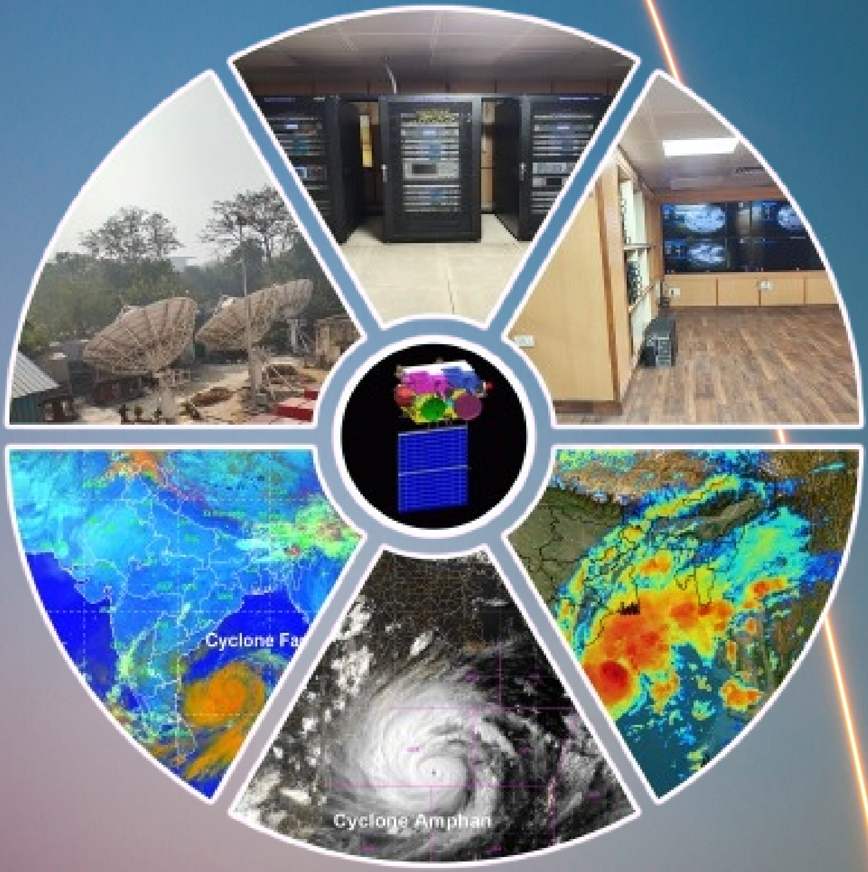
सत्यमेव जयते
MINISTRY OF EARTH SCIENCES

150 Years of Service to the Nation
राष्ट्र सेवा के 150 वर्ष

INDIA METEOROLOGICAL DEPARTMENT

STANDARD OPERATING PROCEDURE (SOP)
NATIONAL SATELLITE METEOROLOGICAL CENTRE



INDIA METEOROLOGICAL DEPARTMENT
MINISTRY OF EARTH SCIENCES
GOVERNMENT OF INDIA
2026

PREFACE

Satellite Meteorology has become an indispensable component of modern weather forecasting, environmental monitoring, and disaster risk reduction. The India Meteorological Department (IMD) has been utilizing meteorological satellite observations for operational weather services since the early 1970s. Beginning with the reception of imagery from NOAA and NASA meteorological satellites, IMD has continuously strengthened its satellite meteorology capabilities in line with technological advancements and the growing demand for accurate and timely weather information.

A major milestone in this journey was the launch of the Indian National Satellite (INSAT) programme in 1982 and the establishment of the first INSAT data reception and processing system in IMD in 1983. Over the years, successive generations of meteorological satellites, including INSAT-3D, INSAT-3DR, and INSAT-3DS, have significantly enhanced the capability of IMD to monitor weather systems over the Indian region and adjoining oceans.

The Satellite Meteorology Division (SMD) of IMD is responsible for the reception, processing, analysis, interpretation, archival, and dissemination of meteorological satellite data and products. To strengthen operational services, IMD established the Multi-Mission Meteorological Data Receiving and Processing System (MMDRPS), which became operational in October 2019. MMDRPS provides an integrated platform for real-time reception, processing, generation, storage, and dissemination of satellite data and products from INSAT-3D, INSAT-3DR, and INSAT-3DS satellites.

The Division generates a wide range of satellite-derived products from Imager and Sounder observations, including cloud imagery, RGB products, Atmospheric Motion Vectors, Quantitative Precipitation Estimates, Sea Surface Temperature, Outgoing Longwave Radiation, Snow Cover, Aerosol Optical Depth, Land Surface Temperature, Integrated Precipitable Water Vapour, and atmospheric temperature and humidity profiles. These products support weather forecasting, nowcasting, aviation, marine, agrometeorological, hydrometeorological, climate, and disaster management services. Satellite radiance and derived products are also assimilated into Numerical Weather Prediction (NWP) models, contributing significantly to improved forecast accuracy.

In addition to INSAT observations, the Division utilizes data from Oceansat-3, Meteosat-9, Himawari, and other international satellite systems. It also operates a network of Global Navigation Satellite System (GNSS) stations for Integrated Precipitable Water Vapour monitoring and manages Data Relay Transponder (DRT) and satellite-aided Search and Rescue services. Satellite products and information are disseminated in near real time to forecasters, research institutions, disaster management agencies, and other users.

With the advent of new-generation satellites, advanced processing systems, and increasing societal requirements for weather and climate services, the scope and complexity of satellite meteorological operations have expanded considerably. Accordingly, this **Standard Operating Procedure (SOP) has been prepared to document** and standardize the operational procedures related to INSAT-3DR/3DS scanning strategies, satellite data reception and processing through MMDRPS, generation of satellite products, utilization of national and international satellite data, GNSS operations, DRT services, and dissemination of satellite information. It is hoped that **this SOP will serve as a valuable reference for scientists, meteorologists, technical officers, and operational personnel engaged in satellite meteorology activities.**

(Dr. M. Mohapatra)

Director General of Meteorology

ACKNOWLEDGEMENT

The present publication has been prepared through the collective efforts of officers and staff members associated with the Satellite Meteorology Division of the India Meteorological Department (IMD). I sincerely appreciate the dedication, commitment, and hard work of all contributors involved in the formulation of this document, namely the *Standard Operating Procedure (SOP) of the Satellite Meteorology Division*.

I express my sincere appreciation to **Dr. Gargi Rakshit, Scientist-C, Shri Pankaj Kumar, Scientific Assistant, Shri Atul Kumar Verma, Meteorologist-A, Shri Harshit Verma, Scientific Assistant, Shri Yogesh Kumar Jha, Meteorologist-A, Dr. A. K. Mitra, Scientist-F and Dr. R. K. Giri, Scientist-F** for their tireless efforts and significant contributions as resource persons in the preparation of this SOP. Their valuable inputs in documenting the operational procedures related to satellite data reception, processing, product generation, dissemination, MMDRPS operations, INSAT-3DR/3DS products, GNSS activities, and associated services have greatly contributed to the successful completion of this document.

I am confident that this SOP will serve as a valuable reference for scientists, meteorologists, technical officers, and operational personnel engaged in satellite meteorology activities and will contribute towards strengthening and standardizing satellite-based meteorological services in the country.

(Dr. M. Mohapatra)

Director General of Meteorology

STANDARD OPERATING PROCEDURE (SOP)
SATELLITE METEOROLOGY DIVISION
INDIA METEOROLOGICAL DEPARTMENT

TABLE OF CONTENTS

Page No.

Chapter 1: Introduction **1-2**

Chapter 2: INSAT-3DR/3DS Scanning Strategy **3-10**

2.1 INSAT- 3DR/3DS -Imager

2.1.1 Flexible Operational Modes
  2.1.2 September Equinox to March Equinox
  2.1.3 March Equinox to September Equinox
  2.1.4 INSAT-3DR/DS Imager can also be operated in RAPID SCAN Mode
  2.1.5 Rapid Scan Mode

2.2 INSAT- 3DR/3DS –SOUNDER
2.3 Equinox-related Scan Cancellation Strategy of INSAT-3DR and INSAT-3DS

Chapter 3: INSAT-3DR/3DS Imager Channel Specifications and Products **11-30**

3.1 Channel-wise Description

  3.1.1 Visible Channel
  3.1.2 Shortwave Infrared Channel
  3.1.3 Midwave Infrared Channel
  3.1.4 Water Vapour Channel
  3.1.5 Thermal Infrared Channel–1
  3.1.6 Thermal Infrared Channel–2

3.2 Specialized Satellite Image Products

  3.2.1 Cloud Top Brightness Temperature/IR-1 BT Blended Image

  3.2.2 IR-1 BT & Visible Sandwich Image

3.2.3 BD Curve and IMD curve Enhancement images for cyclone
3.2.4 Visualization of surface Lighting network Data over satellite images

3.3 Cloud Imageries

3.3.1 Cloud Imagery of INSAT-3DR/3DS IMAGER
3.3.2 Basic Imagery Products
3.3.3 High Resolution Images with District Boundaries
3.3.4. Special Sector Images

3.4 RGB Composite Imagery

3.4.1 Day Microphysics RGB Imagery
3.4.2 Night Microphysics RGB Imagery

3.5 Imager Derived Products from INSAT-3DR & 3DS Satellite

3.5.1 Comparative assessment of different rainfall products of INSAT 3DR/3DS
3.5.2 Atmospheric Motion Vectors (AMV) and wind Derived products
3.5.3 Miscellaneous Geophysical Products
3.5.4 Radiation Products/ Agromet Products

Chapter 4: INSAT-3DR/3DS Sounder Specifications and Products 31-33

4.1 Sounder Channel Specifications

4.2 Sounder Products

Chapter 5: Data Relay Transponder and Satellite Aided Search and Rescue 34

5.1 Data Relay Transponder (DRT)

5.2 Satellite Aided Search and Rescue Transponder

Chapter 6: OceanSat-3 (EOS-06) 35-36

6.1 Overview of OceanSat-3 Mission

Chapter 7: Foreign Satellites 37

7.1 EUMETCast Dissemination System

7.2 Meteosat-9 (Indian Ocean Data Coverage, IODC)

7.3 Himawari Satellite

Chapter 8: Global Navigation Satellite System (GNSS) 38-41

8.1 GNSS Network Infrastructure

8.2 GNSS Operational Access and Display

Chapter 9: Data Flow and Dissemination of MMDRPS 42-45

9.1 MMDRPS System Architecture

9.2 Satellite Data Dissemination Mechanisms

Chapter 1: Introduction

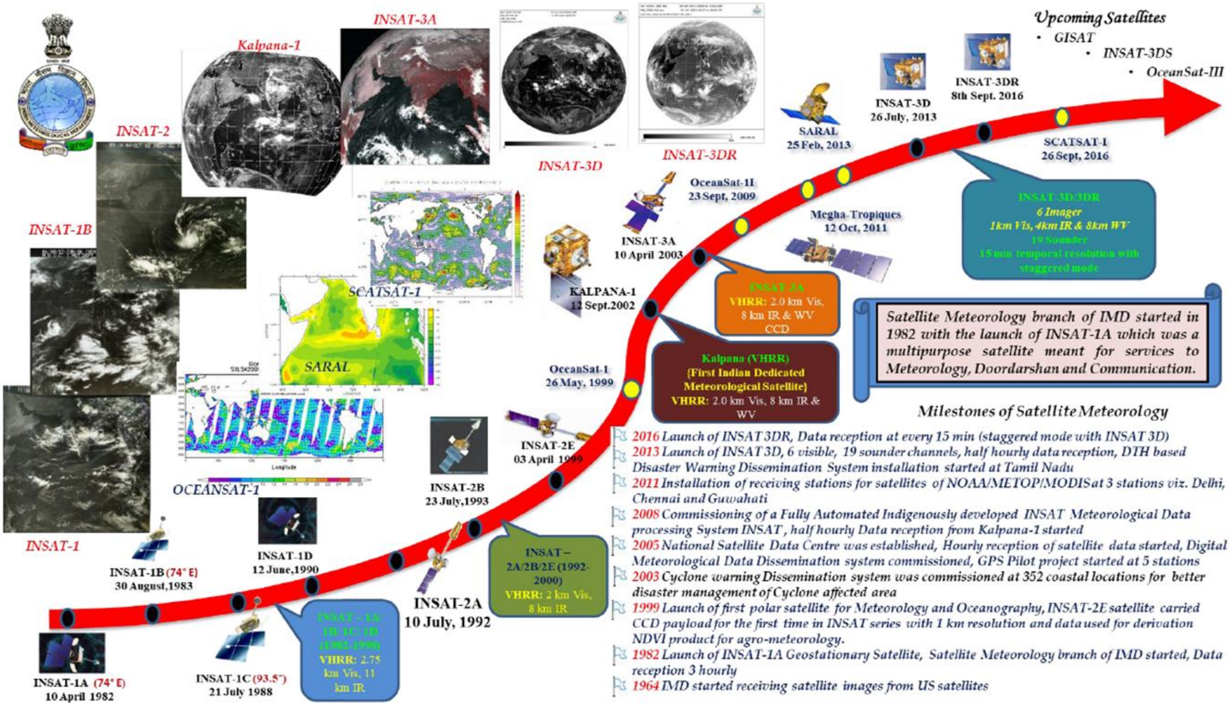
The Satellite Meteorology Division of the India Meteorological Department (IMD) has been operational since the early 1970s. During the period from 1972 to 1982, IMD received satellite imagery from NOAA and NASA meteorological satellites through the Secondary Data Utilization Centre (SDUC). These images were printed on photographic paper and were routinely used for weather forecasting purposes. With continuous advancements in satellite technology, observational capabilities steadily improved, leading to a significant transformation in satellite-based meteorological services. The first generation of the Indian National Satellite (INSAT) programme was initiated in 1982 as a series of multipurpose geostationary satellites by ISRO to meet national requirements in telecommunications, broadcasting, meteorology, and search-and-rescue operations. In 1983, IMD established its first satellite data receiving and processing system to receive and process data from INSAT-1B, marking the formation of a full-fledged Satellite Meteorology Division dedicated to providing meteorological satellite services to the nation. Since then, IMD has continuously provided satellite-based meteorological services to forecasters using data from the meteorological payloads onboard INSAT-1, INSAT-2, and INSAT-3 series satellites.

During the INSAT-1 and INSAT-2 series periods, satellite scan acquisitions were available at a temporal resolution of three hours. Until 1992, satellite images were developed on photographic sheets using conventional photographic processes, after which imagery printing transitioned to thermal Kodak printers. In 1996, IMD initiated the dissemination of satellite imagery through its official website. Over the years, the Satellite Meteorology Division has made steady progress in satellite data reception and in the generation of several new satellite-derived products that have proven highly valuable for weather forecasting. At present, satellite technology plays a crucial role in meteorology and has significantly contributed to improvements in weather forecasting capabilities.

