" in the South Asian Meteorological Lecture (SAMA) series during December, 2023.

Dr. Satyaban B. Ratna, Sc. 'E' presented a talk entitled "**Challenges in Climate Services in Cities**" in the session "**Climate Action in Global Cities**" in the AGU23 meeting at San Francisco, USA on 13th December, 2023.

Dr. O. P. Sreejith Sc. 'E' took online lecture on "**Climate Service activities of IMD**" for the "**Winter School in Basic Science"** conducted by Kannur University on 19th December, 2023.

6.6. Workshop

IMD's major initiative in 2023 was to provide **capacity building** for its officials and personnel from the other organizations in the country as well as from foreign countries particularly personnel from Asia pacific regions through organised training programmes, user workshops, conferences etc. Salient details are as under:

Dr. Iyyappan M., Sc. 'D' participated in workshop-cum-stakeholders meeting **on 12-14 January, 2023 organized by Centre for Development of Advanced Computing (C-DAC) Pune** to understand users specific requirements for further improvement of Decision Support System (DSS).

Dr. Mrutyunjay Mohapatra, DG IMD made an opening address at the "**Stakeholders engagement workshop**" conducted by IMD and IITM for sub-seasonal forecast on 30th January, 2023. **Dr. Kripan Ghosh**, Sc. 'F', attended the Workshop.

Shri Raja Acharya, Met. 'A' participated in the "**WMO OSCAR/Space User Workshop**" organized by the WMO during 7-8 February, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD delivered Inaugural Address at the **Stakeholder workshop under B-EPICC Project** at Magnolia Hall, India Habitat Centre, New Delhi on 9th February, 2023 organised by TERI, India.

Dr. Sanjib Bandyopadhyay, Sc. 'G' attended workshop and delivered a presentation/lecture on "**Weather & climate service provided by India Meteorological Department and its impact on Power System operation**". Organized by ERPC at Biswa Bangla Convention Centre, New Town, Kolkata on 15th February, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD participated as the Chief Guest and delivered Keynote address in the 3rd International Workshop on "**Biodiversity and Climate Change - sustainable Development Perspective**" organised by IIT, Kharagpur on 16th February, 2023.

Shri Umasankar Das, Sc. 'C' attended a Workshop on climate change organized by a Voluntary Integration for Education and Welfare of society (VIEWS), a non-Govt. organization on 16th February, 2023.

Dr. Anwesa Bhatacharya, Sc. 'C', attended The 3rd International workshop on "**Biodiversity and Climate Change**", organized by CORAL, IIT Kharagpur, venue at IIT KGP during 16-19 February, 2023.

Dr. Rajib Chattopadhyay, Sc. 'E' participated in one day stakeholder workshop organized by IIT Bombay on 17th February, 2023. The purpose of the workshop was to discuss the growing needs and requirements in the climate services sector.

Shri Avnish Varshney, Sc. 'D' and **Shri Sunny Chug**, Sc. 'C' attended **WMO workshop session** in virtual mode on **WRC-23 agenda** during 21- 23 February, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD delivered an invited talk through VC on "**Impact Based Forecasting for Cyclones**" during Technical Session 2 of the Pre-Event of 3rd Session of "**National Platform for Disaster Risk Reduction (NPDRR)-2023**", National Workshop on Disaster Risk Reduction and Resilience in Coastal Regions on 23rd February, 2023.

Shri Uday K. Shende, Sc. 'E' has delivered a lecture on the subject as observational network of IMD in "**Journey of Meteorological Instrumentation Systems (JEMIS) workshop-2023**" at SAMEER, Mumbai on 24th February, 2023.

Ms. Suman Gurjar, Sc. 'D' and **Shri Avnish Varshney**, Sc. 'D' participated in "**4th WCSSP India Annual Science Workshop**" during 27th February-3rd March, 2023 at Delhi and Noida.

A workshop on **"Weather forecast and early warnings system in Rajasthan"** was organized by Meteorological Centre Jaipur on 25th March, 2023. **Shri Govindram Meghwal**, Hon'ble minister, Disaster management & relief, Govt. of Rajasthan addressed as the Chief Guest (Fig. 56).



Fig. 56. Workshop organized by Meteorological Centre, Jaipur

Shri Sunit Das, Sc. 'F' and **Dr. Himadri Baishya**, Sc. 'C' are participated in the workshop on "**Hydro-climatological research on Monsoon**", hosted by Centre for clouds and climate change research, Cotton University Guwahati on 21st March, 2023.

Dr. Sankar Nath, Sc. 'F' and **Dr. Iyyappan M.,** Sc. 'D' (ISSD) have participated in National Workshop on "**Web based Dynamic Composite Risk Atlas and Decision Support System (Web-DCRA& DSS)**" on 27th March, 2023.

Dr. Kripan Ghosh, Sc. 'F' attended a brainstorming workshop on "**Urban Groundwater Recharge and Management**" organized by National Hydrology Project, Groundwater Surveys and Development Agency, Water Supply & Sanitation Department, Bhujal Bhavan, Government of Maharashtra at Bhujal Bhavan, Shivajinagar, Pune on 27th March, 2023.

Dr. Kripan Ghosh, Sc. 'F', delivered a Key note address on "**Agricultural Services during monsoon 2022**" during Annual Monsoon Workshop (AMW-2022) held at IITM, Pune organized by Indian Meteorological Society, Pune Chapter (IMSP) in association with IITM and IMD, Pune on 28th March, 2023.

Dr. Rajib Chattopadhyay, Sc. 'E', presented the **hydrological aspects of 2022 Monsoon** on 28th March, 2023 in the Annual Monsoon workshop, Pune.

During the **Annual Monsoon Workshop and National Symposium** on "**Challenges in climate services for health sector in the warming environment**" held at IITM, Pune organized by Indian Meteorological Society, Pune Chapter

(IMSP) during 29-30 March, 2023, **Dr. Ashutosh Kumar Misra**, Sc. 'D' received First Prize in Oral Presentation during **Session III (Extreme weather and Crop Health)** for presenting the paper "**Impact Based Forecast (IBF) for Agriculture for minimizing the production losses in Agriculture"** authored by A. K. Misra, M. R. Deo, J. P. Sable, Ravindra G. Patil, Asha Latwal and Kripan Ghosh and **Dr. Asha Latwal**, Sc. 'C' received Second Prize for Oral Presentation during **Session III (Extreme weather and Crop Health)** for presenting the paper **"Impact of high temperatures on wheat growth and yield over north-west India**" authored by Asha Latwal, Bhairavi Kurtkoti, Jacob Thampan, A. K. Misra and Kripan Ghosh.

Shri H. S. Sawhney, Sc. 'E' attended a user workshop organised by NCMRWF on 18th April, 2023 for the **NWP Data users from the Renewable Energy sector**.

Dr. Kuldeep Srivastava, Sc. 'F' & **Shri Parmod Kumar**, Sc. 'C' attended one day workshop on "**Policy Issue in Tech Spaces**" on 6th April, 2023 at Indian Institute of Public Administration (IIPA), New Delhi.

An online training workshop on **"Thunderstorm Monitoring and Forecasting"** was organised by Nowcast Division, NWFC from 18-22 April, 2023. All officers from RMCs, MCs and O/o CRS attended the meeting.

Dr. Divya Surendran, Sc. 'E' attended the online **thunderstorm workshop** conducted by NWFC from 18-22 April, 2023.

Dr. Rajib Chattopadhyay, Sc. 'E', participated in Brainstorming Workshop under National Hydrology Project on the theme "**Avenues of AI/ML in Groundwater**" in Bhujal Bhavan and gave suggestions for how to use machine learning methods in groundwater resource-related studies on 21st April, 2023.

National Media Workshop on 28th April : IMD conducted National Media Workshop on 28th April (Hybrid Mode) with participation from various media groups countrywide, All India Radio and also disaster management agencies like National Disaster Response Force, National Disaster Management Agency etc. The objective of the workshop was to familiarize the mass media agencies about various new initiatives by IMD, various warning bulletins & graphical products, terms & terminologies, FAQs and website of IMD. The workshop also aimed to gather reviews from eminent journalists present there with the objective to further improve the services of IMD. **Dr. M. Ravichandran, Secretary Ministry of Earth Sciences graced the occasion as the Chief Guest. Dr. M. Mohapatra, DG of IMD** presided over the function (Figs. 57 & 58).



Fig. 57. Secretary MoES, Dr. M. Ravichandran presenting the inaugural address during National Media Workshop on weather and climate



Fig. 58. DG IMD, Dr. M. Mohapatra discussing the future plans of IMD during the Panel Discussionduring National Media Workshop on weather and climate

Dr. Rajib Chattopadhyay, Sc. 'E', **Dr. G. K. Das**, Sc. E and **Shri Umasankar Das**, Sc. 'C' attended

National Media Workshop on **Weather and Climate** on 28th April, 2023 in Mahika Hall, MoES, at New Delhi.

Dr. O. P Sreejith, Sc. 'E', **Dr. Satyaban Bishoyi Ratna,** Sc. 'E' and **Dr. Sabeerali C. T.**,Sc. 'C' attended online Nineteenth Session of the Forum on "**Regional Climate Monitoring-Assessment-Prediction for Asia (RAII) FOCRAII**" organized by Beijing Climate Center (BCC), CMA from 8-10 May, 2023. **Dr. Sreejith O. P.** gave a presentation on "**SACOF25 Seasonal Climate Outlook over South Asia for the 2023 Southwest Monsoon Season (June-September)**".

Dr. O. P. Sreejith, Sc. 'E' attended SAMA and SAFOAM jointly organized an online workshop on "**Long Range Forecast for the 2023 Southwest Monsoon Season Rainfall and its application on South Asian Agriculture**"on 13th May, 2023 and gave presentation on "**Long Range Forecast for the 2023 Southwest Monsoon Season Rainfall for South Asia**".

Dr. Rajib Chattopadhyay, Sc. 'E' had visited WMO, Geneva to attend the **Write shop Workshop** from 16-19 May, 2023.

Shri Abhimanyu Chauhan, Sc. 'C' participated in Joint refresher training workshop of **South Asia Flash Flood Guidance System (SAsiaFFGS)** at New Delhi during 17-19 May, 2023.

M.C. Bhubaneswar conducted three training programme workshops in collaboration with Odisha State Disaster Management Authority on understanding Weather Forecasting at Meteorological Centre, IMD, Bhubaneswar on 17th May, 2023, 24th May, 2023 & 31st May, 2023. District Emergency Officers, District Project Officers and DRR Consultant attended the meeting. **Dr. Gyana Das**, IAS, Managing Director OSDMA, Odisha attended the meeting on 31st May, 2023.

Dr. Rajib Chattopadhyay, Sc. 'E', participated in the '**International Climate Research Conclave 2023 (ICRC 2023)**' being organized jointly by the Ministry of Earth Sciences (MoES) and Department of Science and Technology (DST), Govt. of India. This conclave was hosted by IIT Bombay, Mumbai, India on 26-27 May, 2023.

Dr. Satyaban B. Ratna, Sc. 'E', presented a online talk on "**MJO in conjunction with Large Scale Features and its impact on Rainfall over India**" at the Southwest Monsoon 2023: Preparedness Training Workshop from 16-20 June, 2023.



Fig. 59. Second FFGS Global Workshop during 16-23 June 2023, Skopje, Republic of North Macedonia

Indian Delegation Headed by **Shri Rahul Saxena**, Sc. 'F', **Dr. Ashok Kumar Das**, Sc. 'E', **Ms. Hemlata Bharwani**, Sc. 'C' and **Mr. Asok Raja** S.K., Sc. 'C' IMD & NDMA attended **First Flash Flood Guidance System (FFGS) Programme Management Committee (PMC) Meeting** and the Second **FFGS Global Workshop** during 16-23 June, 2023, Skopje, Republic of North Macedonia. Global FFGS is a Flagship program of WMO with the objective of providing "**EW4ALL (Early Warning for all) by 2030**" (Figs. 59 & 60).



Fig. 60. First Flash Flood Guidance System (FFGS) Programme Management Committee (PMC) Meeting

Smt. Suman Gurjar, Sc. 'D' and **Shri Parmod Kumar**, Sc. 'C' attended e-Office Administrator Capacity Building Workshop from 11-13 July, 2023 at National Data Centre (NDC) Shastri Park New Delhi.

India Meteorological Department jointly with WMO conducted 1-Day Awareness Programmes for Disaster Managers and Media on Flash Flood Guidance Services at Delhi and Chandigarh on 9-10 August, 2023 respectively. Chief Guest of the workshop at Delhi was **Dr. Kamal Kishore**, member secretary NDMA. The workshop at Delhi and Chandigarh was attended by the members from various organizations involved in Flood Management and Disaster management. NDMA, NDRF, Print and electronic media Revenue Department, Irrigation and Water resources, along with the members from WMO Shri Ramesh Tripathi and Ms. Rokaya BA and officials of MC Chandigarh also participated in the workshop (Fig. 61).



Fig. 61. Awareness Programmes for Disaster Managers and Media on Flash Flood Guidance Services at Delhi on 9th August, 2023

Shri S. C. Bhan, Sc.-G, **Shri Rahul Saxena**, Sc.-F, **Dr. A. K. Das**, Sc. 'E', **Dr. (Ms.) Madhulatha Akkisetti**, Sc.-D, **Shri S. K. Manik,** Sc. 'D', **Shri Asok Raja S. K.**, Sc. 'D' attended the "**Awareness Programme for Disaster Managers and Media on Flash Flood Guidance Services**" organized by IMD-WMO on 9th August, 2023.

Dr. G. K. Das, Sc. 'E', **Shri H. S. Pariya**, Met. 'B' and **Shri Shubhendu Karmakar**, Met. 'A' attended **M-SAR (Maritime Search and Rescue) workshop** on 9th August, 2023 at Haldia. **Dr. G. K. Das**, Sc. 'E' delivered lecture on "**Tropical Cyclone Monitoring and Forecast**".

Shri Rohit Thapliyal, Sc. 'D' attended a workshop on "**Flash Flood Guidance services**" on 10-11 August, 2023 at Chandigarh.

"AWS / ARG Calibration Techniques" Workshop organized by ICITC (ISSD) at the ISSD Conference Hall, DGM Building on 4 & 5 September, 2023 for RMC Kolkata region. The event commenced with an insightful introduction by **Mr. Vivek Sinha**, Sc. 'G'. **Dr. M. Mohapatra**, **DG IMD**, delivered an inaugural speech. The event was attended by **Dr. V. K. Soni,** Sc. 'F', **Dr. Gajendra Kumar,** Sc. 'F', **Dr. Manish Ranalkar**, Sc. 'F', **Dr. Sankar Nath**, Sc. 'F', **Mrs. Samanti Sarkar,** Sc. 'E' and **Dr. B. Sudarsan Patro**, Sc. 'D'.

The workshop was an enriching and informative event that brought together experts, researchers, and enthusiasts from the field of Automatic Weather Station (AWS) and Automatic Rain gauge (ARG) Instrumentation, its calibration techniques. The workshop featured distinguished keynote speakers who shared their expertise in AWS and ARG calibration. The "**AWS / ARG Calibration Techniques**" workshop not only enriched participants with knowledge. It served as a platform to discuss challenges, share insights, and explore new horizons in AWS and ARG calibration. Hands-on workshops and practical sessions allowed participants to gain practical experience in AWS and ARG calibration techniques. Participants had the opportunity to work with real instrumentation and learn about calibration best practices (Fig. 62).



Fig. 62. "AWS / ARG Calibration Techniques" Workshop organized by ICITC (ISSD) at New Delhi

Shri Raja Acharya, Met. 'B', participated as an observer in the **Thirtieth Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS-XXX)**, held online during 11-15 September, 2023 organised by the Intergovernmental Oceanographic Commission.

Shri Raja Acharya, Met-B, participated in the WMO Virtual Workshop on **Environmental Sustainability of Observing Systems and Methods** held during 12-13 September, 2023.

Dr. (Smt.) Manorama Mohanty, Sc. 'E' and **Shri Kirit G. Kacha,** Met. 'B' attended an awareness session regarding "**Weather Forecasting & Price Risk Management**" of NCDEX in collaboration with IMD at Rajkot on 12th September and at Mehsana on 14th September, 2023.

South Asia Climate Outlook Forum (SASCOF Activity)



Fig. 63. SASCOF26 Online Session

Twenty-sixth Session of **South Asian Climate Outlook Forum (SASCOF-26)** and **Climate Services User Forum (CSUF)** conducted on 26-27 September, 2023 (Fig. 63). The aim of the workshop was to prepare the Consensus Outlook for 2023 winter season covering the months from October to December. The Climate Services User Forum (CSUF) which conducted on the 3rd October, 2023 had focus on interface with users from the various application sectors to interpret seasonal climate information and understand their specific needs with a view to further customizing climate information.

Dr. Kripan Ghosh, Sc. 'F' and **Dr. Ashutosh Kumar Misra**, Sc. 'D' attended "**26th session of South Asian Climate outlook Forum (SASCOF-26)**" conducted by CR&S, IMD, Pune in collaboration with RIMES and UK Met office during 26-27 September, 2023.

Dr. Kripan Ghosh, attended brainstorming workshop on "**Reorienting Education and Research in Agricultural Meteorology for Efficient Agromet Advisory Services and Climate Resilient Agriculture**" jointly organised by Association of Agro-meteorologists (AAM), Anand and ICAR-CRIDA, Hyderabad during 28-29 September, 2023.

The Office of Climate Research and Services (CRS) organized an "**India (NFCS-India)**" at Lavasa, Pune during 5-6 October, 2023.

A Stakeholder Consultation Workshop for Establishing the National Framework for Climate Services in India (NFCS–India), was organized by the India Meteorological Department (IMD), under the Ministry of Earth Sciences (MoES), Government of India, and co-hosted by Christ University at Lavasa, Pune, Maharashtra, from 5th to 6th October 2023. The participants in this event included a wide range of experts relevant to climate services in the country, such as representatives from various central ministries (including earth sciences, water resources, agriculture, health, energy, defence and space), officials from various state governments, research organizations, academic institutions, professional bodies, industries, non-governmental organizations, students, and the media. The workshop was structured with many presentations and talks by NFCS experts (national as well as from WMO), experts from the five GFCS priority areas (water, agriculture and food security, energy, health, and disaster risk reduction), Indian Navy, Indian Space Research Organization (ISRO), state governments, and several others. Following detailed presentations and discussions focused on the development of well-coordinated climate services in the country, the participants have broadly agreed on a roadmap ahead to ensure the successful establishment and implementation of NFCS-India (Fig. 64).

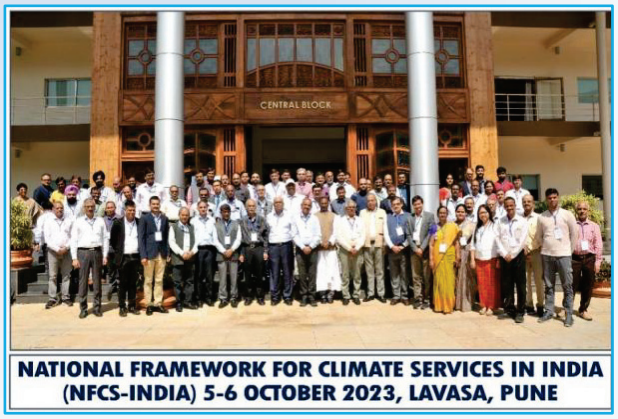


Fig. 64. National Framework for Climate Services in India (NFCS-INDIA)

Dr. A. K. Mitra, Sc. 'F', was invited as a Guest Speaker for the 2nd Indian Space Conclave from 9-11th October, 2023 at the Manekshaw Centre in New Delhi.

Shri Raja Acharya, Met.-A, attended the webinar on "**Disaster risk reduction in the digital transformation age: Leveraging emerging technologies**" on 13th October, 2023 conducted by WMO/ITU and participated online in the "**Ocean Best Practices System (OBPS) workshop**" held during 9-13 October, 2023 organised by the Intergovernmental Oceanographic Commission (UN).

Shri Ramashray Yadav, Sc. 'D', attended 24th International SST Users Symposium during 16-20 October, 2023 organised by ISRO Ahmedabad.

Dr. Divya Surendran, Sc. 'D', attended the Workshop On Vector Borne Diseases For Field Workers organised by Pune Knowledge Cluster in collaboration with the District Malaria Office, Pune on 26th October, 2023 at Primary Health Centre, Wagholi, Pune.

Shri Bikram Singh, Sc. 'F' was nominated by the DGM, IMD, Govt. of India as an expert speaker at a session for the event titled **"Destination Uttarakhand: Decoding sustainable development amidst climate risks"** at Hotel Sarovar Portico, Dehradun on 27th October, 2023 and articipated in a panel discussion on **"Charting developmental pathways amidst rising climate risks for Himalayan states like Uttarakhand"** in the said event.

Shri Raja Acharya, Met.-A, participated online in the "**7th International Port Meteorological Officers Workshop**" held in hybrid mode during 31st October-2nd November, 2023 organised by the WMO and Intergovernmental Oceanographic Commission(UN).

