Indian Meteorological Society, Chennai Chapter

NEWSLETTER
Vol. No.23, Issue No.2, Dec 2023

Contents

Message from the Chairman.,

I am glad to see that the issue of Dec 2023 is being released. I am very happy to learn the response for the issue from the scientists and academia. IMS CC is very much delighted to receive the support from all the council members including the senior scientists. I take this opportunity to welcome our new council member Dr. K.S. Vigensh, SRM IST to this IMS CC team.

I congratulate the editorial team of Breeze for their efforts in bringing out this issue.

I request all the IMS members and readers of the Breeze newsletter to write their views and suggestions to us for further improvement.

Thank you very much,

Yours sincerely,

T. V. Lakshmi Kumar

Dr. T.V. Lakshmi Kumar
Associate Professor
SRM Institute of Science and Technology, Kattankulathur

Editor's Desk :

Dear esteemed members greetings to all of you.
I am happy to inform that the IMSCC newsletter Breeze December Volume 23 Issue 2 is being released and uploaded in IMSCC website.
Five (5) articles are included.
I am happy that more new members are contributing articles. I thank every one who contributes very good standard articles.
I Thank Dr.T V Lakshmikumar Chairman and his team for helping in preparation of the Breeze
I thank the Editorial board for their support.
I am happy to inform that the present Local Council conducted periodical Seminars/Lectures periodically with participation of IMSCC and educational institutions on large numbers.
A Seminar was conducted at Regional Meterological Centre Chennai on 26th Oct 2023.
2 lectures were delivered by two experts
1 Dr T V Lakshmikumar SRMIST on the topic
2.Dr.T.Sudhakar Scientist NIOT (Rtd) on
A panel discussion was arranged on "Curriculam in Higher Educational Institutions " a fresh topic.
It was a coincidence it was an all Women Panel
Dr.(Mrs)N.Jayanthi Former Additional Director General of Meteorology IMD was the Chairperson and the other members were
Prof M.Krishnaveni , Director Dept of Ocean ,Anna University Chennai,
Dr. Christina Nancy HOD Physics Dept WCC women's college.
Dr Jhone Venjhula HOD Physics Dept Ethiraj College for women.
The interactions were very educative.
Under Climate Action: Plant Saplings were distributed to participants to motivate developing greenery by Anna University .
The seminar was participated by more than 100 persons Faculties Research Scholars Students Higher Education Depts from many Popular institutions in and around Chennai
e participation certificates were sent to the participants. Over all the seminar was very usefull.
The HINDU News Paper Chennai published about the seminar and highlighted the speciality of the topic.
It was well received by many who conveyed their appreciations.
I am extreamly happy to inform under the continuous efforts of Chairman and Secretary about 32 new members joined as Life members of IMSCC and showing more intrest in participating.
Now the total strength
increased to 183 perhaps the higest so far.
I welcome all new members to actively participate to take IMSCC to further high level.
I also request to encourage others known to them and request them to join.
Dr.Y E A Raj Former DDGM and Former Chairman IMSCC participated in the TROPMET 23 held at Jaipur.
Understand that next one will be a INTROPMENT 24 at Pune(Dates will be decided and communicated)
The next seminar of IMSCC will be held probably on Feb/March 2024
I once again wish all the members a happy new year with great achievements

With best regards,

(R.NALLASWAMY)

Local Council of IMS Chennai Chapter

2022 -2024

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Rainfall Climatology of Sri Lanka- A brief composition

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1. The rainfall climatology of Sri Lanka, an Island country and India's southeastern neighbour is of interest in view of the influence of the Indian southwest and northeast monsoon seasons on the rainfall of Sri Lanka. In this article, certain characteristic climatological features of rainfall during the various seasons of Sri Lanka, Koppen's climate classification, the onset and withdrawal of northeast monsoon over Sri Lanka, relation between Sri Lanka rainfall and El Nino/ IOD /Southern Oscillation, the frequency of cyclonic disturbances crossing Sri Lanka are discussed.

2. Fig.1. presents the geographical map of Sri Lanka which was earlier known as Ceylon and is called as Ilangai in Tamil. The country lies in the Bay of Bengal or North Indian Ocean within the longitudinal and latitudinal belts of 79.68º – 81.88º E and 5.92º-9.85º N respectively. As seen from Fig.1 the land mass is tear drop shaped and is tapering and getting narrower in the north. Its north-south length is 432 km and its east-west width reaches a maximum value of 224 km. In between the land masses of Sri Lanka and the State of Tamil Nadu the sea is called Gulf of Mannar in the southern side and Palk Strait in the northern side as shown in Fig.2 which depicts the combined map of southern Indian region and that of Sri Lanka. Fig.3 presents the relief map of Sri Lanka. As shown the south central parts of Sri Lanka are elevated and mountainous. The highest peak in Sri Lanka which is called Pidurtalogala has elevation of 2524m asl. Sri Lanka has a coast line which is 1340 km long. It occupies a total area of 65610 sq. km and has a population of 2.2 crores (in 2022) with a population density of 338 people living per sq. km. Colombo is its capital city. The northern town of Jaffna is another major city of Sri Lanka.

3. Sri Lanka's climate is tropical and warm due to its proximity to the ocean. The Sri Lankan Meteorological Department defines the following seasons over Sri Lanka. (i) Inter Monsoon season (March-April), (ii) Southwest monsoon season (May- September), (iii) Second Inter Monsoon season (October-November) and (iv) Northeast monsoon season (December-February). During May-Oct low level winds over Sri Lanka are mainly southwesterlies. Northeasterlies set in by October end and blow up to April. Rainfall in Sri Lanka is of monsoonal, convectional or from transient weather systems such as depressions and cyclones. Fig.4 presents the spatial variation of normal rainfall of Sri Lanka during the seasons May-Sep, Dec-Feb and Annual (Jan-Dec). The annual rainfall varies from under 900mm in the driest parts (northwestern) to over 5000mm in the wettest parts (western slopes of the south central highlands). The station Welliyoa Estate at (80.6ºE, 6.9ºN) at 1258m asl records average annual rainfall of 508 cm. The lowest annual rainfall of 90 cm is recorded in the northern side of the western coast, but precise location at which the lowest rainfall is realised is not readily available. The normal annual rainfall over the entire Sri Lanka is given as 200 cm but season wise break up is not readily obtained.

4. The May-Sep southwest monsoon rainfall over Sri Lanka is highest over the south central region and heaviest west of the mountains, the quantum is 200-400 cm (Figs 3 & 4). Over east of the mountains, the rainfall decreases to 50-70 cm then to 30-50 cm and near the east coast it is under 30 cm. This type of distribution draws a clear parallel to the rainfall distribution west and east of western Ghats of India. Over Sri Lanka also there appears to be a clear pattern of windward and lee side rainfall with reference to the low level westerly wind flow. The occurrence of heavy rainfall over the windward side could obviously be attributed to orographic lifting.

The lowest rainfall over Sri Lanka during May-Sep is realised over a small northwest strip where the rainfall is under 10 cm. This feature draws parallel to the rainfall over Tamil Nadu's Pamban - Tiruchendur coastal strip where normal rainfall during Jun-Sep is under 5 cm. This strip is the driest in India during India's southwest monsoon season, drier than the Thar desert of northwest Rajasthan. The dryness of this strip of Tamil Nadu as well as the adjacent strip over Sri Lanka, both could be attributed to the sheltered nature and the cusp like geography of the region consisting of both the strips, the Gulf of Mannar and Palk Strait (Fig.2).

5. During the Sri Lankan northeast monsoon season of Dec-Feb, the rainfall is much heavier over the eastern parts than over the western parts of the southern region. In the eastern side rainfall exceeds 100 cm in some pockets. Whether there could be some orographic lifting with reference to the easterly winds is an interesting question. It may be noted that over Tamil Nadu and South Andhra there is no clear evidence of any orographic induced heavy rainfall zones on the windward side of the eastern Ghats with reference to the low level easterlies which blow during the season.

6. In Fig.5a and 5b are presented the average monthly rainfall distribution of 8 stations of Sri Lanka: The stations (Figs. 1 &2) and their annual rainfall are: Colombo (240 cm), Galle (238), Jaffna (130), Mannar (107) Batticaloa (165), Trincomalee (156), Kandy (184) and Adam's Peak (436 cm, Elevation 2243m). What is observed is that high rainfall of May and June with the typical southwest monsoon peak is seen only for Colombo and Galle both of which are in the lower latitudes. In most of the other stations the rainfall of Jun-Sep is not that high, similar to what is observed for most stations of Tamil Nadu. Even in the hill station of Adam's Point which receives 436 cm annual average rainfall, May-Sep rainfall does not show month wise sharp peak. Same is the status with Kandy and Trincomalee. This shows that in the interior region of Sri Lanka and even in the heavy rainfall hilly regions, southwest monsoon onset peak is not that prominent. In the northern stations of Jaffna and Mannar the monthly rainfall distribution is similar to that of Pamban of Tamil Nadu with relative dry Jun-Sep and very wet Oct-Dec and prominent rainfall peak in November. The monthly rainfall of both Mannar and Pamban are displayed in Fig.5c for ready comparison. The Batticaloa town located in the eastern coast of Sri Lanka records 165 cm of annual rainfall and interestingly as much as 34 cm is realised in Jan-Feb.

7. How the above rainfall distribution of Sri Lankan stations can be related and compared to the onset and withdrawal patterns of southwest and northeast monsoons of both Sri Lanka and India is of interest. According to historical charts released by India Meteorological Department, the onset date of southwest monsoon over Colombo is 25-th May which is consistent with the monthly rainfall distribution of Colombo and Galle. In most of the other stations representing the interior parts, north and eastern coasts, southwest monsoon onset pattern is not clearly observed. Several stations such as Jaffna, Mannar, Kandy, Trincomalee display relatively less rainfall during Jun-Sep and sharp rise of rainfall in October and peak in November, similar to what is observed for stations located in coastal Tamil Nadu. In the eastern town of Batticaloa, Oct, Nov, Dec, Jan and Feb months receive rainfall of 18,35,42, 21 and 13 cm respectively showing that northeast monsoon commences late at Batticaloa compared to coastal Tamil Nadu but prolongs into late Jan-Feb. This rainfall pattern is also indicative of the northeast monsoon withdrawal line (iso -lines of dates of withdrawal) is longitudinal over Sri Lanka rather than latitudinal.

Over most parts of Sri Lanka, the winter rain is more than the summer rain, barring the southern region represented by Colombo and Galle. In the hilly station of Adam's point the Oct-Dec rainfall is 165 cm obviously an interesting hydro -statistical fact. Such a high rainfall is not realised over the hilly regions of Tamil Nadu and Vedaranyam located on the east coast of Tamil Nadu (Fig. 2) registering 103 cm during Indian northeast monsoon season of Oct-Dec is the rainiest station in Tamil Nadu during Oct-Dec.

8. Fig.5. presents the correlation between Nino 3.4 sea surface temperature and Indian Ocean Dipole Index (IOD) with the Oct-Dec rainfall of Sri Lanka as the dependent variable. Both antecedent and concurrent relations are positive and this relation is similar to that of El Nino and IOD with Indian northeast monsoon rainfall. The Southern Oscillation Index and Sri Lankan Oct-Dec rainfall are negatively related. Thus El Nino, positive IOD and negative SOI favour good Oct-Dec rainfall activity over Sri Lanka.

9. The Koppen's climate classification is a widely used and easily understood classification with 5 groups denoted by A, B, C, D, E and F (Trewartha, 1954). It could be determined for a station if normal monthly rainfall and temperature data are available. Within A there are sub classifications such as Af, Aw and Am. For Af, rainfall of the driest month must be at least 6 cm. For Aw there should be winter dry season and at least one month receiving less than 6 cm rainfall. If a station is Aw with heavy summer rainfall it is called Am. If the climate is A but with rainfall maximum in winter it is called Aw' climate. In Sri Lanka both Colombo, Galle are of Af climate as the average monthly rainfall is more than 6 cm in every month. In all the other stations, the winter rainfall (Oct-Mar) exceeds the summer rainfall (Apr-Sep) and so they are classified as Aw'. In Tamil Nadu, stations which receive average annual rainfall of under 75 cm are likely to be classified as Bs steppe climate, where evaporation exceeds precipitation (E.g. Madurai). But in Sri Lanka the lowest annual rainfall realised is 90 cm over northwest coast and the temperatures are lower due to the maritime effect. As such Bs climate does not seem to prevail over Sri Lanka.

10. During the 52-year period 1971-2022 Sri Lankan east coast has been crossed by 13 depressions and higher intensity systems out of which 5 reached cyclonic storm intensity and 2 reached severe cyclonic storm intensity (Intensity at crossing) (Fig.6a). One could therefore draw the conclusion that cyclonic storms are not a major threat to Sri Lankan coast as they are to Indian east coast. But the Dec 1964 Pamban cyclone which crossed Sri Lankan coast and then Tamil Nadu coast (Fig.6b) was very severe with reported maximum wind of 120 knots at the time of crossing and caused extensive damage and loss of lives over Sri Lanka and Tamil Nadu.

11. In India extensive data sets are available providing onset and withdrawal dates of southwest monsoon over /from India and that of northeast monsoon over / from southern Indian region. Such historical data archives date back to the year 1901 or in some instances even to 1871 and have served as base for further involved research work on monsoons. The normal date of northeast monsoon onset over southern Indian region is 20 October and the normal withdrawal date from Coastal Tamil Nadu is within the pentad 26-30 December. Large number of studies on the various aspects of Indian northeast monsoon have been completed and papers published. Both onset and withdrawal patterns of northeast monsoon are clearly defined over most of the stations of Sri Lanka as inferred from the monthly rainfall distribution. It can also be deduced that, despite Sri Lanka being a relatively small country, the withdrawal date might have a wide spatial range with the occurrence of withdrawal over Batticaloa substantially later than that over Jaffna.

But onset and withdrawal dates of northeast monsoon over the Sri Lankan region both yearwisee and normal are not readily available in the literature. If this problem has not been addressed so far, it will be fruitful and worthwhile for researchers to undertake such an exercise. Weather charts can be generated for any date and satellite imageries, outgoing long wave radiation (OLR) data, satellite sensed sea surface winds such as Quick SCAT and ASCAT winds are also readily available. But in addition authentic daily rainfall data of all days of the year for at least 50 years and 30 stations representing all regions of Sri Lanka is a must for such a study to be undertaken. Onset and withdrawal dates of northeast monsoon over Sri Lanka could be determined region wise, for the northern, southern and eastern region separately for 50 years. Such sets of dates could be compared with the dates of Southern Indian region, which are readily available and inferences could be made. Normal and standard deviation of onset and withdrawal dates could be determined and could be compared with the dates already derived for Southern Indian region.

12. The true extent of northeast monsoon prevailing over the Indian subcontinent can be correctly appraised only if the withdrawal dates over Eastern Sri Lanka both for individual years and normal dates are known. Monsoon does not have any boundaries and to have complete understanding of the northeast monsoon over the south Indian region, we should also have a deeper understanding of this winter monsoon over Sri Lanka which is our nearest neighbouring country. ■

Acknowledgements. The authors have freely used material from Internet and also from various published papers and articles. The same is acknowledged with gratitude.

Fig.1. Geographical Map of Sri Lanka

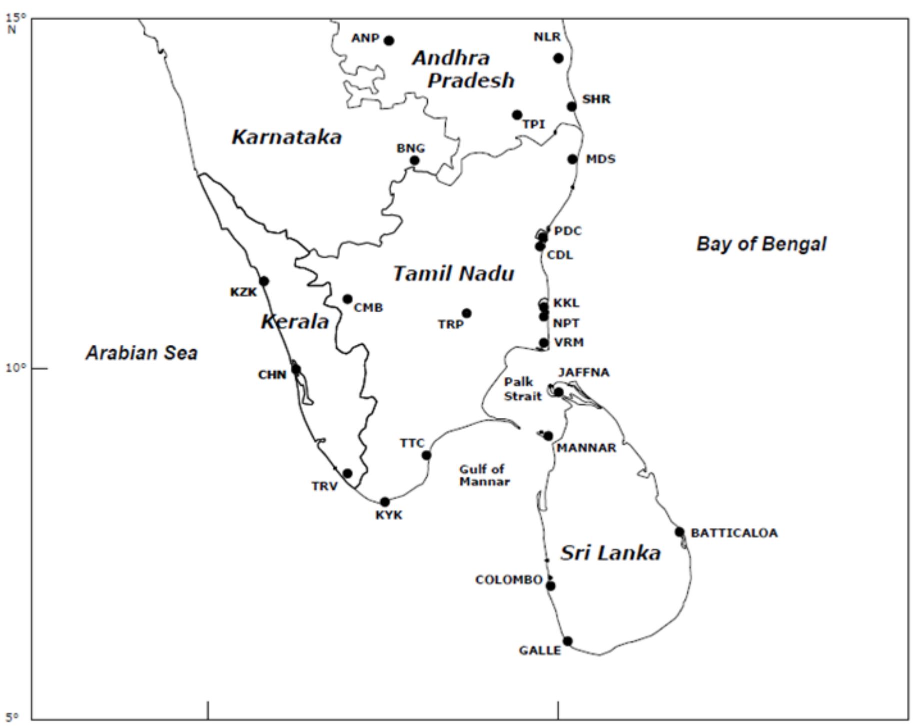


Fig.2. Map depicting Sri Lanka and Southern India

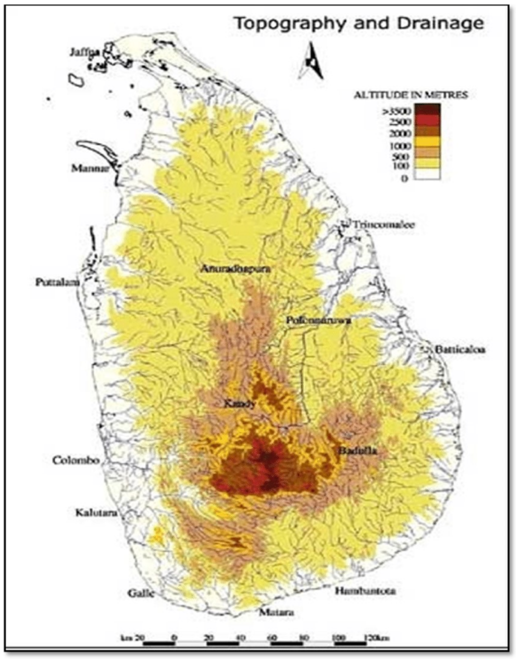
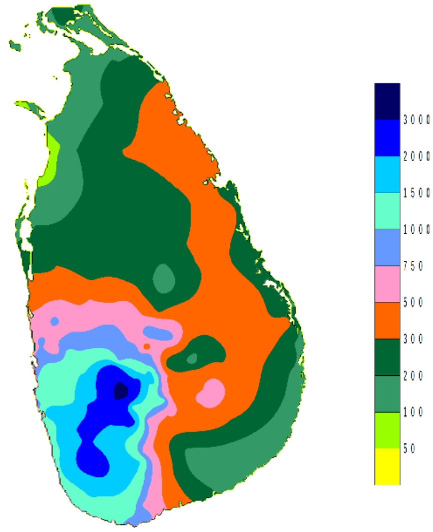
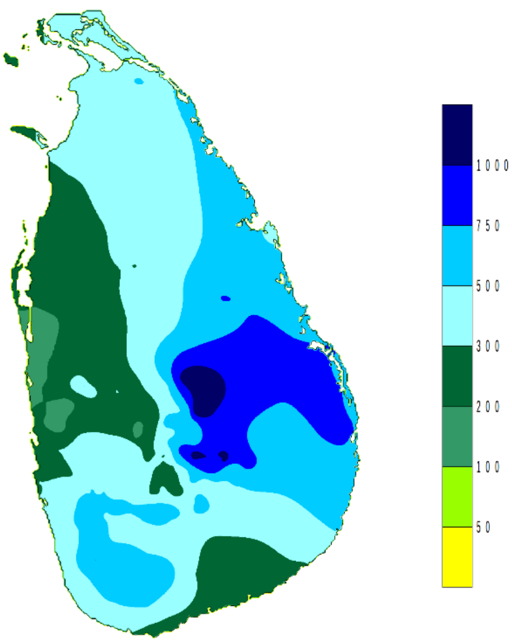
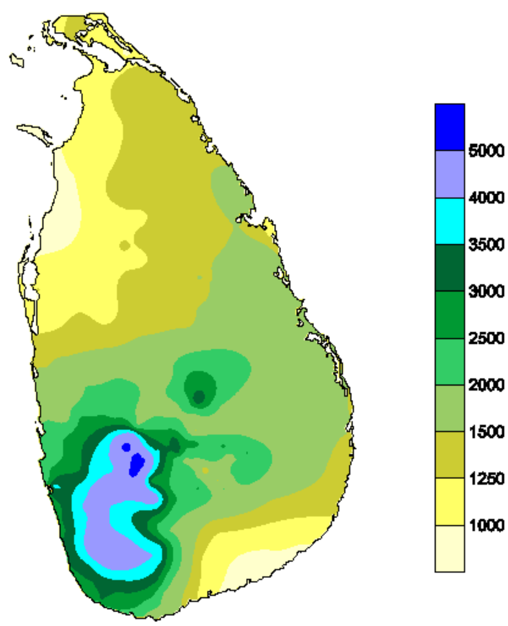