Currently, IMD utilizes data from Indian meteorological geostationary satellites INSAT-3DR and INSAT-3DS, polar-orbiting satellites including Oceansat-3, as well as international geostationary meteorological satellites such as METEOSAT-9 of EUMETSAT and Himawari-9 of JMA. These datasets are received in near real time for operational weather forecasting through the terrestrial EUMETCast system.

INSAT-3DR and INSAT-3DS are dedicated meteorological geostationary satellites positioned at 74°E and 82°E longitudes, respectively. Both satellites carry a multispectral six-channel Imager, a 19-channel Sounder, a Data Relay Transponder, and a Search and Rescue Transponder. The Imager payloads onboard INSAT-3DR and INSAT-3DS are operated in a staggered mode, enabling an effective temporal resolution of 15 minutes. The Sounder payloads of INSAT-3DR and INSAT-3DS are used in an integrated manner, allowing Indian land region sector data to be available on an hourly basis, while Indian Ocean region data become available at 1.5-hour intervals from either INSAT-3DR or INSAT-3DS.

To support enhanced data reception and processing capabilities, IMD has established the Multi-Mission Meteorological Data Receiving and Processing System (MMDRPS) for INSAT-3D, INSAT-3DR, and INSAT-3DS satellites through a Memorandum of Understanding with M/s Antrix Corporation Ltd., ISRO. As part of this initiative, the existing IMDPS system is being phased out. Dedicated new Earth stations have been set up under the MMDRPS project, with the capability to receive data from INSAT-3D, INSAT-3DR, and INSAT-3DS satellite.



Satellite Meteorology branch of IMD started in 1982 with the launch of INSAT-1A which was a multipurpose satellite meant for services to Meteorology, Doordarshan and Communication.

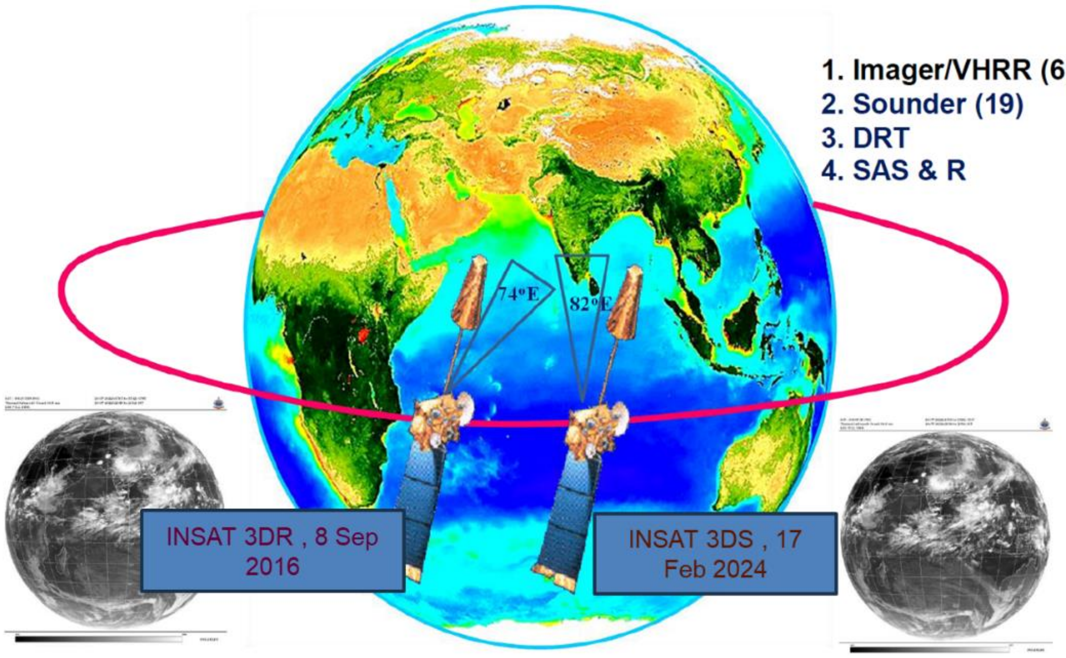
Milestones of Satellite Meteorology

- *2016 Launch of INSAT 3DR, Data reception at every 15 min (staggered mode with INSAT 3D)*
- *2013 Launch of INSAT 3D, 6 visible, 19 sounder channels, half hourly data reception, DTH based Disaster Warning Dissemination System installation started at Tamil Nadu*
- *2011 Installation of receiving stations for satellites of NOAA/METOP/MODIS at 3 stations viz. Delhi, Chennai and Guwahati*
- *2008 Commissioning of a Fully Automated Indigenously developed INSAT Meteorological Data processing System INSAT, half hourly Data reception from Kalpana-1 started*
- *2005 National Satellite Data Centre was established, Hourly reception of satellite data started, Digital Meteorological Data Dissemination system commissioned, GPS Pilot project started at 5 stations*
- *2003 Cyclone warning Dissemination system was commissioned at 352 coastal locations for better disaster management of Cyclone affected area*
- *1999 Launch of first polar satellite for Meteorology and Oceanography, INSAT-2E satellite carried CCD payload for the first time in INSAT series with 1 km resolution and data used for derivation NDVI product for agro-meteorology.*
- *1982 Launch of INSAT-1A Geostationary Satellite, Satellite Meteorology branch of IMD started, Data reception 3 hourly*
- *1964 IMD started receiving satellite images from US satellites*

The MMDRPS infrastructure comprises advanced, state-of-the-art servers capable of processing the complete set of satellite data within seven minutes of scan completion. The system includes a storage capacity of approximately 2.0 PB each for main and mirror storage, along with 324 TB of SSD storage. This infrastructure facilitates online sharing of processed data from all Indian meteorological satellites to registered users, in accordance with IMD's data policy, through a secure web-based Satellite Data Supply System. In due course, all available historical satellite datasets dating back to 1983 will be maintained in online mode for user access.

Chapter 2: INSAT 3DR/DS Scanning Strategy

This chapter outlines the scanning strategy and operational characteristics of INSAT-3DR and INSAT-3DS meteorological satellites. It describes the configuration and functioning of the Imager and Sounder payloads, including routine full-disk observations and sector-based scanning. The chapter also explains seasonal variations in scanning direction and the implementation of Rapid Scan Mode for monitoring severe weather systems. The information provided forms the operational basis for satellite data utilization in weather monitoring and forecasting.



INSAT-3DR & 3DS Satellite Payloads

INSAT-3DR and INSAT-3DS are advanced meteorological satellites designed to support weather monitoring, forecasting, and disaster management activities over the Indian region and surrounding oceanic areas. The satellites carry four primary payloads, namely:

(i) Six channel Imager
(ii) Nineteen channel Sounder
(iii) Data Relay Transponder (DRT)
(iv) Satellite aided Search and Rescue(S&SR) System

These payloads together provide multi-spectral observations, atmospheric sounding data, data collection from remote platforms, and emergency distress signal detection capabilities, thereby strengthening operational meteorological services.

2.1. INSAT- 3DR/3DS -Imager

It is multi-spectral (optical radiometer) capable of generating the images of the earth in six wavelength bands significant for meteorological observations, namely, visible, shortwave infrared, middle infrared, water vapor and two bands in thermal infrared regions. The Imager generates images of the earth disk from geostationary altitude of 36,000 km every 26 minutes and provide information on various parameters, namely, outgoing long-wave radiation, quantitative precipitation estimation, sea surface temperature, snow cover, cloud motion winds, etc.

Several improvements have been incorporated in the INSAT-3DR/3DS Imager compared to earlier Very High Resolution Radiometer (VHRR) sensors. These include:
1. Blackbody calibration sequence is modified as compared to VHRR of earlier satellites.
2. In the Fast Scan direction IFOVs are over sampled by 1.75 times.
3. Satellite is flip after every six months that is a biannual rotation of yaw by 180 degree has been introduced to maintain proper cold patch temperature.

2.1.1 Flexible Operational Modes

The Imager supports two flexible scanning modes to meet routine and special observation requirements:

- **Full Frame Mode:**
This mode scans an 18° × 18° Earth disk in east-west and north-south directions and completes a full disk scan in approximately 26 minutes.

- **Program Mode:**
This mode allows user-defined north-south coverage by specifying the number of scan lines over selected regions, enabling targeted observations.

During full-disk operations, the Earth disk is divided into 36 north-south blocks. Each block requires approximately 45 seconds (0.75 minutes) for scanning.

2.1.2 September Equinox to March Equinox (North → South Scanning)

During this period, scanning starts from the **northernmost block** and moves southward.

- **Example of INSAT-3DS for the time stamp 00:00 UTC**

For a 00:00 UTC scan, Block 1 starts at 00:00 UTC.
The full-disk scan (36 blocks) is completed by about 00:27 UTC

- Example of INSAT-3DR for the time stamp 00:15 UTC

For a 00:15 UTC scan, Block 1 starts at 00:15 UTC.
The full-disk scan is completed by about 00:42 UTC.

The start time of any block (*n*) can be calculated as:

Scan start time + (n × 0.75 minutes)

2.1.3 March Equinox to September Equinox (South → North Scanning)

During this period, scanning starts from the **southernmost block** and moves northward.

- **Example of INSAT-3DS for the time stamp 00:00 UTC**

For a 00:00 UTC scan, Block 36 starts at 00:00 UTC,
and Block 1 is scanned last.

- Example of INSAT-3DR for the time stamp 00:15 UTC

For a 00:15 UTC scan, Block 36 starts at 00:15 UTC,
and Block 1 is scanned last.

The start time of block *n* during this season is calculated as:

Scan start time + (36 − n) × 0.75 minutes

N.B. Couple of scans are cancelled around March equinox and September equinox for FLIP maneuver and FLIP removal maneuver operations respectively.

Latitudinal & longitudinal extensions of the scanning blocks of INSAT 3DR/ DS

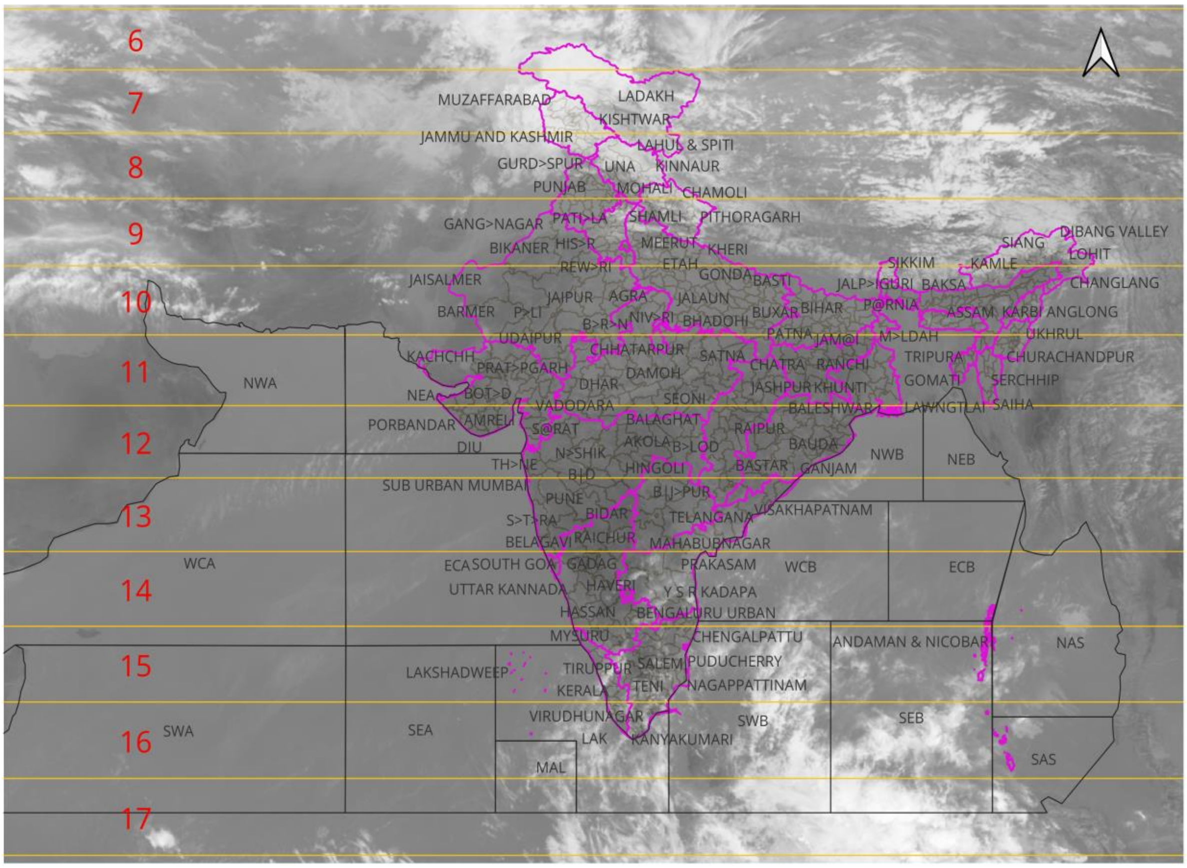
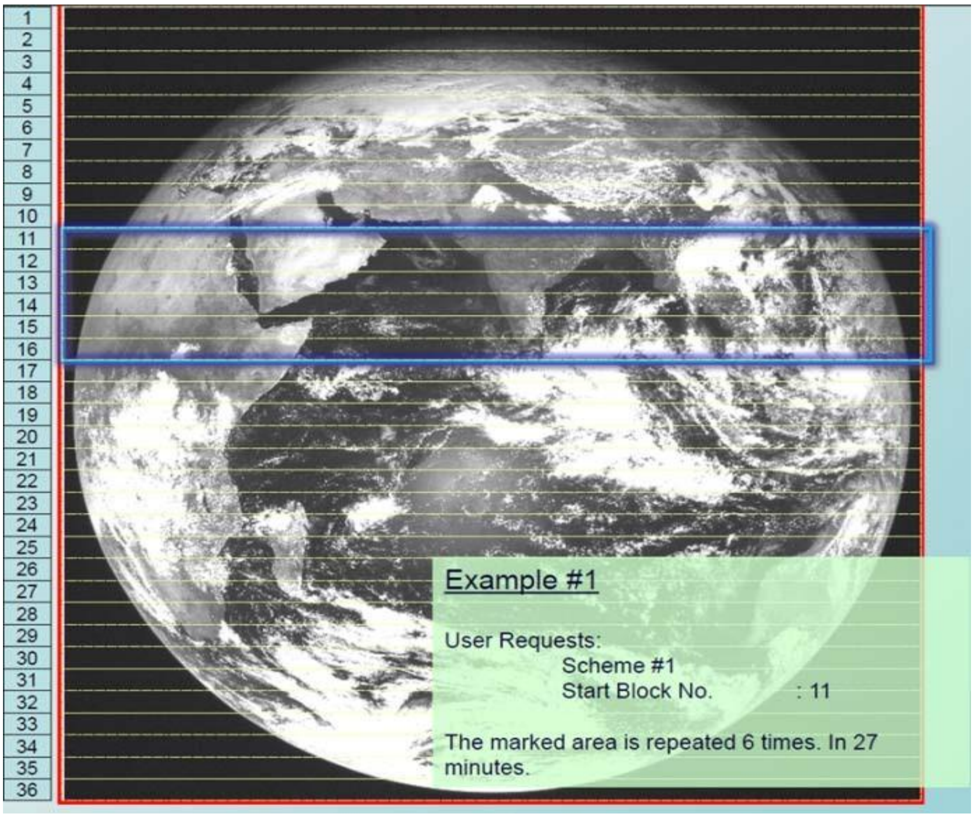