Dr. S. Balachandran, Sc. 'G' attend a National Workshop on "**Self Reliant Farmers: Empowering farmers through Agromet. Advisory Services in Changing Climate**" on 8-9 November, 2023 organized by Agro Climate Research Centre, Directorate of Crop Management, Tamilnadu Agriculture University, Coimbatore and Association of Agro Meteorologists.

Meeting at MoES was held on 16th November, 2023 in the presence of **Dr. M. Ravichandran**, Secretary, MoES and **Dr. M. Mohapatra**, DG IMD and **Dr. A.K Mitra**, Sc. 'F', IMD to review the report on INSAT 4th generation satellite requirements.

Dr. Ashutosh Kumar Misra, Sc. 'D' and **Dr. Asha Latwal,** Sc. 'C' attended an Online Workshop on "**Weather & climate services for the energy and related sectors in South America**" organized by WMO and other organizations on 17-20 November, 2023.

Shri Raja Acharya, Met. 'A', Participated in the "**3rd and 4th session of the Online Workshop on weather & climate services for the energy and related sectors in South America**" held on 17th November and 20th November, 2023 organised by the WMO .

Dr. M. Mohapatra, DG IMD participated in the Inaugural ceremony of the Conference on **G-20 Disaster Resilient Infrastructure** at Scope Conference Hall, New Delhi on 18th November. He also participated in the Panel Discussion - 2 on "**Reducing Disaster Risk & Building of the Delhi State Chapter - NAREDCO"** on 18th November, 2023.

Smt. Arti B Bandgar, Sc. 'D', attended the Workshop on "**Vector Borne Diseases for Field Workers**" arranged by Pune Knowledge Cluster at Maval Panchayat Samiti on 21st November, 2023 and delivered a talk on "**Importance of Disease Data Analysis and use of disease data in understanding disease spread and prediction (special focus on Dengue and Chikungunya)**".

Dr. M. Mohapatra, DG IMD, participated in the Inaugural Ceremony of **TROPMET 2023** as a Guest of Honour organized by India Meteorological Society and Birla Institute of Technology, Mesra, Rajasthan on 21st November, 2023. He also delivered the key note presentation on "**National Frame work of Climate Services**".

Dr. M. Mohapatra, DG IMD participated in the first **WMO Technical Coordination Committee** on 22nd and 23rd November, 2023 through VC.

IMD organised a Technical Conference on "**Advancements of Cyclone Warning services through WMO/ESCAP Panel on Tropical Cyclones"**

on 19th December, 2023 prior to the 50th PTC Session and also made presentations during the 50th Session of PTC. **Dr. D. R. Pattanaik**, Sc. 'G' made a presentation on (i) **Activities to commemorate 50 years of establishment of PTC**, (ii) **Tropical Cyclone Impact based forecast and Risk Assessment through Web based Dynamic Composite Risk Atlas**. **Mrs. Monica Sharma**, Sc. 'D' made a presentation on (i) **Gaps and Challenges in Tropical Cyclones monitoring and forecasting over North Indian Ocean**, (ii) **Review of cyclone season 2022 and 2023 during PTC-50 Meeting on 20th December** and (iii) **Tropical Cyclone Operation Plan (TCP-21) (Edition 2023)** as Rapporteur during PTC-50 meeting.

Dr. (Smt.) Manorama Mohanty, Sc. 'E' and **Shri Kirit G. Kacha**, Met. 'B' participated in **NATPOLREX-IX** at Vadinar organized by Indian Coast Guard on 24-25 November, 2023.



Fig. 65. Dr. (Smt.) Manorama Mohanty at NATPOLREX-IX Vadinar

The SASCOF27 (Twenty-Seventh Session of SASCOF) for the December-February (DJF) 2023/24 for updating the SASCOF26 outlook was held via video conferencing on 29th November, 2023. World Meteorological Organization Regional Climate Centre (WMO-RCC) of Climate Research and Services, India Meteorological Department (IMD), Pune office has conducted the meeting in collaboration with Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), Bangkok. National Meteorological and Hydrological Services (NMHSs) participants from different South Asian countries have participated in the meeting. All participants discussed their views on current climate factors and the regional climate outlook over South Asia for the upcoming season DJF 2023/24.

The meeting was conducted successfully and participants have shared and discussed their views on global climate as well as on regional climate for the upcoming DJF 2023/24 season. These inputs have been used to prepare the Consensus Statement for SASCOF-27, which is available on the link below: Website Link- https://imdpune.gov.in/sascof.php

Dr. Satya Prakash, Sc. 'D' participated and presented **IMD satellite data policy** in WMO Core Satellite Data Workshop at Geneva from 5-7 December, 2023.

Mrs. Monica Sharma, Sc. 'D' Participated in the WMO RA-II Technical **Workshop on Marine and Coastal Services** at Japan Meteorological Agency, Tokyo during 4-7 December, 2023.

Shri Ramashray Yadav, Sc. 'D' attended an online meeting of **WMO Workshop on Aircraft based Water Vapour Measurements for Aviation applications** on 7-8 December, 2023.

6.7. FOREIGN DEPUTATION

Shri B. A. M. Kannan, Sc. 'E' and **Shri Prayek Sandepogu**, Sc. 'C' attended the **Weather Radar Workshop** organized by JMA at Tokyo, Japan from 31st January to 3rd February, 2023.

Dr. Bushair, Sc. 'C' and **Mr. Arulalan**, Sc. 'C' attended the Basic IBF (Impact Based Forecast) Training at Dhaka, Bangladesh on 6-10 Febraury, 2023.

Ms. Hemlata Bharwani, Sc. 'C' and Shri. Asok Raja, Sc. 'C' attended the SAOFFGS Step 5 training, at Cebu, Philippines, from 16-17 Febrauary, 2023.

Shri Rahul Saxena, Sc. 'F' attended the 2nd RA-II HydroSOS Implementation Workshop that will take place from 21-23 February, 2023 at Bangkok.

Dr. M. Mohapatra, DG IMD and Dr. R. K. Giri, Sc. 'F' attended the 76th Session of WMO Executive Council at Geneva, Switzerland from 27th Febrauary - 3rd March, 2023.

Dr. M. Mohapatra, DG IMD, Dr. Sathi Devi, Sc. 'G' and Dr. Suresh Ram, Sc. 'F' attended the WMO Regional Conference in RA II (RA II RECO 2023) at Abu Dhabi, UAE from 13-16 March, 2023.

Dr. A. K. Mitra, Sc. 'E' attended the 24th International TOVS Study Conference hosted by Met Norway in Tromsø, Norway from 16-22 March, 2023.

Sh. Krishna Mishra, Sc. 'C' and Mr. Shobhit Katiyar, Sc. 'C' attended the Mid-Level IBF (Impact Based Forecast) Training for DRR & Agri at Bangkok, Thailand from 20-24 March, 2023.

Shri Gajendra Kumar, Sc. 'F' attended the ICAO Asia and Pacific (APAC), 21st Meeting of the (METIE WG/21) from 27-29 March, 2023 and 13th Meeting of the (METS WG /13) from 29-31 March, 2023 at Bangkok, Thailand.

Shri Sonam Lotus, Sc. 'E' attended the GCW Mountain Snow Workshop, in Darmstadt, Germany (at EUMETSAT) from 27-28 March, 2023.

Shri G. K. Sawaisarje, Sc. 'E' attended the first meeting of **Consortium of WMO Education and Training Collaborating Partners (CONECT)** in Geneva, 17-21 April, 2023.

Dr. M. Mohapatra, DG IMD attended the **High-Level Regional Forum of the Open Consultative Platform** in WMO Regional Associations II and V (RAs II and V) on 18th April, 2023 and Asia Climate Forum Conference from 19-20 April 2023 held at Singapore from 18- 20 April, 2023.

Shri Sourav Adhikary, Sc. 'E' attended the **ICAO APAC Seminar on Meteorology and Air Traffic Management (MET/ATM Seminar)** and the Twelfth Meeting of the Meteorological Requirements Working Group (MET/R WG/12) in Bangkok, Thailand on 1-5 May, 2023.

Dr. Rajib Chattopadhyay, Sc. 'E' attended the To attend Writeshop on **developing the guidance on operational practices for subseasonal prediction**, Geneva, Switzerland from 16-19 May, 2023.

Ms. Hemlata Bharwani, Sc. 'C' attended the **Flash Flood Guidance System Female Empowerment Workshop**, Geneva, Switzerland from 25-27 May, 2023.

Shri Gopal Krishna, MoES and **Shri Kapil Dev Meena**, Director Finance, MoES attended the FINAC 43 from 19.05.2023 to 20.05.2023.

Dr. Mrutyunjay Mohapatra, DG IMD and PR of INDIA to WMO, **Dr. R. K. Giri**, Sc. 'F', **Dr. Kuldeep Srivastav** Sc. 'F' and **Shri Sunny Chug**, Sc. 'C' attended the **EC 77 WMO Congress** from 22nd May to 6th June, 2023, 2nd May to 26th June, 2023 and 29th May to 2nd June, 2023 respectively.

Shri Rahul Saxena, Sc. 'F' and Focal Point, FFGS attended the **1st** FFGS PMC Meeting from 16-17 June, 2023 and the **2nd FFGS Global Workshop** from 19-23 June, 2023 in Skopje, Republic of North Macedonia.

Dr. D. R Pattanaik, Sc. 'F' attended the **S2S Summit**, **Reading**, UK from 3-7 July, 2023.

Dr. M. Mohapatra, DG IMD, **Dr. Naresh Kumar**, Sc. 'F' and **Dr. Sunit Das**, Sc. 'F' attended the **3rd South Asia Hydromet Forum (SAHF) Executive Council (EC-SAHF)** meeting in Brussels, Belgium from 25-27 July, 2023.

Ms. Gargi Rakshit, Sc. 'C' received the Young Scientist Award (YSA), International Union of Radio Science (URSI), Japan from 19-26 August, 2023.

Shri Asok Raja, Sc. 'D' attended the **Northwest South America Flash Flood Guidance System (NWSAFFGS) Regional Workshop** held in Lima, Perúfrom from 21- 25 August, 2023.

Dr. M. Mohapatra, DG IMD attended the UN ECOSOC for DGM, IMD to attend 2nd Session of Executive Board of UNDP UNFPA and UNOPS from 28-31 August 2023 at New York, USA from 28.08.2023 to 31.08.2023.

Dr. D. S. Pai, Sc. 'G' attended the Fourth Leadership and Management Programme for Senior Management of National Meteorological and Hydrological Services (NMHSs), Singapore from 04.09.2023 to 08.09.2023.

Shri Anoop Kumar Mishra, Sc. 'C' attended the **ICAO Asia and Pacific (APAC) Twenty- Seventh Meeting of the Meteorology Sub-Group (MET SG/27**), Bangkok Thailand from 04.09.2023 to 08.09.2023.

Dr. Kuldeep Srivastava, Sc. 'F' and **Shri Asok Raja**, Sc. 'D' attended the FFGS Refresher & Hands-On Operational training for the Southeast Asia Flash

Flood Guidance System (SeAFFGS) in Cambodia and Lao PDR, from 04.10.2023 to 11.10.2023.

Shri Dinesh Kumar, Met-B attended the WIS 2.0 Training workshop in Jakarta, Indonesia from 09.10.2023 to 13.10.2023.

Shri Sunny Chug Sc. 'C' attended the **CAP Implementation Workshop and Training Course** scheduled to be held from 10-12 October 2023 at Geneva from 10.10.2023 to 12.10.2023.

Shri Bibraj, Sc. 'D' and **Shri Rohit Shukla**, Sc. 'D' attended the **JMA Weather Radar Workshop** at Tokyo from 11.10.2023 to 13.10.2023.

Dr. M. Mohapatra, DGM attended the **Technical Coordination Committee** meeting at Geneva, from 17.10.2023 to 19.10.2023.

Shri P. L. N. Murthy, Scientist E attended the **Seventh Port Meteorological Officers (PMO-7) workshop** in Nadi, Fiji, from 31 October to 2 November 2023.

Dr. R. K. Jenamani, Sc. 'G' and **Dr. Shashikant**, Sc. 'D' attended the **WMO PTC/GCC Workshop on IBF Forecast& Warning Services, Muscat, Sultanate of Oman from 05.11.2023 to 09.11.2023.**

Dr. V. K. Soni, Sc. 'F', **Dr. D. R. Pattanaik**, Sc. 'F' and **Dr. O. P. Sreejith**, Sc. 'F' attended the **Scoping TPRCC Workshop** Bangkok, Thailand from 07.11.2023 to 10.11.2023 to 07.11.2023 to 10.11.2023 and 07.11.2023 to 09.11.2023 respectively.

Dr. Akhil Srivastava, Sc. 'D' attended the Harvard Mittal Institute **workshop on Climate Adaptation**, USA from 13.11.2023 to 16.11.2023.

Dr. Satyaban B. Ratna, Sc. 'E' attended the Introductory **Workshop on Climate Services for theNational Adaptation Plans**, Shefayim, Israel, 19.11.2023 to 24.11.2023.

Dr. Asok Kumar Das, Sc. 'E' attended the 2nd face-to-face meeting of **RA II CP-Hydrology in Bangkok**, Thailand from 27.11.2023 to 28.11.2023.

Dr. K. S. Hosalikar, Sc. 'G' attended the WIGOS Implementation Workshop for the WMO RA II Members to be held at Beijing, China from **27.11.2023 to 30.11.2023.**

Dr. M. Mohapatra, DGM and **Dr. D. R. Pattanaik**, Das, Sc. 'F' attended the 15th RIMES Council Meeting, on 1-2 Dec 2023, and 4th SAHF EC Meeting on 30 Nov in Bangkok, Thailand and 2nd Regional Workshop of CARE Component 1, from 28 to 30 November, 2023, in Bangkok, Thailand.

Dr. D. S. Pai, Sc. 'G' attended the COP 28 at Dubai from 08.12.2023 to 10.12.2023.

Shri V. R. Durai, Sc. 'F' RMC Chennai attended the **WMO VCP Workshop on Recent Advances of Severe Weather Forecasting Techniques using Machine Learning**, Hong Kong Observatory, from 4 to 8 December 2023.

Ms. Neetha K. Gopal, Sc. 'F', **Ms. Monica Sharma**, Sc. 'D' and **Dr. T. Balakrishnan**, INCOIS attended the WMO RA II Technical Workshop on Marine and Coastal Services, Tokyo, Japan, 4 - 7 December 2023.

Dr. Satya Prakash, Sc. 'D' attended the WMO Core Satellite Data Workshop (5-7 December 2023) at Geneva.

Dr. Anoop Mishra, Sc. 'C', Mr. Ramashray Yadav, Sc. 'D' and **Dr. Neeti Singh**, Sc. 'C' attended the **WMO Workshop on Aircraft-based Water Vapour Measurement for Aviation Application**, in Offenbach, Germany, on 7 and 8 December 2023. (Online)

Dr. Soma Senroy, Sc. 'F' attended the eighth **Meeting of the Expert Team on Multi-Hazard Early Warning Services Technical Guidance (ET-MTG-8)**, Geneva, Switzerland, 6-8 December 2023.

Dr. Suman Gurjar, Sc. 'D' and **Shri Anshul Chauhan**, Sc. 'C' attended the **APDIM Regional Expert Group Meeting**, Dushanbe, the Republic of Tajikistan, 7 and 8 December 2023.

Dr. Ananda Kumar Das, Sc. 'F' attend the WMO Tropical Cyclone Advisory Group Meeting at Geneva from 12.12.2023 to 14.12.2023.

Dr. Satya B. Ratna, Sc. 'E' attend the AGU Fall Meeting California USA from 13.12.2023 to 13.12.2023.

Dr. M. Mohapatra, DG IMD, **Dr. D. R. Pattanaik**, Sc. 'F' and **Ms. Monica Sharma**, Sc. 'D' attend the 50th Session of WMO/ESCAP Panel on Tropical Cyclones (PTC-50), Kingdom of Bahrain, 19-23 December, 2023.

WMO GAW-Global Air Quality Forecasting and Information System (GAFIS) AQ forecast inter-comparison over Asia meeting was held on 27 September, 2023 in hybrid mode. **Dr. V. K. Soni**, Sc. 'F' participated in the meeting.

The **9th meeting of the WMO S and and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Regional Steering Group (RSG) for Asia** was held during 31st Oct - 1st Nov 2023, at JMA Headquarter, Tokyo, Japan) in hybrid mode. **Dr V. K. Soni**, Sc. 'F' participated in the meeting through online mode.

Shri Asok Raja S. K., Sc. 'C' and **Ms. Hemlata Bharwani**, Sc. 'C' conducted **SAOFFGS Step 5 training** at Philippines during 16 & 17 February, 2023 for providing training on Flash Flood Services to South East Asia Oceania participants from Brunei Darussalam, Indonesia, Timor Leste, Philippines, Malaysia and Papua New Guinea on the invitation of WMO (Fig. 66).



Fig. 66. SAOFFGS Step 5 training at Philippines on 16 & 17 February, 2023

Dr. Anoop Kumar Mishra, Sc. 'C', IMD New Delhi was on deputation to attend the **ICAO Asia and Pacific (APAC) Twenty-Seventh Meeting of the Meteorology SubGroup (MET SG/27)** held at Bangkok, Thailand from 04-08 September, 2023.

Dr. D. S. Pai, Sc. 'G', IMD New Delhi was on deputation to attend **4th Leardership and Management Programme for Senior Management of National Meteorological and Hydrological Services (NMHSs)** held at Singapore from 4-8 September, 2023.

Shri Asok Raja, Sc. 'D', visited Cambodia and Lao PDR for **FFGS Refresher & Hands-On Operational training for the Southeast Asia Flash Flood Guidance System (SeAFFGS)**, on 4-11 October, 2023.

Shri Dinesh Kumar, Met-B, visited Jakarta, Indonesia for **WIS 2.0 Training workshop** in Jakarta, Indonesia 9-13 October, 2023.

Shri Sunny Chug, Sc. 'D', visited Geneva to attend 2023 **CAP Implementation Workshop and Training Course** scheduled which was held from 10-12 October, 2023.

Shri Bibraj, Sc. 'D' and **Shri Rohit Shukla**, Sc. 'D' visited Tokyo attend **JMA Weather Radar Workshop** which was held from 11-13 October, 2023.

Dr. R. K. Jenamani, Sc. 'G', was nominated by the Govt of India for foreign deputation as **expert and resource person** to Oman to deliver lectures at **Second WMO Session on the WMO PTC/GCC Workshopon Impact-based Forecast and Warning Services (IBFWS)**. It was jointly organized by the WMO Panel on Tropical Cyclones and hosted by Director General of Meteorology at CAA, Sultanate of Oman at Muscat, during 5-9 November, 2023.

Dr. V. K. Soni, Sc. 'F', **Dr. D. R. Pattanaik**, Sc. 'F', **Dr. O. P. Sreejith**, Sc. 'F' were on deputation to attend **Scoping TPRCC Workshop** held at UNESCAP Bangkok, Thailand during 7-10 November, 2023.

Shri Akhil Srivastava, Sc. 'D' was on deputation to attend the Introductory Workshop, Harvard Mittal Institute USA, during 13-16 November, 2023.

Dr. Satyaban B. Ratna, Sc. 'E' was on deputation to attend the **Introductory Workshop**, Shefayim, Israel, during 19-24 November, 2023.

Dr. Ashok Kumar Das, Sc. 'E' was on deputation to attend 2nd face-to-face meeting of **RA II CP-Hydrology** in Bangkok, Thailand during 27-29 November, 2023.

Dr. K. S. Hosalikar, Sc. 'G' was on deputation to attend **WIGOS Implementation Workshop for the WMO RA II Members** to be held at Beijing, China from 27-30 November, 2023.

Shri V. R. Durai, Sc. 'F' was on deputation to attend **WMO VCP Workshop on Recent Advances of Severe Weather Forecasting Techniques using Machine Learning**, Hong Kong Observatory, from 4-8 December, 2023.

Dr. Satya Prakash, Sc. 'D' was on deputation to **WMO Core Satellite Data Workshop** on 5-7 December, 2023 at Geneva.

Dr. Suman Gurjar, Sc. 'D', **Shri Anshul Chauhan**, Sc. 'C' were on deputation to **APDIM Regional Expert Group Meeting**, Dushanbe, the Republic of Tajikistan, 7-8 December, 2023.

Dr. Ananda Kumar Das, Sc. 'F' was on deputation to **WMO Tropical Cyclone Advisory Group** Meeting at Geneva 7-8 December, 2023.

6.8. VISITORS

Officer's of NDRF Ist. Bn. Guwahati, visited RMC Guwahati on 12th January, 2023 for demonstration on "**Disaster Risk reduction Activities**". Also an interactive sesson related to weather services provided by IMD on disaster Risk reduction.