Fig.3. Sri Lanka Elevation map



May-Sep





Dec-Feb   Fig.4. Normal annual rainfall of Sri Lanka   Annual

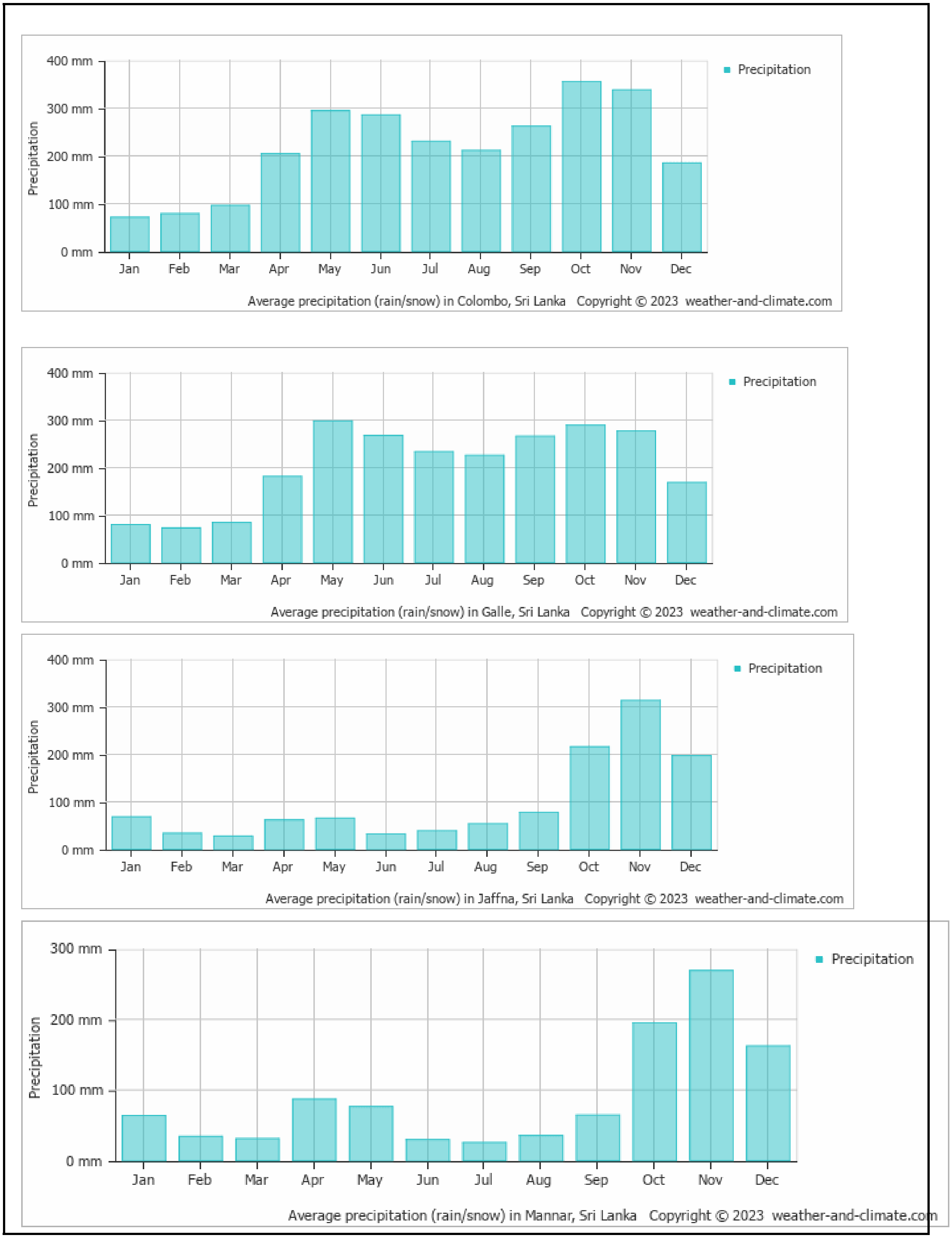


Fig 5a. Average monthly rainfall of Colombo, Galle, Jaffna and Mannar

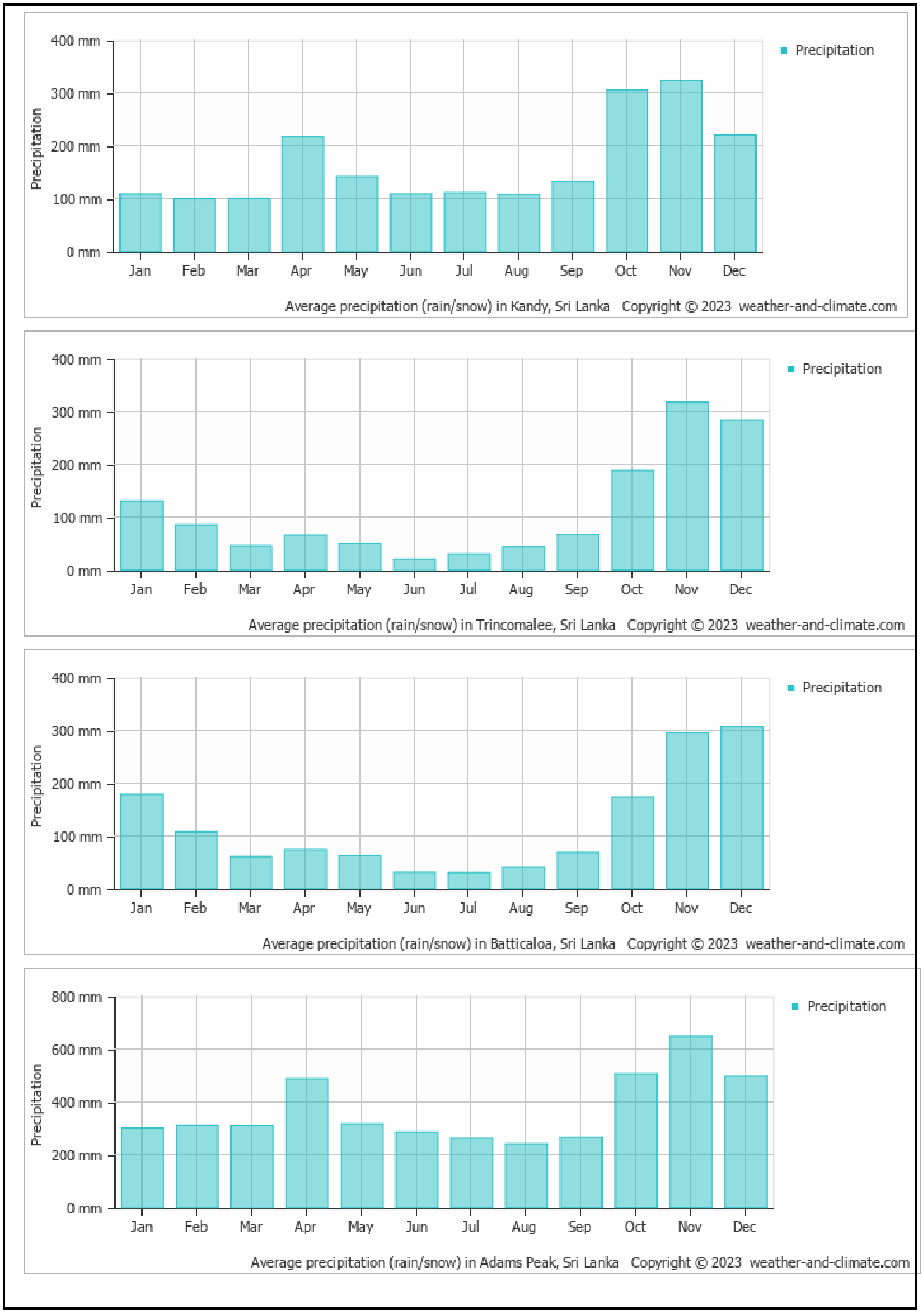


Fig 5b. Average monthly rainfall of Kandy, Trincomalee, Batticaloa and Adams Peak

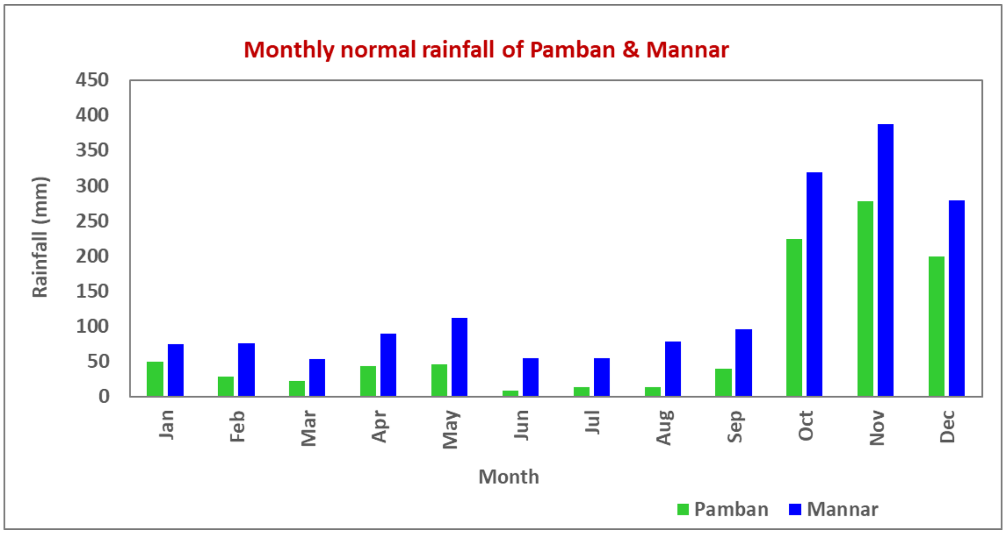


Fig.5c.

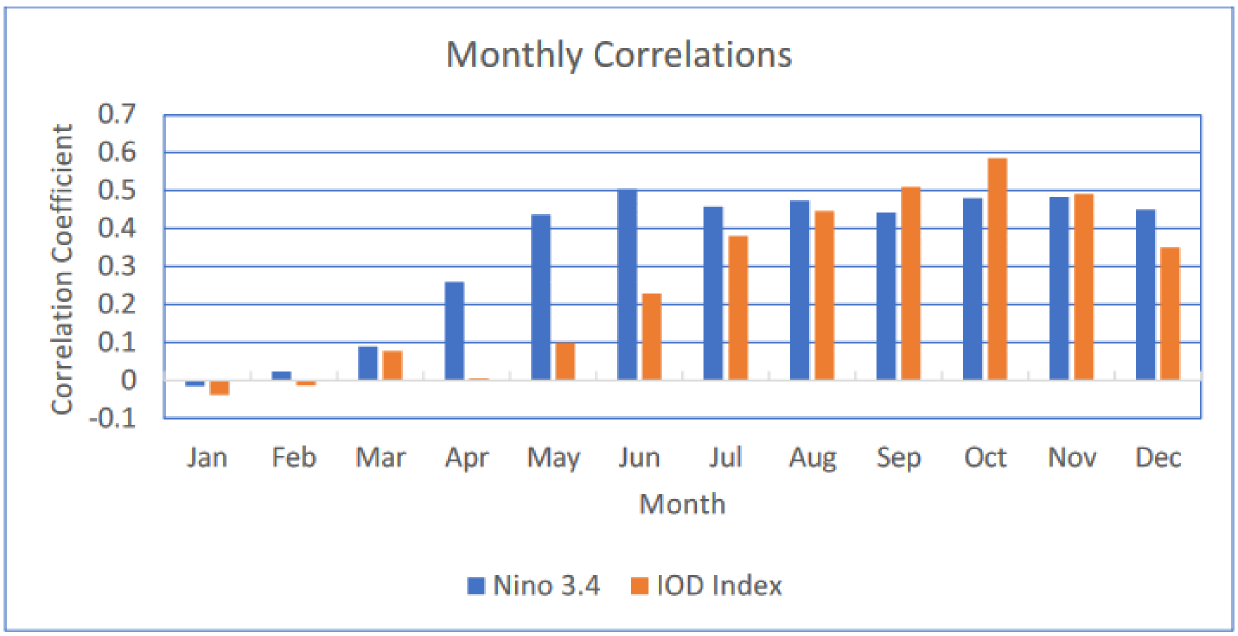


Fig. 6. Monthly correlations between Nino 3.4 (Blue) and IOD index (red) with OND NE monsoon rainfall of Sri Lanka . Data of 1961-2021 was used

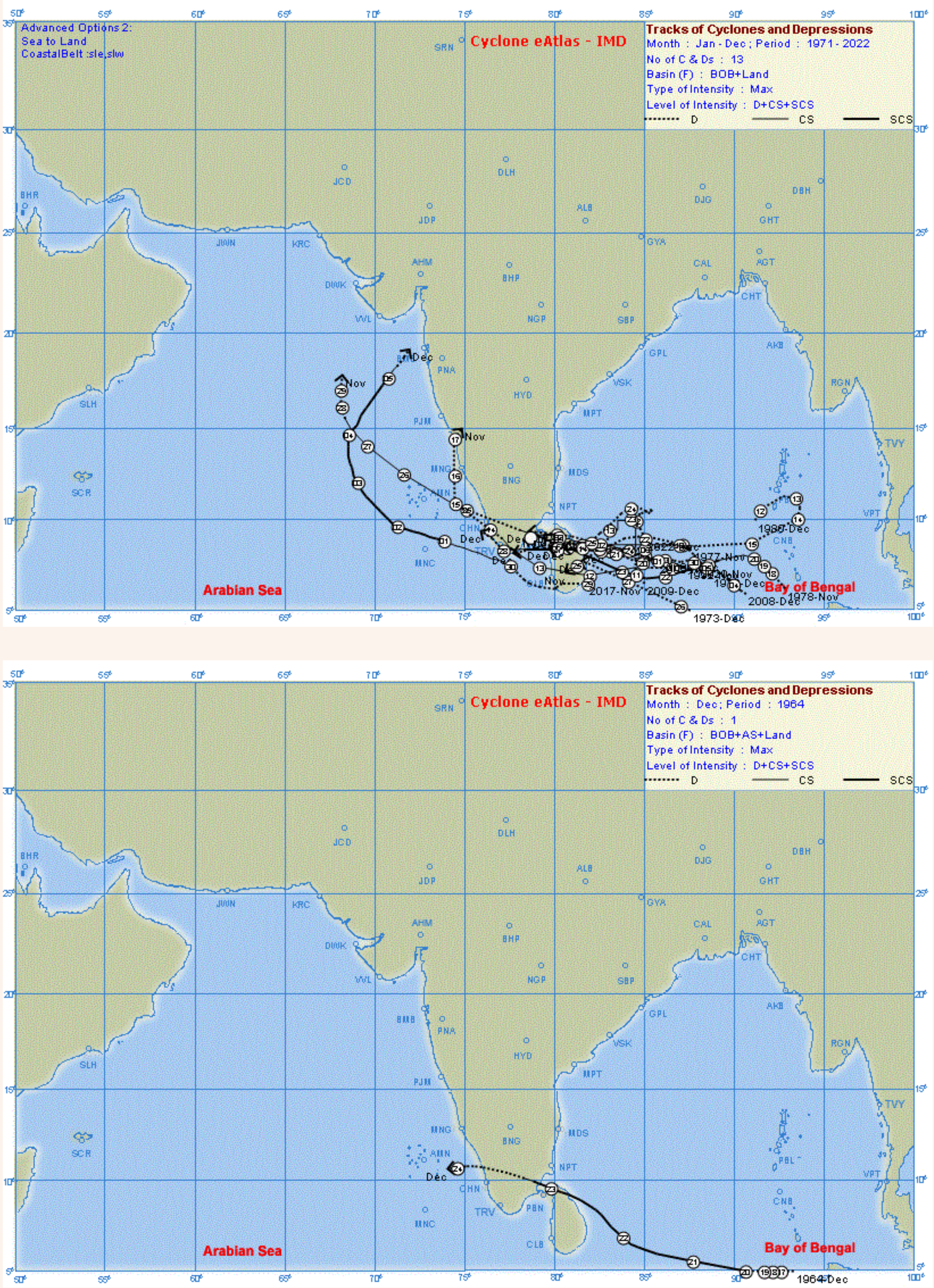


Fig.7. Tracks of Cyclonic disturbances (13 no.) crossing Sri Lanka coast during 1971-2022 and Track of Pamban cyclone Dec 1964

SOUTHWEST MONSOON -2023

R. NALLASWAMY

METEOROLOGIST (Rtd- IMD)

HIGHLIGHTS

- Rainfall over the country as a whole during monsoon season (June-September), 2023 was 94% of its long period average (LPA).
- Seasonal rainfalls over Northwest India, Central India, South Peninsula and Northeast (NE) India were 101%, 100%, 92% and 82% of respective LPA.
- The southwest monsoon seasonal (June to September) rainfall over the monsoon core zone, which consists of most of the rainfed agriculture regions in the country received 101% of LPA and thus was normal (94-106% of LPA).
- Out of the total 36 meteorological subdivisions, 3 subdivisions constituting 9% of the total area of the country received excess, 26 subdivisions received normal rainfall (73% of the total area) and 7 subdivisions (18% of the total area) received deficient season rainfall. The 7 Meteorological subdivisions which got deficient rainfall are Nagaland, Manipur, Mizoram & Tripura (NMMT), Gangetic West Bengal, Jharkhand, Bihar, East UP, South interior Karnataka and Kerala.
- Monthly rainfall over the country as a whole was 91% of LPA in June, 113% of LPA in July, 64% of LPA in August, and 113% of LPA in September.
- Southwest monsoon current advanced to south Andaman Sea and Nicobar Islands in time (on 19th May, 3 days ahead of its normal date). However, further advance thereafter was sluggish. It set in over Kerala on 8th June, 7 days behind the normal date and covered the entire country by 2nd July, 6 days ahead of normal date. Monsoon withdrawal commenced from west Rajasthan on 25th September (with a delay of 8 days).
- The forecast for monsoon onset over Kerala for this year was correct, which is the seventeenth consecutive correct forecast for this event except year 2015 since the commencement of this forecast in 2005. The Forecast date of onset of monsoon over Kerala was 4th June with a model error of ± 4 days and monsoon set in over Kerala on 8th June.
- The forecasts for the rainfall over the country as whole during the season as a whole could be predicted well as the realized rainfall is 94% of LPA against the forecast of 96% ± 4%.