Table 2.1: Detailed Latitudinal & longitudinal extensions of the scanning blocks

Sl. No.	*Min Latitude*	*Max Latitude*	*Min Longitude*	*Max Longitude*
1	47.89216	50	20	130
2	45.69434	47.89216	20	130
3	43.406	45.69434	20	130
4	41.02718	43.406	20	130
5	38.55851	41.02718	20	130
6	36.0013	38.55851	20	130
7	33.35763	36.0013	20	130
8	30.63036	33.35763	20	130
9	27.82319	30.63036	20	130
10	24.94074	27.82319	20	130
11	21.98846	24.94074	20	130
12	18.97274	21.98846	20	130
13	15.90077	18.97274	20	130
14	12.78057	15.90077	20	130
15	9.620854	12.78057	20	130
16	6.430936	9.620854	20	130
17	3.220611	6.430936	20	130
18	0	3.220611	20	130
19	-3.22061	0	20	130
20	-6.43094	-3.22061	20	130
21	-9.62085	-6.43094	20	130
22	-12.7806	-9.62085	20	130
23	-15.9008	-12.7806	20	130
24	-18.9727	-15.9008	20	130
25	-21.9885	-18.9727	20	130
26	-24.9407	-21.9885	20	130
27	-27.8232	-24.9407	20	130
28	-30.6304	-27.8232	20	130
29	-33.3576	-30.6304	20	130
30	-36.0013	-33.3576	20	130
31	-38.5585	-36.0013	20	130
32	-41.0272	-38.5585	20	130
33	-43.406	-41.0272	20	130
34	-45.6943	-43.406	20	130
35	-47.8922	-45.6943	20	130
36	-50	-47.8922	20	130

2.1.4 INSAT-3DR/DS Imager can also be operated in RAPID SCAN Mode:

To ensure simplified and standardized operational use of this capability, a dedicated Rapid Scan operational strategy has been formulated.



The spectral band and products images of rapid scan mode can be assessed through the following link: http://satellite.imd.gov.in/rapid/rapid_scan.htm

2.1.5 Rapid Scan Mode:

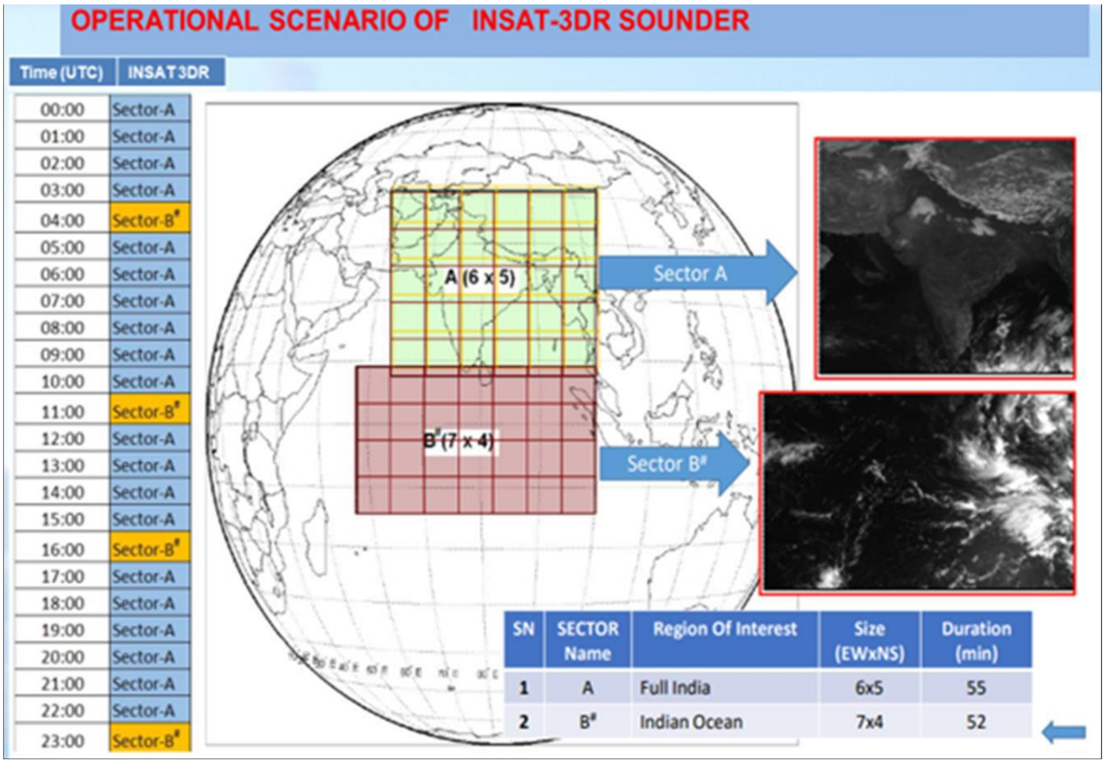
The INSAT-3DR/3DS Imager can be operated in Rapid Scan Mode to closely monitor severe weather phenomena such as tropical cyclones and thunderstorms. The Imager is designed with a flexible scanning capability known as "Program Mode"**,** which allows the number of scan lines over a selected geographic region and the number of repeated scans of that region to be user-defined.

Under severe weather conditions, INSAT-3DR/3DS provides Rapid Scan Mode observations**,** while continuing to maintain routine Full-Disk Scan Mode operations covering the entire Earth disk. In Rapid Scan Mode, the full disk is divided into 36 blocks along the north–south direction, with each block spanning 0.5° in latitude and comprising 40 scan lines (of 6 blocks each). A single Rapid Scan operation covers 240 scan lines and requires approximately 4.5 minutes to complete. The Master Control Facility (MCF), Hassan (ISRO) is notified to initiate Rapid Scan Mode upon receiving a request from the National Weather Forecasting Centre (NWFC), along with the following specifications:

- Starting block number
- Number of blocks to be scanned
- Number of scan repetitions

2.2 INSAT- 3DR/3DS -SOUNDER

The Sounder payload on INSAT-3DR and INSAT-3DS is operated such that the Indian land region sector is covered up to twenty times per day, while the Indian Ocean region is covered four times daily. These Indian Ocean sector observations are scheduled at 04, 11, 16, and 23 UTC for INSAT-3DR, and at 04:30, 11:30, 16:30, and 23:30 UTC for INSAT-3DS, with observations performed on an hourly basis.



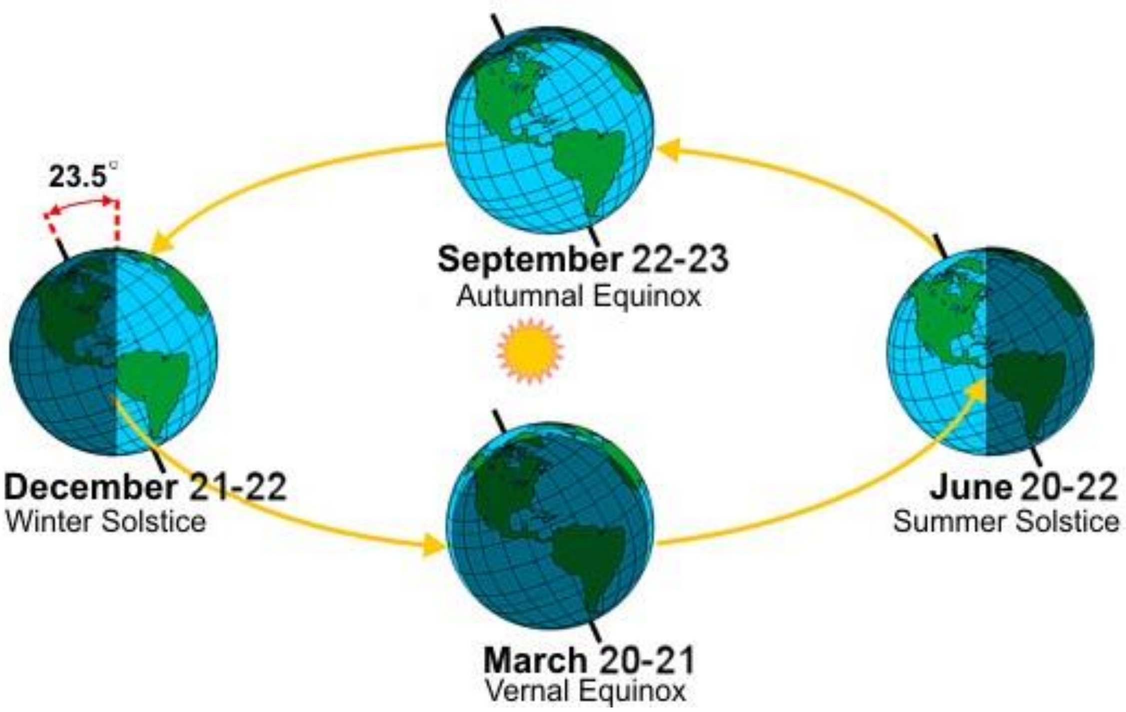
OPERATIONAL SCENARIO OF INSAT-3DR SOUNDER

Time (UTC)	INSAT 3DR
00:00	Sector-A
01:00	Sector-A
02:00	Sector-A
03:00	Sector-A
04:00	Sector-B#
05:00	Sector-A
06:00	Sector-A
07:00	Sector-A
08:00	Sector-A
09:00	Sector-A
10:00	Sector-A
11:00	Sector-B#
12:00	Sector-A
13:00	Sector-A
14:00	Sector-A
15:00	Sector-A
16:00	Sector-B#
17:00	Sector-A
18:00	Sector-A
19:00	Sector-A
20:00	Sector-A
21:00	Sector-A
22:00	Sector-A
23:00	Sector-B#

SN	SECTOR Name	Region Of Interest	Size (EWxNS)	Duration (min)
1	A	Full India	6x5	55
2	B#	Indian Ocean	7x4	52

The Sounder measures radiance simultaneously in eighteen infrared (IR) channels and one visible channel over a footprint of approximately 10 km × 40 km at nadir, with a sampling interval of 100 ms. Using a two-axis gimballed scan mirror, this footprint can be positioned anywhere within a field of regard (FOR) of 24° (east–west) × 19° (north–south). The Sounder operates in a scan program mode, which enables sequential sounding of a user-selected area, interspersed with periodic space views and calibration measurements. In this mode, a “frame” comprising multiple “blocks,” each covering an area of 640 km × 640 km is sounded. The selected frame can be positioned anywhere within the Sounder’s FOR of 24° (E–W) × 19° (N–S).

2.3 Equinox-related Scan Cancellation Strategy of INSAT-3DR and INSAT-3DS



During the equinox seasons, special operational measures are implemented for INSAT-3DR and INSAT-3DS to prevent direct solar radiation from entering the optical path of the Imager and Sounder sensors, which can adversely affect detector performance and calibration accuracy. This phenomenon, commonly referred to as **sun intrusion**, occurs when the Sun aligns with the satellite's line of sight near the equatorial plane. To mitigate this, selected scans are cancelled during specific time windows, with the number and duration of cancelled scans varying depending on the progression of the equinox period.

For INSAT-3DR, equinox-related scan cancellation began on end of January with the omission of approx. three Imager scans between 18:15 and 19:15 UTC. From ~9 February onward, the cancellation increased to four scans between 18:15 and 19:45 UTC, and Sounder scan cancellations also commences during this period. As the equinox approaches, the duration of scan cancellation gradually expanded. From ~11 March, up to six Imager scans are cancelled between ~17:45 and 20:15 UTC. The maximum impact occurred from ~26 March, when up to nine Imager scans are cancelled between 17:45 and 21:45 UTC, representing the most severe phase of equinox operations, which typically persists from late March through April. During this period, up to four Sounder observations are also cancelled. Subsequently, scan availability gradually improved, with seven scans cancelled on around start of May, reducing to six scans by ~7 May (18:15–20:45 UTC), four scans by 10 May (18:45–20:15 UTC), and two scans by mid-May (18:45 and 19:15 UTC). Normal scanning operations fully resumed from ~18 May onward.

A similar equinox impact was observed for INSAT-3DS. Scan cancellation began on ~15 February with omission of scans between 18:30 and 19:00 UTC, increasing in duration through late February and March. However the number of scan cancellations are comparatively less in INSAT 3DS due to improved structural changes in the spacecraft. The most significant cancellations occurred between late March and early May, with multiple scans cancelled between approximately 17:30 and 19:30 UTC. Sounder scan cancellations are also implemented intermittently during this period. Normal scanning operations for INSAT-3DS resumed fully by early May.

These equinox-related scan cancellations represent planned operational procedures to safeguard instrument performance and ensure long-term data quality. The worst impact typically occurs from late March to late April, after which normal scan schedules gradually resume.

During the September equinox season, equinox-related scan cancellation operations for INSAT-3DR and INSAT-3DS typically begin in ~July end, with gradual cancellation of selected Imager and Sounder scans to prevent solar intrusion into the sensors. The impact increases progressively and reaches its peak during late September to October, when the maximum number of scans are cancelled due to near-alignment of the Sun with the satellite viewing geometry. Thereafter, the number of cancelled scans decreases gradually, and good and uninterrupted scan availability is restored from mid-November to January end, when normal satellite operations resume fully.

Chapter 3: INSAT 3DR/DS Imager Channel Specification and Products

The INSAT-3DR and INSAT-3DS satellites are equipped with a six-channel multi-spectral imager designed to support real-time weather monitoring and operational forecasting. Each spectral channel operates in a specific wavelength region and provides complementary information about atmospheric, surface, and cloud characteristics. The selection of these channels enables detailed monitoring of cloud properties, moisture distribution, surface temperature, and severe weather phenomena. The following section describes the spectral configuration, spatial resolution, and primary meteorological applications of each imager channel.