अहमदाबाद की Gems Genesis International स्कूल से दो science teachers एवं 56 students ने दिनांक – 20th January 2023 को मौसम केंद्र अहमदाबाद का दौरा किया एवं सभी को निरीक्षण अनुभाग द्वारा सिनोप्टिक और ऑटोमैटिक वेधर सिस्टम के बारे मे बताया गया।

A group of Technicians from **Royal Government of Bhutan (RGOB)** with a co-ordinator from **North Eastern Regional institute of Water and Land Management (NERIWALM), Assam** visited IMD station at Cherapunji (Sohra) on 11th February, 2023, Shri Arun Kr. VH Sc.c & Shri Sailen Saikia Met-B, from RMC Guwahati attended at Cherapunjee for demonstration to the team of officers.

Prof. (Dr.) Pavel Kabat, Secretary General of the International Human Frontier Science Program Organization (HFSPO) visited Climate Research and Services (CRS), IMD, Pune office on 16th February, 2023 and gave presentation on **"Can predictive skills of our weather and climate models be enhanced by better inclusion of land surface and biological processes**?".



Fig. 67. Prof. (Dr) Pavel Kabat, Secretary General of the International HFSPO

Shri Manish Kumar Verma, Member Bihar State Disaster Management Authority visited Meteorological Centre, Patna and interacted with Officials on various aspects of Meteorological services given by Met Centre, Patna on 5th March, 2022.

WMO Day 23/03/2023 के अवसर पर मौसम केंद्र अहमदाबाद द्वारा आयोजित exhibition/प्रदर्शनी में आए हुये, 300 विद्यार्थियों को AWS/ARG/AIRPORT, MET instruments एवं Weather F/C के बारे में विस्तृत जानकारी प्रदान की गयी।

RMC Office, Alipore, Kolkata had celebrated WMO Day 2023. On that day, RMC Kolkata was open for all the visitors from various institutions and for common people. The visitors were familiarized/briefed about Met. Instruments and Observational Technique, AWS, ARG, HWSR, RS/RW, PBO, AMI, ARS instruments, role of IMD for preparing Agromet Advisories, forecasting for DVC area, making ephemeris by Positional Astronomical Centre (PAC) Kolkata, weather forecasting at ACWC Kolkata. A scientific talk on this year WMO theme and Quiz Programme, video/ lecture with PPT and Documentary show were also organized. On record, 325 numbers of visitors visited this office on WMO Day 2023. They were explained all the things in a precise manner. The students and their teachers and general people expressed their keen interest in acquiring knowledge in Meteorological events and latest development of IMD (Fig. 68).



Fig. 68. Shri Suman Chatterjee, Met.-B briefing the Student about digital pressure measuring instrument

About 214 visitors including students of Sarvodya Bal Vidhyalaya, Gokhle Marg, New Delhi, Green Fields School Safdurjung Enclave New Delhi, Indira Gandhi Technical University Kashmiri Gate Delhi, Department of Environmental Studies Delhi University Delhi, MVN University Palwal, Amity University Noida visited the Central Hydromet Observatory from 1st Jan, 2023 to 31st March, 2023.

On occasion of "**World Meteorological Day**" 2023 an exhibition was organized. **Shri Anupam Phukan,** Senior Geologist, Directorate of Geology and Mining, govt. of Assam, was invited as chief guest of the function.

Shri Tana Tage, Director Centre for Earth Sciences and Himalayan Studies, Govt. of Arunachal Pradesh with his officials visited RMC Guwahati office on 30th March, 2023 to discuss about enhancement of Meteorological Service in the State.

Professors and 32 students from VIT University from Vellore visited DWR Chennai and were explained about functions and utilities of DWR Chennai Radar on 3rd April, 2023.

Approx. 519 visitors visited CRS, Pune were briefed on various activities of the Climate, Agrimet and Instruments division. 60 Civil Engineering Students, 5 Professors from PVPIT, Pune visited AWS & Radiation Lab, Pashan during the period April-June, 2023.

MC Ranchi visited, students from Women's College, Ranchi an Educational tour on 3rd April, 2023.

M.C. Bhubaneswar visited 20 Nos. Botany Honours students & one faculty member of Udayanath Autonomous College of Science and Technology, Cuttack for Project Work on 17th April, 2023.

M.C. Gangtok, visited 190 Nos. of students from Tashi Namagyal Academy, Gangtok an educational tour during April, 2023.

Fifteen (15) Nos. of students from Ramakrishna Mission Vivekananda Educational Research Institute (Deemed University)/Agriculture Students visited this office for familiarization with activities of IMD (RMC Kolkata), on 8th June, 2023.

Eighty six (86) Nos. of students from DPS, Howrah visited RMC Kolkata as educational tour, on 15th June, 2023.

GHMC Director of EVDM (Disaster Manager) visited Meteorological Centre Hyderabad on 23rd June, 2023.

Fourty (40) Nos. of M.Sc. Geography students from Women's College Kolkata visited RMC Kolkata as an educational visit, on 23rd June, 2023 (Fig. 69).



Fig. 69. Students from Women's College Kolkata at PAC Kolkata

Six students of of M.Sc (Physics) from SRM Engineering College, Chennai visited DWR Chennai and were explained about the functioning and utilities of DWR Chennai on 24th June, 2023.

Wing Commander Shri Pranjal Deka (I.A.F.)visited M. O. Tezpur on 12th July, 2023.

Shri Rongsenlemzung, Joint Director Department of Soil & Water Conservation Kohima Nagaland, visited RMC Guwahati on 14th August, 2023.

Students of Lamdon Model School and Ladakh Science Foundation Visits Meteorological Centre Leh : In a significant effort to nurture scientific curiosity and understanding among young minds, Lamdon Model School, in collaboration with the Ladakh Science Foundation, organized a highly enlightening visit to the country's highest Meteorological Centre at Leh-Ladakh (Fig. 70).



Fig. 70. Students of Lamdon Model School and Ladakh Science Foundation visit Meteorological Centre Leh

This visit, which took place on 23rd and 24th August, 2023, aimed to introduce students to the fascinating world of weather science and the crucial role that IMD plays in forecasting weather for India. **Shri Sonam Lotus**, Sc.-E and **Dr. Jigmat Stondus**, S.A, briefed the students.

Mr. Martin Gazak of Micro Step MIS, Slovakia alongwith H.E. **Mr. Robert Maxin**, Ambassador and **Mr. Patrick Lista**, Economic Diplomat, from Slovak Embassy in Delhi visited IMD on 30th August, 2023.

22 Students and 4 Teachers, Dept. of Physics, UCC Barapani College visit at MC Shillong on 22nd September, 2023.



Fig. 71. Student & Teacher of UCC Barapani College visited at MC Shillong

60 students and 2 Professors of GHRCE, Nagpur visited MC Nagpur on 25th September, 2023.

20 Students and 2 Teachers, Deptt.of Geography, Morigaon College visited at MC Shillong on 29th September, 2023.



Fig. 72. Students and Teachers, Dept. of Geography, Morigaon College visited at MC Shillong

A team of delegates from National Institute of Malaria Research (ICMR) and a group of trainees (State Officials) from Gujarat Institute of Disaster Management (GIDM) visited the Met Centre, Ahmedabad on date: 29th August, 2023.



Fig. 73. A team of delegates from National Institute of Malaria Research (ICMR)

Students and teachers from **Doon Business School, Dehradun** and **Himalayan Institute of Medical Science, Dehradun** were visited Meteorological Centre Dehradun premises on 7th July, 26th July, 31st August and 26th September, 2023 respectively.



Fig. 74. Students of various colleges visited MC Dehradun

Shri Rohit Thapliyal, Sc. 'D' delivered a lecture on "**Different Weather Forecasting Products and Climate Services**" being provided by MC Dehradun. **Shri Shambhu Sharan**, Met-B, **Shri Akash Chandra**, Met-A, **Shri Ankit Sharma**, Met-A and **Shri Bhaumik Indrawal**, Met-A, Met. Centre Dehradun briefed the students about RS/RW observation, surface met. Observatory and showed the activities of weather forecasting section.

Officials of NERLDC visited RMC Guwahati office for a meeting dated 12th September, 2023 related to installation of AWS/ARG in various stations in NE- Region.

Group Captain Vinila Vertma, Command Meteorological Offices HQ Eastern Air Command, IAF Shillong, visited M.O Sohra on 14th September, 2023.

About **111 visitors** including students of East Point School, Vasundhara Enclave, Sanskriti School,

Chanakya Puri, New Delhi, trainees from Indian Coast Guard, Indian Navy and Mauritius Meteorological Department, trainees of FTC Training batch no. 196 and Students from Dayal Singh College visited the Central Hydromet Observatory from 1st July, 2023 to 30th September, 2023.

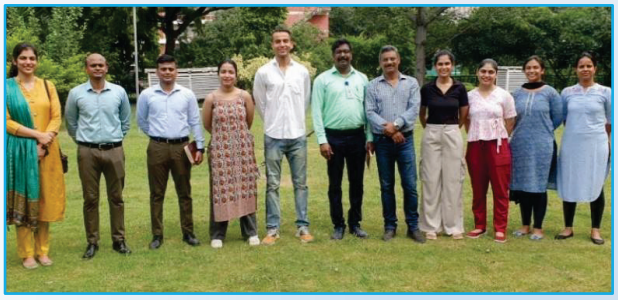


Fig. 75.Trainees from Indian Coast Guard, Indian Navy and Mauritius Meteorological Department

Twenty two Students and one teacher from Agriculture Deptt., William Carey University Shillong visited the MC Shillong on 9th October, 2023. The students were shown the surface and automatic observation stations along with briefing them about IMD activities, MC Shillong website and how to access and visualize AWS data at various sites.



Fig.76. Students and one teacher from Agriculture Deptt.,William Carey University Shillong at MC Shillong

Mr. Carlton Benson, Chief of American Citizen Services and **Ms. Swapna John,** American Citizen Services Assistant made a courtesy visit to Regional Meteorological Centre, Chennai, on 18th October, 2023(Fig.77). Dr. S. Balachandran, Sc. 'G' & Head, RMC Chennai made a presentation comprising Basic Weather Forecasting Process, IMD Observational Network, Weather Forecasting Services, Forecasting Dissemination and Verification methods, recent expansion of urban ARG network, 'X' and 'S' band Radar facilities, function of AWS & ARG etc.



Fig. 77. Visit of the US consul to RMC Chennai

Mr. Kenneth Kwa and Mr. Basil Ting, Vice-Consuls of the Consulate-General of the Republic of Singapore alongwith Ms. Ancy Jose, Assistant, made a courtesy visit to Regional Meteorological Centre, Chennai, on 19 October, 2022 (Fig. 78). **Dr. S. Balachandran,** Sc. 'G', RMC Chennai made a presentation comprising Basic Weather Forecasting Process, IMD Observational Network, Weather Forecasting Services, Forecasting Dissemination and Verification methods, recent expansion of urban ARG network, 'X' and 'S' band Radar facilities, function of AWS & ARG etc.



Fig. 78. Visit of the Singapore vice-consuls to RMC Chennai

Nineteen (19) Students and Four (4) teachers visited MC Shillong from Kristein Johnson Science Club, Ferrado Shelter Home on 2nd November, 2023. The students were shown the surface and automatic observation stations along with briefing them about IMD activities, MC Shillong website and how to access and visualize AWS data at various sites.

Around 60 students of Class 9th and 10th accompanied with 2 Teachers ORCHIDS, The International School, Nagpur visited on 02nd November, 2023 (Fig. 79).



Fig. 79. Students and Teacher ORCHIDS, The International School, Nagpur

Students from (i) Nowgong College (Autonomous), Nowgaon, Assam and (ii) Arunoday University, Naharlagun, Itanagar, Arunachal Pradesh visited Regional Meteorological Centre, Guwahati on 6t November, 2023.



Fig. 80. Students from (i) Nowgong College, Nowgaon (ii) Arunoday University, Naharlagun, Itanagar

Delegation from Ghana, headed visited India Meteorological Department on 23rd November, 2023 to have an overview of the forecasting techniques and practices at India Meteorological Department on 23rd November, 2023. The team visited National Weather Forecasting Centre in India Meteorological Department.

Gp. Cpt. Vinila Verma, Command Met. Officer HQ EAC, IAF Shillong visited MC Shillong on 30th November, 2023. She was briefed about IMD activities by Head MC Shillong. The visit and discussions were fruitful for future collaboration between IMD and EAC Command Met.



Fig. 81. Gp. Cpt. Vinila Verma, Command Met. Officer HQ EAC, IAF Shillong visited MC Shillong

Visit of **H.E. Robert Maxian,** Ambassador of the Slovak Republic to India alongwith Mr. Patrik Liska, Trade Commissioner, Embassy of the Slovak Republic, Mr. Jozef Omelka, Director of Microstep-MIS, Mr. Madhav Rao, Country Manager of Microstep-MIS and Mr. Milind Dande, Manager for Business Development of Microstep-MIS to India Meteorological Department on 6th December, 2023.

Students of various colleges/schools at MC Dehradun

66 UG Geography students from Banaras Hindu University, Varanasi accompanied with 4 staff on 05th December, 2023, **70 B.A. Geography students from Hindu College, Moradabad** with 08 staff on 21st December, 2023, **25 students and 02 teachers from Himalayan Institute of Technology,** Dehradun on 10th October,2023, **50 MBBS students and 02 teachers from Govt. Doon Medical College, Dehradun** on 9th October, 2023, **37 UG/PG students (Geology) and 02 teachers from Doon University, Dehradun** on 1st& 3rd November, 2023 &**55 students pursuing Post Graduation and Research in Geography from D.D.U. Gorakhpur University, Gorakhpur** on 28th November, 2023, **13 students and 01 teacher from Himalayan Institute of Medical Science, Dehradunwere** on 26th September, 2023 and under the program PM Shri Vidyalaya, 60 students of Class 12th with 07 teachers from **Kendriya Vidyalaya, Raiwala** on 20th December, 2023 were visited Meteorological Centre, Dehradun .

Shri Rohit Thapliyal, Sc-'D' delivered lectures on **"Different Weather Forecasting Products and**

Climate Services being provided by MC Dehradun" to them. **Shri Akash Chandra,** Met-'A', **Sh. Bhaumik Inderwal,** Met-'A', **Shri Anuj Kumar Jaiswal**, Met-'A' & **Shri Ankit Sharma,** Met-'A' briefed the students about RS/RW observation, surface met. Observatory and showed the activities of weather forecasting section.



Fig.82 .Students of various colleges/schools at MC Dehradun

6.9. Infrastructure Development and Installation

A prototype of a novel rain gauge, an in-house developed snow gauge, and four pollutant detector semiconductor chips on a **wafer level developed and demonstrated to the Hon. Secretary MoES** on 13th March, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' visited Science City, to take update of the new installation of ARG and to discuss with director, Science City regarding their upcoming climate gallery at Science City, Kolkata on 6th January, 2023.

Three (03) AWS is installed in Kerala, Manipur and Meghalaya State under 400 AWS Project.

GPS Based RS Instrument Installed by M/s SGS Weather & Environment Systems Pvt. Ltd. Under Observation of UAL Touring Party on 19th January, 2023.

Shri K. C. Sai Krishnan, Sc. 'G', visited Chennai for site evaluation for installation of Radar by Tamilnadu state Government during 19-22 February, 2023.

Dr. S. Bandyopadhyay, Sc. 'G' toured to Kalyani for Radar site selection along with twoother Group A officers on 14th March, 2023.

Dr. Praveen Kumar, Sc. 'C', RMC Nagpur was on tour from 17-25 April, 2023 regarding inspection, maintenance and revival of AWS and ARG in various stations of Madhya Pradesh.

Total 65 **Inspection and maintenance work** have been done during the year. 12 departmental/part time observatories have been inspected. 13 AWS, 40 ARG stations have been visited by the officials for revival and maintenance. During this 13 AWS and 36 ARG stations were successfully revived.

IERMON System has been installed in the premises of MC Gangtok by BARC on 18th May, 2023.

DCWIS and PWD systems were installed in April Kalburgi -(RWY 09), Bhopal -(RWYs 30, MID & 12), Sindhudurg-RWY 27, Kolhapur-RWY 07 & Bhavnagar-RWY 25, in May Porbandar-(RWY 27) & Bhuntar-(RWY 34) and in June Shirdi-(RWYs 27 & 09), Jalgoan-(RWY 27), Khajuraho-(RWY 19), Tirupati-(RWY 26) & Vijayawada-(RWY 26 & 08).

Collaborative research project on **application of INSAT 3D/3DR data and WRF Model** for accuracy

of Renewable (Solar & Wind) Energy Forecasting. Following study was done in collaborative study:

1. Actual Wind Speed vs. WRF Wind Speed Study
2. Actual GHI Vs. VIS Counts converted GHI

IMD & Grid India developed an Artificial Intelligence and weather forecast based day-ahead power demand forecasting tool.

A Demo by FCT Energy on Direct Methanol Fuel Cell was conducted at Hydromet Observatory, Mausam Bhawan on 4th October, 2023 to undertake feasibility study to meet IMD's power back requirements at Remote locations.



Fig. 83. DCWIS and PWD systems

Chandrapur Met observatory has been converted into departmental observatory.

6.10. NEW PROJECTS/SCHEMES INITIATED

Cyber security is the practice of defending computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks. IMD is using checkpoint firewall, Server Load Balancer with waf and Wazuh as cyber-security measures. And soon IMD is planning to incorporate SIEM & SOR tool.

1.) Checkpoint firewall is to offer integrated, redundant, hot-standby routing and firewall services. To monitor and filter incoming and outgoing traffic, and then decide whether to allow or block it based on set rules.

2.) Server load balancing (SLB) an application delivery and security solution that manages application traffic across cloud and data center locations, optimizing availability and performance, integrates multiple application protection services to provide protection against an array of cyber threats. It helps improve the security and reliability of a service system by distributing user requests across multiple servers for processing. SLB systems often include network isolation and network traffic control to improve system security.

3.) Wazuh is an open-source security platform that plays a vital role in safeguarding IMD's data assets from various security threats. It offers extensive security visibility, enabling comprehensive monitoring of systems and applications to detect and respond to threats, vulnerabilities, and anomalies effectively. Wazuh empowers IMD to stay ahead of emerging security risks and protect its data assets with confidence.
In addition to this IMD keeps auditing its IT infrastructure regularly

IMD e-AWAS package on 1st July, 2023 which is a web-based application, which helps in the Online Accommodation Application of IMD Quarters. The Employee can request for accommodation online and the In-charge of Quarters can process his request and take further action for allotment. As a pilot project it is started with Delhi Office and in future may be implemented in all IMD offices.

IMD Audit Para Status System (IMD APSS) version 1.0 on 17th August, 2023, which is an online system on METNET for Monitoring the status and obtaining the reply from concerned office/section for the Audit Para received from the Internal and External Audit party. Version 1.0 is launched for DGM Office as a Pilot Project.

New AWS was propose for World's Rainiest place at Mawsynram. The project was approved by Head, RMC Guwahati with site selection completed on 4th August, 2023 and NOC received from DDMA East Khasi Hills.



Fig. 84. New AWS was propose for World's Rainiest place at Mawsynram

A novel rain gauge prototype is tested on a rain gauge calibration test bench at the Surface Instrumentation Laboratory IMD Pune, for syphon volume and total accumulated rainfall intensity up to 88 mm/hr.

DCWIS and PWD systems were installed at the following airports.

July : Gondia (RWY 04); Pantnagar (RWY10); Thiruvananthapuram (RWY 32)

August : Mumbai (RWY 32); Juhu (RWY 08) ; Surat (RWY 22) ; Moradabad (RWY 12); Calicut (RWY 10 & 28); Salem (RWY 04); Coimbatore (RWY 23); Madurai (RWY 27); Trichy (RWY 09/27)

September : Coochbehar (RWY 22); Vadodara (RWY 22); Jharsuguda (RWY 24)

A new Surface Ozone Recording Instrument was installed at MC Shillong and Ranichuri. On December 16.12.2023, the touring officials conducted a field demonstration and training on how to maintain the instruments and share the collected data for staff of MC Shillong.

PWD systems were installed at HAL airport, Bengaluru (RWY 27) during 26.10.2023 to 29.10.2023 and at Mysore airport (RWY 09).

PWD systems were installed at Kannur airport (RWYs 25 & 07) by M.C. Thiruvananthapuram in October, 2023 with technical guidance from SID.

Agro-Observatory at Chhindwara has been installed in the month of November 2023.

6.11. Awareness and Outreach Programme

Impact based forecast (IBF) for Agriculture (Heavy Rainfall/Thunderstorm with Gusty winds/Cold Wave/Hailstorm) and Agromet advisories based on the IBF have been issued for different districts of various States and UTs across the country in co-ordination with NWFC, New Delhi, RMCs/MCs, AMFUs and DAMUs.

Dr. Kripan Ghosh, Sc. 'F' & Head Agrimet Division, **Dr. Ashutosh Kumar Misra,** Sc. 'D' and **Dr. Asha Latwal,** Sc. 'C' attended the Technical Demonstration on "**Use of Common Service Centre (CSC) Kiosk for dissemination of Advisory and Weather Forecast**" with officers from IMD New Delhi, IMD Pune, Nodal Officers & Technical Officers of AMFUs and SMS-Agromet of DAMUs organized by AASD, IMD, New Delhi on 9th January, 2023.