Onset, advance and withdrawal of Southwest Monsoon 2023.

The advance of Southwest Monsoon began on 19th May in the Southeast Bay of Bengal, Nicobar Islands and South Andaman Sea due to persistent westerly winds and rainfalls. It progressed systematically and reached Kerala on 8th June 7 days after the normal on set of 1st June. It further progressed and covered the entire country on 2nd July remarkably 6 days ahead of normal date of 8th July 2023.

FIG3. Track of the low pressure systems formed during 2023 monsoon season. These low-pressure systems helped to get good amount of rainfall in July and September. Out these low-pressure systems one intensified into an extremely Severe Cyclonic Storm [BIPORJOY] FORMED OVER Northeast Arabian Sea during6th to 19th June. There were monsoon depressions during August [1-3 August and another on 30th September against normal frequency of 6. The tracks of the cyclone and depressions formed during 2023 southwest monsoon season is given in.

2. Chief Synoptic Features

During the season, there were 14 low pressure systems formed in the Indian region. The track of low pressure systems are given in **Fig.3**. Their month-wise frequency and intensity is given in the **Table 1** below.

Table 1. Number of low pressure systems in SW Monsoon 2023

Month	L	WML	D	DD	ESCS	Total
June	0	2	0	0	1	3
July	4	1	0	0	0	5
August	1	0	0	1	0	2
September	2	3	0	0	0	5
Monsoon-23	6	6	0	1	1	14

L : Low, WML: Well marked low, D: Depression, DD: Deep Depression, ESCS: Extremely severe cyclonic storm.

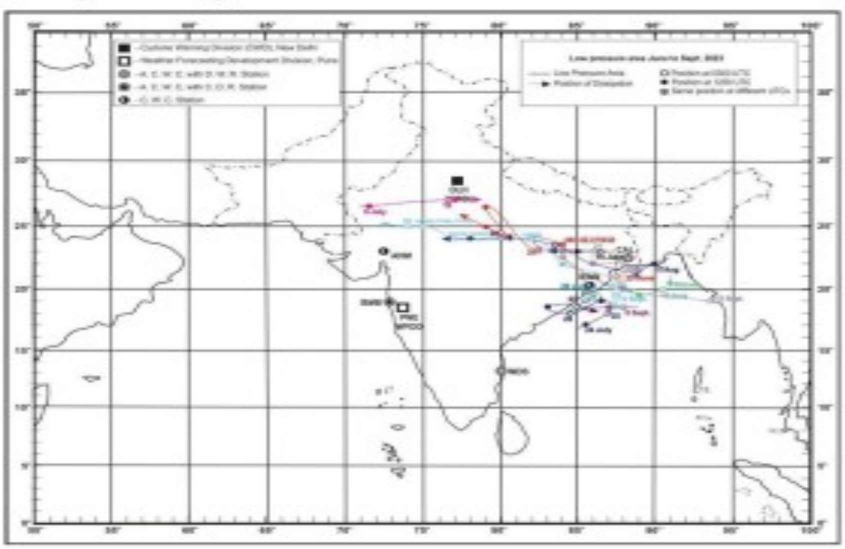
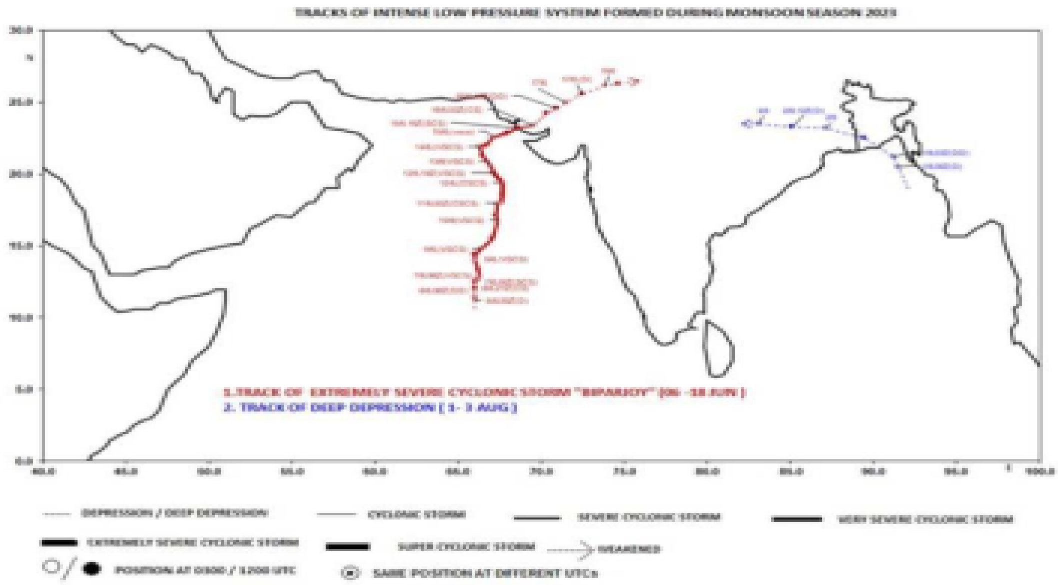


Fig.3: Track of the low pressure systems formed during 2023 monsoon season.

Fig 4 Monsoon Depressions and Cyclonic Storm



Rainfall Distribution

The realized 2023 southwest monsoon season [June to September] rainfall over the country as a whole and four broad geographical regions are given in the table below along with respective long period average[LAP] Values during the 4 months and the second half of the monsoon season[August to September] over the country as a whole are given Table 2.

As seen in the table above, the 2023 season rainfall over the country as a whole [94% of LPA was less than the long period average [LPA].The seasonal rainfalls over two of the four geographical regions 0f the country [except Northwest India and Central India]was also less than the respective LPAs. The highest rainfall [101% of LPA was received by Northwest India and lowest rainfall [82%of LPA] was received by East and Northeast India. Central India and East and South India received season rainfalls of 100% of LPA and 91% of LPA respectively The monthly rainfall over the country as a whole were less than LPA during two months of the season[91% of LPA during two months of the season [91% of LPA in June,64%of LPA in August] and were more than LPA during the months July[113% in July] and September [113% of LPA]

Country as a whole received rainfall 105% of LPA during the 1st half [91% of LPA] in June and 113% of LPA in July] which was more than that during the second half [83% of LPA] WITH 64% of LPA in August and 113% of LPA in September. Thus the 4 months, rainfall deficiency was highest in August and rainfall was excess in July and September. Fig 5 shows the subdivision wise season [June to September] rainfall.

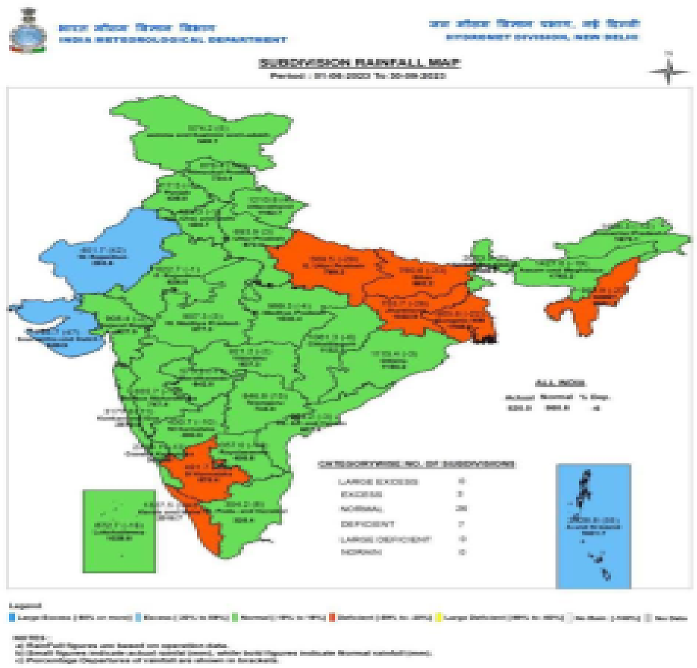


Fig.5: Sub-division wise rainfall distribution over India during southwest monsoon season (June to September) – 2023.

Out of 36 Meteorological subdivisions,3 subdivisions constituting 9% of the total area of the country received excess,26 subdivisions received normal rainfall [73% of the total area] and 7 subdivisions whish got deficient rainfall are Nagaland, Manipur, and Tripura[NMMT], Gangetic West Bengal, Jharkhand, Bihar, East UP, South Interior Karnataka and Kerala.

Subdivisions wise monthly rainfall distribution over India during southwest monsoon season-2023

Fig 6 shows the subdivision wise monthly rainfall ,8 subdivisions received excess rainfall, 6 subdivisions received normal, and 19 subdivisions received deficient rainfall. Most noticeable feature of rainfall distribution during June was the large spatial variability over Northwest India.

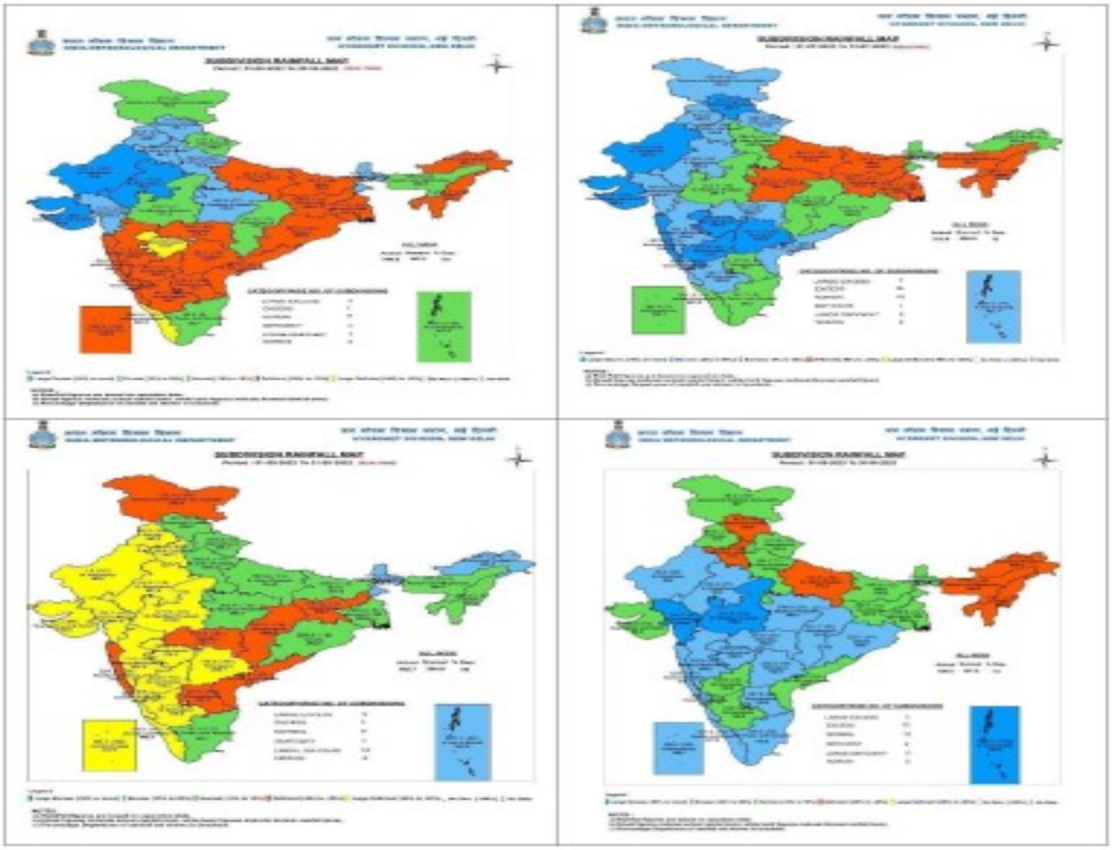


Fig.6: Sub-division wise monthly rainfall distribution over India during southwest monsoon season – 2023

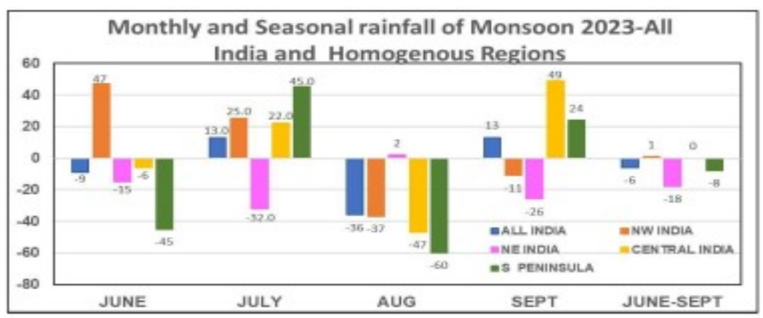


Fig.7. Monthly and seasonal monsoon rainfall of 2023 over Broad homogenous region and Country as a whole in % departure

Fig 8. Week by week progress and cumulative rainfall (% departure from normal) over Country as a whole

During the season, there were 14 low pressure systems formed in the Indian region.

The tracks of the low-pressure systems are given in Fig3.Their month-wise frequency and intensity is given in the Table 1 below.

Verification of Long-Range Forecast

India Meteorological Department [IMD] uses statistical and dynamical [Climate Models]methods ,to be issue seasonal forecast since 2021.IMD has adopted a new strategy for issuing monthly and seasonal operational forecasts for Southwest monsoon rainfall over the country. This new strategy modifying involves the existing two-stage forecasting approach and is based on both the existing statistical forecasting system and the newly developed Multi-Model Ensemble[MME]based forecasting system introduced in 2021.The MME approach utilizes coupled global climate models[CGCMs] from various global climate prediction and research centers, including IMD'S Monsoon Mission Climate Forecasting System[MMCFS] model.

Verification of forecast of El Nino, IOD and MJO conditions

While issuing the long-range forecast in the month of April, ENSO Neutral conditions prevailed over Pacific Ocean. IMD correctly predicted development of weak/moderate EL Nino condition during the monsoon seasonal and emergence of positive normal rainfall [96%+/-4% of LPA] likely to be during the southwest monsoon and also indicated the negative impact of El Nino will be compensated by the factors like IOD. The observed seasonal rainfall was 94% od LPA which is very close to lower limit of normal category and within the error limit of the forecast. It may be noted that the Core Monsoon zone [area where agricultural mainly depend on rain fall]received 101% of LPA and IMD correctly indicated the rainfall situation over the region. The emergence of the positive IOD during end of August was predicted in the press release on31st August.

The favourable and unfavourable phases of MJO were predicted every Thursday for next two weeks and hence the dry and wet spells of monsoon.

Automatic Nowcast system during North East Monsoon (RACAST)

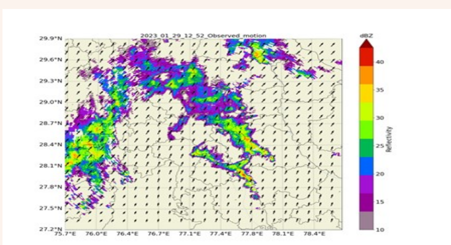
Bibraj R, Scientist-C

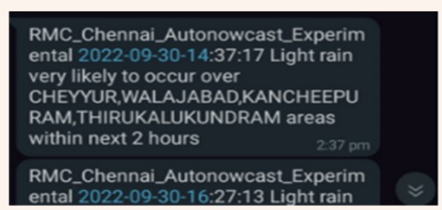
Thunderstorms are meso-scale systems which occur in time scales of an hour to several hours and in spatial scale of few kilometers to hundreds of kilometers. Thunderstorms and its associated weather events have the potential to cause loss of lives as well as economic loss (Selvi and Rajapandian, 2016; Bhardwaj *et al*., 2017). The frequency of thunderstorms increases sharply in the premonsoon season over entire region of India (Tyagi, 2007). State disaster management authorities expect early warning of thunderstorms to effectively reduce the casualties as well as damage to their infrastructure and agriculture crops caused by heavy rainfall, hailstorm, lightning, dust storms and strong winds which are the severe-weather phenomena associated with thunderstorms. Early warning of thunderstorm is a challenge due to their highly localized phenomena, short life period and limited observational network (Sen Roy *et al*., 2019). Observational networks are being upgraded and expanded on a large scale for better prediction of thunderstorms. Doppler Weather Radar has proved to be an important tool for forecasters to issue thunderstorm warnings as the DWR products provide useful information on the various characteristics of the thunderstorms. India Meteorological Department currently has installed 25 Radars in which 5 radars are dual polarized and the remaining radars are single polarized. The S band Single polarization Doppler radars have large spatial coverage of 500 km radius and provide base products such as reflectivity, radial velocity and spectrum width round the clock with a scan interval of ten minutes (Pradhan *et al*., 2012). Dual-Polarization Radars have additional base products such as differential reflectivity, correlation coefficient and specific differential phase which can be effectively used along with single-polarization base

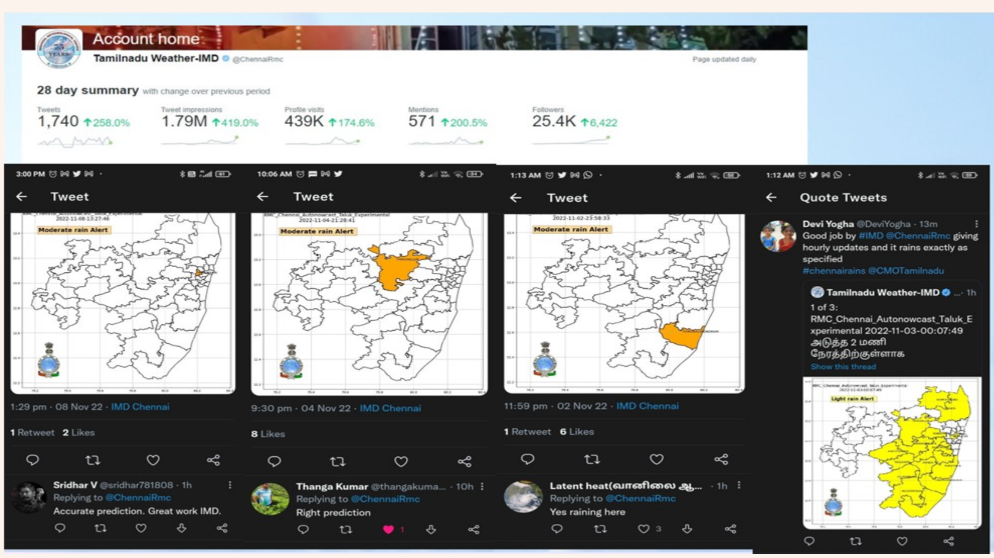
products to classify the different hydro-meteor types observed by the Doppler radar (Lim *et al*., 2005). Many expert systems have been developed based on Doppler weather Radar products to identify the features of the radar echo and provide usable now-casts for 0-3 h period using various techniques as detailed in Sen Roy *et al*. (2019). Forecaster's make use of data available from various observation along with expert systems to issue accurate now-cast alerts to the public/disaster management authorities. These alerts are issued for the geographical region of all districts and selected cities. The alerts are disseminated through various communication medium such as website, email and SMS. A simplistic approach for operational now-casting would be to analyze the DWR products such as MAX(Z), PPI(Z), PPI(V) every 10 minutes and find if there are any thunderstorm signatures in a particular district/city, then draft the warning message and finally update the communication channels to alert theauthorities. This could take several minutes depending on time taken for DWR products to update in the website, analysis time and time taken to disseminate the information. Attempts have been made to issue automatic alerts using DWR data using various algorithms by Hering *et al.* (2015); James *et al.* (2018) and Bally (2004) to reduce the time taken for the alerts to reach the users. As thunderstorm is a mesoscale event, the lead time for warning is less and any increase in the lead time can lead to significant improvement in the response by the end users.