INSAT 3DR/DS Imager Channel Specification:

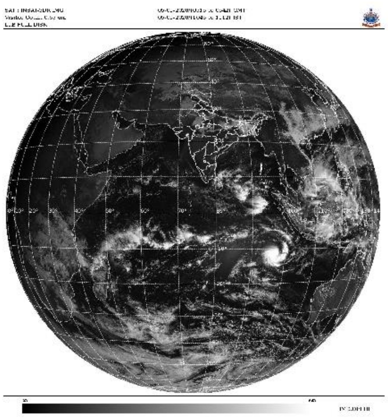
Channel no.	Spectral Band	Spectrum (µm)	Ground Resolution (km)	Purpose
1	Visible	0.55 – 0.75	1 × 1	Clouds, Surface features
2	SWIR	1.55 – 1.70	1 × 1	Snow, Ice and water phase in clouds
3	MIR	3.80 – 4.00	4 × 4	Clouds, Fog, Fire
4	WV	6.50 – 7.10	8 × 8	Upper-Troposphere Moisture
5	TIR1	10.3 – 11.3	4 × 4	Cloud top and surface temperature
6	TIR2	11.5 – 12.5	4 × 4	Lower-Troposphere Moisture

3.1 Channel-wise Description

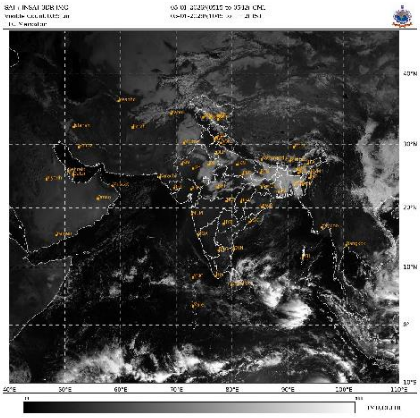
The six spectral channels of the INSAT-3DR/3DS imager provide multi-layered information about the atmosphere and surface. Each channel operates in a distinct portion of the electromagnetic spectrum and contributes uniquely to weather monitoring and forecasting. The detailed operational utility of each channel is described below.

3.1.1 Visible Band Channel

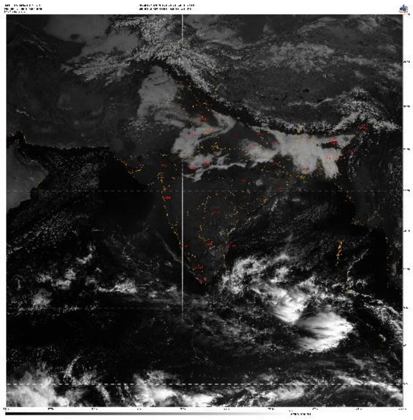
The Visible (VIS) band (0.55–0.75 µm) is a reflective band that relies on incoming solar radiation and is therefore usable only during daytime. Visible images represent the albedo of the observed surface, that is, the fraction of sunlight reflected back to the satellite. As a result, clouds, which generally have a higher albedo, appear bright, while land surfaces, with lower albedo, appear darker in visible imagery. Daytime visible images are widely used for monitoring mesoscale weather features, including cloud cover, air-mass boundaries, low-level convergence zones, cyclone structure and movement, thunderstorms, fog, dust storms, and snow cover. The band also provides useful information on cloud thickness, as thicker clouds reflect more sunlight and appear brighter, whereas thinner clouds appear relatively darker. The VIS band cannot detect clouds or surface features during night-time, as sunlight is absent. In addition, visible imagery does not provide information on precipitation, and therefore cannot be used to determine whether rainfall is occurring beneath the observed cloud systems.



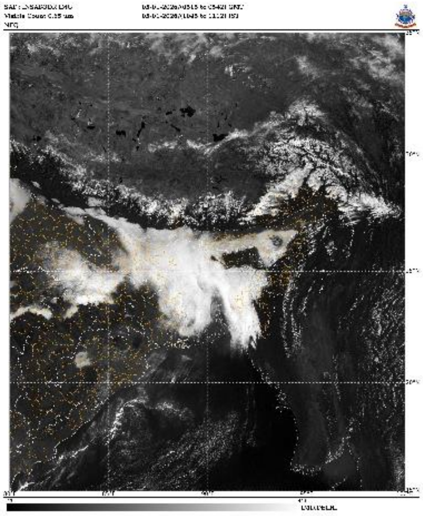
Globe



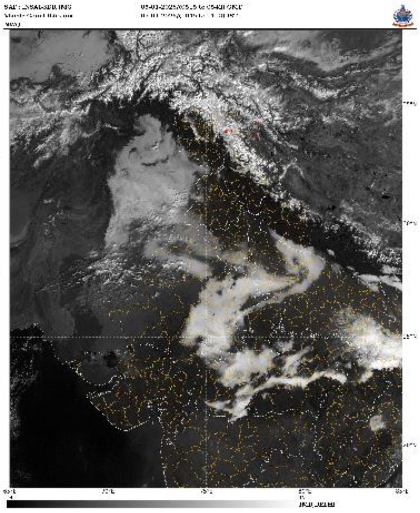
Asia Mer



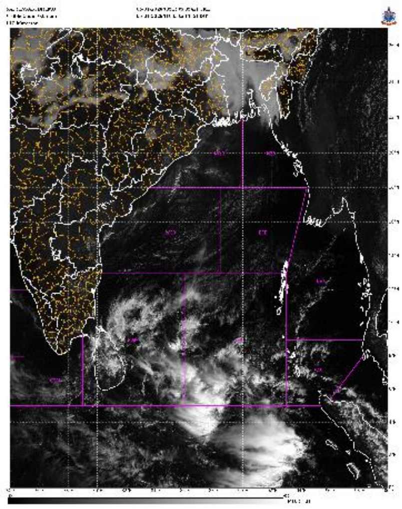
Aviation Sect



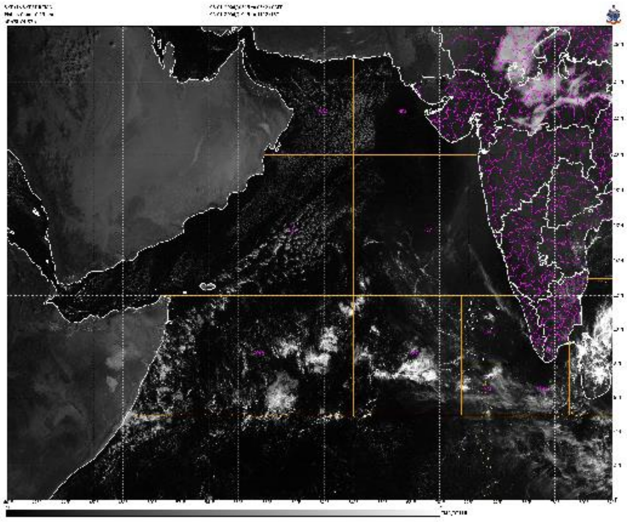
North East Sector



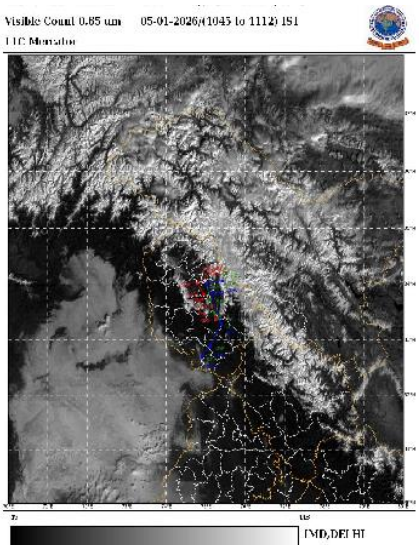
North West Sector



South East Sector



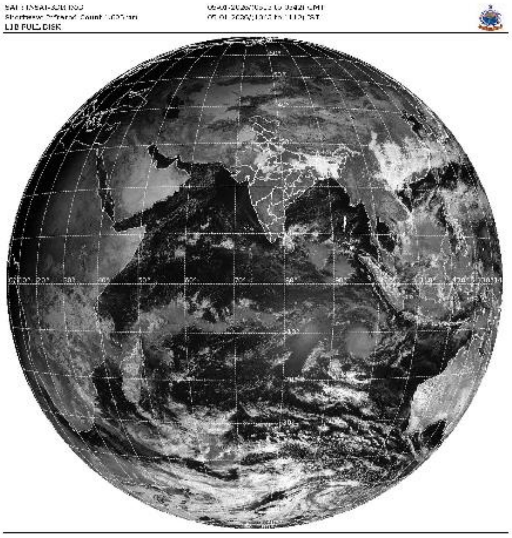
South West Sector



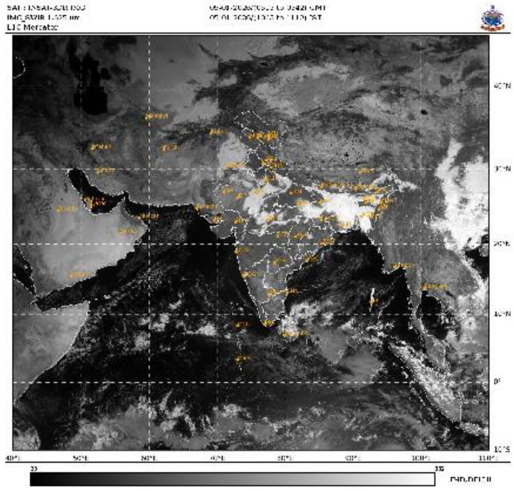
Pilgrim Sector

3.1.2 Shortwave Infra-Red (SWIR) Channel

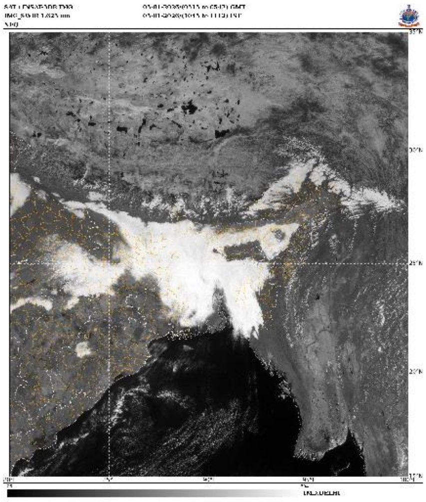
The **Shortwave Infrared (SWIR) band (1.55–1.70 µm)** is a reflective band and therefore usable only during daytime, as it depends on incoming solar radiation. In the SWIR wavelength range, incident radiation is strongly absorbed by water, ice, and snow, while it is efficiently reflected by clouds. In contrast, these surfaces appear relatively transparent in the visible spectrum. As a result, melting snow, ice surfaces, and water bodies, which appear bright in visible images, appear dark in SWIR images. This distinct contrast makes SWIR imagery particularly useful for discriminating between clouds, precipitation-bearing clouds, and snow cover. The SWIR band is also sensitive to surface moisture, causing moist or recently irrigated soils to appear in darker tones compared to dry surfaces. SWIR imagery is widely used for monitoring local snow cover, daytime fog detection, convective rainfall estimation, and the assessment of cloud radiative properties. Owing to its reflective nature, the SWIR band cannot be used during night-time observations.



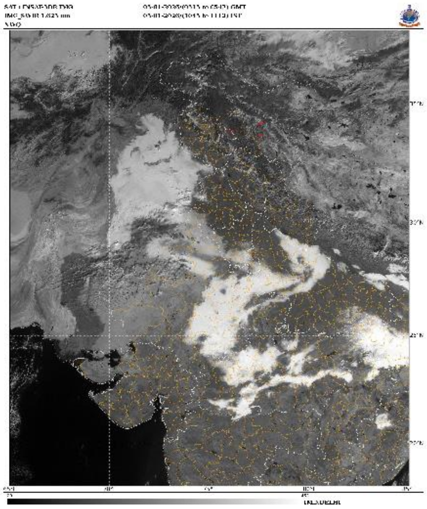
Globe



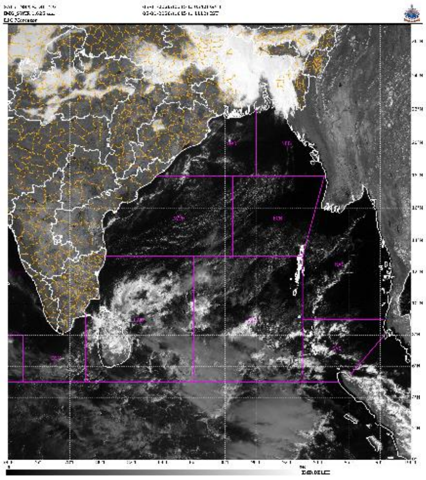
Asia Mer



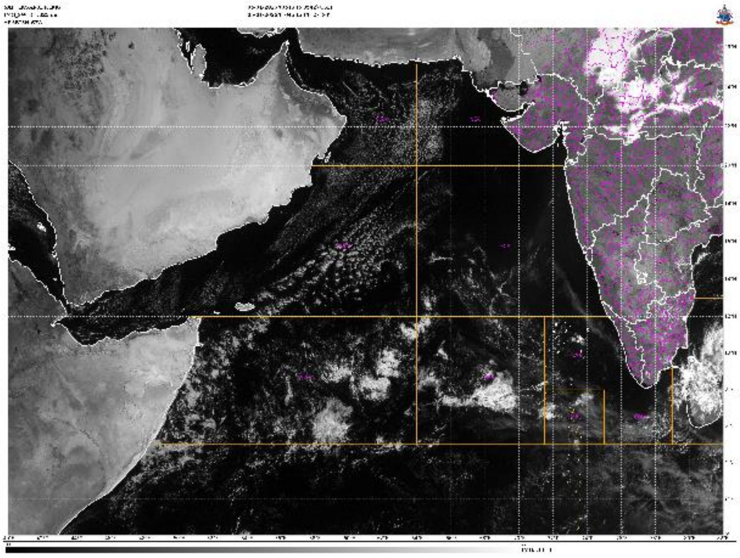
North East Sector



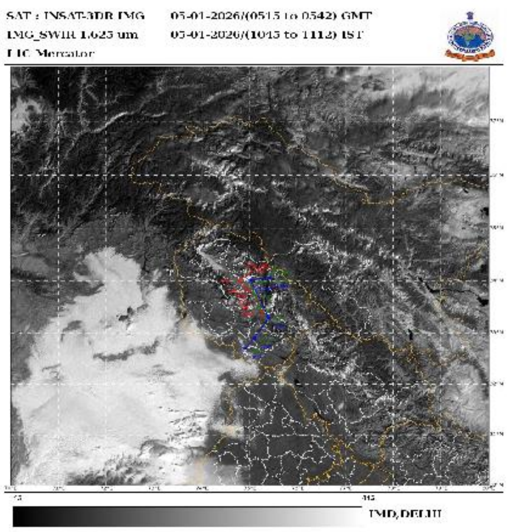
North West Sector



South East Sector



South West Sector

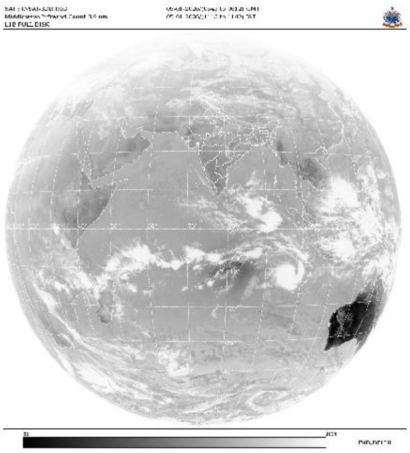


Pilgrim Sector

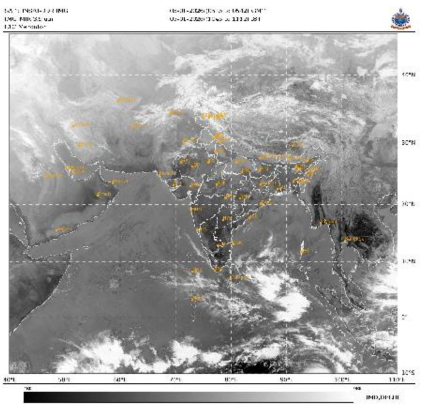
3.1.3 Midwave Infra-Red (MIR) Channel

The **Mid-Infrared (Mid-IR) window channel (3.9 µm)** has higher temperature sensitivity than the conventional thermal infrared (TIR) window channels and is widely used in conjunction with TIR channels for enhanced interpretation of surface and atmospheric features. At night, it is often difficult to detect fog or low clouds using conventional thermal IR channels (10–12 µm) when the fog-top temperature is similar to that of the surrounding land or sea surface. In contrast, the 3.9 µm channel can effectively differentiate fog droplets from land or sea surfaces at the same temperature due to differences in emissivity, making it particularly valuable for night-time fog and low-cloud detection**.**