Shri J. P. Sabale, Met. 'A' participated in the program "**Krushidarshan**" on DD Sahyadri (Marathi Channel) on 20th January, 2023 and delivered talk on "**Importance of accurate weather forecasting to improve agricultural practices**". The program was broadcasted on 20th January, 2023 at 0600 to 0630 pm on DD Sahyadri.



Fig. 85. Krishi Darshan programme by Shri J. P. Sabale

During the quarter, 327 Farmers awareness programmes (FAPs) were organized by AMFUs and DAMUs across the country.

Dr. G. N. Raha, Sc. 'E' has attended Virtual Press Conference on "**Winter Season 2023 Rainfall outlook and Monthly outlook for rainfall and**

temperature for February 2023" on 30th January, 2023.

Dr. G. N. Raha, Sc. 'E' has attended Virtual Press Conference on "**Rainfall and Temperature forecast for February, 2023**" on 1st February, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD addressed live Press Conference on "**Rainfall and Temperature Outlook for the month of February, 2023**" on 1st February.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the 23rd Rashtra Katha Shivir at Pansla, Tehsil Upleta, district Rajkot, Gujarat and addressed students across the country on the "**Role of Science & Technology in combating weather hazards**" on 18th February, 2023.



Fig. 86. Dr. Mrutyunjay Mohapatra, DG, IMD in the 23rd Rashtra Katha Shivir at Pansla

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Panel Discussion on El Nino and its impact on Indian Summer Monsoon organized by Moneycontrol.com on 24th February, 2023.



Fig. 87. Dr. Mrutyunjay Mohapatra, DG IMD participated in the Panel Discussion

Long Range Forecast Issued in February 2023 : IMD issued the Seasonal outlook for the Hot weather Season (March to May) 2023 and Monthly Outlook for March 2023 for Rainfall and Temperature through a press conference held in virtual mode on 28th February, 2023.

A press conference was organized on 16th March, 2023 (25 Phalguna1944 Saka Era) by Positional Astronomy Centre Kolkata (IMD) to Publish Rashtriya Panchang for the Saka Era 1945.

Dr. Sanjib Bandyopadhyay, Sc. 'G', **Dr. Ganesh Kumar Das**, Sc. 'E' and **Shri Debapriya Roy,**Sc. 'C' were present there and released the Rashtriya Panchang for the Saka Era 1945. On that Occasion several media houses were also present there. Approximately 28 media persons attended the press conference.
Media-
Link:https://epaper.telegraphindia.com/imageview/427784/20404869/71.html

Dr. S. Bandyopadhyay, Sc. 'G' delivered a talk in Bengali on All India Radio on the importance of weather forecasting in our day to day life on 21st March, 2023.

Dr. Mrutyunjay Mohapatra, DG IMD joined discussion with Mr. Nitish Arora, All India Radio on the theme "**Future of Weather, Climate and Water across Generations**" on 23rd March, 2023, the WMO Day. The programme was broadcast by All India Radio.

A Door Darshan programme on coastal hazards and special interview by AIR FM Gold with **Dr. M Mohapatra DG**, IMD was held on 23rd March, 2023 on the occasion of WMO Day.



Fig. 88. Special interview by AIR FM Gold with Dr. M. Mohapatra, DG IMD was held on 23rd March, 2023 on the occasion of WM Day

A special documentary on weather forecast, observation & daily activities of the Meteorological Centre, Jaipur was broadcasted by DD Rajasthan on WMO Day 23rd March, 2023.

The officials of the division have actively participated and provided information to the students, farmers and common public during **National Science Day** (8th February, 2023) and **WMO day celebration** (23rd March, 2022) at CR&S Pune.

Dr. G. N. Raha, Sc. 'E' has attended the inauguration events and act as resource person of the Farmers' Awareness Programme of AMFU, Majhian on 24th March, 2023.

Mr. Charan Singh, Sc. 'F' inspected the Meteorological Center, Jaipur on 24-25 March, 2023 and addressed the media workshop.

IMD signed Letter of Agreement with Wingify foundation on 29th March to reach out to people with weather and air quality information.

All India Radio released an interview with **Dr. Mrutyunjay Mohapatra** as the expert speaker during the programme **"Abhyaas"** on the subject **'Climate Change & Winter".** The programme is available at the link https://youtu.be/h6la8j_Ylxs.

Under the **"Idea Exchange Programme",** the Indian Express published the interview of **Dr. Mrutyunjay Mohapatra**, DG, IMD on the on the extreme weather conditions, rising temperatures and climate change. The interview is available at the link https://indianexpress.com/article/idea-exchange/director-general-of-meteorology-indian-meterological-department-mrutyunjay-mohapatra-at-idea-exchange-8411675/. IMD issued press release on **First Long Range Forecast for Southwest Monsoon Season 2023 at National media Centre** on 11th April, 2023. **Dr. M. Mohapatra**, DG IMD made the presentation in this regard.

The Earth Day was celebrated by IMD with (I) plantation of trees, (ii) delivery of a popular lecture by **Dr. V. K. Soni** and address by **Dr. M. Mohapatra**, DG IMD, (iii) awareness campaign by calculating carbon equivalent contribution of individual employees and (iv) a climate pledge by the employees led by **Dr. M. Mohapatra**, DG IMD on 22nd April, 2023.

Dr. M. Mohapatra, DG IMD was interviewed for the show "**Perspective**" on the topic "**WMO's report on state of Global climate - 2022**" organized by Sansad TV on 24th April, 2023.

Dr. M. Mohapatra, DG IMD participated as the guest speaker during the Panel Discussion on "**Cyclone**" for the programme "**Aapdaka Samna**" at the DD News Studio (C/o Ms. Swati Singh, NDMA) on 28th April, 2023.

Monthly Press Conference by DG IMD on **"Rainfall and Temperature Forecast"** for May, 2023:IMD released the monthly forecast of "**Temperature and Rainfall for the month of May, 2023**" on 28th April, 2023. **Dr. Mrutyunjay Mohapatra**,DG, IMDmade a presentation in this regard. The press release was conducted in Hybrid Mode as a side event of National Media Workshop on 28th April.

During the quarter (April-June, 2023) **86 Farmers awareness programmes (FAPs)** were organized by AMFUs and DAMUs across the country. Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division.

Dr. G. K. Das, Sc. 'E', and **Shri Shubhendu Karmakar**, Met. 'A' attended community interaction/outreach programme of the fishing community at Nandigram village, East Midnapore on 30th May, 2023 organised by Indian Coast Guard.

Heavy rainfall warning was issued by India Meteorological Department due to **Cyclonic Storm "BIPARJOY"** over Arabian Sea from 6-19 June, 2023. During the period SMSs have been sent to the farmers in the states of Gujarat and Rajasthan.



Fig. 89. FAP conducted by DAMU, Mokokchung at Longsa Village, Ongpangkong (North) Block, Mokokchung District

TEDx (Technology, Entertainment & Design) is an initiative with a mission to research and discover "**ideas worth spreading**". **Dr. Mrutyunjay Mohapatra**, DG IMD participated in the TEDx on the theme "**InterpreT, visualisE, and Respond**"

organized by S.C.B. Medical College and Hospital, Cuttack, Odisha and presented a story on his life that inspired him to save life against hazard due to cyclones on 5th May, 2023.

India Meteorological Department organized a virtual Press Conference and released monthly outlook of rainfall and temperature for July month on 30th June, 2023. **Dr. M. Mohapatra**, DG IMD made a detailed presentation in this regards and answered queries from media persons during the conference.

Shri Anand Shankar, Sc. 'C' was deployed with thematic teams, Central Multi-Centre for Heat Wave in the State of Bihar, India from 22-26 June, 2023. He interacted with various stakeholders in the State of Bihar on Early Warning System and taken inputs from them. The final report was submitted to the Ministry of Health and Family Welfare, Government of India.

India Meteorological Department issued Press release for Monthly outlook of Monsoon for July, 2023.

During the month of July-2023 under GKMS activities 674 nos. District level AAS Bulletins, **2980 nos. Block level** AAS Bulletins Issued and **3,45,000 nos. Meghdoot mobile apps downloaded**.**Through 17,478 Whats App groups, 16, 04,901 farmers in 1,25,114 villages in 3,995 blocks** Advisories Disseminated to farmers. At state level the Agromet advisories disseminated in Madhya Pradesh 10,00,000 farmers, Tamil Nadu 10,00,000 farmers, Gujarat 36,00,000 farmers, Nagaland, 78,973 farmers , Chhattisgarh, 2,00,000 farmers, Haryana, approximately 3,61,000 farmers, Rajasthan 10000 farmers, Odisha 7,000 farmers, Meghalaya approximately 250000 farmers, Bihar Approximately 8,37,000 farmers and in Kerala Appr Impact based forecast (IBF) for Agriculture (Heavy Rainfall) and Agromet Advisories based on the IBF have been issued for different districts of various States and UTs across the country in co-ordination with NWFC, New Delhi, RMCs/MCs, AMFUs and DAMUs during the quarter.

During the quarter 79 Farmers awareness programmes (FAPs) were organized by AMFUs and DAMUs across the country.



Fig. 90. FAP conducted by DAMU, Baghpat at Gothra Village, Baghpat District, Uttar Pradesh on 19th July 2023

Dr. M. Mohapatra, DG IMD participated as Expert Speaker In the Live Show "**3 July, 2023 - the hottest day**" on DD News on 5th July, 2023.

On self Reliant Farmer's **Empowering Farmer's through Agro-Meteorological Advisory Servic**e in Changing Climate was jointly organized by Ministry of Earth Sciences (MoES) India Meteorological department and Centre for Earth Sciences & Himalayan Studies, Science & Technology, and KVK Papumpare at DK Hall Itanagar (Arunachal Pradesh) on 14th July, 2023.

Dr. M. Mohapatra, DG IMD participated in the meeting with World Bank officials led by Ms. Yeshika regarding Web-DCRA activity at IMD on 28th July, 2023.

A video film on **Cyclone Warning and Management in India : An End to End System** was released by HMoES on the occasion of Foundation Day of MoES on 27th July, 2023.

Dr. M. Mohapatra, DG IMD participated in the interview by **Mr. Rachel Dobbs** of The Economist regarding the monsoon scenario and its likely impact on Indian agriculture sector on 10th August, 2023.

Dr. M. Mohapatra, DG IMD participated in an interview on the Indian Monsoon by Ms. Deexa Khanduri of Sputnik News on 24th August, 2023.

Dr. M. Mohapatra, DG IMD had an interview by BQ Prime on Monsoon on 30th August, 2023.

Dr. M. Mohapatra, DG IMD participated in an interview on Indian Monsoon by Shri Mayank Bhardwaj, India Team Leader - Commodities - Thomson Reuters on 31st August, 2023.

IMD organized the regular monthly on-line Press Conference on Monthly outlook for rainfall and temperature during September, 2023 on 31st August. **Dr. M. Mohapatra**, DG IMD made the presentation and participated in the online QA Session. Media team countrywide participated in the press conference. The detailed Press Release issued in this regard is available at the link: https://internal.imd.gov.in/press_release/20230831_ pr_2505.pdf.

The Press Meet is available at link: https://www.youtube.com/live/m_K4Wa3vYHg?si=GCy_X3XiAv_GM5oU

A local Batesi TV channel visited MC Shillong on 4th July, 2023. They release a 13 minute special video of IMD activities in Meghalaya on their YouTube channel with more than 52k views as of 30 September, 2023. https://youtu.be/8VSgV4NmBCQ?si=4rviS5Wr055NECpA.

Dr. Sreekanth T.S., Sc. 'D', Radar, RMC Nagpur gave interview and introduction to working of Doppler Weather Radar to UCN news dt 27th September, 2023.

https://youtu.be/8O6UI8W_X4c?si=MALemHa4iEE6db0v
https://youtu.be/XF3L6t8pG1c?si=zm7uKn3aVJtVGYGE

IMD released Long Range Forecast of rainfall and temperature for the month of November 2023 on 31st October. Dr. M. Mohapatra, DG IMD made a presentation in this regards and addressed the Press and electronic media through the online conference. Media team countrywide participated in the press conference. The detailed Press Release issued in this regard is available at the link: https://internal.imd.gov.in/press_release/20231031_pr_2608.pdf

The Press Meet is available at link: https://fb.watch/o0HM42XBIv/?mibextid=RUbZ1f

Dr. M Mohapatra, DG IMD participated as an Invited Speaker at the International Solar Energy Society (ISES) Solar World Congress 2023 at Ashok Hotel, New Delhi on 3rd November, 2023.

Farmers' Awareness Programme (FAPs) : FAPs organized at 817 locations so far by November, 2023 by Agromet Field Units (AMFUs) and District Agromet Unit (DAMUs).

Progressive farmers shared their successstories of utilizing AAS bulletin for Weather Based Crop Planning, Optimum Sowing Time, Optimum Seed Rate, Proper & Timely Fertilizer Management, Proper & Timely Crop Protection Technology and Timely & Safe Harvesting. Till November 2023, 33 success stories have been uploaded at the website of Agrimet Division Website.

"Crop Specific Weather Based Agromet Advisories" for the country have been prepared every Tuesday and Friday and sent for telecasting through DD Kisan Channel, New Delhi.

675 bi-weekly District AAS bulletins and 3037 Block AAS Bulletins [1393Block level Agromet Advisories by Agromet Field Units (AMFUs) and 1644 Block level Agromet Advisories by District Agromet Units (DAMUs)] have been prepared and uploaded in the website of Agrimet Division, Pune.

Dissemination of Agromet Advisories to the users' community through SMS and IVR technology is being continued in the country through PPP mode and presently reaching to 5.31 million farmers through PPP mode.

Agromet Advisories are being disseminated to 17,71,406 farmers in 1,34,985 villages in 4,023 blocks through 18,650 WhatsApp groups.

Heavy rainfall warning was issued by India Meteorological Department due to Cyclonic Storm "Michaung" over Bay of Bengal from 1-6 December 2023. During the period 6000884 SMSs was sent to 2334216 number of farmers in the States of Andhra Pradesh, Tamil Nadu and Odisha. Special Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division.

Impact based forecast (IBF) for Agriculture (Heavy Rainfall/Thunderstorm with Gusty winds/ Hailstorm/Cold Wave) and Agromet Advisories based on the IBF have been issued for different

districts of various States and UTs across the country in co-ordination with NWFC, New Delhi, RMCs/MCs, AMFUs and DAMUs during the October-December, 2023.

During October-December, 2023, 165 Farmers awareness programmes (FAPs) were organized by AMFUs and DAMUs across the country .



Fig. 91. FAP conducted by DAMU, Chitrakoot at Ganiwan Village, Pahari Block, Chitrakoot District, Uttar Pradesh



Fig. 92. FAP conducted by AMFU, Roorkee at Dugadda Village

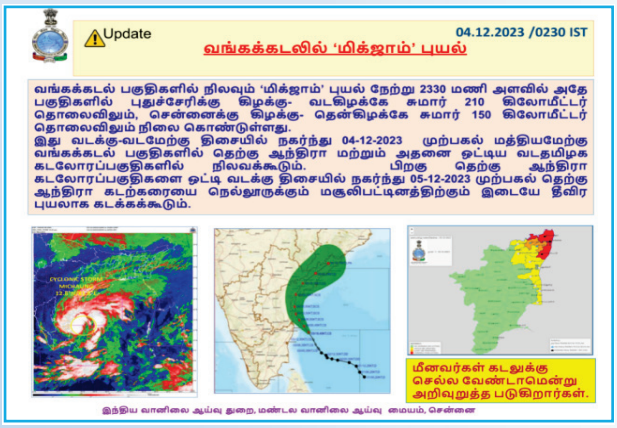


Fig. 93. Website and social media update in regional language

CHAPTER 7

RESEARCH PUBLICATIONS

MAUSAM (Formerly Indian Journal of Meteorology, Hydrology & Geophysics), established in January 1950, is the quarterly research journal brought out by the department. It is a premier scientific research journal in the field of Meteorology, hydrology & Geophysics for publication of original scientific research work. MAUSAM is being indexed and abstracted by Thomson Reuter U.S.A.

7.1. Research contributions

Twenty (20) research papers got published in Quarterly Journal '***Mausam***', Vol. **74**, Issue No.1.

Twenty two (22) research papers got published ***'Mausam'*** Vol. **74**, No. 2 (Special issue on "**Seventh WMO International Workshop on Monsoon (IWM-7) - The Global Monsoon System: Research and Forecast 5th Edition**").

Twenty Four (24) research papers got published in Quarterly Journal '*MAUSAM*', Vol. **74**, Issue No. 3.

Twenty Five (25) research papers got published in Quarterly Journal '*MAUSAM*', Vol.**74**, Issue No. 4.

Research contributions Published in 'MAUSAM'

1. K. Chandu, **A. Dharmaraju, S.,Kumar, G**.Satyanarayana, and M. Dasari, "**Determinants and Impact of Fog, Mist and Haze phenomena: The case of Rajiv Gandhi International Airport, Hyderabad**", *MAUSAM*, **74**, 1, 19-28, **DOI:** https://doi.org/10.54302/mausam.v74i1.1519.

2. **Siddhartha Singh**, P. Saroj, C. Ghosh, and P. Sinha, "**Calibration of Indian Dobson Spectrophotometer Nos. D112 and D036 during WMO Dobson Intercomparison Campaigns**", *MAUSAM*, **74**, 1, 73-82, DOI: https://doi.org/10.54302/mausam.v74i1. 5910.

3. **Raghu Nandimpalli**, S. Nekkali, K. Osuri, S. Sil, and A. Das, "**Study of the impact of high resolution ROMS-SST on the simulation of two intense tropical cyclones over Bay of Bengal using ARW modeling system**", *MAUSAM*, **74**, 1, 105–118, DOI: https://doi.org/10.54302/mausam. v74i1.576.

4. H. Bisht, S. Loo, T. Suna, **L. Vishnoi,** S. Gautam and D. Singh, "**Drought assessment and trend analysis using SPI and SPEI during southwest monsoon season over Bundelkhand region of Uttar Pradesh, India**", *MAUSAM*, **74**, 1**,** 119–128, DOI: https://doi.org/ 10.54302/ mausam.v74i1.3519.

5. **R. Thapliyal**and **B. Singh**, "**Heavy rainfall forecasting for Dehradun capital city during monsoon season 2020**", *MAUSAM*, **74**, 1, 141–150, DOI:https://doi.org/10.54302/mausam.v74i1.4951.

6. S. Kant, S. Manik, and R. Ram, "**Study of Southwest Monsoon Rainfall over Uttar Pradesh during last two decades (2001-2020)**", *MAUSAM*, **74**, 1, 161–168, DOI:https://doi.org/10.54302/ mausam. v74i1.2254.

7. **M. V. S. Ramarao, D. C. Ayantika, R. Krishnan, J. Sanjay, T. P. Sabin, M. Mujumdar and K. K. Singh**., "**Signatures of aerosol-induced decline in evapotranspiration over the Indo-Gangetic Plain during the recent decades**", *MAUSAM*, **74**, 2, 297-310.

8. **Mohapatra, Anshul Cauhan, Avnish Varshney, Suman Gurjar, M. T. Bushair, Monica Sharma, R. K. Jenamani, Kuldeep Srivastava, Pulak Guha Thakurta, Rajib Chattopadhyay, Mamta Yadav, Radheshyam Sharma, A. K. Mitra, Ananda Kumar Das, Sankar Nath, Naresh Kumar, Soma Senroy, T. Arulalan, Amit Bharadwaj, D. R. Pattanaik, B. P. Yadav, Rahul Saxena, Ashok Kumar Das, Asok Raja, Hemlata B., Arun K. V. H., Nitha S., Atul K. Singh, Shobhit Katiyar, Krishna Mishra, Surendra Pratap Singh, Shashikant Mishra, Akhil Srivastava, Geetha B., Rahul M., K. Nagaratna, H. R. Biswas, Manorama Mohanty, R. Thapliyal, Shivinder Singh, Sonam Lotus, Sandeep**

Kumar Sharma, V. K. Mini, Sunit Das, K. Das, Abhishek Anand and Gayatri Vani K., "**Short to medium range impact based forecasting of heavy rainfall in India**", *MAUSAM*, **74**, 2, 311-344.

9. U. C. Mohanty, Hara Prasad Nayak, M. R. Mohanty, P. Sinha, **Raghu Nadimpalli**and K. K. Osuri,"**Role of land surface processes on Indian summer monsoon rainfall : Understanding and impact assessment**", *MAUSAM*, **74**, 2, 345-360, https://doi.org/10.54302/mausam.v74i2.6199.

10. **Bushair, M. T.; Pattanaik, D. R.; Mohapatra, M.,** "**A multi-model ensemble tool for predicting districts level monsoon rainfall and extreme rainfall events over India**", *MAUSAM*, **74,** 2, DOI:10.54302/mausam.v74i2.6118, 429-454.

11. R. Bhatla, Manas Pant, SoumikGhosh, ShrutiVerma, NishantPandey and Sanjay Bist, 2023, "**Variations in Indian Summer Monsoon Rainfall patterns in Changing Climate**", *MAUSAM*, **74**, 3, 639-650, https://doi.org/10.54302/mausam.v74i3.5940.