A system (RALERT) was designed using open_source libraries to issue thunderstorm alerts to the endusers automatically without manual intervention. The volumetric data generated from the Radar is used as the primary input. Identification of severe weather like Thunderstorm, Rainfall and lightning from Radar data by applying various thresholds has been shown by Voormansik *et al*. (2017); Li *et al*. (2012); Yang *et al*. (2020) and Shi *et al.* (2019). Vincent *et al.* (2004) had provided a reflectivity and height threshold for prediction of cloud to ground lightning. A similar approach was used in the system to predict the formation of Thunderstorms. Though meteorological events are not constrained by administrative boundaries, the forecaster's at state level are entrusted with providing thunderstorm warnings for each district/city. The geographical information of each district and city is also provided as one of the input to the system. Once the analysis is done the forecaster disseminates the information through website, SMS and email. The system essentially performs the complete process automatically, based on the thresholds of the severe weather, an automatic analysis is done on the Radar data and if any signature of the severe weather is present in the given geographical boundary, the warning is disseminated to the concerned authorities through email, SMS and represented through a live Display.

An advancement to the RALERT software is the RACAST software generates the nowcast from the past radar data and generates alerts based on the nowcast output. The short term ensemble prediction system is used for probablistic nowcast generation. The alerts are generated based on the probability thresholds provided in the configuration of the system. The observed reflectivity and the motion vectors are shown in the Figure . Based on the movement of the cloud cells in the next two hours, the alerts are generated in different taluks. The alerts are disseminated through whatsapp, email as well as social media handles such as twitter and facebook as shown in figures







Salient features of Northeast Monsoon – 2022

Dr. B.Geetha, IMD Chennai

During the year 2022, the southwest monsoon withdrew from the Indian region on 23rd October and the Northeast monsoon (NEM) of 2022 commenced over the southeastern parts of peninsular India on 29th October against the normal date of 20th October. All the five meteorological sub divisions benefitted by the NEM [Tamil Nadu, Puducherry & Karaikal (TN), Coastal Andhra Pradesh & Yanam (CAP), Rayalaseema (RYS), Kerala & Mahe (KER), and South Interior Karnataka (SIK)] received **normal to excess** rainfall during the NEM season (October-December) (Table-1).

Table-1: Seasonal sub-divisional rainfall during October-December 2022

OCT-DEC 2022			
Met sub division	Actual rainfall (mm)	Normal rainfall (mm)	PDN (%)
CAP & Yanam	**341.7**	**322.9**	6
RYS	**288.1**	**236.4**	22
TN, PDC & KKL	**445.6**	**443.3**	1
SIK	**300.1**	**199.0**	51
KER & Mahe	**476.2**	**492.0**	-3

Two cyclones, two depressions & one well marked low pressure area were the major synoptic systems that formed over the Bay of Bengal during the season. The **Cyclonic storm (CS)** ‘***Sitrang***’ over the Bay of Bengal during 22nd-25th October moved northwards (Fig.1) and crossed Bangladesh coast and delayed the commencement of the NEM. The **Severe Cyclonic Storm (SCS)** ‘***Mandous***’ over the Bay of Bengal during 06th-10th December crossed coast close the **Mamallapuram** (north Tamilnadu) (Fig.1) around the midnight of 09th December as a cyclonic storm with maximum sustained surface wind speed of **65-75 kmph gusting to 85 kmph**. Associated with the passage of cyclone ‘Mandous’, *very heavy to extremely heavy* rainfall occurred over the extreme north Tamilnadu and adjoining Rayalaseema with Vembakkam (Thiruvannamalai district, TN), Srikalahasti (Chittoor district, RYS) & Thottambedu (Chittoor district, RYS) reporting **25 cm, 23 cm & 22 cm** respectively during the 24-hour ending 0830 IST of 10th December.

Two **Depressions** that formed over the Bay of Bengal – one in November (20th-22nd) and another in December (22nd-25th) did not contribute significantly to NEM rainfall over the peninsular India. Whereas the 20th-22nd November Depression weakened off North Tamilnadu coast, the Depression during 22nd-25th December crossed Sri Lanka coast, and weakened gradually.

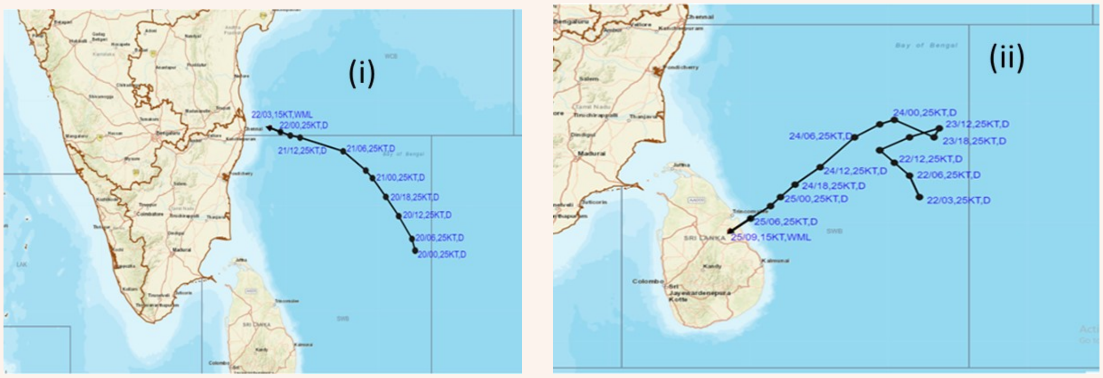


Fig.2: Tracks of Depressions over the Bay of Bengal (i) during 20-22 Nov 2022 & (ii) during 22-25 Dec 2022

However, associated with the passage of a **Well marked Low pressure area (WML)** during 09th-13th November, isolated *heavy to very heavy/ extremely heavy* rainfall occurred during 12th-16th November with **Sirkazhi** (Mayiladuthurai district) reporting **44 cm of rain** followed by Kollidam (Mayiladuthurai district): **32 cm**, Chidambaram (Cuddalore district): **31 cm**, Annamalai nagar (Cuddalore district): **28 cm** & Bhuvanagiri (Cuddalore district): **21 cm** during the 24-hr ending 0830 IST of 12th November. Under the influence of this event, the seasonal rainfall of TN which was 'minus 4%' on 10th November rose to 'plus 15%' on 17th November.

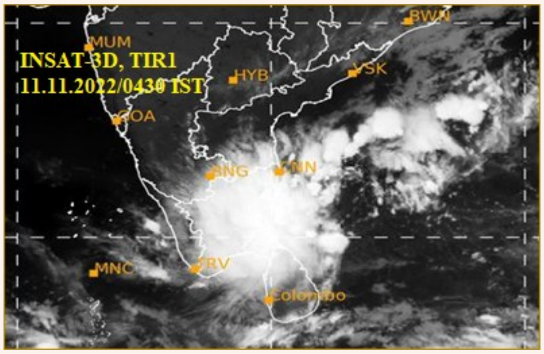


Fig.2 Satellite imagery associated with well marked low pressure area as on 11.11.2022/ 0430 IST

Under the influence of various synoptic systems, upper air cyclonic circulations and east-west shear zone over the southern peninsula there were 18 days of *active* to *vigorous* monsoon conditions over TN, SIK & KER during the season. Also, there were **51** days of *isolated heavy* rainfall activity with 20 days of *isolated very heavy* rain including 04 days of *isolated extremely heavy rainfall* activity over TN. After the Depression during the last week of December, with the gradual decrease in rainfall activity, the cessation of NEM 2022 rainfall over peninsular India was declared on **12.01.2023**.

Are we alone in Nature ?

Pradip Kumar Pal

In Nature, there is a huge jungle of stars, called Universe. We call it Universe, because it is supposed to be unique in Nature. There may be multiverses from which we do not receive any light as of today, but they may exist in our imagination. If they really exist, we do not know whether they are similar to or mirror image of our Universe. In this Universe jungle there are a large population of stars from which we receive light and many others from which we do not receive any light. Actual number of them is not known as they can not be counted in the vast Universe, which is continuously expanding in all directions with time. We also do not know the shape or size of the Universe. It may be expanding like a sphere, or ellipse, or a cylinder or just like an infinite flat plain. In this jungle there is one very hot star called Sun which may be considered as our grandmother. The Sun may be considered as a spherical container of gases which is spinning around its own vertical axis and radiating energy in all directions. Long ago, some parts of the Sun came out of it and gave birth to eight planets which are rotating around the Sun. It is not known whether they all came out at the same time or at different times one by one. They are called Mercury,Venus, Mars, Earth, Jupiter, Saturn, Uranus and Neptune. For some time it was believed that there was one more planet Pluto, farthest from the Sun, but later it was thrown out of the planet family, because it was not following the laws of Nature to be in the same category of planets. Planet Earth is considered to be our mother. All other planets are our maternal uncles and aunts. The planets having its own natural satellites may be considered as aunts and the rest may be considered as uncles. The Earth has one natural satellite, called Moon, which may be considered as our sister, as it came out from mother Earth and rotating around it. In our mother Earth, there are a large number of various living beings like plants and animals. There are countless species of plants and micro animals. All these species are surviving with the energy received from the Sun. Some species are getting extinct with time and some new species are getting formed with time. Some species called homo-sapiens gradually evolved into our form, called human, which is supposed to be having intelligence to think and imagine. Though the number of these so called intelligent human beings is finite, but that number is continuously increasing with time, like the natural law of expansion of the Universe, and we do not know what is the tipping point for our mother Earth to hold and survive. Sometimes these intelligent beings behave in such a way that as if they are digging their own grave and waiting for a catastrophe to happen. At the same time, they are progressing in such way that they started venturing into other maternal uncle and aunt planets whether they can settle there in future. We do not know as of today whether there is such intelligent beings in some other planet family of some other star of our Universe, but search is going on. So, today we can only tell that ‘We are alone in the Nature’, till we find such a silly story by some other intelligence at some other place in the jungle of our Universe.

Photographs of the event “Meteorology and Oceanography in Higher Educational Institutes” 25-10-2023, RMC,

Photographs of the event "Seminar on Meteorology and Celebration of 150 years of India Meteorological Dept" 30.03.2024, SRM IST, Vadapalani

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Seminar organised on meteorology and oceanography in higher education

The seminar focused on education, career, and research opportunities in the fields

Published - October 26, 2023 09:18 pm IST - CHENNAI

THE HINDU BUREAU

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The Indian Meteorological Society, Chennai Chapter (IMSCC) organised a seminar on 'Meteorology and Oceanography in Higher Education Institutions' at the Regional Meteorological Centre in Chennai on Thursday. The seminar focused on education, career, and research opportunities in meteorology and oceanography through scientific talks by T.V. Lakshmi Kumar, Chairman, IMSCC, and T. Suthakar, former scientist, National Institute of Ocean Technology. A panel discussion chaired by senior meteorological scientist N. Jayanthi on the curriculum in higher education institutions was also held. *Breeze*, IMSCC's newsletter was also released on the occasion, said R. Nallaswamy, IMSCC

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IMD is in the process of enhancing weather prediction tools to maximise forecast accuracy

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THE HINDU BUREAU

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India Meteorological Department (IMD) is in the process of enhancing its weather prediction techniques to maximise forecast accuracy.

பொழில் எனும் மழைக்காடு

முனைவர் கு.வை. பாலசுப்பிரமணியன்

Retired Meteorologist, RMC Chennai

மழைக்காடு என்பது அதிகமான மழைப்பொழிவினால் உருவாகும் காடுகளாகும். பொதுவாக இக்காடுகள் உள்ள பகுதிகளில் ஓராண்டில் குறைந்தது 172 முதல் 198 செமீ மழை பெய்யும். மழைக்காடுகள் மிகவும் மென்மையான அல்லது சூடான காலநிலைகளைக் கொண்டிருக்கின்றன மற்றும் உலகில் பல்லுயிரிகள் மிக அதிகமாக வாழும் பகுதிகளாகவும் உள்ளன. கூடுதலாக, வெப்பமண்டல மழைக்காடுகள் "பூமியின் நுரையீரல்" எனக் கருதப்படுகின்றன, ஏனெனில் இங்கே அதிக அளவு ஒளிச்சேர்க்கை ஏற்படுகிறது; அதாவது கரியமில வாயு உள் வாங்கப்பட்டு, உயிர்வளி வெளியிடப் படுகிறது.

படம் 1: மழைக்காடுகள்

தமிழகத்தில் கொடைக்கானல், ஊட்டி பகுதிகளில் சோலைக் காடுகள் (shola forests) பல காணப்படுகின்றன.

இவை புல்வெளியும் அதன் நடுவே காடுகளும் அமைந்த மலைச் சரிவுப் பகுதிகளாகக் காணப்படும். மழைக்காடுகளைத் தமிழில் **பொழில்** என அழைக்கிறார்கள். ‘பொழிதல்’ என்ற சொல் ‘மழை பெய்தல்’ எனப் பொருள்படும். இதுவே காடுகளுக்காகிவந்து ‘பொழில்’ என்று மாறிவிட்டது. இச்சொல் இன்றைய அறிவியலில் மழைக்காட்டினைக் குறிக்கப் பயன்படுகிறது.

அதிக மழையும், சூடான தட்பவெப்பமும் உயரமான மரங்களும் கொண்ட பூமத்தியரேகைப் பகுதியில் இத்தகைய காடுகள் காணப்படும். இந்த மழைக்காடுகள் ஆப்பிரிக்கா, ஆசியா, ஆஸ்திரேலியா, மத்திய மற்றும் தென் அமெரிக்கப் பகுதிகளில் பரவியுள்ளது. இப்பூமியின் பரப்பளவில் இரண்டு பங்கிற்கும் குறைவாகவே இருந்தாலும் இவ்வுலகின் ஐம்பதுக்கும் மேற்பட்ட தாவரங்களையும் விலங்குகளையும் இக்காடுகள் தன்னகத்தே கொண்டுள்ளன. உலகில் வேறெங்கும் வசிக்காத உயிரினங்கள் பலவற்றை இம்மழைக்காடுகளில் காணலாம்.

படம் 2: மேற்குத் தொடர்ச்சி மலைப் பகுதியில் காணப்படும் மழைக்காடுகளில் வாழும் சில சிறப்பு விலங்குகள் (அ) கருஞ்சிறுத்தை, (ஆ) செந்நாய், (இ) யானை, (ஈ) காட்டுமாடு

பூமத்திய ரேகைக்கு அருகாமையில் அமைந்துள்ளதால் அதிக சூரிய ஒளியைப் பெற்று தாவரங்கள் ஒளிச்சேர்க்கை புரிகின்றன. இதனால் தாவரங்களில் சேமிக்கப்பட்ட அதிகமான இச்சக்தி மழைக்காட்டிலுள்ள விலங்குகளுக்கு உணவாக அமைகிறது. அதிக உணவு இருப்பதால் அதிக விலங்குகளும் மழைக்காடுகளில் வாழ்கின்றன. இப்புவியின் உயிர்ச்சூழ்நிலைக்கு மழைக்காடுகளின் சேவை மிகவும் முக்கியமானது. ஏனெனில் மழைக்காடுகள் பலவிதமான தாவரங்களுக்கும் விலங்குகளுக்கும் உறைவிடமாகிறது. உலகின் தட்பவெப்பநிலையை சமப்படுதுகிறது. வெள்ளம், வறட்சி மற்றும் மண்ணரிப்பிலிருந்து பாதுகாக்கிறது.

உலக அளவில் முக்கியத்துவம் வாய்ந்த சில மழைக்காடுகள் உள்ளன. அவற்றுள் ஹரப்பன் மழைக்காடுகள் ஒன்றாகும். இந்த மழைக்காடுகள் 98,555 ஹெக்டேரில் சுமத்ரா, இந்தோனேஷியா, ஜாம்பி என்று பல தீவுகளில் விரிந்து கிடக்கிறது. The British Royal Society for the Protection of Birds என்ற அமைப்பு ஒரு மில்லியன் மரங்களை நட்டு இந்த காடுகளை மறு உற்பத்தி செய்துள்ளனர். ஏனெனில் சுமத்திரா புலி, சுமத்திரா காண்டாமிருகம் போன்ற அழியும் நிலையில் உள்ள முந்நூறுக்கும் மேற்பட்ட பல உயரினங்கள் இந்த வனத்தில் வசிக்கின்றன.

ஆசியக்கண்டத்தில் உள்ள மற்றொரு முக்கியமான மழைக்காடு சிங்கராஜா மழைக்காடுகள் ஆகும். சிங்கராஜா வனம் இலங்கையில் அமைந்துள்ளது. இது UNESCOவால் பாதுகாக்கப்படும் தேசிய வனமாகும். இது இலங்கையின் தென் மாகாணங்களின் எல்லையில் இரத்தினபுரி, கலாலி, மாத்தறை மாவட்டங்களில் அமைந்துள்ளது. சிங்கராஜா வனம் கடல் மட்டத்தில் இருந்து 300 மீட்டர் முதல் 1170 மீட்டர் உயரம் கொண்ட மழைக்காடாகும்.