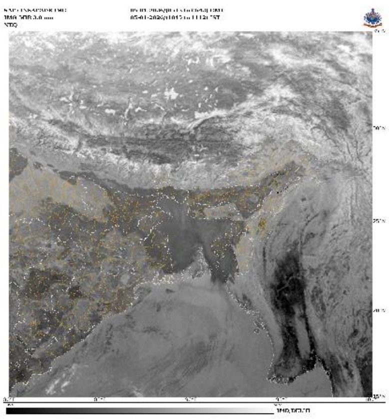
The Mid-IR window channel is also used for night-time detection of fires and hotspots, as well as volcanic eruptions and ash clouds, when analyzed together with thermal infrared window channels. During the daytime, the 3.9 µm channel signal is influenced by reflected solar radiation, causing daytime brightness temperatures to appear warmer than night-time values**.** Additionally, sun glint from the sea surface produces a pronounced bright signature in this channel, often making the ocean appear brighter than thin cirrus clouds**.**



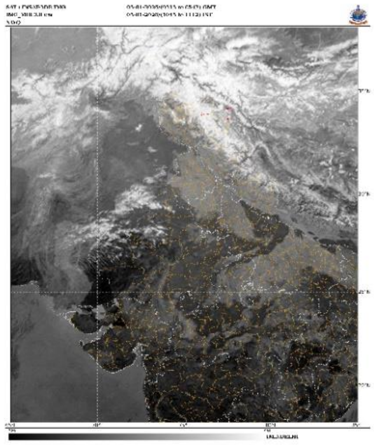
Globe



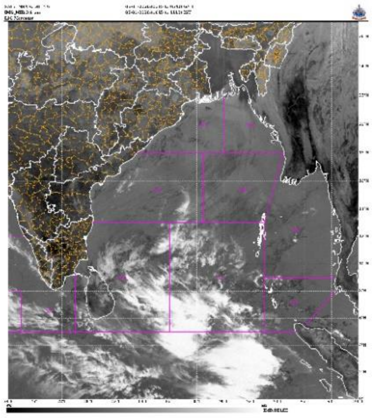
Asia Mer



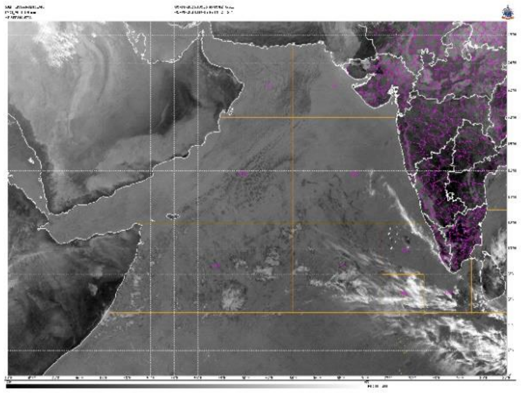
North East Sector



North East Sector



North West Sector



South East Sector

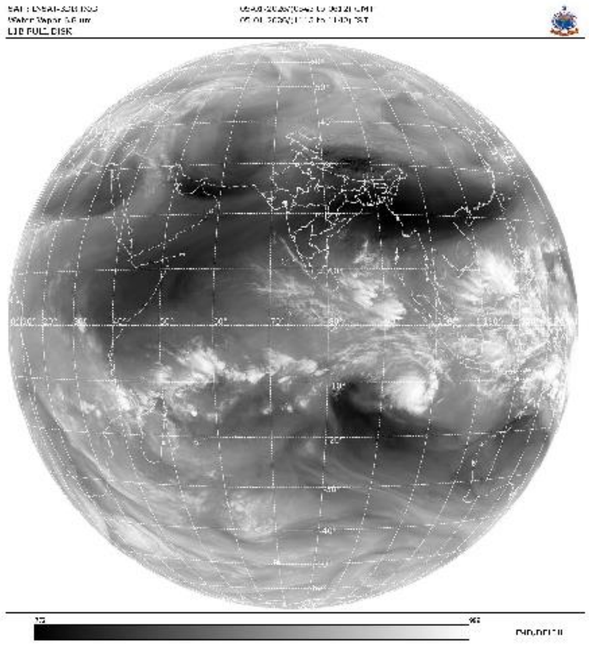
3.1.4 Water Vapour (WV) Channel

The 6.5–7.1 µm band, commonly referred to as the Water Vapour (WV) band, lies in a portion of the infrared spectrum where water vapour is the dominant absorbing and emitting gas. This band is not an atmospheric window, and therefore surface or baseline information is not available in WV imagery. In a typical moist atmosphere, most of the radiation sensed by the satellite in this band originates from the middle to upper troposphere. As a result, moisture and clouds in the lower troposphere are poorly represented in WV images. However, thick high-level clouds, such as cumulonimbus clouds and their anvils, appear prominently due to their strong emission and absorption characteristics.

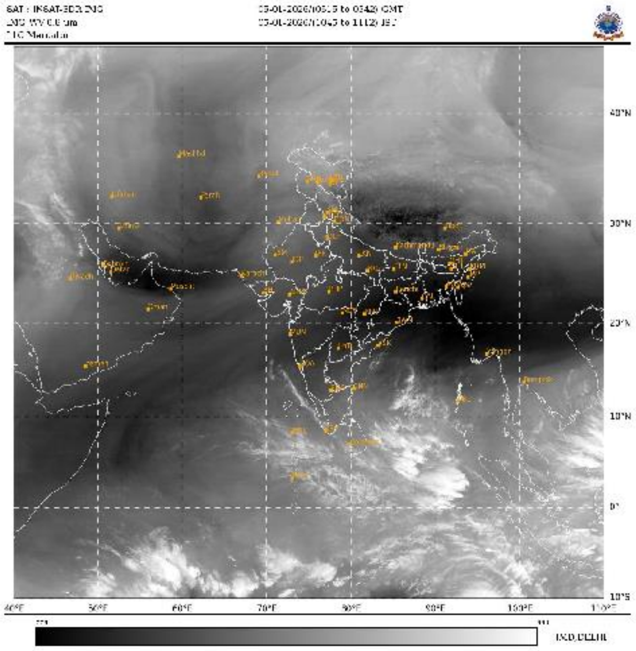
WV imagery is particularly useful for identifying large-scale moisture patterns and upper-tropospheric dynamics. Regions of rising motion and moist air appear bright, while areas of subsidence and dry air appear dark. Upper-level cyclonic circulations, troughs, and shortwave disturbances moving within the flow are clearly depicted. Jet streams are often marked by sharp moisture gradients, with dry air typically present on the poleward side of the jet.

The WV band effectively represents the temperature of an "effective layer" of water vapour in the mid to upper troposphere. Warmer brightness temperatures indicate a dry upper troposphere, while colder temperatures signify higher concentrations of water vapour and/or ice clouds at upper levels. However, the WV channel cannot provide quantitative information on moisture below this effective layer and generally does not show low clouds or near-surface water vapour.

One of the most important applications of WV imagery is in tracing atmospheric motions in the middle and upper troposphere, even in regions with little or no cloud cover. Atmospheric Motion Vectors (AMVs) derived from WV imagery are directly assimilated into Numerical Weather Prediction (NWP) models, making this channel critical for weather analysis and forecasting.



Globe



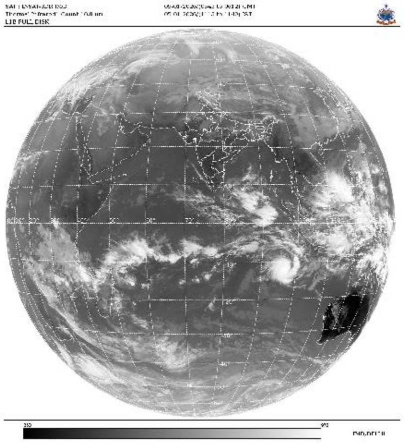
Asia Mer

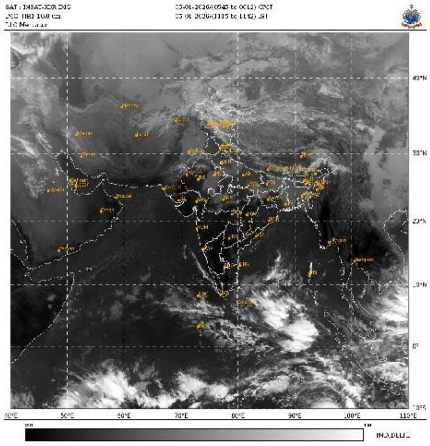
3.1.5 Thermal Infra-Red (TIR-1)

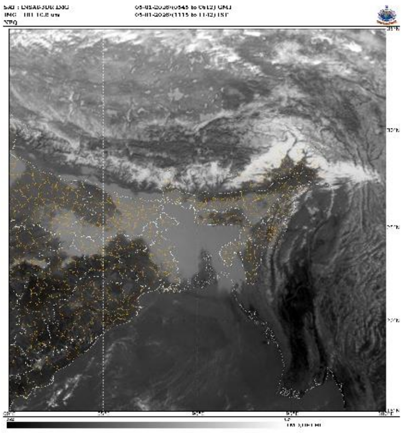
The 10.3–11.3 µm band, commonly referred to as Thermal Infrared (TIR) Band-1, lies within a region of the infrared spectrum known as the clear atmospheric window. Around 10.7 µm, most of the thermal energy emitted by the Earth's surface and cloud tops reaches the satellite sensor with minimal absorption by atmospheric gases. As a result, the measured brightness temperature closely represents the actual scene temperature, making this band highly reliable for thermal observations.

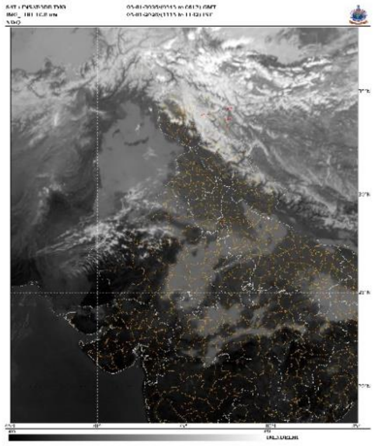
This band is extensively used for monitoring cloud-top temperature and surface temperature, as well as for identifying cloud cover, air-mass boundaries, convergence zones, surface low-pressure systems, and thunderstorm development. One of the key advantages of the thermal infrared window channel is its ability to operate both during day and night, independent of sunlight.

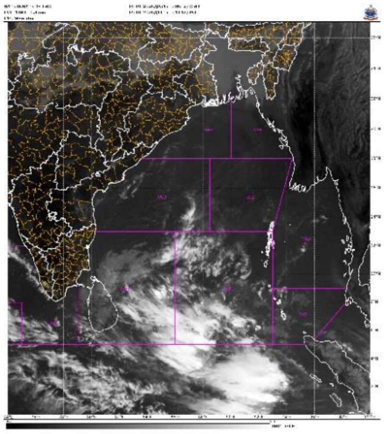
Since cloud-top brightness temperature decreases with increasing cloud height, TIR imagery provides strong contrast between clouds at different vertical levels, unlike visible imagery. This property makes the thermal infrared window channel particularly valuable for analyzing cloud structure, cloud height, and convective intensity in weather systems.