12. RohitThapliyal and Bikram Singh,2023, "**A case study of exceptionally heavy rainfall event over Uttarakhand, India on 18th October, 2021 and its forecasting**", *MAUSAM*, **74**, 3, 717-740, https://doi.org/10.54302/mausam.v74i3.4754.

13. **Dr. A. Sravani, Dr. K. Naga Ratna, R. Sudheer Kumar** and **N. Rekha,** 2023, "**Quantitative precipitation forecast for the Godavari basin using the synoptic analogue method**" *MAUSAM*, **74**, 4, 1043-1052. https://doi.org/10.54302/mausam.v74i4.5267.

14. **Chetana Patil, Somenath Dutta, G. K. Sawaisarje** and **Pooja Yadav,** "**A study on some dynamical aspects of Uttarakhand heavy rainfall events**", *MAUSAM*, 74, **4**, 1073-1080, DOI:10.54302/mausam.v74i4.5379, 1073-1080.

15. Verma, Aashna; Vishwakarma, Akash; **Bist, Sanjay**; Kumar, Sushil; Bhatla, R.,"**A long-term drought assessment over India using CMIP6 framework : present and future perspectives**", *MAUSAM*, **74**, 4, DOI:10.54302/mausam.v74i4.6198, 963-972.

16. **Tomar, C. S.;** Bhatla, Rajiv**; Soni, V. K.; Giri, R. K.,** "**Convective weather event monitoring with multispectral image analysis of INSAT-3D/3DRover Indian domain**", *MAUSAM*, **74**, 4, DOI:10.54302/mausam.v74i4.6176, 1113-1130.

17. **Babita Dani, Vaibhava Srivastava, A. P. Singh and R. Bhatla,** 2023, "**Numerical Modelling of tsunami wave to assess the possible impacts along western coasts of India**", *MAUSAM*, **74**, 4, 1131-1140. https://doi.org/10.54302/mausam.v74i4.6028.

18. Johari, Pushpendra; Kumar, Sushil; Pattanayak, Sujata; **Sahu, Dipak Kumar**; Routray, A., "**Performance of land surface schemes on simulation of land falling tropical cyclones over Bay of Bengal using ARW model**", *MAUSAM*, **74**, 4, DOI:10.54302/mausam.v74i4.5861, 1155-1172.

19. Gupta, J. P and **Sharma, Pradeep,** "**Severe dust storm/thunderstorm activity over Uttar Pradesh on 13th May, 2018-A case study**", *MAUSAM*, **74**, 4, DOI:10.54302/mausam.v74i4.6404, 1141-1154.

20. Srivastava, Harsh; **Verma, Shikha**; Pant, Triloki, "**Analysis of the effect of COVID-19 lockdown on air pollutants using multi-source pollution data and meteorological variables for the state of Uttar Pradesh, India**", *MAUSAM*, **74**, 4, DOI:10.54302/mausam.v74i4.6124, 999-1014.

21. Yadav, Gaurav; Singh, Geeta; **Attri, S. D.**, "**Poor air quality as an important predictor of climate change in Delhi**", *MAUSAM*, **74**, 4, DOI:10.54302/mausam.v74i4.5903, 1015-1028.

7.2. Research contributions Published in Extra Departmental Journals (Indian & Foreign Journals)

1. George, K. Amal; Sunil, P. S.; Anish, A. U.; Gopinath, Girish; **Mini, V. K.**, "**A Pilot Assessment of the Fatal Landslide on 29 August 2022 in Kudayathoor, Idukki, Kerala**", *Journal of the Geological Society of India,* **99**, 1, 141-144, DOI:10.1007/s12594-023-2277-1.

2. Pawar, Pooja V.; Ghude, Sachin D.; Govardhan, Gaurav; Acharja, Prodip; Kulkarni, Rachana; Kumar, Rajesh; Sinha, Baerbel; Sinha, Vinayak; **Jena, Chinmay; Gunwani, Preeti**; Adhya, Tapan Kumar; Nemitz, Eiko; Sutton, Mark A.,"**Chloride (HCl / Cl-) dominates inorganic aerosol formation from ammonia inthe Indo-**

Gangetic Plain during winter: modeling and comparison withobservations", *Atmospheric Chemistry and Physics*, **23**, 1, 41–59, DOI:10.5194/acp-23-41-2023.

3. **Thapliyal, Rohit**, "**The Monsoon Low-Level Jet: Climatology and Impact on Monsoon Rainfall over the West Coast and Central Peninsular India**", *Journal Of Meteorological Research*, **37**, 1, 112 – 125, DOI:10.1007/s13351-023-2099-5.

4. **Bondyopadhyay, Sourish; Mohapatra, M.,** "**Determination of suitable thermodynamic indices and prediction of thunderstorm events for Eastern India**", *Meteorology And Atmospheric Physics*, **135**, 1, DOI:10.1007/s00703-022-00942-1.

5. **Shahenaz Mulla, Rizwan Ahmed, K. K. Singh**, Sudhir Kumar Singh, Naseem Deshmukh and F. Kurne Inamdar, "**Climate Change Effect On-Climate Parameters Like Temperature Rainfall and Water Resources Sectors in India**", *Springer Cham Switzerland*, **1**, 1, 9-59, DOI https://doi.org/10.1007/978-3-031-42056-6_2.

6. Bhate, Jyoti; Kesarkar, Amit; Munsi, Arpita; Singh, Kasturi; Ghosh, Asish; Panchal, Abhishek;**Giri, Ramkumar**; Ali, M. M., "**Observations and mesoscale forecasts of the life cycle of rapidly intensifying super cyclonic storm Amphan (2020)**", *Meteorology And Atmospheric Physics*, **135**, 1, DOI:10.1007/s00703-022-00944-z.

7. Roy, Partha; Rao, ThotaNarayana; Biswasharma, Rupraj; Sharma, Sanjay;**Das, Sunit,** "**Space-time variation of large hail-producing mesoscale convective systems over a complex terrain of the Indian subcontinent as revealed by the integrated Tropical Rainfall Measuring Mission and Global Precipitation Measurement observations**", *International Journal of Climatology*, **2023**, DOI:10.1002/joc.8015.

8. **Naskar, Pravat Rabi; Pattanaik, DushmantaRanjan,** "**Observed changes in summer thermal discomfort over Indian region during 1990-2020**", *Journal of Earth System Science*, **132**, 1, DOI:10.1007/s12040-023-02056-7.

9. Rose, M. S.; Sunil, P. S.; Zacharia, Johnson; Sreejith, K. M.; Sunda, S.; **Mini, V. K.;** Sunil, A. S.; Kumar, K. Vijay,"**Early detection of heavy rainfall events associated with the monsoon in Kerala, India using GPS derived ZTD and PWV estimates: A case study**", *Journal of Earth System Science*, *Journal of Earth System Science*, **132**, 1, DOI:10.1007/s12040-022-02034-5.

10. Mohanty, Shyama; Swain, Madhusmita; **Nadimpalli, Raghu**; Osuri, K. K.; Mohanty, U. C.; Patel, Pratiman; Niyogi, Dev, "**Meteorological Conditions of Extreme Heavy Rains over Coastal City Mumbai**", *Journal Of Applied Meteorology And Climatology*, **62**, 2, DOI:10.1175/JAMC-D-21-0223.1, 191-208.

11. **Shashi Kant**, "**Meteorological conditions associated with extremely heavy rainfall over some Indian states in July 2022**", *Current Science*, **125**, 10, 1068-1077, 10.18520/cs/v125/i10/1068-1077.

12. Atanu Bhattacharya, Kriti Mukherjee, Owen King, **Shubhendu Karmakar**, S. N. Remya, Anil V. Kulkarni, Jan kropek, Tobias Bolch., Shubhendu Karmakar, "**Influence of climate and non-climatic attributes on declining glacier mass budget and surging in Alaknanda Basin and its surroundings**", *Global And Planetary Change*, **230**, 104260, https://doi.org/10.1016/j.gloplacha.2023.104260.

13. **Jena, Chinmay**; Zhang, Yang; Wang, Kai; Campbell, Patrick C.,"**Decadal Application of WRF/Chem under Future Climate and Emission Scenarios: Impacts of Technology-Driven Climate and Emission Changes on Regional Meteorology and Air Quality**", *Atmosphere*, **14**, 2, DOI:10.3390/atmos14020225.

14. **Naskar, Pravat Rabi; Pattanaik, DushmantaRanjan,** "**Variations of central pressure of intense tropical cyclones over the Bay of Bengal with latent heat flux and other parameters**", *Journal Of Earth System Science*, **132**, 2, DOI:10.1007/s12040-023-02065-6.

15. **Rohini, P.; Rajeevan, M.,** "**An Analysis of Prediction Skill of Heat Waves Over India Using TIGGE Ensemble Forecasts**", *Earth And Space Science*, **10**, 3, 15-45, DOI:10.1029/2020EA001545.

16. Kumar, Bipin; Atey, Kaustubh; Singh, BhupendraBahadur; **Chattopadhyay, Rajib**; Acharya, Nachiketa; Singh, Manmeet; Nanjundiah, Ravi S.; Rao, Suryachandra A.,"**On the modern deep learning approaches for precipitation**

downscaling", *Earth Science Informatics*, **16**, 1459-1472, DOI:10.1007/s12145-023-00970-4.

17. Miinalainen, Tuuli; Kokkola, Harri; Lipponen, Antti; Hyvarinen, Antti-Pekka; **Soni, Vijay Kumar**; Lehtinen, Kari E. J.; Kuhn, Thomas, "**Assessing the climate and air quality effects of future aerosol mitigation in India using a global climate model combined with statistical downscaling**", *Atmospheric Chemistry and Physics*, **23,** 6, DOI:10.5194/acp-23-3471-2023, 3471-3491.

18. Rani, S. Indira; Jangid, BuddhiPrakash; Francis, Timmy; **Sharma, Priti**; George, Gibies; Kumar, Sumit; Thota, Mohan S.; George, John P.; **Nath, Sankar**; Das Gupta, Munmun; Mitra, Ashis Kumar,"**Assimilation of aircraft observations over the Indian monsoon region: Investigation of the effects of COVID-19 on a reanalysis**", *Quarterly Journal Of The Royal Meteorological Society*, **149**, 752,894-910, DOI:10.1002/qj.4439, 894-910.

19. **Prakash, Satya; Bhan, S. C**., "**How accurate are infrared-only and rain gauge-adjusted multi-satellite precipitation products in the southwest monsoon precipitation estimation across India?**",*Environmental Monitoring And Assessment (Springer Nature)*, **195**, 4, 1-18, DOI:10.1007/s10661-023-11148-2.

20. **Chakraborty, Tapajyoti; Pattnaik, Sandeep; Baisya, Himadri,** "**Investigating the precipitation features of monsoon deep depressions over the Bay of Bengal using high-resolution stand-alone and coupled simulations**", *Quarterly Journal of the Royal Meteorological Society*, **149**, 753, 1213-1235, DOI:10.1002/qj.4449.

21. **Sudeepkumar, B. L.**; Jayasankar, C. B.; Mudra, B. Lekshmi; **Singh, Om Mani**, "**A diagnostic study of heavy rainfall events in upper Ganga and Sharda river basins, India**", *Meteorology And Atmospheric Physics*, **135**, 20, 1-14, DOI:10.1007/s00703-023-00954-5.

22. Borgohain, Arup; Gogoi, Manasi; Barman, Nilamoni; Kundu, Arundhati; **Banik, Trisanu**; Kundu, Shyam S.; Bhuyan, Pradip K.; Aggarwal, S. P., "**Impact of Biomass Burning on Black Carbon and NO_2 Over North Eastern Region of India Using Multi-satellite Observations**", *Journal Of The Indian Society Of Remote Sensing*, 2023, DOI:10.1007/s12524-023-01692-2.

23. Bhattacharya, Aninda; Thomas, Abin; **Soni, Vijay K.;** Roy, P. S.; Sarangi, Chandan; Kanawade, Vijay P., "**Opposite trends in heat waves and cold waves over India**", *Journal Of Earth System Science*, **132**, 2, DOI:10.1007/s12040-023-02069-2.

24. Ghude, Sachin D.; **Jenamani, R. K.**; Kulkarni, Rachana; Wagh, Sandeep; Dhangar, Narendra G.; Parde, Avinash N.; Acharja, Prodip; Lonkar, Prasanna; Govardhan, Gaurav; Yadav, Prafull; Vispute, Akash; Debnath, Sreyashi; Lal, D. M.; Bisht, D. S.; **Jena, Chinmay**; Pawar, Pooja, V; Dhankhar, Surendra S.; Sinha, V.; Chate, D. M.; Safai, P. D.; Nigam, N.; Konwar, Mahen; Hazra, Anupam; Dharmaraj, T.; Gopalkrishnan, V.; Padmakumari, B.; Gultepe, Ismail; Biswas, Mrinal; Karipot, A. K.; Prabhakaran, Thara; Nanjundiah, Ravi S.; Rajeevan, M., "**Walk into the Warm Fog over Indo-Gangetic Plain Region**", *Bulletin Of The American Meteorological Society*, **104**, 5, E980-E1005, DOI:10.1175/BAMS-D-21-0197.1, E980 - E1005.

25. Reyes-Villegas, Ernesto; Lowe, Douglas; Johnson, Jill S.; Carslaw, Kenneth S.; Darbyshire, Eoghan; Flynn, Michael; Allan, James D.; Coe, Hugh; Chen, Ying; Wild, Oliver; Archer-Nicholls, Scott; Archibald, Alex; **Singh, Siddhartha**; Shrivastava, Manish; Zaveri, Rahul A.; Singh, Vikas; Beig, Gufran; Sokhi, Ranjeet; McFiggans, Gordon, "**Simulating organic aerosol in Delhi with WRF-Chem using the volatility-basis-set approach: exploring model uncertainty with a Gaussian process emulator**", *Atmospheric Chemistry And Physics*, **23**, 10, 5763-5782, DOI:10.5194/acp-23-5763-2023, 5763-5782.

26. **Thapliyal, Rohit; Singh, Bikram,** "**Diurnal climatology of thunderstorms, precipitation spell and visibility over Uttarakhand**" Journal Of Earth System Science, **132**, 2, 88-107, DOI:10.1007/s12040-023-02103-3.

27. **Naskar, Pravat Rabi**; Naskar, Somnath, "**The most suitable mode decomposition technique for machine learning in meteorological time series prediction**", *Journal Of Earth System Science*, **132**, 2, DOI:10.1007/s12040-023-02091-4.

28. **Goroshi, Sheshakumar**, "**Annual and seasonal trends in actual evapotranspiration over different meteorological sub-divisions in India using satellite-based data**", *Theoretical And*

Applied Climatology, **152**, 3-4, 999-1017, DOI:10.1007/s00704-023-04436-x.

29. **Debnath, Sreyashi; Karumuri, Rama Krishna; Govardhan, Gaurav; Jat, Rajmal; Saini, Himadri; Vispute, Akash; Kulkarni, Santosh H.; Jena, Chinmay; Kumar, Rajesh; Chate, D. M.; Ghude, Sachin D.,** "**Implications of Implementing Promulgated and Prospective Emission Regulations on Air Quality and Health in India during 2030**" (vol 22, 220112, 2022), MAY, 23, 5, DOI:10.4209/aaqr.231001.

30. **Gunwani, Preeti**; Govardhan, Gaurav; **Jena, Chinmay**; Yadav, Prafull; Kulkarni, Santosh; Debnath, Sreyashi; Pawar, Pooja V.; Khare, Manoj; Kaginalkar, Akshara; Kumar, Rajesh; Wagh, Sandeep; Chate, Dilip; Ghude, Sachin D., "**Sensitivity of WRF/Chem simulated $PM_{2.5}$ to initial/boundary conditions and planetary boundary layer parameterization schemes over the Indo-Gangetic Plain**", *Environmental Monitoring And Assessment*, **195**, 5, DOI:10.1007/s10661-023-10987-3.

31. **Arulalan, T.**; AchutaRao, Krishna; Sagar, Ambuj D., "**Climate science to inform adaptation policy: Heat waves over India in the 1.5°C and 2°C warmer worlds**", *Climatic Change*, **176**, 5, DOI:10.1007/s10584-023-03527-y.

32. Mandodi, MidhunaThayyil; **Pattanaik, D. R.,** "**Predictive skill of extended range forecast of 2020-21 winter precipitation over North India**", *Meteorology And Atmospheric Physics*, **135**, 3, DOI:10.1007/s00703-023-00965-2.

33. **Sawaisarje, Gaurishankar K.**; Chaudhari, Hemantkumar S., "**Influence of Continentality and Oceanity Over India During 1981-2010 and its Teleconnections to ENSO and IOD**", *Pure and Applied Geophysics*, 180, 6, 2443-2460, DOI:10.1007/s00024-023-03280-4.

34. Mandodi, MidhunaThayyil; **Pattanaik, D. R.,** "**The dependence of Indian winter precipitation extreme on the North Atlantic Oscillation**", *Natural Hazards*, **117**, 2, 1869-1885, DOI:10.1007/s11069-023-05932-z.

35. **Kumar, Vivek;** Devara, Panuganti C. S.; **Soni, Vijay K.**, "**Multisite Scenarios of Black Carbon and Biomass Burning Aerosol Characteristics in India**", *Aerosol And Air Quality Research*, **23**, 6, DOI:10.4209/aaqr.220435.

36. Longkumer, Imolemba; Biswasharma, Rupraj; Pongener, Imlisunup; **Roy, Partha**; Samanta, Debajyoti; Konwar, Mahen; Sharma, Sanjay, "**A study of rain drop size distributions and associated rain microphysical over a station in the Northeast India**", *Journal of the Atmospheric and Solar-terrestrialPhysics*, **JUN**, 247, DOI:10.1016/j.jastp.2023.106073.

37. Ghosh, Rakesh; Pawar, S. D.; Hazra, Anupam; Wilkinson, Jonathan; Mudiar, Dipjyoti; Domkawale, Manoj A.; **Vani, K. Gayatri**; Gopalakrishnan, V., "**Seasonal and Regional Distribution of Lightning Fraction Over Indian Subcontinent**", *Earth And Space Science*, **10**, 6, DOI:10.1029/2022EA002728.

38. Yaswanth, P.; **Kannan, B. Arul Malar**; Bindhu, V. M.; Balaji, C.; Narasimhan, Balaji, "**Evaluation of Remote Sensing Rainfall Products, Bias Correction and Temporal Disaggregation Approaches, for Improved Accuracy in Hydrologic Simulations**", *Water Resources Management*, **37**, 8,3069-3092 DOI:10.1007/s11269-023-03486-0.

39. Patnaik, Kavita; Kesarkar, Amit P.; Rath, Subhrajit; Bhate, Jyoti N.; Panchal, Abhishek; Chandrasekar, Anantharaman; **Giri, Ramakumar**, "**A 1-D model to retrieve the vertical profiles of minor atmospheric constituents for cloud microphysical modeling: I. Formulation and validation**", *Science Of The Total Environment*, 881, DOI:10.1016/j.scitotenv.2023.163360.

40. **Naskar, Pravat R.**; Singh, Gyan P.; **Pattanaik, Dushmanta R.; Katyar, Shobhit**, "**CMIP6 projections of spatiotemporal changes in rainfall and droughts over India**", *Journal Of Earth System Science*, **29**, 132, 3, DOI:10.1007/s12040-023-02143-9.

41. Boragapu, Raja; **Guhathakurta, Pulak; Sreejith, O. P.,** "**Tropical cyclone vulnerability assessment for India**", *Natural Hazards*, **117**, 3, 3123-3143, DOI:10.1007/s11069-023-05980-5.

42. Saha, Pallabi; **Rakshit, Gargi**; Maitra, Animesh, "**Study of melting layer features related to atmospheric parameters over a tropical location**",*Advances In Space Research*, **72**, 2, 378-388, DOI:10.1016/j.asr.2023.03.013.

43. **Kumar, Amit; Sharma, Neerja; Varma, Atul Kumar; Bhan, S. C., "Performance Evaluation of Hydro-Estimator Technique-Based Rain Products from INSAT-3DR During Indian Summer Monsoon 2020**", *Journal of The Indian Society Of Remote Sensing*, 51, 1673-1681, DOI:10.1007/s12524-023-01723-y.

44. Debnath, Sreyashi; Govardhan, Gaurav; Saha, Subodh Kumar; Hazra, Anupam; Pohkrel, Samir; **Jena, Chinmay**; Kumar, Rajesh; Ghude, Sachin D., "**Impact of dust aerosols on the Indian Summer Monsoon Rainfall on intra-seasonal time-scale**", *Atmospheric Environment*, **305**, DOI:10.1016/j.atmosenv.2023.119802.

45. **Ramaraj, A. P.**; Rao, K. P. C.; Kumar, G. Kishore; Ugalechumi, K.; Sujatha, P.; Rao, Suryachandra A.; Dhulipala, R. K.; Whitbread, A. M.,"**Delivering context specific, climate informed agro-advisories at scale: A case study of iSAT, an ICT linked platform piloted with rainfed groundnut farmers in a semi-arid environment**", *Climate Services*, **31**, DOI:10.1016/j.cliser. 2023.100403.