இலங்கையின் வெப்பமண்டல மற்றும் ஈரப்பதமான பசுமை மாறாத வனங்களில் மிகுதியாக இருக்கும் வனமாக சிங்கராஜ வனம் காணப்படுகின்றது. கோண்டுவானா நிலப்பரப்பின் நினைவுச்சின்னமான தாவரங்கள் சில இருக்குமிடமாகவும், கண்டப்பெயர்ச்சி குறித்த அறிவியல்

மற்றும் உயிரியல் சம்பந்தமான ஆய்வுகளினை மேற்கொள்வதற்கு சிறந்ததொரு தளமாகவும் விளங்குகிறது.

இது மலர்களின் பூர்வீக நிலமாக காணப்படுகின்றது. இங்கு 139 வகை தாவர இனங்கள் காணப்படுவதோடு அவற்றுள் சில அரிதானவையாகவும் திகழ்கின்றன. இங்கு விலங்கினங்களும் அதிகம். நாட்டின் 50 விழுக்காட்டிற்கும் மேற்பட்ட பாலூட்டிகள், பறவைகள் மற்றும் பட்டாம்பூச்சிகள் இங்கு காணப்படுகின்றன. இலங்கையை சேர்ந்த 20 உள்ளூர் பறவை இனங்களில், 19 பறவை இனங்கள் இந்த காட்டில் தான் வாழ்கின்றன. அதுமட்டுமல்லாது பயங்கரமான வன விலங்கினங்களான சிறுத்தை மற்றும் இலங்கையின் ஈரநில யானைகளின் வாழ்விடமாகவும் சிங்கராஜ வனம் காணப்படுகின்றது.

படம் 3: இலங்கையில் உள்ள சிங்கராஜக் காடு

இந்தியாவில் இவ்விதமான மழைக்காடுகள் அடர்ந்து இருப்பது மேற்குத் தொடர்ச்சி மலைப்பகுதிகளிலும்,

அஸ்ஸாம், அருணாசல பிரதேசம் போன்ற வடகிழக்கு மாநிலங்களிலும்தான்.

மழைக்காடுகள் மிகுந்திருந்த மேற்குத்தொடர்ச்சி மலைப்பகுதிகள் தேயிலை, காப்பி போன்ற ஒரே வகையான பயிர்த் தோட்டங்களுக்காகவும், நீர்மின் திட்டங்களுக்குகாகவும், மரம் வெட்டும் தொழிலுக்காகவும் கடந்த சில நூற்றாண்டுகளாக அழிக்கப்பட்டு வருகிறது. இதனால் மழைக்காடுகள் பல இடங்களில் முற்றிலுமாக அழிக்கப்பட்டு, தொடர்பற்று துண்டுதுண்டாகிப்போனது.

மேற்குத் தொடர்ச்சி மலையில் ஆனைமலைப் பகுதியிலுள்ள வால்பாறையில் கண்ணுக்கெட்டும் தூரம் வரை பச்சைப்பசேலென தேயிலைத் தோட்டங்களைக் காணலாம். காப்பி, தேயிலை, ஏலம், யூக்கலிப்டஸ் போன்ற ஒரே வகையான தாவரத் தோட்டங்களின் நடுவே இவை பயிரிடத் தகுதியில்லாத இடங்களில் இன்னும் அழிக்கப்படாத மழைக்காடுகள் சிறியதும் பெரியதுமாக ஆங்காங்கே தீவுகளைப் போல காட்சியளிக்கும். இவற்றை மழைக்காட்டுத்தீவுகள், துண்டுச்சோலை என்றும் அழைக்கின்றனர்.

இத்துண்டுச் சோலைகள் மிகவும் முக்கியத்துவம் வாய்ந்தவை. ஏனெனில் வால்பாறையைச் சுற்றிலும் ஆனை மலை புலிகள் காப்பகம், பரம்பிகுளம் புலிகள் காப்பகம், வாழச்சால் வனப்பகுதி, எரவிகுளம் தேசியப் பூங்கா, சின்னார் சரணாலயம் போன்ற இடங்களில் தொடர்ந்த பரந்து விரிந்து பாதுகாக்கப்பட்ட வனப்பகுதிகளாக அமைந்துள்ளன. இதனால் சுற்றிலும் வனத்தைக் கொண்ட வால்பாறை பகுதியில் பலவிதமான அரிய, அழிவின் விளிம்பில் இருக்கும் விலங்குகளையும், தாவரங்களையும் பார்க்க முடியும். இந்த உயிரினங்களுக்கெல்லாம் புகலிடமாக இத்துண்டுச் சோலைகள் உள்ளன.

ஒரு மழைக்காட்டு மர விதை முளைத்து, துளிர்விட்டு, நாற்றாகி மரமாக உயர்ந்து வளர்வதற்குள் பலவிதமான இன்னல்களை சந்திக்க நேரிடுகின்றது. வறட்சியிலிருந்தும், நாம் காட்டுக்குள் கொண்டு செல்லும், ஆடு,

மாடுகளிடமிருந்தும், அங்கு வாழும் தாவர உண்ணிகளிடமிருந்தும், சூரிய ஒளிக்காக, நீருக்காக அதனைச் சுற்றியுள்ள தாவரங்களிடமிருந்தும், களைச்செடிகளிடமிருந்தும் எல்லாவற்றிற்கும் மேலாக மரவெட்டியின் கோடாலியிடமிருந்தும் தப்பிக்க வேண்டும். ஒரு மரம், நடப்பட்டத்திலிருந்து 15 மீட்டர் வரை வளர்வதற்கு சுமாராக 12 ஆண்டுகள் பிடிக்கிறது.

தாவரங்களைப் போல, மழைக்காடுகள் வனப்பகுதிகளில் பல்வேறு உயிரினங்கள், விலங்குகளுக்கு ஆதரவு அளிக்கிறது. உதாரணமாக குரங்குகள் வெப்பமண்டல மழைக்காடு தோப்புகளில் வாழ்கின்றன, அதே நேரத்தில் ஆந்தைகளும் வழ்கின்றன. காட்டுப்பகுதி முழுவதும் பாலூட்டிகள், ஊர்வன, பறவைகள் ஆகியவை பொதுவானவை. கூடுதலாக, பல்வேறு வகையான பூஞ்சைகள் இங்கே உள்ளன. உலகெங்கிலும் உள்ள தாவர மற்றும் விலங்கு வகைகளில் பாதிக்கும் மேலானவை மழைக்காடுகளிம் வசிக்கின்றன.

மழைக்காடுகளால் மனித இனம் பெறும் பயங்கள்

தாவர இனங்களும் உயிர் இனங்களும் மிகுதியாக இருப்பதால், மனிதர்கள் நூறாயிரக்கணக்கான ஆண்டுகளாக மழைக்காடுகளைப் பயன்படுத்துகின்றனர். பூர்வீக மக்கள் விலங்குகளையும் உணவு, கட்டுமான பொருட்கள், மருந்துகள் ஆகியவற்றையும் இந்தக் காடுகளில் இருந்து பெறுகின்றனர். இன்று, மழைக்காடுகள், காய்ச்சல்கள், மற்றும் தீக்காயங்கள் போன்ற பல்வேறு வியாதிகளுக்கு மருந்து அளிக்கின்றன.

மழைக்காடுகள் மனிதர்களுக்கு மிகவும் பயன்தருவதாக இருந்தபோதிலும் மனிதர்கள் காட்டினை அழித்து நாட்டினை உருவாக்குகின்றனர். மிதமான மழைக்காடுகளில், மரங்கள் பெரும்பாலும் கட்டிடப் பொருட்களுக்காக வெட்டப்படுகின்றன. வெப்பமண்டல மழைக்காடுகளும் காடழிப்புக்கு உட்படுகின்றன. ஆனால் இந்த பகுதிகளில் நிலங்களை வேளாண் பயன்பாட்டிற்காக மாற்றுவதற்கு காடழிப்பு செய்கிறார்கள்.

மழைக்காடுகளின் பல பகுதிகள் மனித நடவடிக்கைகளின் விளைவாக, தங்கள் காடுகளில் கணிசமான பகுதியை இழந்துள்ளன, நூற்றுக்கணக்கான தாவர மற்றும் விலங்கு இனங்கள் அழிக்கப்படுகின்றன. இதன் காரணமாக பிரேசில் நாட்டில் காடழிப்பினை எதிர்த்து ஒரு தேசிய அவசர நிலை அறிவிக்கப்பட்டுள்ளது. இதனால் உலகெங்கிலும் உள்ள நாடுகளில் இப்போது மழைக்காடுகளைப் பாதுகாப்பதற்கான திட்டங்களை அமைத்து வருகின்றனர்.

Tamil Nadu Agricultural University's contribution to Agrometeorology

Agronomy Faculty of TNAU, Coimbatore

The Tamil Nadu Agricultural University (TNAU) is one of the leading providers of agricultural technologies in India. It has made a commitment to ensure food security for both the state of Tamil Nadu and the country as a whole, It works tirelessly to advance agriculture-related research, education, and extension. By 1868, TNAU had evolved as a "Agricultural School" at Saidapet, Chennai, Tamil Nadu. It was later moved to Coimbatore in 1906, and on June 1, 1971, it became Tamil Nadu Agricultural University. The Agricultural College and Research Institute in Coimbatore was founded in 1907, while the Agricultural Research Station at Kovilpatti is among the oldest in the nation (1900) for the rainfed and dryland research. Now the TNAU is offering 15 UG, 33 PG and 2 Diploma Programs in 15 Colleges distributed all over Tamil Nadu. Besides, the University has five Centres of Excellence and 36 Research Stations for agrotechnology development and 14 Farm Science Centers for outreach. So far TNAU released 1107 crop varieties / hybrids, number of component technologies, farm implements to enhance the sustainable agriculture in the state of Tamil Nadu. TNAU is currently headed by renowned agrometeorologist Professor Dr. V. Geethalakshmi, Honourable Vice Chancellor, TNAU.

Agro Climate Research Centre (ACRC) is the agrometeorology component of TNAU, which established as Department of Agrometeorology during 1998 and later renamed ACRC during 2007. The primary aims are to carry out the basic and applied research on weather *in relation to* agriculture and allied sectors, to develop human resource in agricultural meteorology and climate change through PG and Ph. D programmes, to support the national and international organizations for the benefit of research, education and extension activities, to conduct trainings and conferences on various aspects of agricultural meteorology, to focus location specific and need based research for sustaining natural resources and agricultural productivity under changing climate scenarios and to provide technical inputs for strengthening the policies of the Government of Tamil Nadu towards climate variability and change.

TNAU has the 118-year-old (established by 1906) Principal Observatory of our country, which is the greatest strength of Agrometeorological education and research of TNAU, maintaining zero gab records and received the best maintained observatory award for twice. ACRC is also act as centre for the different Agromet observations in the State of Tamil Nadu, having five "A Class" observatories, 14 "B class" observatories and 385 Automatic Weather stations in the state of Tamil Nadu.

TNAU in Agrometeorology Education

M.Sc (Ag) in Agricultural Meteorology was started from the academic year 2004-05 onwards. Doctorate Programme in Agricultural Meteorology was initiated from the academic year 2010-11 onwards to render quality manpower and further strengthen and foster the agricultural meteorological science through research activities relevant to the state and the country. With these programmes, TNAU is committed to strengthen the agricultural meteorology education in the State of Tamil Nadu and to provide manpower to the national and international meteorological organizations. TNAU's students are well placed in many national and international institutes like FAO, IMD, CRIDA, ICRISAT etc. TNAU provides good exposure to its students with internationally comparable climate labs, SPAR unit, climate control chambers, micrometeorological instruments, numerical & statistical weather forecasting methods and weather based Agromet advisory preparation.

TNAU's contribution to Agrometeorological Research

TNAU has undertaken several climate change-related research in agriculture with the support of government and externally funded projects. Climate change projections are done for Tamil Nadu based on the regular updates by The Intergovernmental Panel on Climate Change (IPCC). Climate projections were made using AR5- RCP scenarios by employing 29 GCMs defined under CMIP5 of IPCC at a spatial grid resolution of 0.25°x0.25° and near, mid and end century time scales. Multi-model approach was applied to project future climate with reduced uncertainty.

Climate change projections: Projected the future climate of Tamil Nadu for RCP 4.5 and RCP 8.5 scenarios by employing 29 Global Climate Models (GCMs) defined under Coupled Model Inter Comparison Project (CMIP5) of IPCC. Increase in maximum temperature is projected up to 3.7°C /4.7°C and minimum temperature up to 4.9°C / 5.7°C by the end of mid-century for RCP 4.5 / RCP 8.5 scenarios respectively. The rate of increase in minimum temperature is higher than the maximum temperature. SWM is projected to have a higher increase in both maximum and minimum temperatures than NEM. Annual rainfall is expected to vary from (-)17.1 % to 34.6 % and (-)33.0 % to 45.1 % as projected through RCP 4.5 and RCP 8.5 scenarios. Rainfall during the SWM is expected to have wider variation in future than NEM.

Recently, TNAU has validated the latest version of climate models listed in Coupled Model Inter-Comparison Project 6 (CMIP6) to select the best suitable climate model for projecting future climate in Tamil Nadu and projected the future climate, weather extremities and agro-climatic indicators using new SSP-based scenarios featured in AR6-IPCC.

TNAU has assessed the impact of Tsunami on agriculture by remote sensing, GIS techniques and helped in reclamation of soils and improving crop productivity. Climate smart technologies implemented in Tsunami affected panchayats of Nagapattinam district helped the farming community improve their crop productivity and livelihood.

Agro Climate Research Centre, TNAU undertook research to assess the impacts of climate change on agriculture. **ClimaRice I**, a project funded by the Norwegian Ministry of Foreign Affairs, **assessed the impacts of climate change**

on rice production in Cauvery basin, Tamil Nadu, India. Through this project, behavior of Indian monsoon in different **climate scenarios**, its impact on water availability, rice production and resultant socio economic vulnerability was assessed, relevant coping and adaptation mechanisms identified and techniques developed to address the issues of climate vulnerabilities in rice production. To give **local ownership,** some of the techniques identified in ClimaRice I were validated and field-tested in close co-operation with farmers and local agencies through a follow up project **ClimaRice II** . This enabled the effective use of the **active stakeholder networks** and to meet their expectations in terms of capacity building and a toolbox with options of adaptation technologies they need, to counter the impacts on rice production due to extreme weather changes. A follow up project, ClimaAdapt project focused on development of climate change adaptation framework for water and agriculture sectors in Andhra Pradesh and Tamil Nadu states in India through an integrated science-stakeholder approach and contribute to the state-level climate adaptation policy.

DST has supported a project entitled "Climate Change: Assessing Impacts and Developing Adaptation Strategies for Agriculture in Tamil Nadu" and the ENSO were studied to understand its implications on monsoon rainfall over the river basins. Analysis of hydrology of Cauvery basin using SWAT model was done. These Calibrated and validated models (DSSAT and APSIM) were utilized to assess the impact of climate change on crop water requirement, growth and productivity of crops through integrated modeling approach and identified adaptation options such as screening temperature tolerant cultivars, identification of best sowing window, use of Nano-fertilizers, altering the cultivation method (SRI), etc. to reduce climate change impacts. These scientific findings were published in peer reviewed scientific journals.

TNAU has participated in Agricultural Model Intercomparison and Improvement Project (AgMIP - I) project for Integrated Assessment of Climate change impacts on Principal crops and farm household incomes in Southern India and AgMIP – II for Evolving climate resilient farming systems in South India through Integrated modeling, adaptation and stake-holders participation. It is a 40-country collaborative research programme participated by the scientists across five continents. Cross learning to reduce the uncertainty in climate projection, impact assessment and development of adaptation option happened. Policy makers were the main stakeholders and this programme has developed evidence-based policies.

TNAU has developed the Regional Agricultural Pathways (RAPs) and assimilated them into the building of a climate-resilient food system for Cauvery Delta Zone of Tamil Nadu. Mapped the climate change vulnerability to strengthen food security with climate smart adaptation and mitigation options in Tamil Nadu.

Weather based crop insurance protocols developed for implementation of Weather Based Crop Insurance scheme (WBCIS) programme in various districts of Tamil Nadu. This has helped the farmers in getting compensation for their crop losses during the extreme weather conditions

Differential impact of climate change on the physiological responses of crops: : Developed the Genetic co-efficient for rice, maize, pearl millet, groundnut, cotton, black gram and redgram for DSSAT. Performed sensitivity analysis for the changes in T, CO2 and moisture stress levels on the Phenology, Nutrient Use Efficiency, Water Use Efficiency and yield using cutting edge technologies such as controlled environmental facilities and dynamic crop simulation models. Elevated temperature negatively affected rice, maize and groundnut productivity. C3 crops (rice, groundnut) found to be highly sensitive to the temperature than C4 crops (maize, cotton). Cotton had beneficial effect due to increased temperature up to 4 °C and thereafter the yield got declined. Elevated temperature had a negative impact on Blackgram and redgram. Pearl millet productivity declined under increased temperature and enhanced CO_2. Greengram yield was adversely affected by High Night Temperature (HNT) and elevated CO_2 from 35 to 56 DAS (flower initiation stage to pod filling stage). Seed quality parameters such as protein, total sugars, polyphenols, seed moisture, proline, phytic acid, calcium and iron were reduced under HNT and CO_2 from 50% flowering to pod development stage (42 to 56 DAS). Increased temperatures resulted in reduction in crop duration. C3 crops obtained comparatively more benefit from enriched CO_2 than C4 crops which showed very slight response to CO_2 enrichment. In groundnut, WUE was reduced by 17.6,37.8,56.1,70.7 and 81. % for temperature increase of 1˚C, 2˚C, 3˚C,4˚C and 5˚C respectively. The reduction in NUE varied between 13.5 and 78.8 % for the increase in temperature from 1ºC to 5ºC.

Impact of Climate Change on Soil Nutrient Dynamics: Decomposition of OM and available NPK from the soil with elevated temperature and moisture stress assessed under controlled environmental conditions

Microbiome studies to understand the connect between rhizosphere and atmosphere: Evaluated carbon Sequestration potential in rice ecosystem with bio-inoculants (Azolla, BGA, Cyanobacteria) in normal and elevated temperatures

Impact of elevated temperature and elevated carbon dioxide on the biology of maize fall armyworm: Survival rate and Fecundity rate of *S. frugiperda* wrt. elevated temperature and CO_2 levels assessed under OTC and SPAR. Analyzed the biochemical changes in host plant. The potential geographic distribution of maize fall armyworm *Spodoptera frugiperda* was predicted using MaxEnt ecological niche model.