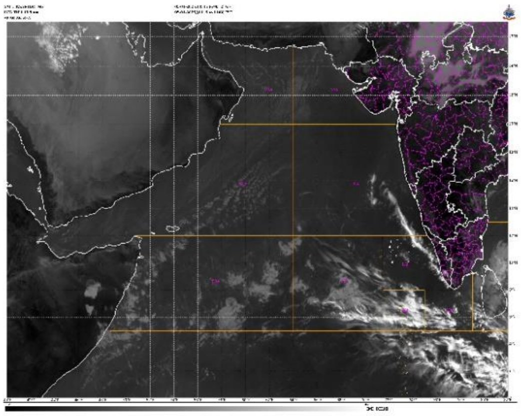

Globe


Asia Mer


North East sector

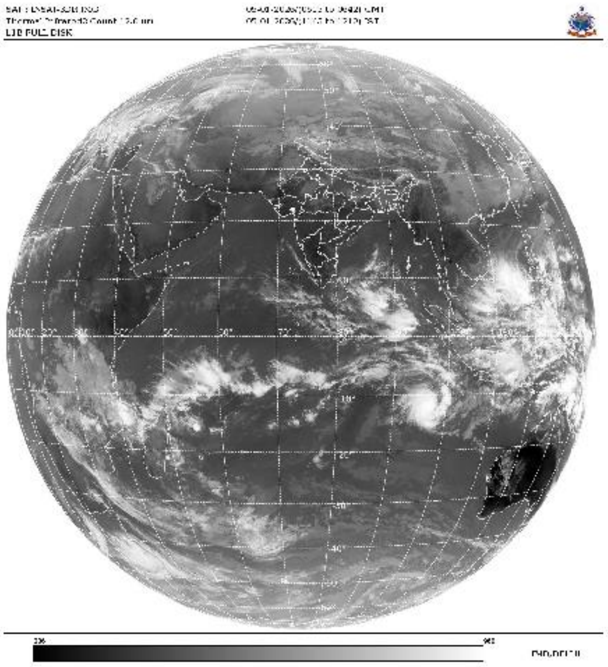

North East Sector


North West Sector

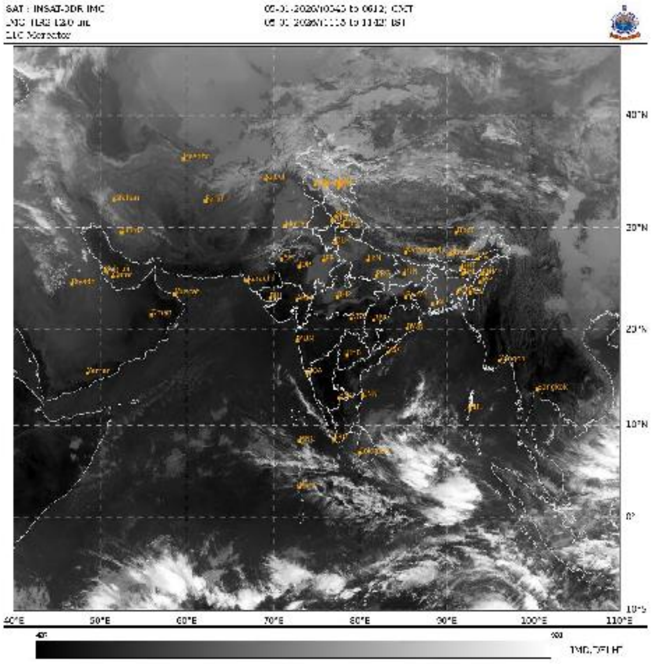

South East Sector

3.1.6 Thermal Infra-Red (TIR-2)

The 11.5–12.5 µm band, commonly referred to as Thermal Infrared (TIR) Band-2, lies in another atmospheric window region near 12 µm. Unlike the cleaner 10.7 µm window, this region is partially contaminated by low-level water vapour absorption and is therefore often termed the "dirty window." Because of its sensitivity to lower-tropospheric moisture, TIR-2 imagery is useful for identifying near-surface water vapour variations. When used together with the cleaner thermal infrared window channel (TIR-1), this band enables improved correction for atmospheric effects, leading to higher accuracy in sea surface temperature (SST) retrievals. The 12 µm channel is also valuable for noise correction and radiative transfer (RT) modelling, particularly over oceanic regions.



Globe

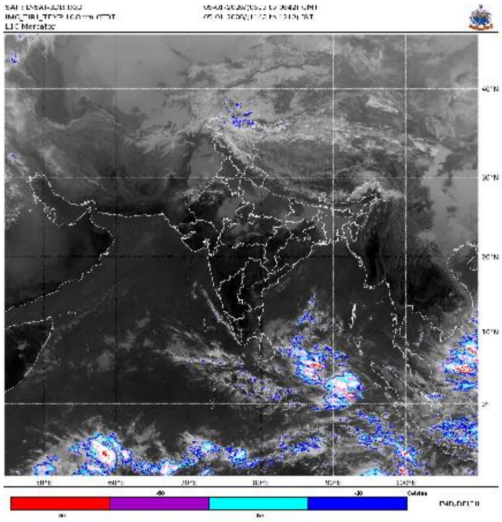


Asia Mer

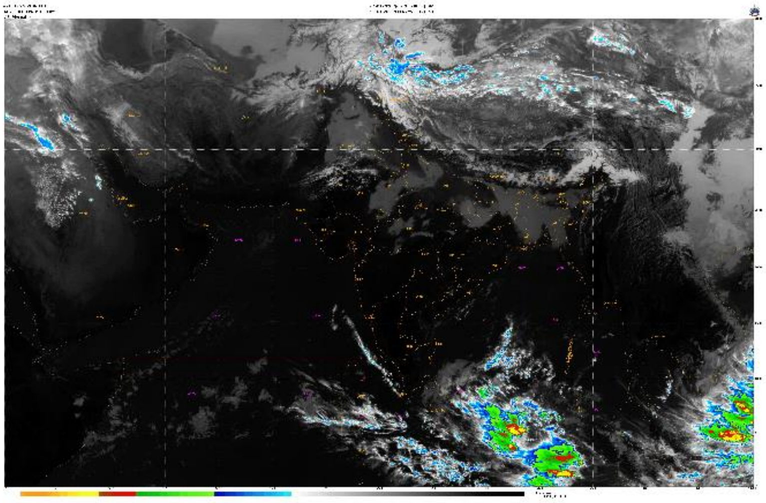
3.2 Specialized Satellite Image Products

3.2.1 Cloud Top Brightness Temperature/IR-1 BT Blended Image

Brightness Temperature (BT) represents the temperature a body would have if it were assumed to behave as a perfect blackbody (i.e., emissivity = 1). Although clouds are not perfect blackbodies, they are conventionally treated as such for the derivation of Cloud-Top Brightness Temperature (CTBT). In CTBT contour imagery, CTBT values are overlaid as contours on the grey-scale representation of the thermal infrared (IR-1) imager band, thereby providing a quantitative depiction of cloud-top temperatures. The magnitude of CTBT serves as an indicator of the vertical development and intensity of convective clouds, with lower (more negative) CTBT values corresponding to deeper and more intense convection. In addition, a blended IR-1 BT product is generated using two different lookup tables within a single image: a grey-scale display is applied for BT values ranging from +30 °C to −30 °C, while a colour scale is used for the −30 °C to −100 °C range to effectively highlight well-developed convective cells.



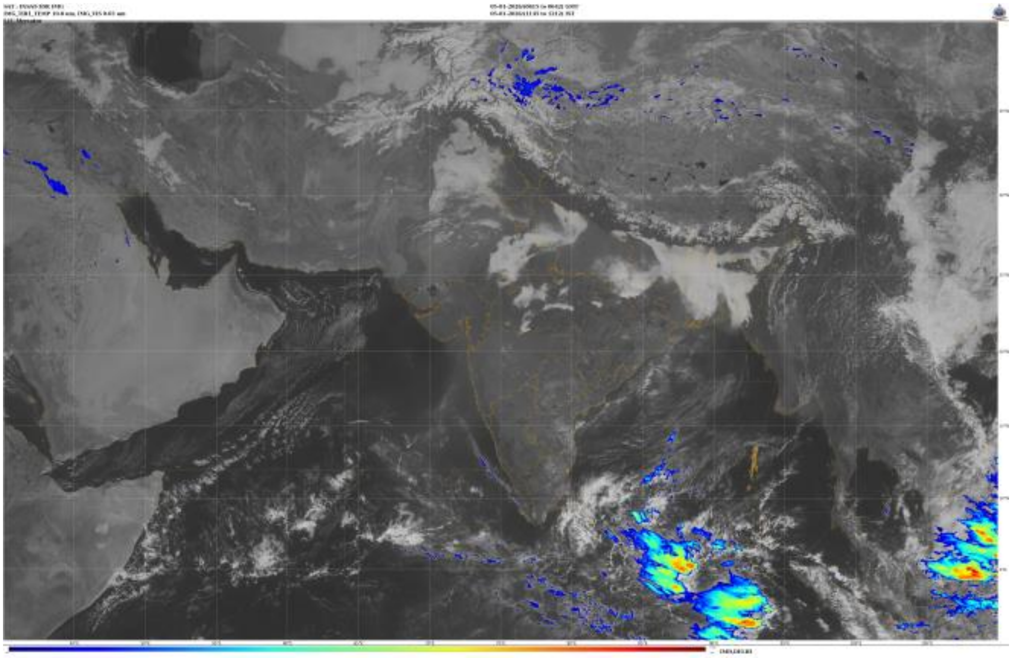
CTBT



IR-1 BT Blended Image

3.2.2 IR-1 BT & Visible Sandwich Image

Overshooting tops are typically manifested as bubble-like features spanning several image pixels and are detected either in the visible and near-infrared spectral bands, where they are identifiable through their distinct texture and the shadows they cast, or in thermal infrared bands as localized minima in brightness temperature surrounded by sharp thermal gradients. Under favourable conditions, overshooting tops are accompanied by smaller-scale warm spots or by larger, more persistent embedded warm areas that form downwind of the overshooting tops and are readily observed in colour-enhanced thermal infrared imagery. Conventionally, overshooting tops and their associated downwind warm features are detected independently using two stand-alone datasets: the visible band imagery and colour-enhanced IR 10.8 µm brightness temperature products. In the present study, a new composite image product is introduced in which these two spectral bands are merged, enabling the simultaneous visualization of overshooting tops and their associated thermal signatures within a single integrated product.

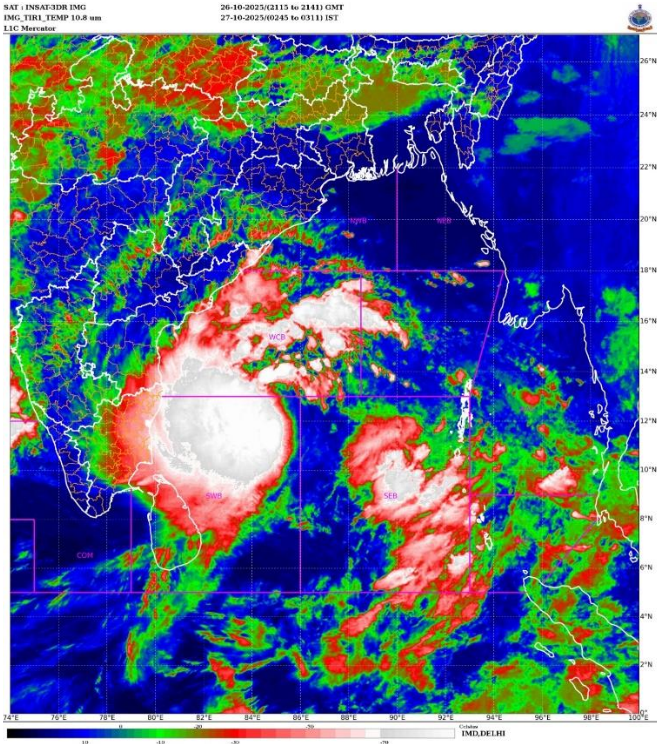


3.2.3 BD Curve and IMD curve Enhancement images for cyclone

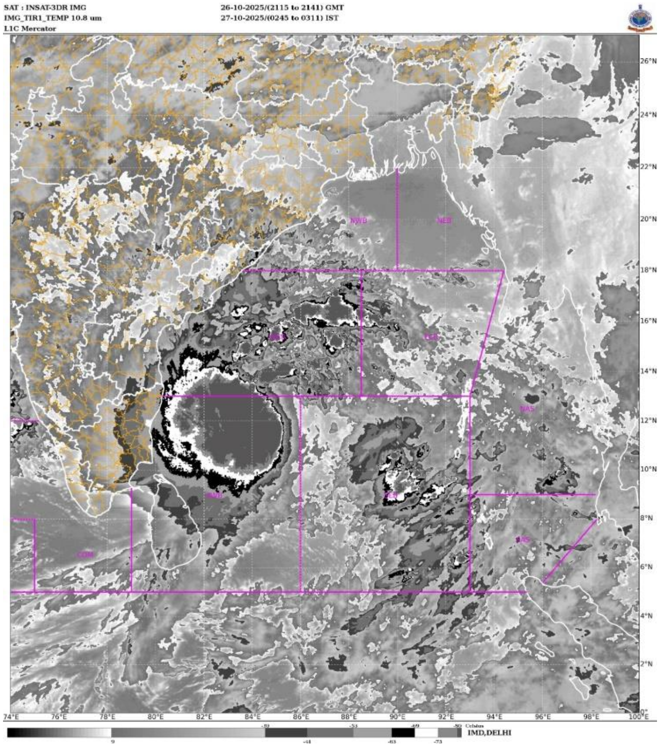
Infrared-1 brightness temperature (IR-1 BT) images derived from the INSAT-3D and INSAT-3DR imager payloads are generated and displayed using two primary enhancement curves. These enhancement techniques are applied to emphasize different features within the imagery, with each serving a distinct purpose. The two enhancement schemes are referred to as the **BD Curve** and the **IMD Curve** enhancements.

The BD Curve enhancement is extensively used within the research and tropical cyclone forecasting communities for assessing storm intensity. This enhancement, also known as the *Dvorak Hurricane Curve for Tropical Cyclone Classification*, is applied exclusively to infrared (10.8 µm) imagery. The various black, white, and grey shades correspond to different intensity categories defined in the Subjective Dvorak Intensity Classification Technique (NOAA Technical Report NESDIS-11, 1984). The temperature values displayed in the imagery are approximate and represent the absolute temperature ranges associated with each grey shade.

The IMD Curve enhancement is primarily employed to enhance infrared (10.8 µm) imagery for visual presentation in television broadcasts, newspapers, and internet-based platforms. This enhancement is generally provided for media applications, as colour-enhanced imagery is preferred over monochrome representations for effective communication and dissemination.



IMD Curve

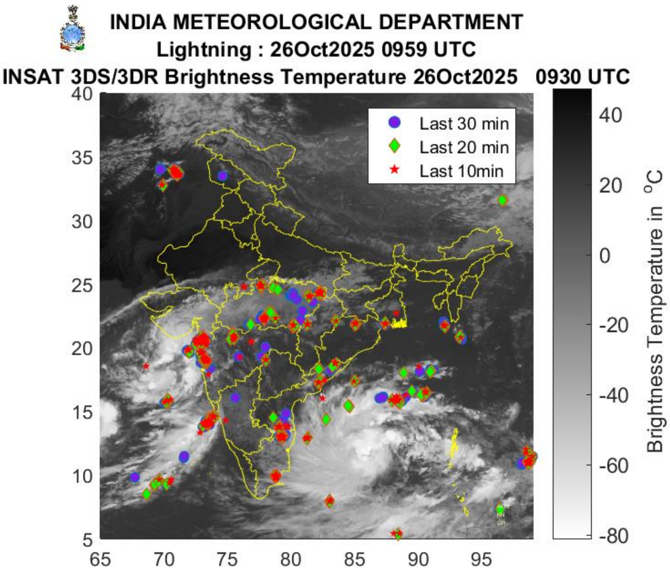


BD Curve

3.2.4 Visualization of surface Lighting network Data over satellite images

To enhance severe weather monitoring, lightning observations from the IITM national lightning detection network are integrated with satellite cloud-top temperature data. A nationwide lightning detection network has been established by IITM Pune. Lightning observations are collected at a 1-

minute temporal resolution and are provided to the India Meteorological Department (IMD) on a real-time basis. A merged real-time product combining lightning observations with satellite-derived cloud information from INSAT-3DR/3DS is generated as a half-hourly animation. In this animation, lightning data are categorized into three temporal bins of 10, 20, and 30 minutes and are displayed using different colours; the product is updated every 15 minutes. A time lag of approximately one hour exists between the satellite and lightning observations, primarily due to the satellite scan strategy. The 10-, 20-, and 30-minute intervals shown in the imagery correspond to the timing of the received lightning data.