46. Roose, Shinto; Ajayamohan, R. S.; Ray, Pallav; Xie, Shang-Ping; **Sabeerali, C. T.; Mohapatra, M.**; Taraphdar, S.; Mohanakumar, K.; Rajeevan, M., "**Pacific decadal oscillation causes fewer near-equatorial cyclones in the North Indian Ocean**", *Nature Communications*, 14, 1,1-9, DOI:10.1038/s41467-023-40642-x.

47. **Mishra, Anoop Kumar, Chander Singh Tomar, Gajendra Kumar**, and **Subhash Chander Bhan**, "**Reconstructing radar reflectivity by integrating GPM and INSAT-3D observations for near real-time monitoring of convective storms over India**", *Weather*, **78**, 8, 224-227, https://doi.org/10.1002/wea.4443.

48. Kanase, Radhika; Tirkey, Snehlata; Deshpande, Medha; Krishna, R. Phani Murali; Johny, C. J.; Mukhopadhyay, P.; Iyengar, Gopal; **Mohapatra, M.**, "**Evaluation of the Global Ensemble Forecast System (GEFS T1534) for the probabilistic prediction of cyclonic disturbances over the North Indian Ocean during 2020 and 2021**", *Journal Of Earth System Science*, **132**, 3, DOI:10.1007/s12040-023-02166-2.

49. **Sharma, Pradeep andSen Roy, Soma,** "**Hailstorms over India during the summer season**", *Meteorology and Atmospheric Physics*, **135**, 4, DOI:10.1007/s00703-023-00980-3.

50. **Prakash, Satya; Mohapatra, M.,** "**Mean rainfall characteristics of tropical cyclones over the North Indian Ocean using a merged satellite-gauge daily rainfall dataset**", *Natural Hazards*, n**119**, 1437-1459 DOI:10.1007/s11069-023-06158-9.

51. **Singh, Neeti**; Shukla, Bipasha Paul; Kaushik, Nitesh; Varma, A. K.;**Mitra, A. K.; Bhan, S. C**., "**Validation of INSAT-3D/3DR based nowcasting rain occurrences for heavy rainfall using Hydro-Estimator product**", *Advances In Space Research*, **72**, 6,2185-2194, DOI:10.1016/j.asr.2023.05.030.

52. Soyam, P. S.; Safai, P. D.; Mukherjee, S.; Kondle, S.; Bankar, S.; Todekar, K.; Malap, N.; **Surendran, D.**; **Gaikwad, A.; Lohogaonkar, S**.; Prabhakaran, T., "**Significant abundances of alkaline components in the fine and coarse aerosols over a tropical rain shadow location in peninsular India**", *Journal Of Atmospheric Chemistry*, **80**, 3, 191-209, DOI:10.1007/s10874-023-09447-6.

53. Mandal, Raju; Joseph, Susmitha; Sahai, A. K.; Dey, Avijit; Phani, R.; **Pattanaik, D. R**.; Kaur, M.; Karmakar, N., "**Diagnostics and real-time extended range prediction of cold waves over India**", *Climate Dynamics*, 61, 5-6, 2051-2069, DOI:10.1007/s00382-023-06666-1.

54. Abhiram Nirmal, C. S.; Abhilash, S.; Martin, Max; Sankar, Syam; **Mohapatra, M**.; Sahai, A. K., "**Changes in the thermodynamical profiles of the subsurface ocean and atmosphere induce cyclones to congregate over the Eastern Arabian Sea**", *Scientific Reports*, 13, 1, DOI:10.1038/s41598-023-42642-9.

55. **Bondyopadhyay, Sourish; Mohapatra, M.,** "**Suitable thermodynamic indices for the prediction of thunderstorm events for different cities throughout India**", *Meteorology And Atompheric Physics*, **135**, 5, DOI:10.1007/s00703-023-00984-z.

56. Beasley, Parker; Misra, Vasubandhu; Jayasankar, C. B.; **Bhardwaj, Amit,** "**Heat waves in Florida and their future from high-resolution regional climate model integrations**",

International Journal Of Climatology, DOI:10.1002/joc.8278.

57. Tibrewal, Kushal; Venkataraman, Chandra; Phuleria, Harish; Joshi, Veena; Maithel, Sameer; Damle, Anand; Gupta, Anurag; Lokhande, Pradnya; Rabha, Shahadev; Saikia, Binoy K.; Roy, Sayantee; Habib, Gazala; Rathi, Shubham; Goel, Anubha; Ahlawat, Sakshi; Mandal, Tuhin Kumar; Hashmi, M. Azharuddin; Qureshi, Asif; Dhandapani, Abisheg; Iqbal, Jawed; Devaliya, Sandeep; Raman, Ramya Sunder; Lian, Yang; **Pandithurai, Govindan**; Kuppili, Sudheer Kumar; Nagendra, M. Shiva; Mukherjee, Sauryadeep; Chatterjee, Abhijit; Najar, Tanveer Ahmad; Jehangir, Arshid; Singh, Jitender; Sinha, Baerbel, "**Reconciliation of energy use disparities in brick production in India**", *Nature Sustainability*, **6**, 10, 1248-1257, 10.1038/s41893-023-01165-x.

58. Kalita, Gayatry; Yadav, Prafull P.; Jat, Rajmal; Govardhan, Gaurav; Ambulkar, Rupal; Kumar, Rajesh; **Gunwani, Preeti**; Debnath, Sreyashi; Sharma, Pratul; Kulkarni, Santosh; Kaginalkar, Akshara; Ghude, Sachin D., "**Forecasting of an unusual dust event over western India by the Air Quality Early Warning System**", *Atmospheric Environment*, **311**, 10.1016/j.atmosenv.2023. 120013.

59. U. N. Athira, S. Abhilash and **C. T. Sabeerali**, "**Paradigm shift in the onset phase of the Indian Summer Monsoon since 2000 and its potential connection to South Indian Ocean**", *Atmospheric Research*, 296, 107050, 10705, 1-10, https://doi.org/10.1016/j.atmosres.2023.107050.

60. **Shankar, Anand**; Sahana, Bikash Chandra, "**Efficient prediction of runway visual range by using a hybrid CNN-LSTM network architecture for aviation services**", *Theoretical And Applied Climatology*, DOI:10.1007/s00704-023-04751-3.

61. **Madhulatha, A**.; Dudhia, Jimy; Park, Rae-Seol; **Bhan, SubhashChander; Mohapatra, Mrutyunjay,** "**Effect of Single and Double Moment Microphysics Schemes and Change in Cloud Condensation Nuclei, Latent Heating Rate Structure Associated with Severe Convective System over Korean Peninsula**", *Atmosphere*, **14**, 11, DOI:10.3390/atmos14111680.

62. Bhowmick, Mansi; Sahany, Sandeep; **Das, Ananda Kumar,** "**Recent changes in the climatological characteristics of daily contiguous rain areas over India**", *Npj Climate And Atmospheric Science*, **6**, 1, DOI:10.1038/s41612-023-00464-6.

63. Goswami, Mangesh M.; Mujumdar, Milind; Singh, Bhupendra Bahadur; Ingale, Madhusudan; Ganeshi, Naresh; **Ranalkar, Manish**; Franz, Trenton E.; Srivastav, Prashant; Niyogi, Dev; Krishnan, R.; Patil, S. N., "**Understanding the soil water dynamics during excess and deficit rainfall conditions over the core monsoon zone of India**", *Environmental Research Letters*, **18**, 11, 10.1088/1748-9326/acffdf.

64. Goswami, Mrinal; **Mahato, Somnath**; Ghatak, Rowdra; Bose, Anindya, "**Potential of Satellite-Based Augmentation Systems (SBAS) in Test and Evaluation of Missiles in Indian Test Range Applications**", *Journal Of The Indian Society Of Remote Sensing*, **51**, 2537–2547, 10.1007/s12524-023-01787-w.

65. Baral, Rakesh; Mohanty, Pratap Kumar; Pradhan, Subhasis; Rajawat, Ajay Singh; Samal, RabindroNath; **Das, Umasankar,** "**Natural opening of a new inlet in Chilika Lagoon: A cause and impact analysis**", *Regional Studies In Marine Science*, **68**, DOI:10.1016/j.rsma.2023.103248.

66. Boyaj, Alugula; **Nadimpalli, Raghu**; Reddy, Dpranay; Sinha, P.; Karrevula, N. R.; Osuri, Krishna K.; Srivastava, Akhil; Swain, Madhusmita; Mohanty, U. C.; Islam, Sahidul; Kaginalkar, Akshara, "**Role of radiation and canopy model in predicting heat waves using WRF over the city of Bhubaneswar, Odisha**", *Meteorology And Atmospheric Physics*, **135**, 6, DOI:10.1007/s00703-023-00994-x.

67. Mohanty, Shyama; **Nadimpalli, Raghu**; Mohanty, U. C.; Pattanayak, Sujata, "**Storm surge prediction improvement using high resolution meso-scale model products over the Bay of Bengal**", *Natural Hazards*, **1**, 1, 1-25, DOI:10.1007/s11069-023-06160-1.

68. Kumar, Nishant; Nair, Anjali S.; Soni, Kirti; Shingare, A. A.; Motghare, Vidyanand M.; Rajput, Karansingh A.; **Soni, V. K.;** Kumar, Anikender; Jha, Arvind Kumar, "**Characteristics of atmospheric boundary layer structure using monostatic SODAR system over Mumbai region**", *Journal Of Earth System Science*, **132**, 4, DOI:10.1007/s12040-023-02191-1.

69. Pande, Chaitanya B.; Moharir, Kanak N.; Varade, Abhay M.; Abdo, HazamGhassan; **Mulla, S.**; Yaseen, ZaherMundher, "**Intertwined impacts of urbanization and land cover change on urban climate and agriculture in Aurangabad city (MS), India using google earth engine platform**", *Journal Of Cleaner Production*, **422**, DOI:10.1016/ j.jclepro.2023.138541.

70. Patel, Pratiman; Ankur, Kumar; Jamshidi, Sajad; Tiwari, Alka; **Nadimpalli, Raghu**; Busireddy, N. K. R.; Safaee, Samira; Osuri, Krishna K.; Karmakar, Subhankar; Ghosh, Subimal; Aliaga, Daniel; Smith, James; Marks, Frank; Yang, Zong-Liang; Niyogi, Dev, "**Impact of Urban Representation on Simulation of Hurricane Rainfall",** *Geophysical Research Letters*, **50**, 21, DOI:10.1029/2023GL104078.

71. **Sanap, S. D.,** "**Dynamical linkages between Arctic Oscillations and winter precipitation patterns over the Indian Region**", *Global And Planetary Change*, **231**, DOI:10.1016/j.gloplacha. 2023.104293.

72. **Srivastava, Akhil; Mohapatra, M.; Das, Ananda K.; Nadimpalli, Raghu**; Dwivedi, Suneet, "**A new approach to generate dynamical cone of uncertainty for cyclone track forecast over North Indian Ocean**", *Natural Hazards*, **1**, 1, 1-19, DOI:10.1007/s11069-023-06339-6.

73. M. Mayer, L. Haimberger, **C. T. Sabeerali,** V. Schenzinger, **D. E. Surendran** and **O. P. Sreejith, "State of the Climate in 2022 (Chapter: Uppper air winds)***", Bulletin Of The American Meteorological Society*, **104**, 9, S74-S76, https://doi.org/10.1175/ 2023BAMSStateoftheClimate.1.

74. Srivastava, H. N.; **Prajapati, Sanjay K.**; Rajkumar, "**Comparison of the Felt Earthquakes since Historical Times with NCS Catalogue and ISR Telemetry Network in Gujarat (2006 to date)**", *Journal Of The Geological Society Of India*, **99**, 9, 1211-1217, 10.1007/s12594-023-2453-3.

75. **Das, Siddarth Shankar**; Kishore Kumar, K.; Subrahmanyam, K. V.; Venkat Ratnam, M.; Suneeth, K. V.; Sunilkumar, S. V.; Sinha, P. R.; Ghosh, Asish Kumar; Das, Subrata Kumar; Sonwabne, Sunil; Muralikrishna, U. V.; Kolte, Yogesh; Naja, Manish; Abhilash, S.; Satheesan, K.; Rakesh, V.; Mahesh, P.; Koushik, N.; Satheesh Chandran, P. R.; Girach, I. A.; Namboodiri, K. V. S.; Pandithurai, G.; Kirankumar, N. V. P., "**Impact of Annular Solar Eclipse on the Trace Gases and Dynamics of the Lower and Middle Atmosphere: Results Inferred From an Integrated Campaign Suryagrahan-2019**", *Earth And Space Science*, **10**, 9, 10.1029/2023EA003044.

76. **Gaurav Kumar,** Prof. Rajveer Singh Yaduvanshi, "**Design of a Dielectric Resonator Antenna with Two Drilled Hollow Cylinders for Wide Bandwidth**", *International Conference on Communication Networks And Computing 2022*, **1893**, CCIS, 215-225, 10.1007/978-3-031-43140-1_19.

77. Chaitanya B., Pande Kanak, N. Moharir, Abhay M. Varade, Hazam Ghassan Abdo, **S. Mulla,** Zaher Mundher Yaseen, "**Interwind impacts of urbanization land cover changes on urban climate agriculture in Aurangabad city(MS)**", *Journal Of Cleaner Production (Elsevier)*, **422**, 6, 138541, 1-18, https://doi.org/10.1016/j.jclepro.2023.138541.

78. Joseph, Susmitha; **Chattopadhyay, R.**; Sahai, A. K.; Martin, Gill M.; Dey, Avijit; Mandal, Raju; Phani, R., "**Evaluation and comparison of the subseasonal prediction skill of Indian summer monsoon in IITM CFSv2 and UKMO GloSea5**", *Climate Dynamics*, **61**, 3-4, 1683-1696, 10.1007/s00382-022-06650-1.

79. Chandu Kavitha, **Raju Dharma A.,** Kumar S.V.J. Chilaka Rao M, "**Air Quality Concentration Transport/Dispersion and pathways of particulate matter during community celebration of Diwali days over Visakhapatnam city**", *Research Journal Of Chemistry And Environment*, **27**, 8, 22-34, doi: https://doi.org/10.25303/2708rjce022034 (2023).

80. Craig Earl-Spurr, Andrea Schumacher, Craig Arthur, **T. Arulalan**, Iosefo Cauravouvinaka, Philippe Caroff, Mark DeMaria, Jeff Kepert, **Monica Sharma, "Forecasting Tropical Cyclone Wind Hazards and Impacts: Summary from the Tenth International Workshop on Tropical Cyclones (IWTC-10)**", *Tropical Cyclone Research And Review*, **12**, 2, https://doi.org/10.1016/j.tcrr.2023.06.002.

81. Victor, Jeni N.; Afreen, Shaista; Siingh, Devendraa; Chandra, Sagarika; Singh, R. P.; Potdar, Swapnil S.; Bashir, Gowher; **Kazhugasalamoorthy, S.;** Kumar, R. Nirmal; Singh, Vatsala; Ahmad,

Nissar, "**Electrical Characteristics of Thunderstorms Under Different Weather Conditions in the Kashmir Valley, India**", *Pure And Applied Geophysics*, **180**, 3, 1185-1204, 10.1007/s00024-022-03223-5.

82. Chandu Kavitha, **A. Dharma Raju,** S.V.J. Kumar, "**Variability and Trend in Summer Monsoon Rainfall and its Correlation with Crop Yield in the Districts of Andhra Pradesh During 2011-2020**", *Nature Environment And Pollution Technology*, **22**, 1, 97-107, 10.46488/NEPT.2023. v22i01.008.

83. Friederike E. L. Otto, Mariam Zachariah, Fahad Saeed, Ayesha Siddiqi, Shahzad Kamil, Haris Mushtaq, **T. Arulalan**, Krishna AchutaRao, S T Chaithra, Clair Barnes, Sjoukje Philip, Sarah Kew, Robert Vautard, Gerbrand Koren, Izidine Pinto, Piotr Wolski, Maja Vahlberg, Roop Singh, Julie Arrighi, Maarten van Aalst, Lisa Thalheimer, Emmanuel Raju, Sihan Li, Wenchang Yang, Luke J Harrington and Ben Clarke, "**Climate change increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan**", *Environmental Research Climate*, **2**, 2, 025001, 10.1088/2752-5295/acbfd5.

84. Madhusmita Swain, **Raghavendra Raju Nadimpalli**, Uma Charan Mohanty, , **Pulak Guhathakurta**, Akhilesh Gupta, Akshara Kaginalkar, Fei Chen, Dev Niyogi, "**Delay in timing and spatial reorganization of rainfall due to urbanization-analysis over Indias smart city Bhubaneswar**", *Computational Urban Science*, **3**, 8, 1-8, https://doi.org/10.1007/s43762-023-00081-2.

85. **M. Sunanda, S. Prayek, Harsha Soni, KVS Srinivas, Ch. Ramana**, "**Extreme Hydrological Events in January 2022: A Case Study over Telangana and Andhra Pradesh State, India**", *International Journal Of Environment And Climate Change*,**13**, 1, 99-116, 10.9734/ijecc/2023/ v13i11642.

86. **M. Sunanda, S. Prayek, Pravath Naskar, Kvs. Srinivas., Harshasoni, Ch. Ramana, S. Stella, Karuna Sagar**, "**Synoptic and Dynamical Characteristics of Severe Cyclonic Storm ASANI May 2022**", *International Journal Of Environment And Climate Change*, **13**, 2, 166-183, 10.9734/ijecc/2023/v13i21671.

87. Swain M., **Raghu Nadimpalli, Ananda K Das**,Mohanty UC,Dev Niyogi, "**Urban modification of heavy rainfall : a model case study for Bhubaneswar urban region**", *Computational Urban Science*, **3**, 1, 1-19, https://doi.org/10.1007/s43762-023-00080-3.

88. Swapna, M.; **Raju, Reba**; Nayak, Rabindra K. K.; Mohanty, Prakash C. C.; SeshaSai, M. V. R.; Kumar, Raj, "**Spatiotemporal Characteristics of Thermal Fronts in Relation to Potential Fishing Zones in the Continental Shelf Sea Around India**", *Journal Of The Indian Society Of Remote Sensing*, **51**, 335.348, 10.1007/s12524-022-01629-1.

89. Singha, Chiranjit; Gulzar, Shahid; Swain, Kishore Chandra; **Pradhan, Devendra**, "**Apple yield prediction mapping using machine learning techniques through the Google Earth Engine cloud in Kashmir Valley, India**", *Journal of Applied Remote Sensing*, **17**, 1, 10.1117/1.JRS.17.014505.

7.3. IMD MET. Monograph

1. MOES / IMD / H.S. / Basin Hydrology / 01(2023)/15, **"Verification of River Sub-Basin-Wise Quantitative Precipitation Forecast during SW Monsoon 2022",** Dr. A. K. Das, Sc. 'E' .

2. MoES/IMD/RMC Mumbai/CLI-REP(Bhuj)/ 01(2023)/15, "**Climate of Bhuj**", MC Ahmedabad.

3. MoES/IMD/RMC Mumbai/CLI-REP(Baroda)/ 02(2023)/16 "**Climate of Baroda**", MC Ahmedabad.

4. MoES/IMD/HS/Technical report-DSS(2022)/ 01(2023)/61, "**Technical report on Design Storm Studies undertaken during 2022**", Hydromet. Division.

5. MoES/IMD/HS/Rainfall **report/02(2023)/62, "Rainfall Studies of India-2022",** Hydromet. Division.

6. MoES/IMD/HS/BasinHydrology/01(2023)/15 , "**Quantativeprecipationforwecast during South-west Monsoon-2022**", Hydromet. Division.

7. MoES/IMD/FDP/Storm-Report/01(2023)/17, "**Pre-Monsoon Thunderstorm during 2022: A report**", NWFC.

8. MoES/IMD/Synoptic Met/01(2023)/28, "**Met monograph on cold wavews and heat waves in India**", M. Rajeevan.

9. MoES/IMD/MoES/IMD/RMC Mumbai/CLI-REP(Surat)/ 03(2023)/17, "**Climate of Surat**", MC Ahmedabad.

10. MoES/IMD/RMC Mumbai/CLI-REP(Rajkot)/ 04(2023)/18 "**Climate of Rajkot**", MC Ahmedabad.

11. MoES/IMD/Annual Report 2022/(01) 2023/ 02, "**IMD Annual Report 2022**", IS & KRDD.

7.4. Other Publications

Publications released on the occasion of IMD Foundation Day 15th January, 2023

Mausam Manjusha

RSMC Report on **Cyclonic Disturbances over the North Indian Ocean during 2022**.

Report on "**Multi-Model Ensemble (MME) based district level rainfall forecast during the southwest monsoon 2022"**.

Report on "**Pre-Monsoon Thunderstorms During 2022**".

Report on "**Climatological Normals of upper air weather parameters 1991-2020**".

Report on "**Daily ClimatologicalNormals based on 1991-2020**".