Adaptation to climate change: Irrigation optimization, sowing window, N optimization was done under changing climate for maximizing maize and cotton productivity. Maize yield could be achieved to the current level of productivity under future climatic condition through optimization of irrigation amount (315 mm) and schedule (At sowing, 4,15,25,55,65,75 and 85 DAS) under 25 per cent water deficit. Optimized nitrogen dose (120 kg ha^{-1}) in maize would enhance the productivity under the elevated temperature and atmospheric carbon dioxide concentrations. Earlier date of sowing (September 1st against September 15th (normal sowing) has reduced the negative impact of climate change on maize productivity. Cotton crop responded up to 120 N kg ha-1 for the increased temperature and carbon dioxide concentrations. The combined application of Vermicompost along with 3 % Panchagavya as foliar spray had significantly reduced the ill effects of high temperature stress on Cowpea.

Since 2011, TNAU provides its own weather forecast services to the farmers at higher resolution for addressing the spatial variability. The Seasonal Rainfall Forecast for the both SWM and NEM are issued at district scale and the Medium Range Weather Forecast is updated daily for 18555 revenue villages with higher accuracy. No other SAUs are directly involved in these type of downscaling forecast for the farmers. Now working on extended range of forecast and long range weather forecast @ block level at monthly interval.

TNAU's contribution to Agrometeorological Extension

TNAU is continuously working to protect the farmers from weather risks through timely weather based agro advisories. In collaboration with the Weather Giant "India Meteorological Department (IMD)", TNAU provides Regional forecast based Agromet Advisory services, since 1998. TNAU lead as Nodal Centre for the IMD's pride Gramin Krishi Mausam Sewa project in Tamil Nadu and Pondicherry region with 9 AMFU and 9 DAMU centres. First of its kind in India, TNAU has rolled out the Automation in weather based Agro Advisories dissemination. Automated weather based agromet advisory service (TNAU-AAS: web cum Mobile App) has been launched for 108 crops and 54 weather perils. Based on crop stage, past, present and forecasted weather, the agromet advisories are broadcasted automatically without human intervention which guaranteed the location-specific response farming to cope with climate variability.

TNAU is playing a vital role in assessing damages caused by cyclones and drought through its Drone centre and supporting the government in policy level decisions on the cyclone and drought affected areas.

TNAU's facilities for Agrometeorology research and education

Principal Agromet observatory

Established during 1907 and received "Best maintained observatory award" from IMD twice.

Automatic Weather Station (AWS)

ACRC is having 385 AWS, each one at every block of Tamil Nadu and recording 10 weather parameters including soil temperature, soil moisture and leaf wetness @ every hour interval.

Temperature Control Chamber (TCC)

ACRC is having one set of +2ºC and +4ºC chamber, monitored at every 15 minutes with open-air condition. Highly useful for climate change research.

Climate Control Chamber (CCC)

ACRC is having one CC, can maintain temperature and CO_2 at required level.

Soil Plant Atmospheric Research (SPAR) Unit

ACRC established one SPAR unit, can maintain different levels of temperature and CO_2 . Useful for climate change impact studies on crops, pest and disease.

Temperature Gradient Tunnel (TCC)

ACRC established two TCC unit, can maintain 4 different levels of temperature. Useful for climate change impact studies with different gradients in a stretch.

Gas Chromatography (GC)

ACRC is having one GC, many other faculty students are also using it.

Radiation instruments

ACRC is having following radiation instruments for micrometeorological studies.

- Plant canopy analyzer
- Line quantum sensor
- Pyranometers

Handheld instruments

ACRC is having following hand held instruments

- Infra Red Thermometer
- Chlorophyll (SPAD) meter
- Whirling Psychrometers
- Hand held Anemometer
- Soil moisture and soil thermometers

Portable Photosynthetic System (PPS)

ACRC is having one PPS for the measurement of physiological leaf gas exchange and photosynthetic parameters. Many other faculty students are also using PPS

Computational facility

ACRC is having High Performance Computation (HPC) facility and students are familiarized to operate it.

High performance server– 5 Nos.

MAC X server Clusters – 20 Nos.

MAC computers – 13 Nos.

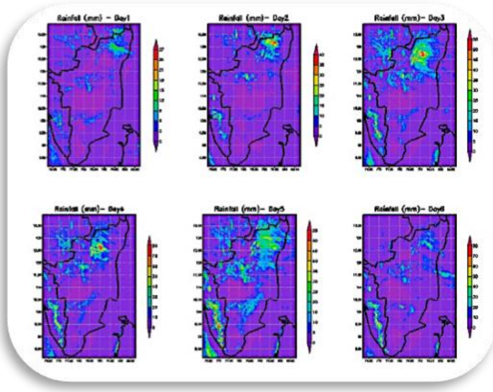
Windows Desktops – > 10 Nos.

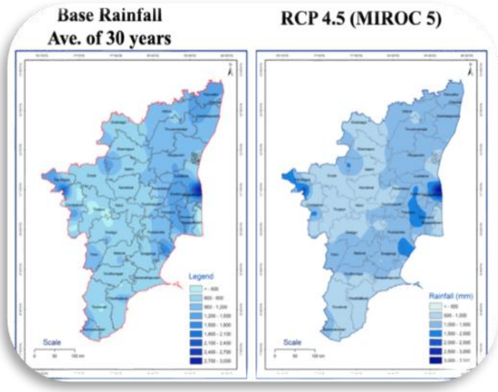
Internet facility

ACRC is equipped with 50 MBPS ILL facility with 20 IP address for data downloading and complete wifi connection for the entire department.

Numerical Weather Forecasting Model

ACRC faculties are expertized in numerical weather models such as WRF and RegCM. Students are given with hands on training on MRWF for agricultural purpose. First in India, Village level forecast are issued from TNAU for 18850 revenue villages.



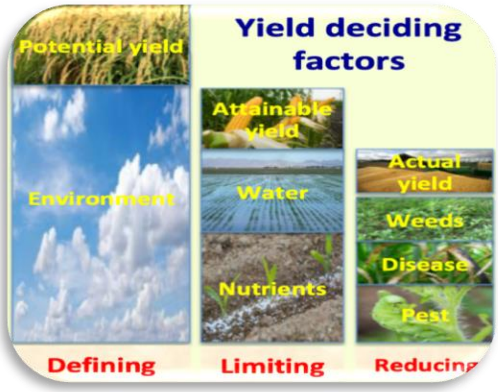


Climate Models

ACRC faculties are expertized and pioneer in climate models and ensemble modeling research. Climate change impact studies with 28 multiple models are being taught to students during their course work

Crop Simulation Models

ACRC faculties are expertized in crop simulation and hydrological models such as DSSAT, Infocrop, APSIM, AquaCrop. Students are being regularly given with separate capacity building programmes in addition to their course work.



Agro Advisory development

ACRC is giving practical training on weather based agro advisory development to all the students. Advance software tools also provided to students for the agro advisory development.

Flood Preparedness in Chennai for 2023-2025

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Chennai region of Bay of Bengal has witnessed excess rainfall in 2023 which was foreseen based on the long-term rainfall analysis done by the author. Long term rainfall analysis was one of the components of the research work of the author which largely covers on Community Based Flood Preparedness for Adayar Sub-basin of the Chennai Basin. For this research work, 30 year period (1984-2013) of daily rainfall pattern as one of the key parameters for flood vulnerability was studied. The Adayar sub-basin covers 9 rain gauge stations and out of which only 4 (Chembarambakkam, Meenambakkam, Sriperumbudur and Tambaram) rain gauge stations fall within the sub-basin.

Flood height as evidenced (wall wetness) from the affected localities in Chennai - 2023

The daily rainfall data was grouped into four seasons (winter, summer, southwest and northeast). Upon plotting the rainfall data, author could observe some distinct pattern of peak rainfall which coincided with 1985, 1995-1996 and 2005 followed by drop in rainfall with gradual increase to secondary peak in 5th or 6th year. Again, a drop and continue with low rainfall and gradually increase to 8-10th year with record rainfall with potential for extensive flooding. So, from the data, author could notice the peaks in 1985, 1995-1996, 2005 and anticipated the 2015 flood in his findings. This finding was published in newspaper for larger reach and preparedness. We are heading towards a similar rainfall pattern which could be a potential rainfall peak as also coincides with El-Nino in 2023 as was the original part of this article.

Flood risk is no exception to any country and affecting all 188 countries globally. With an impact at 668 million people, East Asia has the highest number of flood vulnerable people, which corresponds to about 28% of its total population. Across Sub-Saharan Africa, Europe, Central Asia, the Middle East, North Africa, Latin America, and the Caribbean flood exposure ranges between 9% and 20% of the population. Nearly 70 % (1.24 billion) of flood vulnerable population live in South and East Asia, with China and India alone contribute to over one-third of global vulnerability.

For any disaster, community involvement has become one of the chief priorities for establishing effective partnerships for disaster risk reduction, according to the UNISDR Hyogo Framework for Action (2005-2015) (UN-ISDR, 2005). Regarding disasters, identifying risk factors and understanding the way in which communities cope and adapt themselves to hazardous environments are considered important determinants for risk reduction and decision making at local and municipal level.

As part of the research recommendations, both structural and non-structural measures were suggested with some of the key points below:

Structural measures

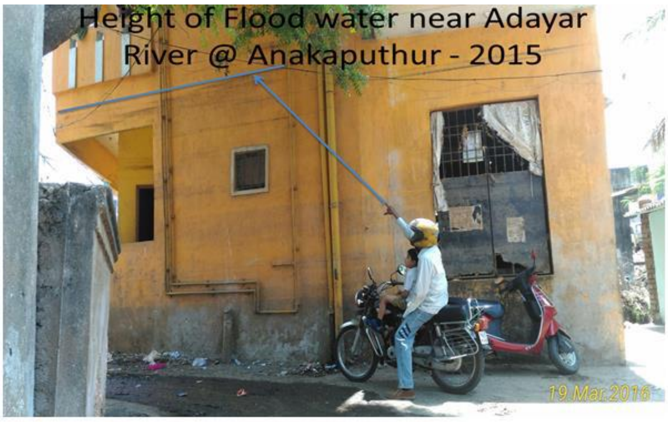
- Timely and periodic cleaning (solid waste), de-silting and deepening of natural water courses and drainage channels (both urban and rural) must be taken up.
- Encroachments on tanks and lakes or natural drainage channel to be relocated permanently.
- Construction and protection of all the flood protection embankments, ring bunds and other bunds are important aspect of flood mitigation strategy.
- Interconnectivity of all drains to be taken up on priority as most of the connection of drains has been permanently lost due to urbanisation.
- Developing parks and green corridor along the river, lake, tanks to protect against soil erosion (breach). This further reduces the flood impact in the neighbourhood.
- All urban planning and development in Chennai environs should take into consideration of sub-watersheds and micro watersheds. Otherwise, these watersheds are permanently changed for human developments.

Non-structural measures

- Flood plain zoning, which places restrictions on the use of land on flood plains, can reduce the cost of flood damage. This involves comprehensive urban land use management with year on year updates to monitor the emergence of illegal construction.
- Local governments should pass laws that prevent uncontrolled building or development on flood plains to limit flood risks and to protect natural courses.
- An effective Early Warning System is one that can release warning in advance, i.e. 72 hrs, 48 hrs, 24 hrs, 12 hrs or on hourly basis in times of landfall of cyclone . It can change the existing scenario substantially and render informed decision making in adopting proper measures towards disaster preparedness, mitigation, control, planning and management. This kind of advance warning can help the authorities for better flood preparedness and also effective flood mitigation. Therefore, initiatives have to be taken to modernize the operation of Flood Forecasting & Warning by adopting the state of art technology and integrating it into the forecast and warning dissemination process.
- Long term rainfall data analysis will further help to understand the behavior of rainfall distribution and pattern so that it further helps towards flood preparedness. This research work has concluded an 8-10 year return period of exceptionally heavy rainfall with extensive flood potential.
- Displaying the flood vulnerability maps at prominent locations (vulnerable locations) would improve the knowledge level of the populace. As a support to this, free digital maps of each vulnerable communities/localities could be made available to the community leaders to prepare their neighborhood.
- Communities living along the water bodies should also be part of the decision making process aimed at reducing the impact of flood and other disasters. They should be part of rescue, relief, rehabilitation and reconstruction phases of the disaster management cycle.
- Conduct Change detection (Time Series Analysis) study every 1-2 years in cities with population of 1 million and above to know the extent of reduction of water bodies and natural vegetation to human settlements. For this, Survey of India (SOI) topographical maps should be used to delineate the original (past) boundary of the water bodies and use the recently acquired satellite imagery to know the current extent of water bodies. This will reveal whether the damage is reversible or irreversible to the water bodies and flood reduction attempt worth doing so or not. SOI maps were surveyed and prepared during British era and obviously will reveal the original water bodies of its extent. A typical example is Velachery Lake which now covers only ¼ of its original extent.

- Water bodies turning into dump yards – Some of the key natural water bodies like Pallikaranai Marshland and Pallavaram lake (last few years), to name a few, have turned partially into municipal dump yard. This significantly reduces the water holding capacity of the lakes and hence increases the flood risks, but also pollute the surface and sub-surface water quality.
- Blocked water courses – Key example of diversion or blocked water course is the Sriperumbudur temple tank. In 2015, the temple tank almost dried and was shocking to the local residents and the author has not seen such an emptiness of the tank for over 40 years obtained through reliable sources. Though 2015 rain has completely filled the wells adjoining the temple tank, but tank remained less than 50 % filled. It is a clear indication of intentional blocking of its recharge routes which needs to be rejuvenated.

Administrative demarcation against flood will greatly help the corporation and disaster managers to mobilise timely rescue, response, relief, rehabilitation of the affected population.



Decolouration (river sedimentation) due to flood inundation to nearly 10 feet at Anakaputhur (suburban of Chennai embracing the Adyar River) – 2015 and 2023 (same house)

Study of Heat Waves in Summer, 2023 in Andhra Pradesh and Telangana States

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Abstract:

The heatwaves conditions (days with abnormally warmer temperature i.e. $\geq 5^0$C above normal) result in adverse impacts on human health, water resources, power generation and on agriculture. Failure of monsoons in the previous years may cause surface and underground water sources to dry up, crops to wither and may create water crisis in summer impacting hydro-electric generation from rivers. In the year 2014, in Telangana, both southwest (R/F Dep -34%) and northeast (R/F Dep – 52%) monsoons failed. Moderate drought (R/F deficiency -26 to -50%) conditions prevailed in Telangana. As a consequence, districts Medak, Nizamabad, Ranga Reddy, Hyderabad and Nalgonda experienced water crisis in summer 2015. (The term 'drought' became obsolete and nowadays large deficit rainfall is used in its place).

Hot weather conditions ($\geq 40^0$C) were experienced in Rayalaseema districts from 28th March 2023 and over coastal Andhra Pradesh and Telangana districts from 10th April 2023. The hot spell was suppressed due to advance of moist southwesterly monsoon current in Andhra Pradesh on 22nd June and in Telangana on 24th June, 2023. The salient aspects have been analysed in this study.

Introduction:

During hot weather season, in addition to the incoming solar radiation during day time, hot dry winds from northwesterly to northerly direction blow from north and central parts of India and transfer heat as they sweep over inland area of eastern half of south peninsular India and Odisha and cause rise in day temperatures in the areas. Generally, the cumulative effect of these factors, results in appreciable (3 to 4^0C) to marked rise (more than 4^0C) in day temperatures.

In March, the hottest area lay over Deccan with maximum temperatures of 38 to 40^{0}C and hence normally heatwaves don't occur over states in March. In April, maximum temperatures of 40 to 42^{0}C occur with heat low pressure area over Madhya Pradesh and Gujarat states and the hot dry winds flow from central parts of India over Andhra Pradesh and Telangana states. They are more pronounced from mid-April. In May, the highest day temperatures of 42 to 45^{0}C are found over northern India with the formation of the shallow heat low pressure area over northwest India. Day temperatures of 49^{0}C or more are not infrequent in the northwest desert. In May, generally the states record the highest number of heatwave days, as hot dry north and northwesterly winds blow from north and central parts of India and sweep over the states. The winds continue in June till southwest monsoon current suppress hot weather.

In the southwest monsoon season, Coastal Andhra Pradesh generally experiences relatively cool weather due to the outflow of moist southerly to southwesterly winds from the anticyclone which lies over the Bay of Bengal. These winds arrest rise of day temperatures over coastal areas. In case of a synoptic situation of an axis of low pressure trough line lying along and or off Andhra Pradesh Coast, it act as a barrier and inhibits flow of winds from sea and hence coastal areas also experience heat wave conditions. It is observed that northern districts Visakhapatnam to Srikakulam generally lie to the right of the areas of the trough line and experience relatively cool weather and are less prone to heatwaves.

<u>Synopsis of heatwaves in Andhra and Telangana States:</u>

Studies indicate that in Andhra Pradesh, south Coastal Andhra Pradesh and Godavari districts are more prone to heatwave conditions. Guntur and Krishna districts are vulnerable to severe heatwave conditions. In comparison, the northern districts, Srikakulam, Vizianagaram and Visakhapatnam are less prone to heatwaves. In Telangana, northern districts of Adilabad, Nizamabad, Karimnagar and Warangal and in South Telangana, Khammam and Nalgonda districts are more prone to heatwaves conditions. Khammam district experiences severe heatwave conditions and Adilabad and Karimnagar districts rarely experience severe heatwave conditions. Other districts in Telangana are less prone to heatwaves. Rayalaseema is less prone to heatwave conditions and however, it experiences hot weather with record maximum temperatures varying from 39^0 to 44^{0}C during hot weather season. Telangana rarely experiences severe heatwave conditions ($\geq$ 47^{0}C or maximum temperature departure of 6.5^{0}C or more) except over Khammam district and Rayalaseema nil as the long period average day temperatures used while computing heatwaves, itself are high enough of 40^0C to 42^0C in the month of May and in the first ten days of June.

Categorisation of heatwaves

The severity of the hot spell is qualified as heatwave or severe heatwave and categorized based on maximum temperatures recorded at a station. When the actual maximum temperature recorded at a station is 45^0C to 46^0C, it is categorised as heatwave condition and if it is 47^0C or more, as severe heatwave condition. Otherwise, when the maximum temperature recorded at a station reaches a threshold value of 40^0C at a plain station or 37^0C at a coastal station and also besides this when the recorded maximum temperature departure value from normal is in the range of +4.5 to +6.4^0C, then it is categorized as heatwave. If the departure value is 6.5^0C or more it is known as severe heatwave condition.

Weather and Human Comfort

Weather elements viz. temperature, wind and humidity affect human comfort. People feel discomfort and experience hotness when the temperature of the surrounding air rises markedly ($\geq 4^0$C) above that of human body bare skin temperature of 33^0C and feel like hot spell when the air maximum temperature reaches 40^0C or more. Hot winds reduces water content in the human body, which may lead to dehydration and prolonged exposure to hot winds may prove to be fatal. The presence of high humidity in the air coupled with hot winds may cause sultry weather especially in coastal areas.