The points are lightning flashes/strikes (cloud-to-ground) which is being generated by the ground networks. These flashes/strikes are also superimposing on INSAT-3DR/DS cloud top temperature. User can access this data through a dedicated link on IMD website: https://mausam.imd.gov.in/ http://internal.imd.gov.in/section/satmet/lightning/

3.3. Cloud Imageries

Satellite cloud imagery forms one of the primary inputs for operational weather forecasting. Multiple types of cloud imagery products using INSAT-3DR/3DS imager observations are generated.

3.3.1 Cloud Imagery of INSAT-3DR/3DS IMAGER

IMD generating different type cloud imageries of different domain using INSAT-3DR/3DS imager data for issuing weather forecast as one input along with other observation inputs. The different spectral band images are generated using the grey count /digital numbers values transmitted by the sensor of different locations of scan areas. The values of grey count/ digital number are lies between (0 to 1023) depending upon the quantized energy level by the sensors. In case of imager channel (MIR, TIR1, TIR2 & WV) images are generated by the inverting the grey count values (1024- Actual grey count), So that cloud appears brighter similar to Visible & SWIR images. Normal Images are generated by resampling of the grey count at coarser resolution and high-resolution images are generated at channel resolution. The details of different type of images generated are giving below:

3.3.2 Basic Imagery Products

Standard imagery products include full-disk and regional sector images generated at multiple spatial resolution. These products provide comprehensive monitoring of atmospheric conditions across the Indian region and surrounding oceanic areas.

Globe/Sector	**Bands/parameter**	**Spatial Resolution**	**Domain**	**Frequency of Updating**
Standard Full Disk	Visible, SWIR, MWIR, WV, TIR1, TIR2, IR-1 Brightness Temperature, Day Microphysics/& Night Microphysics	1 x 1 Km 4 × 4 Km 8 x 8 Km	80°S to 80°N, 0°E to 140°E (3DR), 10°E to 150°E (3DS),	Every fifteen minutes, either from **INSAT-3DR/3DS**
Asiamer Sector	Visible, SWIR, MIR, WV, TIR1, TIR2 Day Microphysics & Night Microphysics RGB, IR-1 Brightness Temperature	1 x 1 Km 4 × 4 Km 8 x 8 Km	10°S to 45°N, 40°E to 110°E.	Every fifteen minutes, either from **INSAT-3DR/3DS**

3.3.3 High Resolution Images with District Boundaries

High-resolution sector imagery is generated with district boundary overlays to support localized weather monitoring. These products provide enhanced spatial detail for regional weather forecasting and disaster monitoring. Currently high high-resolution sector images are generated from INSAT 3DR only.

Globe/ Sector	Bands/parameter	Resolution of the image	Domain	Frequency of Updation
Asiamer Sector	Visible,SWIR	1 x 1 Km	0°N to 40°N, 40°E to 110°E.	Every fifteen minutes either from INSAT-3DR/3DS
	MIR, TIR1, TIR2, WV, IR-1-BT Blended Image,IR-1- BT & Visible Sandwich Image	4 x 4 Km		
North East-Sector	Visible, SWIR	1 x 1 Km	15°N to 35°N, 80°E to 100°E.	Every fifteen minutes either from INSAT-3DR/3DS
	MIR, TIR1, Day Microphysics &Night Microphysics	4 x 4 Km		
North West-Sector	Visible, SWIR	1 x 1 Km	18°N to 38°N, 65°E to 85°E.	Every fifteen minutes either from INSAT-3DR/3DS
	MIR, TIR1, Day Microphysics & Night Microphysics	4 x 4 Km		
South East-Sector	Visible, SWIR	1 x 1 Km	0°N to 27°N, 74°E to 100°E.	Every fifteen minutes either from INSAT-3DR/3DS
	MIR ,TIR1	4 x 4 Km		
	Day Microphysics &Night Microphysics			
South West-Sector	Visible, SWIR	1 x 1 Km	0°N to 27°N, 40°E to 82°E.	Every fifteen minutes either from INSAT-3DR/3DS
	MIR ,TIR1	4 x 4 Km		
	Day Microphysics & Night Microphysics	4x4Km		

3.3.4 Special Sector Images

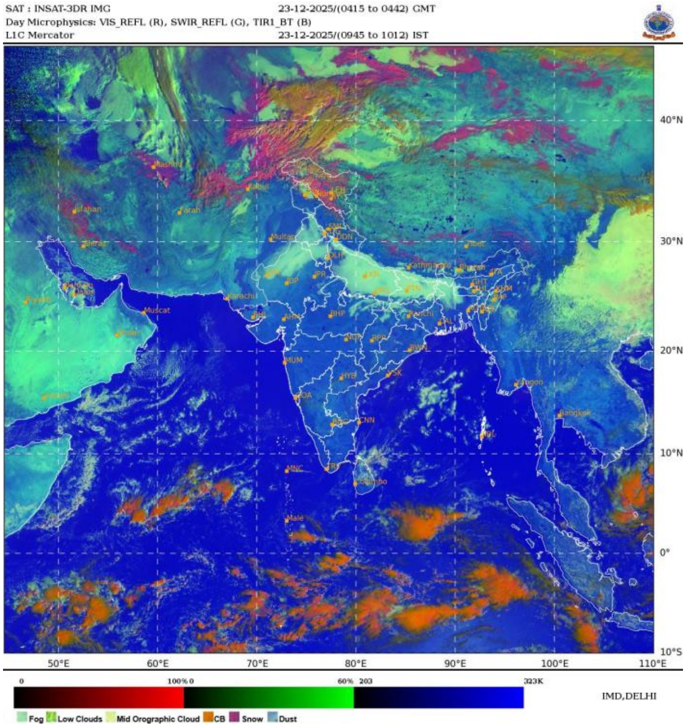
Specialized sector imagery is generated for aviation operations, cyclone monitoring, and pilgrimage management. These products are customized for specific operational applications and are updated regularly.

Globe/Sector	Bands/parameter	Spatial Resolution	Domain	Frequency of Updation
Aviation Sector	Visible	1 x 1Km	10°S to 45°N, 45°E to 110°E (3DR) 40°E to 110°E (3DS)	Every fifteen minutes either from **INSAT-3DR/3DS** Every fifteen minutes either from **INSAT-3DR/3DS**
	TIR-1, Cloud top BT (< - 30 Deg. C)	4 x 4 Km		
Cyclone Enhancement SW Sector	TIR-1BT using Cyclone enhancement LUT (BD curve & IMD Curve)	4 x 4 Km	0°N to 27°N, 40°E to 82°E	Every thirty minutes from **INSAT-3DR**
Cyclone Enhancement SE Sector	TIR-1BT using Cyclone enhancement LUT (BD curve & IMD Curve)	4 x 4 Km	0°N to 27°N, 74° E to 100° E	Every thirty minutes from **INSAT-3DR**
Pilgrimage Sectors	Visible, SWIR	1 x 1 Km	25° N to 40° N, 70° E to 85° E	Every fifteen minutes either from **INSAT-3DR/3DS**
	TIR1	4 x 4 Km		

3.4 RGB Composite Imagery

3.4.1 Day Microphysics RGB Imagery

The Day Microphysics RGB composite combines visible, SWIR, and thermal infrared channels to provide enhanced visualization of cloud properties, and surface features. The colour scheme enables identification of convection, fog, fires, and snow cover during daytime conditions.



Channel combination “recipes” of the Day Microphysics RGB

- **In the RED beam** - The visible reflectance at 0.64 µm approximates the cloud optical depth (thickness) and amount of cloud water and ice. Typically, water cloud is more reflective than ice cloud and thus will have a stronger red beam component. This channel also gives information about the surface of the earth.

- **In the GREEN beam** – The 1.67 µm SWIR (shortwave infrared) solar reflectance gives a qualitative measure for cloud particle size and phase. Typically, smaller water droplets or small ice particles have a higher reflectivity, resulting in a stronger green beam component. A sandy earth surface also has a strong reflectance in this channel.

- **In the BLUE beam** - The 10.8 µm TIR1 brightness temperature is a function of surface and cloud top B. temperatures. The scaling for this beam results in a strong blue beam component for warm surfaces, whereas cold cloud tops will not have any contribution in this beam.

This color scheme is useful for cloud analysis, convection, fog, snow, and fires.
Day microphysics RGB scheme

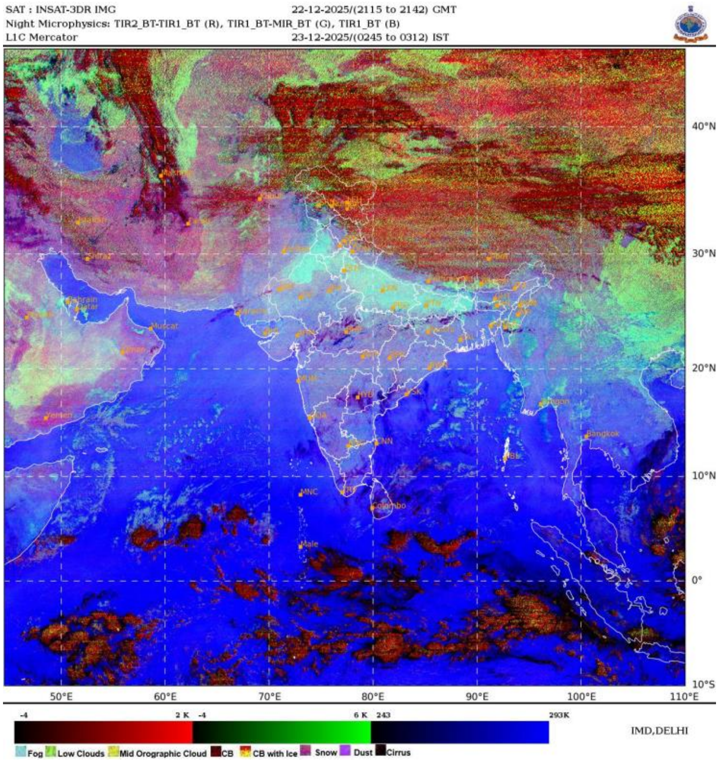
Beam	Channel	Range	Gamma
Red	VIS(0.55-0.75 µm)	0 …+100 %	1.0
Green	SWIR(1.67µm)	0 ... +60 %	1.0
Blue	IR(10.8 µm)	+203 ... +323 ºK	1.0

This product is used during the daytime because a solar reflectance component is adopted. Colors and their interpretation are based on :
Refrence: I. M. Lensky and D. Rosenfeld : Clouds-Aerosols- Precipitation Satellite Analysis Tool (CAPSAT), Atmos. Chem. Phys.,8, 6739-6753, 2008i.

Mitra, A. K., Parihar, S., Peshin, S. K., Bhatla, R., & Singh, R. S. (2019). Monitoring of severe weather events using RGB scheme of INSAT-3D satellite. *Journal of Earth System Science*, *128*(2), 36.

3.4.2 Night Microphysics RGB Imagery

The Night Microphysics RGB product is designed and tuned for monitoring the evolution of night time fog and stratus clouds. Other secondary applications include detecting fires, classification of clouds in general, snow and low-level moisture boundaries.
The distinction between low clouds and fog is often a challenge. While the difference in the TIR1 10.8µm and MIR 3.9µm channels is applied to meet this challenge, the Night-time Microphysics RGB adds TIR2 12.0µm channel difference to indicate cloud thickness and enhance areas of warm clouds where fog is more likely. Other applications of Night-time Microphysics RGB include analysis of cirrus and contrail clouds, fire hot spots, and snow.



Channel combination recipe of the Night Microphysics RGB

- **In the GREEN beam:** This channel differencing is used in fog/low cloud detection method. It uses TIR1 – MIR. The 3.9 µm radiation has lower emissivity compared to the 10.8 µm radiation for small water droplet clouds. Therefore, there is a large contribution to the green beam in this RGB product for water clouds with small droplets. There is also a significant contribution from desert surfaces.

- In the RED beam: The channel differencing gives an indication of optical depth. It uses TIR2 – TIR1. There is a strong signal in this beam for thick clouds. For thin meteorological cloud there is greater absorption by the "dirty window" 12 µm channel. In addition, the 12 µm radiation is absorbed more strongly in ice phase cloud compared to water phase clouds.

- **In the BLUE beam:** The 10.8 µm infrared brightness temperature is a function of surface and cloud top temperatures. The scaling for this beam results in a strong blue beam component for warm surfaces.

Night-time microphysics RGB scheme:

Beam	Channel	Range	Gamma
Red	IR12.0 µm - IR10.8 µm(TIR2-TIR1)	-4 … +2 K	1.0
Green	IR10.8 µm - IR3.9 µm (TIR1-MIR)	-4 … +6 K	1.0
Blue	IR10.8 µm (TIR1)	+243 … +293 K	1.0

Mitra, A. K., Parihar, S., Peshin, S. K., Bhatla, R., & Singh, R. S. (2019). Monitoring of severe weather events using RGB scheme of INSAT-3D satellite. *Journal of Earth System Science*, *128*(2), 36.

Fog can also be detected through **Night-time Microphysics RGB Imagery.** Fog and low clouds in warm climates tend to have aqua or light blue areas in the RGB. This appears very light green in colder climates because the 10.8 μm thermal channel used for the blue band contributes less.

Lists the DMP and NMP thresholds along with their resolution and time of use for the identification of fog and low clouds

Product	**Pixel Resolution**	**Time**	**Source**	**Use (Conditions)**
Night Time RGB (3.9, 10.8 μm)]	1 to 4Km	Half Hourly	RAPID rapid.imd.gov.in	1.TIR2-TIR1 BT DIFF > must be negative and -4 to 1.5K 2. TIR1-MIR BT must be -26K to -1, if positive = Ice/Snow clouds 3. TIR1 BT < 255K ===>Thunderstorm with Rain i) TIR2-TIR1 BT DIFF>becoming positive and -2 to 2K ii) TIR1-MIR BT must be -26K to 25 iii) TIR1 BT < 250K ===>Thunderstorm with Hail
Day Time RGB (TIR,SWIR, Vis)	1-4 Km	Half Hourly	RAPID rapid.imd.gov.in	i) TIR1 BT Rate of Change is (in consecutive hours) -5 to -15 K ii) VIS 26-55% (Increasing trend) iii)SWIR < 28% (Decreasing trend) and iv) VIS>SWIR ==>Thunderstorm with Rain i) TIR1 BT Rate of Change (in consecutive hours) is -5 to -38 K ii) VIS 18-58% (Increasing trend) iii) SWIR < 25% (Decreasing trend) and iv) VIS>SWIR ==>Thunderstorm with Hail

Refrence: Mitra, A. K., Parihar, S., Peshin, S. K., Bhatla, R., & Singh, R. S. (2019). Monitoring of severe weather events using RGB scheme of INSAT-3D satellite. *Journal of Earth System Science*, *128*(2), 36.