Report on "**Instructions to Observers at the Surface Observatories**".

Technical Report entitled **"Design Storm Studies undertaken during 2022"**

DSS report for **"Hirehalla Reservoir Project, Karnataka"** (June 2023).
The publication entitled "**Pentad Normals of Observatories in India 1991-2020**".

ENSO bulletin for the month of March, April, and May 2023 and Seasonal Climate Outlook for South Asia for the period of April to August 2023 were issued.

Climate Diagnostic Bulletin for December 2022 and Post monsoon 2022 has been published and uploaded on the website.

CDMS, CRS Pune prepared Aerodrome Climatological Summaries of the following airports for the period 2018-2022:

Swami Vivekanand Airport,
Raipur Mysore Airport
Maharana Pratap Airport, Dabok, Udaipur

Daily normals of global and diffuse radiation for the period 1991-2020 for 32 stations were published.

WMO publication "**State of the Climate in Asia 2022 (WMO-No. 1321)**" Contributing experts from CRS, IMD, Pune **Dr. O. P. Sreejith**, (lead Author) and **Dr. Sabeerali C. T.** published.

Climate Diagnostic Bulletin for October and Monsoon Season 2023 has been published and uploaded on the website.

ENSO bulletin for the month of December 2023 and Seasonal Climate Outlook for South Asia for the period of December to March 2024 were issued.
(QuickLink:https://imdpune.gov.in/cmpg/Product/ENSO_Bulletin/ENSO_IOD_Update_Bulletin_12_23.pdf.

Climate Summary for the month of November 2023 Issued.

Climate Diagnostic Bulletin for August and September 2023 has been published and uploaded on the website.

7.5. Books/ Book Chapter

Shri M. L. Sahu, Sc. 'F', RMC Nagpur and **Shri A. M. Bhatt**, Met. 'A', M.O. Ambikapur written a book **"आंकड़ों की दृष्टि से अम्बिकापुर की जलवायु"** published in June, 2023.

CHAPTER 8

FINANCIAL RESOURCES AND MANAGEMENT PROCESS

8.1. Budget Outlay of approved schemes of IMD

IMD received its budget allocation under two categories namely, budget for implementation of Central Sector schemes and budget for Establishment related expenditure. Budget Estimates (B.E.) during Financial Year 2023-24

Budget Estimate 2023-24 (Rs. In Crores)		
Central Sector Schemes	Establishment	Total
242.70	505.20	747.90

8.2. Expenditure incurred during FY 2022-23

Budget Estimate 2022-23 (Rs. In Crores)		
Central Sector Schemes	Establishment	Total
211.00	463.32	674.32

8.3. Atmospheric & Climate Research - Modelling Observing System & Services (ACROSS)

To upgrade the forecasting capabilities, following programs are being implemented in IMD under the umbrella scheme "Atmospheric & Climate Research - Modelling Observing System & Services (ACROSS)" of the MoES for the period from 2021-26.

S. No.	Name of the Scheme/Project
1.	Atmospheric observations Network (AON)
2.	Upgradation of Forecast System (UFS)
3.	Weather & Climate Services (WCS)
4.	Commissioning of Polarimetric DWRs

The projects under ACROSS-IMD are continuing programs from previous Plan periods encompassing various activities in an integrated manner to sustenance & augmentation of observations & enhancement of facilities required for the weather forecasting services. The programs are being implemented by various Offices/Divisions across the country having long and requisite experience in the required fields. The implementation of the activities is under the overall guidance of the General of Meteorology and other senior scientist.

8.4. REVENUE GENERATED DURING THE YEAR 2023

Sale of Meteorological Data

RCs/MCs	Total revenue received by sale of meteorological data during the month (Amount in Rupees)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DGM, New Delhi												
DGM SATMET	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
DGM HYDROLOGY	6,31,990	NIL	NIL	NIL	NIL	NIL	4,52,093	NIL	NIL	2,99,448	2,37,144	3,89,790
DGM (Publication)	36000	15075	5350	22700	14100	20675	4450	NIL	3300	5000	NIL	NIL
RMC, New Delhi												
New Delhi	26,598	11,823	41181	28010	28848	0	46,564	68,831	51,388	32,698	36,724	15,097
Jaipur	41008	32187	0	0	90154	30444	124471	47697	3068	31800	15913	0
Lucknow	21338	4838	27152	19625	20378	21842	21122	14936	43452	60001	29523	21919
Srinagar	12,278	0	16,159	2,655	11,239	23,882	20,879	13,529	16,306	9,515	18,636	25,653
Chandigarh	6,443	9,773	22,308	62,834	10,142	20,992	4,071	39,814	60,142	18,833	23,895	10,561
Shimla	0	10,141	29,553	13,570	0	12,634	16,166	8,891	42,588	6,232	0	13,227
Dehradun	30881	2806	9284	2950	7669	35627	12838	33578	36803	17700	5974	17964
RMC, Mumbai												
Mumbai	21698	29994	45888	5101	16429	49184	52270	8359	3508	15067	9338	7045
RMC, Nagpur												
Nagpur	10856	17936	53190	34200	94020	21583	52987	30450	71734	48943	20904	7476
Bhopal	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	9872	Nil	Nil
RMC, Kolkata												
RMC Kolkata	16251	25724	37219	30842	300812	24612	52117	29910	77164	11395	9256	17023
PAC Kolkata	Nil	13394	Nil	Nil	18950	15882	7596	Nil	0	33845	Nil	Nil
Patna	Nil	9854	Nil	9166	6033	25195	Nil	22761	35782	11212	Nil	Nil
Bhubaneswar	15521	26852	6760	5370	Nil	13870	23009	13692	31346	34074	42576	5548
Gangtok	5102	Nil	Nil	3894	Nil	9842	7788	Nil	Nil	Nil	Nil	20768
Ranchi	9796	1948	Nil	6760	Nil	12401	12334	2596	20014	Nil	7788	2828
RMC, Guwahati												
Guwahati	45,965	44,271	26,395	38,549	77,681	63,618	83,585	1,76,687	59,072	97,687	56,774	62,265
Agartala	8,310	NIL	NIL	NIL	NIL	NIL	28,271	21,927	10,051	10,119	13,635	NIL
RMC, Chennai												
Chennai	31167	77992	39749	57420	52948	27004	37605	81535	60635	58596	24648	130283
Thiruvananthapuram	6623	14537	7080	0	7788	22579	10620	3540	14201	8591	17700	14315
Hyderabad	18315	8431	0	14014	33007	24570	13905	32301	23605	14976	59265	82933
Bangalore	109964	116136	126197	105218	127535	181629	144397	58120	68275	151743	86059	77875
ACWC Chennai	7080	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
CWC Visakhapatnam	3661	7333	17524	2469	Nil	7224	7922	Nil	4419	1594	3160	11856
CRS, Pune												
Pune	INR 58,90,125 and USD 2,969											

CHAPTER 9

राजभाषा नीति का कार्यांवयन

संसदीय राजभाषा समिति द्वारा निरीक्षण

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 03.01.2023 को मौसम केंद्र - राँची का निरीक्षण किया गया। इस निरीक्षण में मंत्रालय की ओर से श्रीमती डॉ जगवीर सिंह, वैज्ञानिक 'जी' और श्री मनोज आबूसरिया, संयुक्त निदेशक (राजभाषा) तथा मुख्यालय से डॉ. एस. डी. अत्री, वैज्ञानिक 'जी' तथा उपनिदेशक (राजभाषा) श्रीमती सरिता जोशी और प्रादेशिक मौसम केंद्र-कोलकाता से डॉ. संजीव बंदोपाध्याय, वैज्ञानिक 'जी' ने भाग लिया। यह निरीक्षण डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ। माननीय संसदीय राजभाषा समिति के सदस्य श्री सुशील कुमार गुप्ता – संसद सदस्य (राज्य सभा) तथा श्रीमती संगीता यादव - संसद सदस्य (राज्य सभा) भी निरीक्षण के दौरान उपस्थित रहे। निरीक्षण सफल एवं संतोषजनक रहा।



संसदीय राजभाषा समिति द्वारा मौसम केंद्र-राँची का निरीक्षण

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 18.01.2023 को प्रादेशिक मौसम केंद्र-मुंबई का मुंबई में निरीक्षण किया गया। इस निरीक्षण में मंत्रालय से श्री सेंथिल पांडियन, संयुक्त सचिव और श्री मनोज आबूसरिया, संयुक्त निदेशक (राजभाषा) तथा मुख्यालय से महानिदेशक महोदय डॉ. मृत्युंजय महापात्र और श्रीमती सरिता जोशी उपनिदेशक (रा.भा.) ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति की सहसंयोजक महोदया श्रीमती रंजन बेन भट्ट जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



संसदीय राजभाषा समिति द्वारा मौसम केंद्र–
मुंबई का निरीक्षण

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा द्वारा 24.02.2023 को पवन सूचक गुब्बारा वेधशाला - बीकानेर का जैसलमेर में निरीक्षण किया गया। इस निरीक्षण में पवन सूचक गुब्बारा वेधशाला-बीकानेर के कार्यालय प्रमुख श्री जय शंकर पुरोहित ने भाग लिया। यह निरीक्षण डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



संसदीय राजभाषा समिति की दूसरी उपसमिति पवन सूचक गुब्बा0रा वेधशाला - बीकानेर का जैसलमेर में निरीक्षण किया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 08.05.2023 को मौसम केंद्र - पटना का पटना में राजभाषायी निरीक्षण किया गया। इस निरीक्षण में मंत्रालय की ओर से श्री सेंथिल पांडियन, संयुक्त सचिव और श्रीमती विमला दहिया सहायक निदेशक (राजभाषा), मुख्यायलय से श्रीमती रंजू मदान, उप महानिदेशक (प्रशा.) / वैज्ञानिक 'जी' और श्रीमती सरिता जोशी उपनिदेशक (रा.भा.) तथा प्रादेशिक मौसम केंद्र-कोलकाता से डॉ. संजीव बंद्योपाध्याय, वैज्ञानिक 'जी' ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति के उपाध्यक्ष महोदय श्री भर्तृहरि महताब जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम केंद्र - पटना का पटना में राजभाषायी निरीक्षण किया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 13.05.2023 को विमानन मौसम स्टेशन - अमृतसर का अमृतसर में निरीक्षण किया गया। इस निरीक्षण में विमानन मौसम स्टेशन - अमृतसर के कार्यालय प्रमुख श्री संजीव कुमार, मौसम विज्ञानी 'बी' ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति की सह संयोजक महोदया श्रीमती रंजनबेन भट्ट जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा विमानन मौसम स्टेवशन - अमृतसर का निरीक्षण किया गया

माननीय संससदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 13.05.2023 को डॉप्लर मौसम रेडार - पटियाला का अमृतसर में निरीक्षण किया गया। इस निरीक्षण में डॉप्लर मौसम रेडार-पटियाला के कार्यालय प्रमुख श्री राकेश कुमार, वैज्ञानिक 'सी' ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति की सह संयोजक महोदया श्रीमती रंजनबेन भट्ट जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 25.05.2023 को मौसम केंद्र - देहरादून का देहरादून में राजभाषायी निरीक्षण किया गया। इस निरीक्षण में मंत्रालय से डॉ. निलय खरे, वैज्ञानिक 'जी' और श्रीमती विमला दहिया,

सहायक निदेशक (राजभाषा), मुख्यालय से श्रीमती रंजू मदान, उप महानिदेशक (प्रशा.) / वैज्ञानिक 'जी' और श्रीमती सरिता जोशी उपनिदेशक (रा.भा.) तथा प्रादेशिक मौसम केंद्र - नई दिल्ली से श्री चरण सिंह, वैज्ञानिक - 'एफ'/प्रमुख ने भाग लिया। निरीक्षण माननीय संसदीय राजभाषा समिति की सह संयोजक महोदया श्रीमती रंजनबेन भट्ट जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम केंद्र - देहरादून का देहरादून में राजभाषायी निरीक्षण किया गया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 23.06.2023 को मौसम केंद्र - लखनऊ का लखनऊ में निरीक्षण किया गया। इस निरीक्षण में मंत्रालय से डॉ. जगवीर सिंह, वैज्ञानिक 'जी' और श्रीमती विमला दहिया - सहायक निदेशक (राजभाषा), मुख्यालय से महानिदेशक महोदय डॉ. मृत्युंजय महापात्र और श्रीमती सरिता जोशी उपनिदेशक (रा.भा.) तथा प्रादेशिक मौसम केंद्र - नई दिल्ली से श्री चरण सिंह, वैज्ञानिक - 'एफ' / प्रमुख ने भाग लिया।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम केंद्र - लखनऊ निरीक्षण किया गया

यह निरीक्षण माननीय संसदीय राजभाषा समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा। इस अवसर पर महानिदेशक महोदय को विश्व् मौमस विज्ञान संगठन का तीसरा उपाध्यरक्ष चुने जाने पर संसदीय राजभाषा समिति की दूसरी उपसमिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी द्वारा सम्मारनित किया गया।



महानिदेशक महोदय को विश्वत मौसम विज्ञान संगठन का तीसरा उपाध्य क्ष चुने जाने पर संसदीय राजभाषा समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी द्वारा सम्मानित किया गया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 10.07.2023 को मौसम केंद्र - अहमदाबाद का राजकोट में राजभाषायी निरीक्षण किया गया। इस निरीक्षण में मंत्रालय से डॉ. निलय खरे, वैज्ञानिक 'जी' और श्रीमती विमला

दहिया, सहायक निदेशक (राजभाषा), मुख्या लय से श्रीमती रंजू मदान, उपमहानिदेशक (प्रशा.) / वैज्ञानिक 'जी' और श्रीमती सरिता जोशी उपनिदेशक (रा.भा.) तथा प्रादेशिक मौसम केंद्र - मुंबई से श्री सुनिल जी. काम्बले, वैज्ञानिक - 'एफ' / प्रमुख ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम केंद्र - अहमदाबाद निरीक्षण किया गया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 10.07.2023 को विमानन मौसम कार्यालय - राजकोट का राजकोट में राजभाषायी निरीक्षण किया गया। इस निरीक्षण में विमानन मौसम कार्यालय - राजकोट के कार्यालय प्रमुख श्री जे. एच. त्रिवेदी, मौसम विज्ञानी 'बी' ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा विमानन मौसम कार्यालय - राजकोट का निरीक्षण किया गया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 12.07.2023 को मौसम विज्ञान वेधशाला - कोषिक्कोकड का बेंगलुरू में निरीक्षण किया गया। इस निरीक्षण में मौसम विज्ञान वेधशाला - कोषिक्कोकड के कार्यालय प्रमुख श्री पी. जयप्रकाश, मौसम विज्ञानी 'बी' ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में मौसम विज्ञान वेधशाला-कोषिक्कोड का बेंगलुरू में निरीक्षण किया गया



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम विज्ञान वेधशाला - मंगलुरू का निरीक्षण किया गया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 12.07.2023 को मौसम विज्ञान वेधशाला - मंगलुरू का बेंगलुरू में निरीक्षण किया गया। इस निरीक्षण में मौसम विज्ञान वेधशाला - मंगलुरू के कार्यालय प्रमुख श्री सुधीर बाबू सी. वी., मौसम विज्ञानी 'बी' ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम केंद्र - हैदराबाद निरीक्षण किया गया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 21.08.2023 को मौसम केंद्र - हैदराबाद का विजयवाड़ा में राजभाषायी निरीक्षण किया गया। इस निरीक्षण में मंत्रालय से डॉ. निलय खरे, वैज्ञानिक 'जी', मुख्यायलय से श्री विवेक सिन्हा, वैज्ञानिक 'जी' और श्रीमती सरिता जोशी उपनिदेशक (रा.भा.) तथा प्रादेशिक मौसम केंद्र - चेन्नै से डॉ. एस. बालचन्द्रन, वैज्ञानिक-'जी'/प्रमुख ने भाग लिया। यह निरीक्षण माननीय संसदीय राजभाषा समिति के उपाध्यक्ष महोदय श्री भर्तृहरि महताब जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 24.08.2023 को चक्रवात चेतावनी केंद्र-विशाखापट्टनम का विशाखापट्टनम में निरीक्षण किया गया। इस निरीक्षण में मंत्रालय की ओर से श्री सेंथिल पांडियन, संयुक्त सचिव और श्रीमती विमला दहिया, सहायक निदेशक (राजभाषा), मुख्यालय से श्रीमती रंजू मदान, उप महानिदेशक (प्रशा.)/वैज्ञानिक 'जी' और श्रीमती सरिता जोशी उपनिदेशक (रा.भा.) तथा प्रादेशिक मौसम केंद्र - चेन्नै से डॉ. एस. बालचन्द्रन, वैज्ञानिक - 'जी'/प्रमुख ने भाग लिया। यह निरीक्षण सह संयोजक महोदया श्रीमती रंजन बेन भट्ट जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा चक्रवात चेतावनी केंद्र - विशाखापट्टनम का निरीक्षण

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 03.10.2023 को मौसम केंद्र - शिमला का धर्मशाला में निरीक्षण किया गया। इस निरीक्षण में मौसम केंद्र - शिमला के कार्यालय प्रमुख श्री सुरेंद्र पॉल, वैज्ञानिक 'एफ' ने भाग लिया। यह निरीक्षण समिति की सह संयोजक महोदया श्रीमती रंजनबेन भट्ट जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम केंद्र - शिमला निरीक्षण किया गया

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 30.11.2023 को मौसम कार्यालय - वाराणसी का वाराणसी में निरीक्षण किया गया। इस निरीक्षण में मौसम कार्यालय - वाराणसी के कार्यालय प्रमुख श्री मनीष राय, वैज्ञानिक 'डी' ने भाग लिया। यह निरीक्षण समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम कार्यालय - वाराणसी का निरीक्षण

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 27.12.2023 को खगोल विज्ञान केंद्र - कोलकाता का कोलकाता में निरीक्षण किया गया। इस निरीक्षण में मंत्रालय से श्री सेंथिल पांडियन, संयुक्त सचिव और श्रीमती विमला दहिया, सहायक निदेशक (राजभाषा) तथा मुख्या लय से श्री विवेक सिन्हा, वैज्ञानिक 'जी' और श्रीमती सरिता जोशी उपनिदेशक (रा.भा.) ने भाग लिया। यह निरीक्षण समिति की संयोजक महोदया डॉ. रीता बहुगुणा जोशी जी की अध्यक्षता में हुआ। निरीक्षण सफल एवं संतोषजनक रहा।



माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा खगोल विज्ञान केंद्र - कोलकाता का निरीक्षण किया गया

बैठकें/सम्मेलन

विज्ञान और प्रौद्योगिकी मंत्रालय तथा पृथ्वी विज्ञान मंत्रालय की संयुक्त हिंदी सलाहकार समिति की 34वीं बैठक दिनांक 15.12.2023 (शुक्रवार) को आर्यभट्ट सभागार, न्यू बिल्डिंग ब्लॉक-1, टेक्नोलॉजी भवन, नई दिल्ली में आयोजित की गई। इस बैठक में श्रीमती रंजू मदान, उपमहानिदेशक (प्रशासन) वैज्ञानिक 'जी' ने भाग लिया। उपनिदेशक (रा.भा.) श्रीमती सरिता जोशी और वरिष्ठ अनुवाद अधिकारी श्री बीरेन्द्र कुमार भी इस बैठक में उपस्थित रहे।

विभाग की पुस्तकालय सलाहकार समिति की दिनांक 26.09.2023 आयोजित 123वीं बैठक में श्रीमती सरिता जोशी, उपनिदेशक (रा.भा.) ने भाग लिया।

14 से 15 सिंतबर 2023 के दौरान पुणे (महाराष्ट्र) में आयोजित होने वाले तृतीय अखिल भारतीय राजभाषा सम्मेलन में मुख्यालय तथा देश भर में फैले उपकार्यालयों से 36 कार्मिकों को नामित किया गया।

राजभाषा नीति का कार्यान्वुयन

राजभाषा नियमावली 1976 के नियम 10 (4) के अंतर्गत विभागीय कार्यालय (1) मौसम केंद्र - शिमला (2) पवन सूचक गुब्बारा वेधशाला - वेरावल (3) वैमानिक मौसम कार्यालय - के शोद (4) वैमानिक मौसम कार्यालय - जलगांव (5) वैमानिक मौसम कार्यालय - कांडला एवं (6) वैमानिक मौसम कार्यालय - राजकोट को अधिसूचित कराने का मामला अनुमोदन हेतु पृथ्वी विज्ञान मंत्रालय को भेजा गया।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 26.08.2022 को हवाई अड्डा मौसम स्टेशन - कोयंबटूर के निरीक्षण के दौरान समिति को दिए गए 'आश्वासनों' तथा 'ध्यान देने योग्य बातें' पर की गई कार्रवाई की अनुपालन रिपोर्ट संसदीय राजभाषा समिति सचिवालय को प्रेषित करने के लिए पृथ्वीं विज्ञान मंत्रालय को भेजी गई।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 26.08.2022 को मौसम केंद्र - चंडीगढ़ के निरीक्षण के दौरान दिए गए 'आश्वानसनों' तथा 'ध्याकन देने योग्य बातें' की गई कार्रवाई की अनुपालन रिपोर्ट संसदीय राजभाषा समिति सचिवालय को प्रेषित करने के लिए पृथ्वी विज्ञान मंत्रालय को भेजी गई।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 17.10.2022 को मौसम केंद्र - जयपुर और दिनांक 14.11.2022 को मौसम केंद्र - रायपुर का निरीक्षण किया गया। निरीक्षण के दौरान समिति को दिए गए 'आश्वासनों तथा 'ध्यान देने योग्य बातें' पर की गई कार्रवाई की अनुपालन रिपोर्ट समिति सचिवालय को प्रेषित करने के लिए पृथ्वी विज्ञान मंत्रालय को भेजी गई।

संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 19.10.2022 को किए गए मौसम केंद्र - भोपाल के निरीक्षण के दौरान समिति को दिए गए 'आश्वासनों' तथा 'ध्यान देने योग्य व बातें' पर की गई अनुवर्ती कार्रवाई की रिपोर्ट दिनांक 14.06.2023 को पृथ्वी विज्ञान मंत्रालय को भेजी गई।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 03.01.2023 को किए गए मौसम केंद्र - राँची के निरीक्षण के दौरान समिति को दिए गए 'आश्वासनों' तथा 'ध्यान देने योग्य बातें' पर की गई अनुवर्ती कार्रवाई की रिपोर्ट दिनांक 14.06.2023 को पृथ्वीं विज्ञान मंत्रालय को भेजी गई।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 16.11.2022 को किए गए प्रादेशिक मौसम केंद्र- कोलकाता के निरीक्षण के दौरान समिति को दिए गए 'आश्वासनों' तथा 'ध्यान देने योग्य बातें' पर की गई अनुवर्ती कार्रवाई की रिपोर्ट दिनांक 14.06.2023 को पृथ्वी विज्ञान मंत्रालय को भेजी गई।

पुरस्कार/सम्मान

विभाग के 148वें स्थापना दिवस के अवसर पर दिनांक 15.01.2023 को माननीय मंत्री महोदय डॉ. जितेन्द्र सिंह जी द्वारा राजभाषा हिंदी में सर्वश्रेष्ठ कार्य करने के लिए प्रादेशिक मौसम केंद्र- नागपुर को 'राजभाषा शील्ड्' प्रदान की गई।



माननीय मंत्री महोदय डॉ. जितेन्द्रों सिंह जी द्वारा राजभाषा हिंदी में सर्वश्रेष्ठ कार्य करने के लिए प्रादेशिक मौसम केंद्र - नागपुर को 'राजभाषा शील्डि' प्रदान की गई

'यू.एस.एम. पत्रिका' एवं सुलभ इंटर्नेशनल सोशल सर्विस ऑर्गनाइज़ेशन, नई दिल्ली द्वारा दिनांक 10-03-2023 को आयोजित एक दिवसीय 26वें राष्ट्र भाषा विकास सम्मेलन में राष्ट्र भाषा और हिंदी के महत्व पर राजभाषा हिंदी प्रोत्साहन पुरस्कार के अंतर्गत भारत मौसम विज्ञान विभाग की उपनिदेशक (राजभाषा) को "राजभाषा रत्न' तथा वरिष्ठ अनुवाद अधिकारी और कनिष्ठ अनुवाद अधिकारी को 'हिंदी भाषा भूषण' से सम्मानित किया गया।



26वें राष्ट्रभाषा विकास सम्मेलन में राष्ट्रभाषा और हिंदी के महत्वन पर राजभाषा हिंदी प्रोत्साहन पुरस्काकर

भारतीय भाषा एवं संस्कृति केंद्र द्वारा दिनांक 27 अप्रैल से 29 अप्रैल 2023 तक आयोजित होने वाले 40वें अखिल भारतीय सम्मेलन एवं प्रशिक्षण शिविर में भाग लेने हेतु श्री सोनम लोट्स, वैज्ञानिक 'ई'/ प्रमुख, मौसम केंद्र - श्रीनगर/लेह को नामित किया गया। श्री सोनम लोटस, वैज्ञानिक 'ई' / प्रमुख, मौसम केंद्र – श्रीनगर / लेह सम्मेलन में भारत मौसम विज्ञान विभाग को दिए जाने वाले 'राजभाषा नायक' पुरस्कांर प्राप्त किया।



श्री सोनम लोटस, वैज्ञानिक 'ई' भारत मौसम विज्ञान विभाग को दिए जाने वाले 'राजभाषा नायक' पुरस्कार प्राप्ति किया

नगर राजभाषा कार्यान्वयन समिति (का.-2), पुणे द्वारा वर्ष 2022-2023 के लिए दिनांक 29.11.2023 को जलवायु अनुसंधान एवं सेवाएँ कार्यालय, पुणे का राजभाषा संबंधी निरीक्षण किया गया। प्रमुख, जलवायु अनुसंधान एवं सेवाएं कार्यालय, पुणे को उत्कृष्ट राजभाषा कार्यान्वयन हेतु प्रथम पुरस्कार प्रदान किया गया। पुरस्कार वितरण दिनांक 05.12.2023 को एनसीएल, पाषाण, पुणे में आयोजित नराकास (का.-2) की छमाही बैठक में हुआ।



प्रमुख, जलवायु अनुसंधान एवं सेवाएं कार्यालय, पुणे को उत्कृष्ट राजभाषा कार्यान्वयन हेतु प्रथम पुरस्कार प्रदान किया गया

नगर राजभाषा कार्यान्वयन समिति (का.-1), चंडीगढ द्वारा वर्ष 2022-2023 के लिए मौसम केंद्र - चंडीगढ को उत्कृष्ट राजभाषा कार्यान्वयन हेतु द्वितीय पुरस्कार प्रदान किया गया।



मौसम केंद्र - चंडीगढ को उत्कृष्ट राजभाषा कार्यान्वयन हेतु द्वितीय पुरस्कार प्रदान किया गया

प्रकाशन

'मौसम मंजूषा' के 36वें संस्करण का विमोचन विभाग के 148वें स्थापना दिवस के अवसर पर दिनांक 15.01.2023 को माननीय मंत्री महोदय डॉ. जीतेन्द्र सिंह जी द्वारा किया गया।

मौसम मंजूषा के 37वें संस्करण का विमोचन हिंदी दिवस समारोह - 2023 के अवसर पर महानिदेशक महोदय डॉ. मृत्युंजय महापात्र और मुख्य अतिथि वरिष्ठ प्रोफेसर पूरनचन्द टंडन जी द्वारा दिनांक 27.09.2023 को किया गया।



मौसम मंजूषा के 37वें संस्करण का विमोचन महानिदेशक महोदय डॉ. मृत्युंजय महापात्र और मुख्यट अतिथि वरिष्ठ प्रोफेसर पूरनचन्द टंडन जी द्वारा किया गया

हिंदी दिवस समारोह



महानिदेशक महोदय ने दिल्ली विश्वविद्यालय के वरिष्ठ प्रोफेसर पूरनचन्द टंडन का स्वागत किया

मुख्यालय में दिनांक 27.09.2023 हिंदी दिवस/ हिंदी पखवाड़ा समापन समारोह 2023 का महानिदेशक महोदय की अध्यनक्षता में आयोजन किया गया जिसमें मुख्य अतिथि के रूप में दिल्ली विश्वविद्यालय के वरिष्ठ प्रोफेसर पूरनचन्द टंडन उपस्थित रहे।

मुख्याrलय में हिंदी दिवस / हिंदी पखवाड़ा-2023 के दौरान आयोजित की गई 06 प्रतियोगिताओं के 30 विजेताओं को महानिदेशक महोदय डॉ. मृत्युंजय महापात्र एवं मुख्य अतिथि वरिष्ठ प्रो. पूरनचन्द टंडन जी तथा उपमहानिदेशक (प्रशा.) श्रीमती रंजू मदान के करकमलों से पुरस्कार एवं प्रमाण पत्र प्रदान किए गए।



महानिदेशक महोदय डॉ. मृत्युंजय महापात्र एवं मुख्य अतिथि वरिष्ठ प्रो. पूरनचन्द टंडन जी तथा उपमहानिदेशक (प्रशा.) श्रीमती रंजू मदान के करकमलों से पुरस्कार एवं प्रमाण पत्र प्रदान किए गए

मुख्यालय में हिंदी दिवस समारोह दिनांक 27.09.2023 के अवसर पर राजभाषा हिंदी में सर्वश्रेष्ठ कार्य करने हेतु 'सूचना का अधिकार प्रकोष्ठ' को वर्ष 2022-2023 के लिए 'राजभाषा चलशील्ड्' प्रदान की गई।



राजभाषा हिंदी में सर्वश्रेष्ठ कार्य करने हेतु 'सूचना का अधिकार प्रकोष्ठ' को वर्ष 2022-2023 के लिए 'राजभाषा चलशील्ड' प्रदान की गई

वर्ष 2022-2023 के लिए सरकारी कामकाज मूलरूप से हिंदी में करने की प्रोत्साहन योजना के अंतर्गत महानिदेशक महोदय द्वारा हिंदी दिवस के अवसर पर मुख्यालय में कार्यरत 06 कार्मिकों को प्रमाण-पत्र प्रदान किए गए।



महानिदेशक महोदय द्वारा हिंदी दिवस के अवसर पर मुख्यालय में कार्यरत 06 कार्मिकों को प्रमाण-पत्र प्रदान किए गए

हिंदी कार्यशाला / व्यारख्यांन

मुख्यालय द्वारा दिनांक 29.03.2023 को ई-हिंदी कार्यशाला का आयोजन किया गया जिसमें दिल्ली सहित विभिन्न उपकार्यालयों के लगभग 120 कार्मिकों ने भाग लिया। ई-हिंदी कार्यशाला को महानिदेशक महोदय डॉ. मृत्यंजय महापात्र ने संबोधित किया। इस कार्यशाला में सेवानिवृत्त उपनिदेशक (रा.भा.) सुश्री रेवा शर्मा, श्रीमती सरिता जोशी, उपनिदेशक (रा.भा.) एवं श्री बीरेन्द्र कुमार, वरिष्ठ अनुवाद अधिकारी ने व्याख्यान दिए।

मुख्यालय नई दिल्ली द्वारा दिनांक 27.12.2023 को पूर्ण दिवसीय ई - हिंदी कार्यशाला का आयोजन किया गया। इस कार्यशाला में मुख्यालय के कार्मिकों के साथ उपकार्यालयों के लगभग 55 कार्मिकों ने भाग लिया। सुश्री रेवा शर्मा, सेवानिवृत्त उपनिदेशक (रा.भा.) तथा श्री बीरेन्द्र कुमार, वरिष्ठ अनुवाद अधिकारी ने व्याख्यान दिए।

CHAPTER 10

STATUS OF SC/ST/OBC AS ON 01.01.2023

(i) Status of SC/ST/OBC as on 01.01.2023 (Group wise)

	Representation of SCs / STs/ OBCs as on 1.1.2022				Appointments by Promotion during the calendar year		
Groups	No. of Employees	SCs	STs	OBCs	SCs	STs	Total
Group A	214	31	13	60	19	14	111
Group B (Gaz.)	1514	258	121	327	30	21	141
Group B (Non- Gaz.)							
Group C							
TOTAL	1728	289	134	387	49	35	252

(ii) Status of SC/ST/OBC as on 01.01.2023 (Pay Scale Wise)

	Representation of SCs / STs / OBCs as on 01.01.2022				Appointments by promotion during the calendar year		
Pay Scale in Rs.	No. of Employees	SCs	STs	OBCs	SCs	STs	Total
PB-3 + GP 5400	0	0	0	0	0	0	0
PB-3 + GP 6600	98	12	5	31	13	11	53
PB-3 + GP 7600	18	1	1	5	3	2	37
PB-4 + GP 8700	44	8	4	15	0	0	0
PB-4 + GP 8900	42	10	3	9	3	0	16
PB-4 + GP 10000	11	0	0	0	0	1	5
75500-80000	1	0	0	0	0	0	0
TOTAL	214	31	13	60	19	14	111

CHAPTER 11

MISCELLENEOUS

11.1. Honours and Awards

ACHIEVEMENTS / APPRECIATIONS / AWARDS RECEIVED

Dr. Sabuj Sahoo Memorial Lifetime Achievement Award was conferred upon Dr. Mrutyunjay Mohapatra, DG, IMD on 29th January, 2023 by the Society for Agricultural Research and Management (SARM) during the International Conference, Agri-Vision, 2023 on Agriculture and Rural Development organized by Centurion University and SARM at Centurion University, Bhubaneswar Campus, Odisha.



Dr. Sabuj Sahoo Memorial Lifetime Achievement Award, conferred to Dr. Mrutyunjay Mohapatra, DG IMD

Utkal University Physics Alumni Association felicitated **Dr . Mrutyunjay Mohapatra**, DG, IMD on the occasion of Golden Jubilee celebration of the Physics Department of the university on 4th January, 2023.

IMD Foundation Day Awards for the year 2022-23

8.5	Name of Award	Station / Persons
1.	Best RMC/MC	M.C. RanchI, RMC Kolkata
2.	Best AMO/MWO/AMS	AMS Bajpe, RMC Chennai
3.	Best M.O.	M.O. Barmer, RMC New Delhi
4.	Best DWR	DWR Patiala
5.	Raj Bhasha Shield	RMC Nagpur
6.	Best Employee Group 'A' (Scientific Staff)	Shri R. Balasubramanian, Sc-E, MC Bhopal, RMC Nagpur
7.	Best Employee Group 'B' (Gaze.) (Scientific)	Shri Surjay Lama, Met.-B, M.C. Gangtok, RMC Kolkata
		Dr. Rizwan Ahmed, Met.-B, NWFC, DGM Office, New Delhi
8.	Best Employee Group 'B' (Gaze.) (Non-Scientific)	Shri P.S. Sengupta, AO-II, Establishment-I Section DGM Office New Delhi
9.	Best Employee Group 'B' (Non-Gaze.) (Scientific)	Ms Anamika Sarma, S.A, RMC Guwahati
		Shri Pankaj Kumar, S.A RMC Chennai
10.	Best Employee Group 'B' (Non-Gaze.)(Non-Scientific)	Ms Poonam P Korpade, Assistant, RMC Mumbai
11.	Best Employee Group 'C' (Non-MTS)	Shri N. Thirumalai, Radio Mechanic RMC Chennai
12.	Best Employee Group 'C' (MTS)	Shri Arjun Singh, MTS, DGM Secretariat, New Delhi
		Shri Manjit, MTS, M.O Bhuntar, RMC New Delhi

WMO had issued an appreciation letter to Shri Raja Acharya, Met. 'A' in connection with his participation through virtual mode in the 10th International Workshop on Tropical Cyclones (IWTC-10) organised by the WMO during 5-9 December 2022 in hybrid mode on 13th February, 2023.

WMO recognised three IMD observatories, viz., Dwarka & Veraval in Gujarat and Cuttack in Odisha as long term observing stations for more than 100 years of hydrological observations. Dr. M. Mohapatra, DG, IMD received the certificates from the President during Cg-19.



Dr. M. Mohapatra, DG IMD received the certificates from the President during Cg-19

Hon'ble Chief Minister of Odisha Shri Naveen Pattanaik appreciated IMD for providing quality hydrological observations which are essential for dealing with climate hazards.

M.C. Ahmedabad received'**Appreciation letter**' from **Shri Bhupendra Patel, Hon. Chief Minister of Gujarat State and from Gujarat Frontier of BSF** for providing the accurate and precise forecast services during "**BIPARJOY CYCLONE**".

Dr. G. N. Raha, Sc. 'E', **Shri Debjit Das**, S.A. & **Shri Himanshu Gupta**, S.A., M. C. Gangtok, received the appreciation letter for significant contributions made during 2022-2023 issued by the Director General of Meteorology.

AWARDS

Smt. Sulekha Sonal, S.A., **Ms. Meenakshi Yadav**, Upper Division Clerk, **Smt. Lata Sridhar**, Met. 'B' and **Ms. Ruby Verma**, S.A. of Regional Meteorological Center, Nagpur received the first and consolation prizes respectively in the competitions organized by the Town Official Language Implementation Committee (Narakas).

ACHIEVEMENTS/APPRECIATIONS/AWARDS RECEIVED



Dr. M. Mohapatra was felicitated by the SECI

Dr. M. Mohapatra, DG, IMD participated as Chief Guest during the National Student Convention 2023 on Solar Energy in association with Solar Energy Society of India on 22nd August, 2023. **Dr. M. Mohapatra** was felicitated by the SECI during the event for his exemplary contribution to Society through Early Warning Services '**Anticipating Adversity, Protecting Lives**'.

MC Ahamadabad received Appreciation letter from DGM New Delhi for providing the accurate and precise forecast services during "**BIPORJOY CYCLONE**".



IMS Bhubaneswar felicitated Dr. M. Mohapatra on his election as 3rd Vice President of WMO



The Climate Research Centre, Pune also felicitated Dr. Mohapatra on his election to the post of 3rd Vice President of WMO

Mrs. Latha Sridhar, Met-B, RMC Nagpur completed Ph.D. synopsis presentation on "**Analysis of Rainfall Characteristics and Extreme Rainfall Events over India at different Spatial and Temporal Scales**".

Ms. Apoorva Singhroul, Met-A, **Mr. Ajay Kumar Rai**, S.A., MC Sagar and **Mr. Mukul Tripathi**, S.A. M.C. Jabalpur were awarded for their best articles/poem for the ninth issue of hindi magazine Riturang.

Hindi Protsahan Yojana 2022-2023, Winners

1. **Mrs. Sulekha Sonal**, S.A., Mr. S.A. Pawar, Assistant and **Mrs. Pushpa Sawarakar**, UDC - 2nd Prize.
2. **Mrs. Reena V. Surpam**, Met- A, 3rd Prize.



Hindi Pakhwada Celebration (RMC Nagpur) 1-14, September, 2023



On behalf of MoES the Officers of IMD(RMC Kolkata) receiving certificate and a memento for participation in 26th National Science Exhibition

Appreciation was received from D.I.G. of Indian Coastguard for the relentless efforts of team of **M.C. Ahmedabad for installation of AWS at ICGAS Daman.**

11.2 ADDRESSES OF VARIOUS REGIONAL METEOROLOGICAL CENTRES & METEOROLOGICAL CENTRES

RMC New Delhi
Head, Regional Meteorological Centre,
IMD, RMC Building,
Lodi Road, New Delhi – 110003
e-mail : rmc.delhi@imd.gov.in

RMC Chennai
Head, Regional Meteorological Centre,
IMD, RMC Chennai, New 6, Tamil Nadu – 600006
e-mail : rmc.chennai@imd.gov.in

RMC Mumbai
Head, Regional Meteorological Centre,
IMD, RMC Mumbai, Colabba,
Maharashtra – 400005
e-mail : rmc.mumbai@imd.gov.in

RMC Kolkata
Head, Regional Meteorological Centre,
RMC Kolkata, 4, Dual Avenue, Alipur
Kolkata – 700027
e-mail : rmc.kolkata@imd.gov.in

RMC Nagpur
Head, Regional Meteorological Centre,
IMD, DBAI Airport, Sonegaon, Nagpur – 440005
e-mail : rmc.nagpur@imd.gov.in

RMC Guwahati
Head, Regional Meteorological Centre,
IMD, RMC Guwahati, LGB I Airport,
Guwahati – 781015
e-mail : rmc.guwahati@imd.gov.in

Delhi Region

Head
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Sector 39 C, Chandigarh – 160036.
e-mail: chandimet@yahoo.com

Head
Meteorological Centre, Budhsinghpura, Sanganer,
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e-mail: mcjpr@imd.gov.in

Head
Meteorological Center Lucknow,
Chaudhary Charan Singh International Airport,
Amausi, Kanpur Road, Lucknow (Uttar Pradesh) – 226009.
e-mail: amo.lkn@imd.gov.in

Head
Meteorological Centre,
Ram Bagh Bridge, Airport Road,Ram Bagh,
Srinagar,
(Jammu and Kashmir) – 190015.
e-mail: mc.srn@imd.gov.in

Head
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Road, Dehradun (Uttarakhand) – 248005.
e-mail: metcentre-dehradun@imd.gov.in

Head
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Shimla (Himachal Pradesh) – 171001.
e-mail: mc.sml@imd.gov.in

Head
Meteorological Centre,Leh Ladakh Ecological
Hostel, Yurthung Leh, Ladakh – 194101.
e-mail: metcentreleh@gmail.com

Chennai Region

Head
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e-mail: mchyd@imd.gov.in amo.hyd@imd.gov.in

Head
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Thiruvananthapuram (Kerala) – 695033.
e-mail: mc.trv@imd.gov.in

Head
Meteorological Centre,
AmaravatiSRM University Campus,
Neerukonda, Guntur District,
(Andhra Pradesh) – 522503.
e-mail: mc.amaravati@gmail.com

Mumbai Region

Head
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