Salient Features :

In the year 2023, people in Coastal Andhra Pradesh experienced the worst hot weather season. If the last ten years period 2014 to 2023 (Table 1.A) is considered, the frequency of occurrence of heatwave days was the highest with 31 days, while the previous nearly highest figure was 24 days in the year 2019, which are against the normal of 15 days in an year. **In the month of June 2023 heatwaves occurred for 17 days in the period of 21 days (Table-1 B) before the advance of southwest monsoon.**

Death Toll

In the year 2023, the death toll due to heatstroke was 3 as reported by A.P. State Disaster Management Authority (APSDMA). However, death toll due to lightning during years 2019 to 2022 were 302 as per the APSDMA. Particulars of yearwise death toll that occurred from 2014 are presented in the Table -1.C)

There was a drastic reduction in deaths toll due to heat strokes as it was 1369 in year 2015 and it was a single digit 3 in year 2023. It is mainly due to increase in awareness among the public at large and also due to the advance warnings issued by India Meteorological Department and APSDMA. Data in respect of Telangana is incomplete.

Severe heatwave conditions (Table-2) in the season prevailed at isolated pockets for 7 days in East Godavari, for 6 days in Guntur, for 5 days in Visakhapatnam, for 3 days each in Srikakulam and West Godavari and for 2 days in Krishna Districts of Coastal Andhra Pradesh. In Telangana State, severe hot weather prevailed with heatwaves for 20 days in the period of 23 days in the month of June 2023, against normal of 15 to 20 days in the season in an year. In the months of April and May heatwaves were not recorded in Telangana State. Severe heatwave conditions were realised for 7 days in Khammam and for a day each in Adilabad and Karimnagar districts of Telangana. In Rayalaseema sub-division heatwaves occurred for 5 days in the month of June 2023 against normal of nil to 5 days in a year. Due to delay in advance and coverage of southwest monsoon by 12 days in the states, hot weather season got extended up to third week of June, 2023.

In the year 2023, in the hot weather season, the frequency of occurrence of heatwave days (Table.2) districtwise in Coastal Andhra Pradesh were, 1 in Nellore, 6 each in Srikakulam and Prakasam, 8 in West Godavari, 12 each in East Godavari and Krishna and 16 each in Guntur and Visakhapatnam. East Godavari, Guntur and Visakhapatnam districts were worst affected with severe heatwave conditions as they recorded severe heatwaves for 7 days, 6 days and 5 days respectively. The frequency of occurrence of heatwave days in Telangana were 16 days in Khammam, 9 each in Adilabad, Karimnagar, and Medak, 8 each in Warangal and Nalgonda, 2 in Ranga Reddy and one in Hyderabad districts. It was nil in Mahabubnagar district. Khammam district was worst affected with severe heatwave conditions for 7 days in Telangana. Rayalaseema experienced heatwaves for 3 days in Ananthapur, 2 days in Kurnool and 1 day in Chittoor and nil in Cuddapah districts respectively. Heatwaves were realised in Telangana and Rayalaseema sub-divisions in the month of June only and more so before the onset of monsoon on 24th June, 2023 with frequency of occurrence 20 days and 5 days respectively in the season. In Coastal Andhra Pradesh the frequency of occurrence of heatwaves in the season were 31 days, with breakup of 10 in April, 4 in May and 17 in June, 2023.

Salient Points :

1. In the hot weather season 2023, Tuni in East Godavari district recorded highest maximum temperature of 46.4^{0}C (with maximum temperature departure from normal of 10.5^{0}C) on 16-06-2023.
2. Visakhapatnam city (Waltair) people experienced the worst severe heatwave conditions with the record highest maximum temperature of 43.4^{0}C (with maximum temperature departure from normal 11.0^{0}C) on 10.06.2023, which is the highest since the date of starting of observatory on 01.06.1963 i.e. in 60 years period. In addition, sea breeze was arrested due to the location of the axis of trough line over the station and very light dry winds from westerly direction prevailed. Relative Humidity fell rapidly from 76% in the morning to 29% in the afternoon (Fig.5). Due to dry hot and very light westerly winds, citizens in Visakhapatnam experienced miserable severe hot weather on 10.06.2023. Visakhapatnam Airport recorded maximum temperature of 44.6^{0}C (45^{0}C) with departure from normal of 9.5^{0}C on the same day.
3. Heatwave conditions prevailed at Khammam City on 3rd & 4th and continuously from 6th to 19th June 2023 for 14 days, totaling 16 days out of 23 days, before the advance of southwest monsoon on 24th June over Telangana. Out of these, it realised 7 severe heatwave days. The reason for occurrence of 16 days of heatwaves out of 23 days in one month may be attributed to the geographical feature of Khammam City as it is located over rocky area, as evinced by the fact of granite excavation activity in the city.
4. Tuni, the only station, which continuously realized heatwave conditions for 10 days i.e. from 10th to 19th April, 2023 and of which it experienced severe heatwave for 2 days. It is the station which recorded the highest number of 22 days out of 31 days of heatwaves days in the season in Coastal Andhra Pradesh. It is the area of greatest heat in April in the states. The geographical feature of its location over rocky area and surrounded by hilly ranges, is the principal reason for the increase in frequency of occurrence of heatwaves days. However, Kakinada city located in a south-southwesterly direction at a distance of 60 km away from Tuni, didn't record

heatwaves, not even a single day in April, 2023. Tuni station may be considered as 'Isolated Mini Heat Island' in summer season.

5. The highest maximum temperatures recorded during the hot weather season 2023, were 46.4^{0}C at Tuni on 16.06.2023 in Coastal Andhra Pradesh, 44.2^{0}C at Nandyal on 17.05.2023 in Rayalaseema and at Khammam City, 44.6^{0}C on 3.6.2023 in Telangana State respectively.
6. On examination of maximum temperatures recorded on 16th June 2023, Andhra Pradesh and Telangana States experienced hottest day in the season as it can be substantiated by the fact that in Coastal Andhra Pradesh districts from Srikakulam to Guntur experienced severe heatwave conditions and however in Prakasam and Nellore districts heatwave conditions prevailed. In Rayalaseema, Ananthapur and Kurnool districts realized heatwave conditions. In the state of Telangana, in five north Telangana districts and two south Telangana districts Nalgonda and Khammam, heatwave conditions prevailed. Of these in Khammam district, Khammam and Bhadrachalam cities experienced severe heatwave conditions. However, two districts in Rayalaseema, Cuddaph and Chittoor and three districts in Telangana, namely Hyderabad, Rangareddy and Mahabubnagar experienced only hot weather.
7. Reason for delay in advance of southwest monsoon over the states. The hot weather season in Andhra Pradesh and Telangana States was extended up to the third week of June 2023. Southwest monsoon advanced and entered the southern tip of Coastal Andhra Pradesh, Nellore District (Sriharikota) by 11th June and southern tip of Rayalaseema, Anantapur district (Puttaparthi) on 12th June, 2023. Further advance of southwest monsoon was hindered from 12th to 19th June, due to deflection and injection of Arabian Sea branch of southwest monsoon current into the existing Extremely Severe Cyclonic Storm namely, 'BIPARJOY' over the eastcentral Arabian Sea, starting from 12th June. Subsequently, the system crossed Kutch area of Gujarat coast on the mid-night of 15th June as Severe Cyclonic Storm. Later moving in a northeasterly direction and gradually weakening, it moved over Pakistan and over to the central parts of northeast Rajasthan by 19th June, when its intensity was Well Marked Low Pressure Area. The system had its sway over the monsoon current till 19th June. With the revival of monsoon current, southwest monsoon advanced and covered entire Andhra Pradesh State by 22nd and entire Telangana State by 24th June, 2023.

Synoptic features which cause changes in maximum temperatures and heatwave conditions over Andhra Pradesh and Telangana States.

a) Shift in location of trough line.

Normally a trough of low pressure exists over the states during the hot weather season. The axis of the trough line (line joining areas of low pressure) normally extends from Chhattisgarh to south Tamilnadu across Telangana – Rayalaseema or across upland areas of Coastal Andhra Pradesh – Rayalaseema and it is more pronounced from April. At times it may shift eastward and extend from interior Odisha – along and off Andhra Coast-to South Tamilnadu. Fluctuation in hot weather conditions or changes in maximum temperatures over the states are caused due to changes in pressure distribution and its associated pressure trough line shifts eastwards or westwards from its position. It is the principle cause for changes of maximum temperatures over the states. In addition, advection of heat energy from north and central parts of India by north or northwesterly winds over the states from mid-April plays a pivotal role and concentration of heat energy over a place and thus causes hottest / greatest area of heat. The axis of low pressure trough and the area of greatest heat can be delineated and identified on weather maps. (Fig. 3 & 4) shows schematic presentation of pressure trough line and areas experienced heat and severe heatwave condition on 10.06.2023.

i) When the axis of the trough line passes across Telangana – Rayalaseema (for example on 6-4-2023 it is observed that) all inland stations experienced hot winds (37 to 41^{0}C) and coastal stations in Andhra Pradesh experienced relatively cool weather (33 to 37^{0}C maximum temperatures)

At times under favourable wind field in association with low level convergence and mid-tropospheric level divergence, deep humid currents either from the Bay of Bengal or the Arabian Sea are drawn into the trough and it results in the development of severe thunderstorms in the evening at a few places along the trough line. These local thunderstorm are normally accompanied by hail and squally winds (mean wind speed more than 37 kmph) which may cause damage to agricultural produce. Due to the thundershowers, people may experience temporary relief from the hot spell for a day or two and then hot weather will roll back, over the area.

Telangana state generally experience hailstorms in summer and in Andhra Pradesh their occurrence is rare. In the year 2023, as per media reports incorporated in daily weather reports of Met. Centre Hyderabad, Telangana experienced hailstorms at different places for 22 days with breakup of 12 in April, 9 in May and 1 in June 2023. **Hailstorm**

occurred at isolated places on 6-4-2023 at Hyderabad, Medchal Malkajgiri, Rangareddy and Kamareddy districts of Telangana.

ii) On 16-5-2023 (Fig. 1 & 2) the axis of trough line ran off Tamilnadu – Off south Andhra Coast and just east of Kakinada - across northern districts of Coastal Andhra Pradesh – across heat low pressure area over interior Odisha and thence to the low pressure area over Jharkhand area. Stations located to the left of the trough line experienced hot weather (41-45^{0}C) and those located to the right in or on coastal areas of northern districts of Andhra and Coastal areas of Odisha experienced relatively cool weather (35 to 39^{0}C)

Over Godavari, Krishna, Guntur, Prakasam and Nellore districts heat wave conditions prevailed (maximum temperature departure $\geq$ 5^{0}C) and severe heat ware conditions at isolated pockets in Guntur and West Godavari districts (maximum temperature departure $\geq$ 7^{0}C).

iii) When the axis of trough line passes over or lies along and off the Andhra Coast, the flow of moist southerly or southwesterly winds from the Bay of Bengal is arrested and in its place hot dry winds from northwesterly to northerly direction from north and central parts of India may extend even over Andhra Coast. The advection of heat is concentrated over Andhra Coast and may cause heatwave condition there. On 10.06.2023, (Fig. 3,4) the axis of the low pressure trough line delineated on weather maps ran along Madurai - Cuddalore – west of Chennai – off Nellore and Prakasam district coasts – West of Machilipatnam and Narsapuram stations – Kakinada – along coast of northern districts of A.P. - across low pressure area over interior Odisha – thence the low pressure area over Bihar. Heatwave conditions prevailed over Nellore, upland areas of Guntur, Khammam district of Telangana, East Godavari, northern districts of Coastal Andhra Pradesh, interior districts of Odisha and Jharkhand. The maximum temperature departure from normal recorded in those areas were in the range of 5 to 11^{0}C.

In Andhra Pradesh severe heatwave conditions realized over East Godavari and northern districts Visakhapatnam, Vizianagaram and Srikakulam districts. Stations in Krishna, West Godavari and coastal areas of Odisha located to the right of trough line experienced relatively cool weather and they recorded maximum temperatures in the range of 33 to 38^{0}C. However, stations to the left of axis of the trough recorded maxim temperatures in the range of 41^{0}C to 45^{0}C. Even small deviation of axis of line is reflected in the form of entry of moist winds from sea over Krishna and West Godavari districts and they experienced relatively cool weather.

b) **Sea Breeze:**

Sea breeze is defined as a local circulation observed at sea coasts. On clear hot days in the absence of general wind particularly in hot weather season, sea breeze blows from cold sea to warm land by day and the moist winds arrest rise of day temperature at the coastal stations of Andhra Pradesh. The sea breeze normally extends up to 50 KM in land and it advance over coastal areas in the afternoon and generally after attainment of maximum temperatures at inland stations. It is observed that on 5-4-2023, temperature recorded at coastal stations on seacoast was in the range from 32 to 35^0C and inland station in coastal Andhra Pradesh recorded temperature in the range 36 to 39^0C. On cloudy days the sea breeze is non – existent, as clouds prevent the land from heating up by day.

c) **Cloudy day**

Thick cloud canopy at a place arrests rise of day temperature, Nizamabad recorded maximum temperature of 30.3^0C, with maximum temperature departure from normal of -11.6^0C, on 28.04.2023. Markedly below normal maximum temperature recorded on 28^{th} April may clearly be attributed due to cloud cover and rain on the date at the station. All other stations in Telangana recorded maximum temperatures in the range of 33 to 37^0C.

The Record Highest Maximum Temperature at Visakhapatnam City (Waltair)

Hourly meteorological observations recorded at Waltair and Visakhapatnam Airport on 10.06.2023 in day time are plotted (Fig.5). On 10.06.2023, day temperature at Waltair rose between 0300 to 0900 UTC by 9^0C and at Visakhapatnam Airport by 8^0C due to very light to light westerly winds. Maximum temperatures recorded were 43.4^0C at Waltair which is record highest maximum temperature in last 60 years period and at Airport it was 44.6^0C. Thereafter, very light south-southwesterly winds at Waltair and very light westerly winds at Airport continued till evening of 10^{th} June. Due to dry hot winds, there was a fall of relative humidity from 76% at 0000UTC to 29% by 0600UTC at Waltair and at Airport the fall continued and it was from 59% at 0300UTC and 38% at 1200UTC.

The reason for record of high maximum temperatures were one absence of see breeze which normally prevails and the other principal one, the axis of low pressure trough line lay over the station and which extended along and off Andhra Coast on 10.06.2023. It resulted in concentration of advected heat from north and central parts of India over the station and also along north Andhra Coast and interior Odisha.

Concluding Remarks:

Forecast of changes in weather elements on micro-scale can be well identified and their evolution and movements are traced based on analysis and following sequence of synoptic weather charts. However, observation of cloud images from satellites and Radar can augment information availability to a forecaster.

Source of Date: Collected from 1.MD Websites and A.P. State Disaster Management Authorities. The Author collected data while in service and afterwards.

Table 1

(A)Frequency of occurrence of Heatwave days in Andhra Pradesh And Telangana during period 2014 to 2019 & 2021 to 2023

Sub-Division Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Coastal Andhra Pradesh	17	12	14	17	6	24	NA	6	12	31
Rayalaseema	NA	Nil	8	3	Nil	13	NA	1	Nil	5
Telangana	NA	14	27	24	7	47	NA	3	9	20

(B) Frequency of occurrence of Heat wave days in April, May, June months in Andhra Pradesh and Telangana

Sub-Division Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Coastal Andhra Pradesh	A	0	0	5	5	0	2	NA	2	2	10
	M	0	12	7	10	0	11	NA	2	4	4
	J	12	0	0	2	6	11	NA	0	6	17
Rayalaseema	A	NA	0	6	1	0	0	NA	0	0	0
	M	NA	0	1	2	0	8	NA	0	0	0
	J	NA	0	0	0	0	5	NA	0	0	5
Telangana	A	NA	0	10	7	0	7	NA	2	1	0
	M	NA	14	14	17	7	21	NA	0	0	0
	J	NA	0	1	0	0	19	NA	0	8	20

(C) Death Toll due to Heat stroke in Andhra Pradesh & Telangana

State / Year		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Andhra Pradesh		448	1369	723	236	8	15	0	0	0	3
Telangana		150	541	-	108	NA	NA	NA	NA	NA	NA

Death toll due to lightening during years 2019 to 2022 : 302

Source: In respect of Andhra Pradesh: Andhra Pradesh state Disaster Management Authority (APS DMA)

In respect of Telangana : Print Media

Note: In year 2016 in the month of March Heat Wave occurred for 2 days in Coastal AP Rayalaseema land Telangana 2 days.

In year 2014 significantly Coastal Andhra Pradesh experienced heatwave in the month of July for 5 days (1st to 5th July) due to break in monsoon current in June twice and finally suppressed by strong monsoon current on 7th July.

Table 2

Particulars of Heatwaves monthwise and districtwise prevailed in Andhra Pradesh and Telangana in Hot Weather Season, 2023

Station (District)	April	May	June	Total			Remarks
				H	S	T	
Coastal Andhra Pradesh							Number of heat wave days
Kalingapatnam (SRK)	H 3		S 3	H 3	S 3	6	In coastal Andhra Pradesh
Visakhapatnam City (VSK)			H S 5 1	H 5	S 1	6	April 10
Visakhapatnam Airport (VSK)	H 6		H S 5 5	H 11	S 5	16	May 4
Tuni (E.G)	H S 8 2		H S 7 5	H 15	S 7	22	June 17
Kakinada (E.G)		H 2	H S 8 2	H 10	S 2	12	Total – 31
Narsapuram (WG)	H 1	S 2	H S 4 1	H 5	S 3	8	
Machilipatnam (KRI)	H 1	H 3	H S 6 2	H 10	S 2	12	
Gannavaram (KRI)			H 5	H 5		5	
Nandigama (KRI)	H 1		H 8	H 9		9	
Bapatla (GNT)	S 1	H S 2 2	H S 8 3	H 10	S 6	16	
Jangameswara puram (GNT)		H 2	H S 6 4	H 8	S 4	12	
Ongole (PSKM)		H 1	H 5	H 6		6	
Kavali (NLR)		H 1	H 6	H 7		7	
Nellore (NLR)			H 1	H 1		1	
Rayalaseema							
Ananthapur (ANT)			H 3	H 3		3	In Rayalaseema
Kurnool (KRN)			H 2	H 2		2	April 0
Nandyal (KRN)			H 2	H 2		2	May 0
Tirupathi			H 1	H 1		1	June 5
						Total	5
Telangana							
Adilabad (ADL)			H S 8 1	H 8	S 1	9	In Telangana
Ramagundam (KRM)			H S 8 1	H 8	S 1	9	April 0
Nizamabad (NZB)			H 5	H 5		5	June 0

Medak (MDK)			H 9	H 9		9	June 20
Hanuma Konda (WRGL)			H 8	H 8		8	TOTAL 20
Khammam (KHM)			H S 9 7	H 9	S 7	16	
Bhadrachalam (KHM)			H S 9 3	H 9	S 3	12	
Nalgonda (NLG)			H 8	H 8		8	
Hyderabad (Hyd)			H 1	H 1		1	
Hakimpeta (RR)			H 2	H 2		2	
Mahabubnagar						0	

Legend : H : Heatwave conditions prevailed at isolated pockets
S : Severe Heatwave conditions prevailed at isolated pockets.

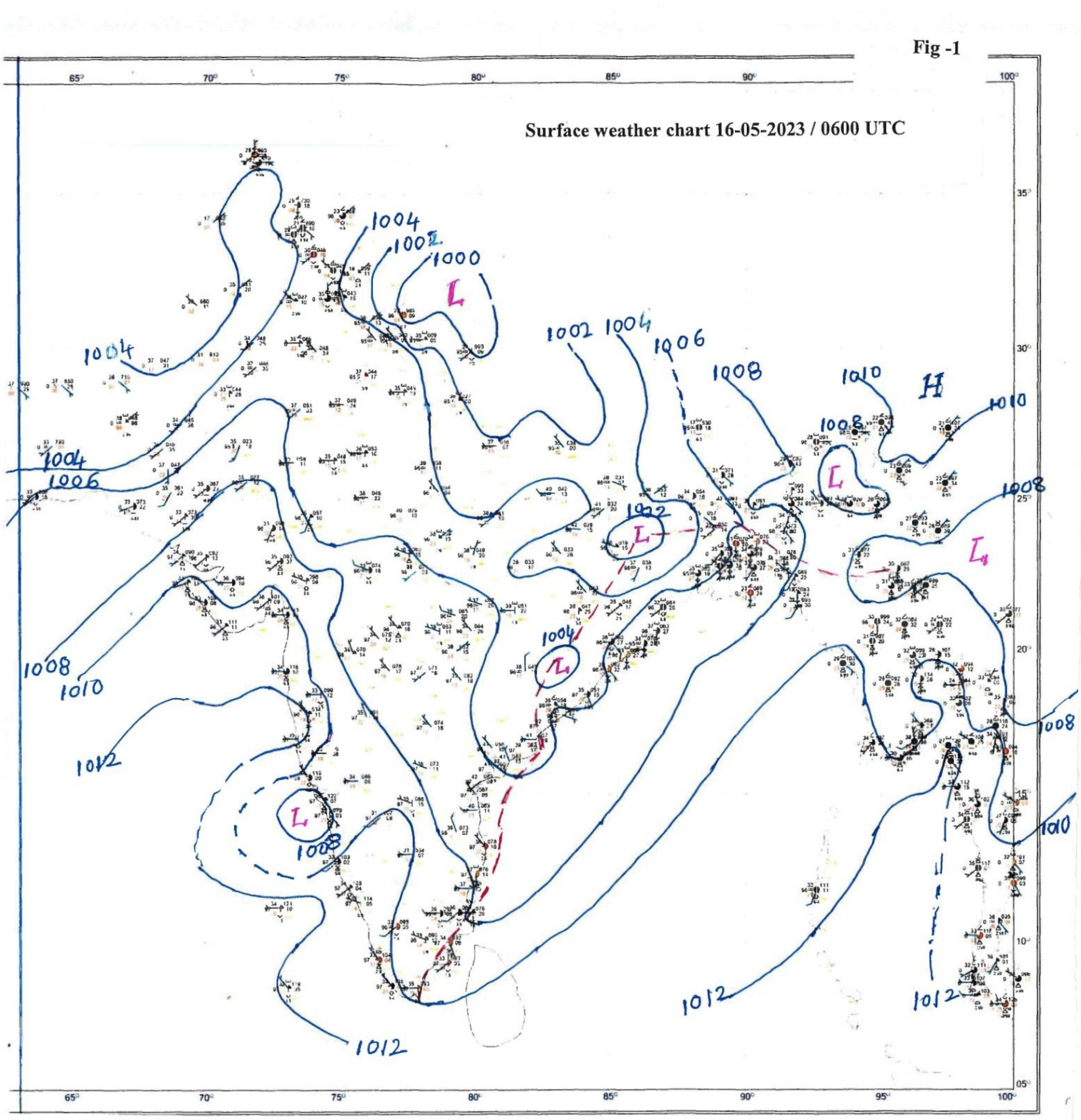


Fig.1 Surface Weather Chart of 16.05.2023 – 0600 UTC

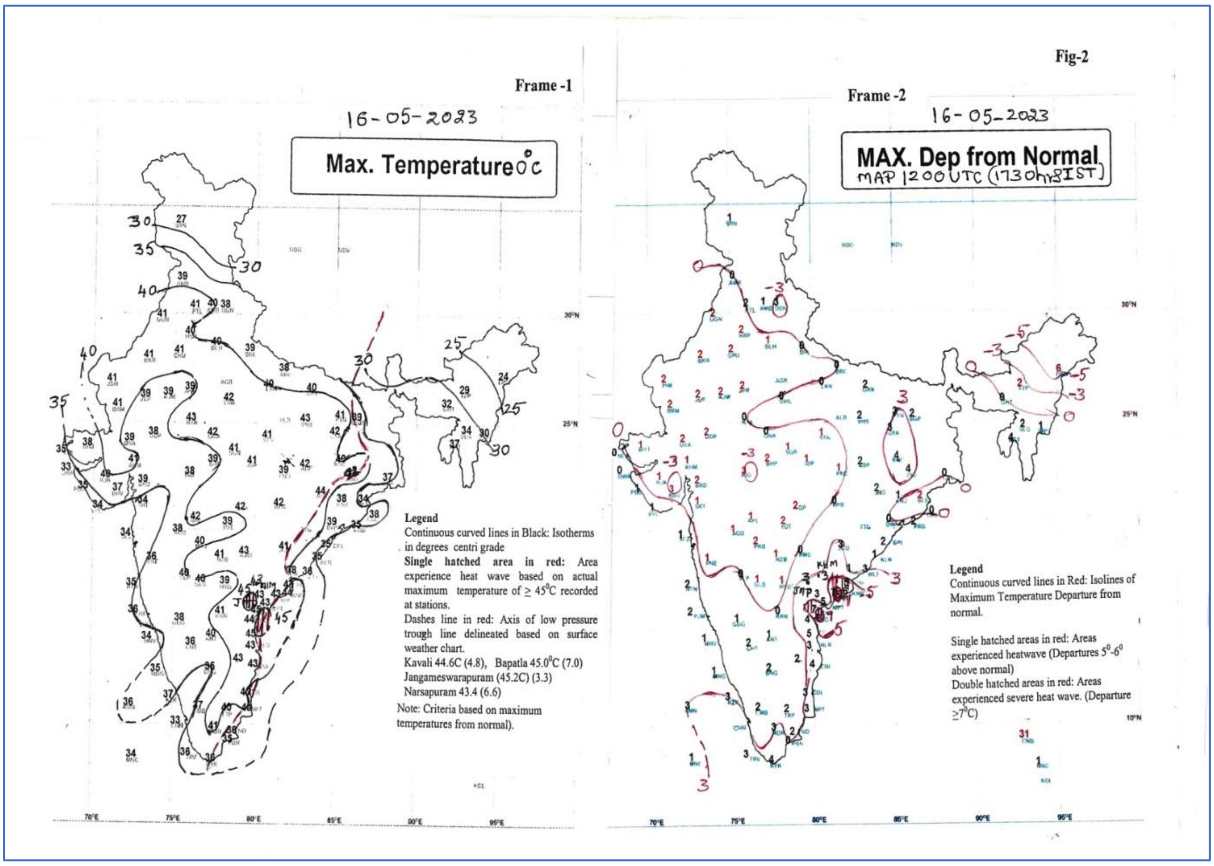


Fig. 2 : Maximum temperature and its departure from normal – 16.05.2023

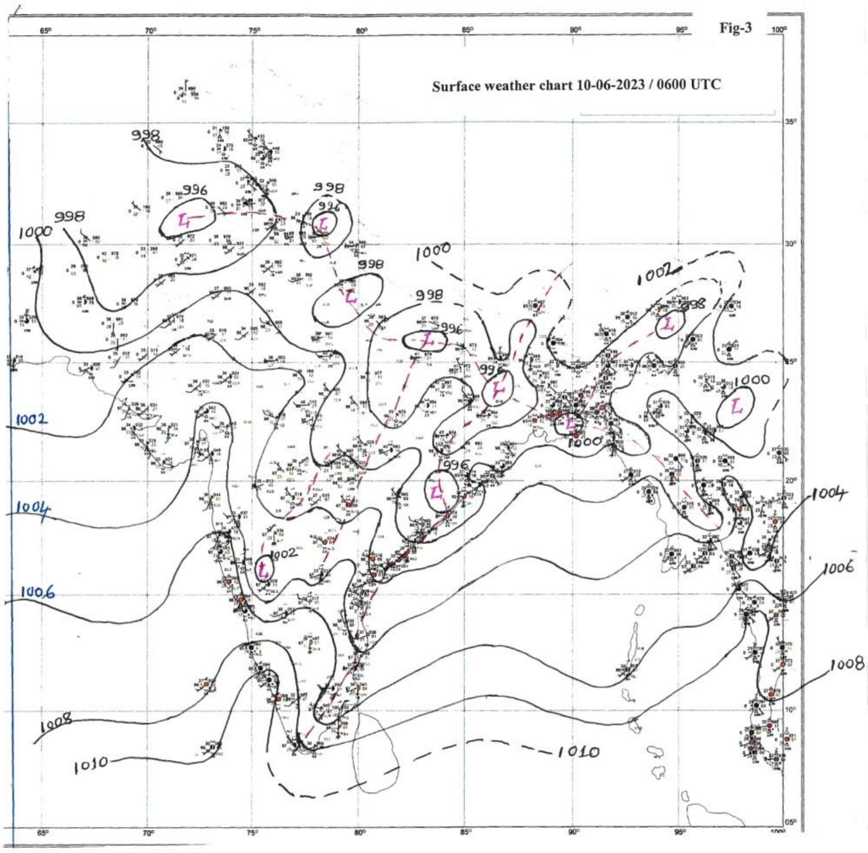


Fig. 3 Surface Weather Chart of 10.06.2023 / 0600 UTC

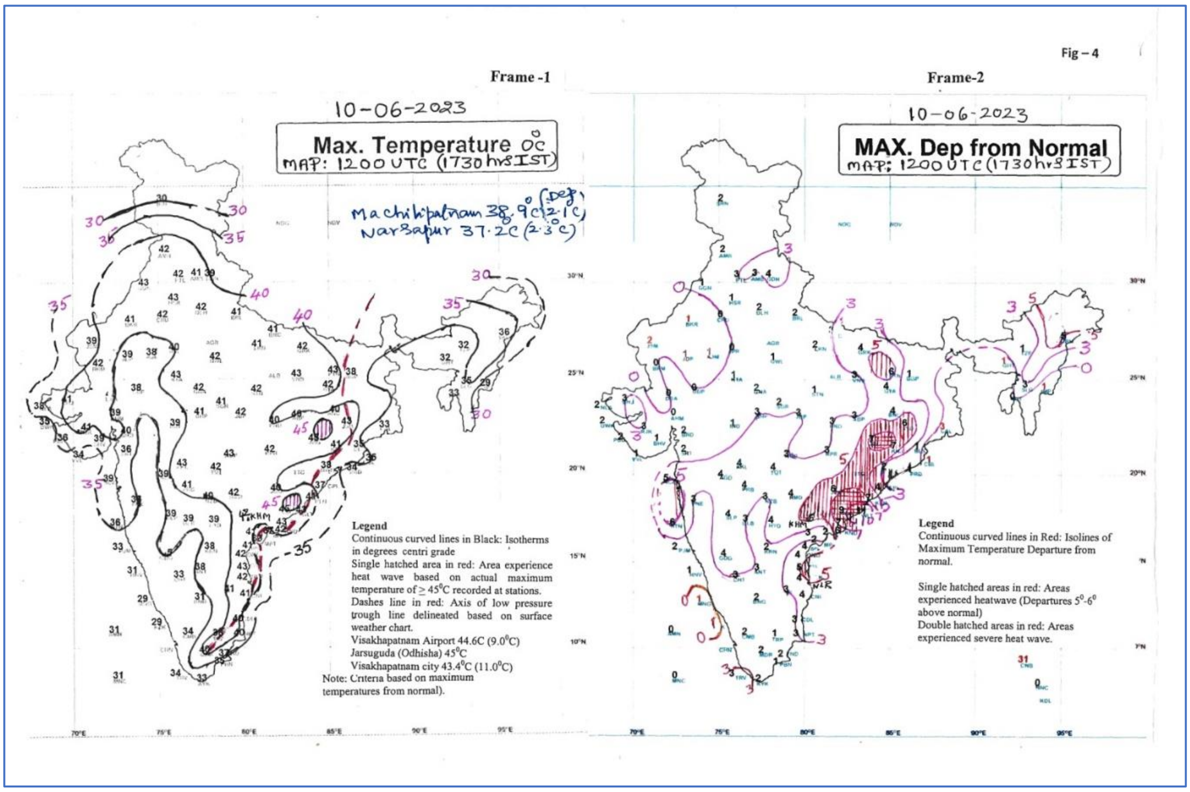


Fig.4 Maximum temperature and its departure from normal – 10.06.2023

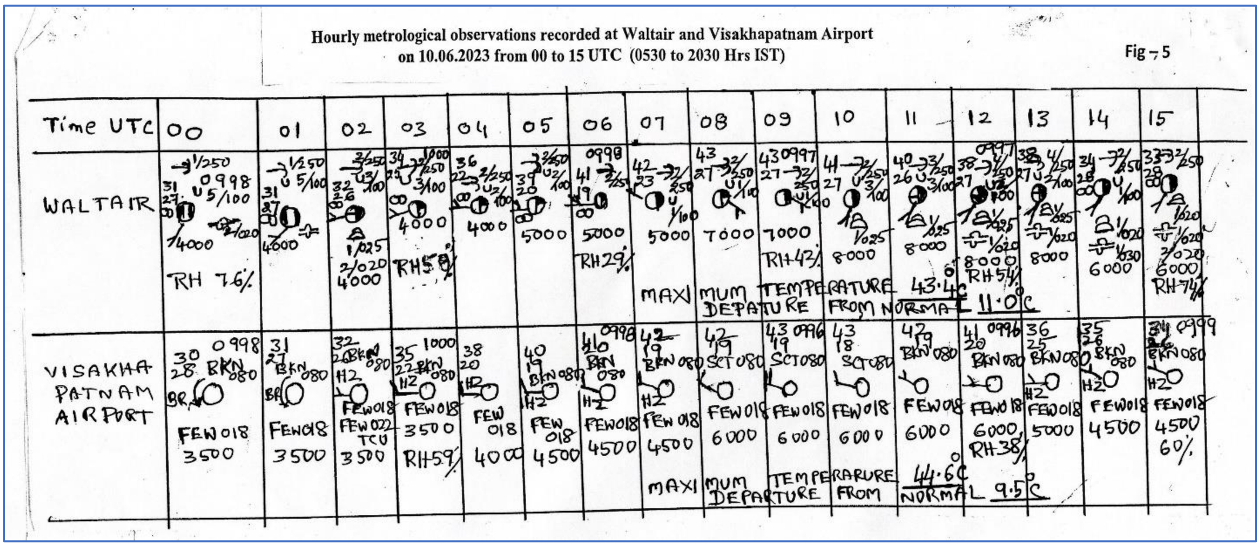


Fig.5 Hourly meteorological observations of Waltair and Visakhapatnam Airport

1st Sept 2023

Coastal A.P. saw the most heatwave days in 2023, highest in the last decade

Heatwaves prevailed in Telangana for 20 days in June this year; Tuni recorded highest maximum temperature of 46.4 degree Celsius, with maximum departure of 10.5 degree Celsius from normal

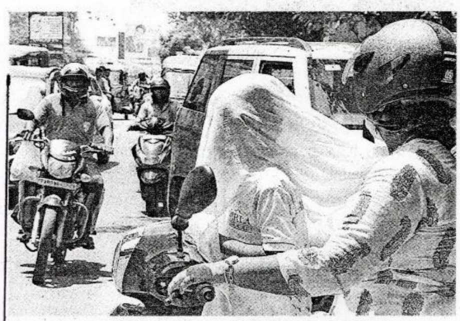
B. Madhu Gopal
VISAKHAPATNAM

Coastal Andhra Pradesh experienced the worst hot weather season in 2023. Visakhapatnam city (Waltair) experienced severe heatwave conditions with a record highest maximum temperature of 43.4 degrees Celsius (with maximum temperature departure of 11 degrees C from normal) on June 10, the highest in the last 60 years.

Though children and senior citizens had suffered the most due to the erratic weather, even those in the middle-age group complained of the sun sapping their energy for more days, this year, compared to previous years.

During the last 10 years starting with 2014, the frequency of heat wave days, during the hot weather season, was the highest this year with 31 days, while the previous highest figure was 24 days in 2019, which was against the normal of 15 days a year.

In June 2023, heatwaves occurred for 17 days before the advance of southwest monsoon. Severe heatwave conditions in the season prevailed at isolated pockets for seven days in East Godavari, for six days in Guntur, for five days in



A woman uses her stole to protect her child from the sun on a particularly hot, sultry day in Visakhapatnam. V. RAJU

Visakhapatnam, for three days each in Srikakulam and West Godavari and for two days in Krishna districts of coastal Andhra Pradesh, says P.V. Rama Rao, retired IMD Director.

Due to a delay in advance and coverage of southwest monsoon by 12 days in the State, the hot weather season was extended up to the third week of June, 2023, says Mr. Rama Rao, who has made a study, based on the data collected from IMD and the A.P. State Disaster Management authorities.

"The severe heatwave conditions in Visakhapatnam on June 10, 2023, can be attributed to the arrest of sea breeze due to the location of the axis of trough line over the station and prevailing very light dry winds from a westerly direction. The relative humidity fell rapidly from 76% to 29% in the afternoon resulting in the citizens experiencing severe heat waves. Visakhapatnam airport recorded a maximum of 44.6 degree C, with a departure of 9.5 degree C from the normal on the same day," he recalls.

Tuni in East Godavari district recorded the highest maximum temperature of 46.4 degree C, with maximum temperature departure of 10.5 degree C from normal.

"Tuni is the only station in AP, which continuously experienced heat wave conditions for 10 days from April 10 to 19, 2023, which includes two days of severe heat wave. It is also the station which recorded the highest number of 22 days out of 31 days of heat waves in the season in coastal Andhra Pradesh. Its location over rocky areas, and hill ranges surrounding it, are the one of the main reasons for the increase in the frequency of heat wave days. However, Kakinada city, located in a south-south westerly direction at a distance of 60 km away from Tuni, didn't record heat wave even a single day in April, 2023," says Mr. Rama Rao.

In Rayalaseema subdivision, heatwaves occurred for five days in June 2023, against normal of nil to five days in a year, he says. Rayalaseema is less prone to heat wave conditions and however, it experiences hot weather with record maximum temperatures varying from 39 to 44 degree Celsius during hot weather season.

Studies indicate that in Andhra Pradesh, south Coastal Andhra Pradesh and Godavari districts are more prone to heat wave conditions. Guntur and Krishna districts are vulnerable to severe heat wave conditions. In comparison, the northern districts of Srikakulam, Vizianagaram and Visakhapatnam are less prone to heatwaves.