DMP and NMP thresholds along with its pixel resolution and time of use for thunderstorms prior to the event

Product	Resolution	Time	Source	Use (Conditions)
Night Time RGB (3.9, 10.8 µm)]	1 to 4Km	Half Hourly (During Night Time)	RAPID rapid.imd.gov.in	1. TIR2-TIR1 BT DIFF>must be +1 to -1 K 2. TIR1-MIR BT >2.5K 3. TIR1 BT> 279K ==> Fog 1. TIR2-TIR1 BT DIFF> -1 to 0 K 2. TIR1-MIR BT >2.5K 3. TIR1 BT< 275K ==> Low cloud/Mist/Haze
Day Time RGB	1 to 4Km	Half Hourly (During Day Time)	RAPID rapid.imd.gov.in	TIR1 BT between 255- 275K & VIS 30-45% & SWIR 31-60% ==>Low Cloud TIR between 276-290K & VIS 16-55% & SWIR 31-60% ===> FOG

Refrence: Mitra, A. K., Parihar, S., Bhatla, R., & Ramesh, K. J. (2018). Identification of weather events from INSAT-3D RGB scheme using RAPID tool. *Current Science*, *115*(7), 1358-1366.

3.5 Imager Derived Products from INSAT-3DR & 3DS Satellite

INSAT-3DR/3DS imager observations are used to generate a wide range of geophysical products including humidity parameters, sea and land surface temperature, cloud products, rainfall estimation products, and precipitation indices. These products support operational forecasting, climate monitoring, and hydrological applications.

Product	Temporal Resolution	Horizontal Resolution	Format	Domain	Unit
Upper Tropospheric Humidity (UTH)	Half-hourly, Daily, Weekly, Monthly	Per pixel	HDF/JPEG	Globe coverage	Percentage (%)
Total Precipitable Water Vapour (New Product)	Half hourly	Per Pixel	HDF/JPEG	Globe (Ocean)	cm
Sea Surface Temperature (SST)	Half Hourly	Per Pixel	HDF/JPEG	Globe (Ocean)	degree Celsius
LST (Land Surface Temperature)	Half Hourly	Per pixel	HDF/JPEG	Globe (Land)	Kelvin
Cloud Products					
Cloud Mask	Half Hourly	Per pixel	HDF/JPEG	Globe	0-Pixel is clear, 1- pixel is cloudy, 2- pixel is probably clear 3- pixel is probably cloudy

CTT (Cloud top temperature)	Half Hourly	9x9 Pixel (36x36 km)	HDF/JPEG	Globe	Kelvin
Cloud top pressure	Half Hourly	9x9 Pixel (36x36 km)	HDF/JPEG	Globe	hPa
Effective cloud emissivity	Half hourly	9x9 Pixel (36x36 km)	HDF/JPEG	Globe	percentage (%).
Cloud Fraction	Half Hourly	9x9 Pixel (36x36 km)	HDF/JPEG	Globe	Expressed in fractions
Cloud Particle Effective Radius	Half hourly	Per Pixel	HDF/JPEG	30^{0}E-130^{0}E 50^{0}S-50^{0}N	Microns
Cloud Optical Thickness	Half hourly	Per Pixel	HDF/JPEG	30^{0}E-130^{0}E 50^{0}S-50^{0}N	percentage (%)
Rain Fall products					
Hydro Estimator Precipitation (HEM)	Half-hourly, Daily, Weekly, Monthly	Per pixel	HDF/JPEG	Globe	mm/hr (mm-Daily, Weekly, Monthly)
Insat Multispectral Rainfall (IMSRA)	Half-hourly, Daily, Weekly, Monthly	0.25 deg x 0.25 deg	HDF/JPEG	30^{0}E-120^{0}E 40^{0}S-40^{0}N	mm/hr (mm-Daily, Weekly, Monthly)
Global precipitation Index (GPI)	Three Hourly Accumulated	0.5 deg x 0.5 deg	HDF/JPEG	30^{0}E-120^{0}E 40^{0}S-40^{0}N	mm
IMSRA (Improved)	Half-hourly, Daily, Weekly, Monthly	Per pixel	HDF/JPEG	Globe	mm/hr (mm-Daily, Weekly, Monthly)

3.5.1 Comparative assessment of different rainfall products of INSAT 3DR/3DS

Feature	Hydro Estimator Precipitation (HEM)	Insat Multispectral Rainfall (IMSRA)	IMSRA (Improved)	Global precipitation Index (GPI)
Data Sources	TIR + NWP Model Parameters (Varma & Gairola, 2015)	TIR + WV Channels (Saikrishna et al., 2015)	TIR + WV + Orographic zones (Saikrishna et al., 2015)	TIR (Single channel)
Spatial Resolution	High (typically 4 km at nadir)	Moderate (0.25° × 0.25°)	High (4 km)	0.5° × 0.5°
Strengths	Better for **heavy rainfall** and captures cyclone eye-walls well. (Mitra et al., 2018).	Better for **light to moderate** rainfall patterns (Mitra et al., 2018).	Improved representation of **mountainous rain** compared to IMR (Mahesh et al., 2014).	Simple; suitable for large-scale climate studies.
Weaknesses	It can show higher errors in complex orographic regions if uncorrected.	Often **overestimates** rainfall in central India and misses orographic rain.	May not show significant improvement over IMR in specific cyclone cases.	Indirect; cannot sense hydrometeors directly.
Cyclone	Shows smaller bias	Shows higher	Similar to IMR but	Typically used

Performance	magnitudes but can have large local errors.	correlation with ground data over land than HEM/IMC.	with slight bias adjustments.	for broader spatial scales.

3.5.2 Atmospheric Motion Vectors (AMV) and wind-derived products

Atmospheric Motion Vectors derived from satellite imagery provide wind information at multiple atmospheric levels. These products support synoptic analysis, cyclone monitoring, and numerical weather prediction assimilation.

Product	Temporal Resolution	Horizontal Resolution	Format	Domain	Unit
Cloud Motion Vector (CMV/IR1-wind)	Half Hourly at Levels (100-400mb 401-700mb 701-975mb)	Point	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots
Water Vapor Winds (WVW)	Half Hourly at Levels (100-250mb 251-350mb 351-500mb)	Point	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots
Visible (during day) /MIR (during night) Winds	Half Hourly at levels (600-800mb 801-975mb)	Point	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots
IRW –Merged winds	Half hourly	Point	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots
WVW-Merged winds	Half hourly	Point	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots
Vis-HR winds	Half hourly	Point	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots
Vorticity (850,700,500 & 200 hPa)	Half hourly	0.5^0 X0.5^0	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	10^{-5} x /sec
Low Level Convergence (850-925 hPa)	Half hourly	0.5^0 X0.5^0	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	10^{-5} x /sec
Upper level Divergence (150-300 hPa):	Half hourly	0.5^0 X0.5^0	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	10^{-5} x /sec
Wind Shear:	Half hourly	0.5^0 X0.5^0	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots
Mid-Level wind Shear	Half hourly	0.5^0 X0.5^0	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots
Wind Shear Tendency	Half hourly	0.5^0 X0.5^0	Gif/JPEG	30^0E-130^0E 40^0S-40^0N	Knots

3.5.3 Miscellaneous Geophysical Products

Additional satellite-derived products include snow cover, fire detection, smoke monitoring, fog detection, and aerosol optical depth retrievals, which support disaster management and environmental monitoring.

Product	Temporal Resolution	Horizontal Resolution	Format	Domain	Unit
Snow cover	0500, 0530, 0600, 0630 UTC	Per pixel	HDF/JPEG	20^0E-130^0E 50^0S-50^0N	Unit-less
Fire	Half Hourly	Point	HDF/JPEG	45^0E-110^0E 10^0S-45^0N	Unit-less
Smoke	Half Hourly	Point	HDF/JPEG	Globe	Unit-less
Fog (Night Time/ Day Time)	Half Hourly	Per pixel	HDF/JPEG	45^0E-110^0E 10^0S-45^0N	Unit-less
Fog Intensity	Half Hourly	Per pixel	HDF/JPEG	45^0E-110^0E 10^0S-45^0N	Unit-less (1,2,3,4)
Aerosol Optical Depth (AOD)	0530 to 0830 UTC on half hourly basis	0.1x0.1 deg	HDF/JPEG	45^0E-100^0E 10^0S-45^0N	Unit-less

3.5.4 Radiation Products/ Agromet Products

Radiation-based products such as outgoing longwave radiation, net radiation, albedo, evapotranspiration, and insolation are generated to support agricultural meteorology and climate analysis.

Product	Temporal Resolution	Horizontal Resolution	Format	Domain	Unit
Outgoing Long Wave Radiation (OLR)	Half hourly, Daily, Weekly, Monthly	Per pixel	HDF/JPEG	Globe	Watt/m^2
Net Radiation	Half hourly	Per Pixel	HDF/JPEG	60^0E-100^0E 5^0N-40^0N	Watt/m^2
Land surface Albedo	Half hourly	Per Pixel	HDF/JPEG	60^0E-100^0E 5^0N-40^0N (land)	Unit - less
Short Wave Radiation	Half hourly	Per Pixel	HDF/JPEG	40^0E-110^0E 15^0S-25^0N (Ocean)	Watt/m^2
Evapotranspiration (PET)	Half hourly	Per Pixel	HDF/JPEG	50^0E-105^0E 5^0S-41^0N (land)	mm
Actual Evapotranspiration	Half hourly	Per Pixel	HDF/JPEG	60^0E-100^0E 5^0N-40^0N	mm/day
Insolation	Half Hourly	Per pixel	HDF/JPEG	45^0E-110^0E 10^0S-45^0N	Watt/m^2

Chapter 4: INSAT-3DR/3DS-Sounder Specifications and Products

The INSAT-3DR and INSAT-3DS satellites are equipped with advanced atmospheric sounding capabilities designed to complement the imaging observations described in the previous chapter. While the imager provides high-resolution spatial information on clouds and surface features, the sounder enables vertical profiling of atmospheric thermodynamic parameters. Together, these instruments provide a comprehensive framework for monitoring atmospheric structure, moisture distribution, and convective environment, which are essential for operational weather forecasting and numerical weather prediction. INSAT-3DR/3DS carries a 19 channel sounder, which is the first such payload to be flown on an ISRO satellite mission. The Sounder has eighteen narrow spectral channels in shortwave infrared, middle infrared and long wave infrared regions and one channel in the visible region. The ground resolution at nadir is nominally 10 × 10 km for all nineteen channels. Atmospheric Sounding System, provide retrieved temperature and humidity profiles at 40 pressure levels and integrated ozone from surface to top of the atmosphere. The specification of Sounder is as follows.

4.1 Sounder Channel Specification

The sounder observations are processed into multiple data products through standardized operational processing chains. These products are categorized into standard radiance products and derived geophysical parameter products.

Detector	Ch. No.	Central Wavelength (mm)	Principal absorbing gas	Purpose
Long wave	1	14.67	CO_2	*Stratosphere temperature*
	2	14.32	CO_2	*Tropopause temperature*
	3	14.04	CO_2	*Upper-level temperature*
	4	13.64	CO_2	*Mid-level temperature*
	5	13.32	CO_2	*Low-level temperature*
	6	12.62	water vapor	*Total precipitable water*
	7	11.99	water vapor	*Surface temp., moisture*
Mid wave	8	11.04	window	*Surface temperature*
	9	9.72	ozone	*Total ozone*
	10	7.44	water vapor	*Low-level moisture*
	11	7.03	water vapor	*Mid-level moisture*
	12	6.53	water vapor	*Upper-level moisture*

Short wave	13	4.58	N_2O	*Low-level temperature*
	14	4.53	N_2O	*Mid-level temperature*
	15	4.46	CO_2	*Upper-level temperature*
	16	4.13	CO_2	*Boundary-level temp.*
	17	3.98	window	*Surface temperature*
	18	3.76	window	*Surface temp., moisture*
Visible	19	0.695	visible	*Cloud*

Similar to the Imager, the Sounder provides **adequate radiometric resolution** to support its intended scientific and operational applications.

4.2 Sounder Data Products

S.No.	Data Product	Processing Level	Code	Format	Images	Remarks
Standard Products (L1B)						
1	Standard Product	L1B	3SSND_L1B_SA1	HDF	37 (18 IR,18 IR BT and 1 VIS)	India Region
2	Standard Product	L1B	3SSND_L1B_SB1	HDF	37	Indian Ocean Region
Geo-Physical Parameters (L2B)						
1	Vertical Profiles and Derived products	L2B	3SSND_L2B_SA1	HDF	62	Profile on 3x3 Pixels (Average)
2	Vertical Profiles and Derived products	L2B	3SSND_L2B_SB1	HDF	62	Profile on 3x3 Pixels (Average)

The algorithm for sounder products is designed to retrieve vertical profiles of atmospheric temperature and moisture, along with total column ozone content, from clear-sky infrared radiances in different absorption bands observed by INSAT-3DS/3DR.
Sounder-derived profiles include temperature, humidity, and geopotential heights. Images of the temperature and geopotential height profile are generated at 17 vertical pressure levels from 1000 hPa to 10 hPa, and of water vapor at 12 levels from 1000 hPa to 100 hPa in the operational chain. The following application products are derived from sounder-derived atmospheric profiles:

The profiles generated include:

(i) Temperature

(ii) Humidity
(iii) Geopotential height

Derived Geophysical products include:

(iv) Total Column Ozone
(v) Total precipitable water
(vi) Precipitable Water at 3 Levels (L1: 1000-900hPa, L2: 900-700hPa, L3: 700-300hPa)
(vii) Lifted index
(viii) Dry microburst index
(ix) Maximum vertical theta-e
(x) Wind index
(xi) Emissivity
(xii) Surface Skin Temperature

INSAT-3DS/3DR Sounder L2 Products

LIFTED INDEX: Lifted index is an indicator of convective activity.

LI >2 –No Significant Activity
-2<LI<0 -Thunderstorm possible
LI < -4 -Severe thunderstorm possible

Dry microburst index (DMI): A Dry microburst occurs in situations characterized by high convective cloud bases and strong evaporation cooling in the sub-cloud layer, resulting in little or no precipitation at the surface. Such conditions occur in mountainous and high plain regions.

Wind Index: Wind index provides guidance on the maximum possible wind gusts that can occur with given atmospheric conditions, if convection were to occur. This is useful for generating short-range warnings and forecasts.

Maximum vertical theta-e (θ_e) differential: The equivalent potential temperature (θe) is a measure of the total static energy (sensible heat, latent heat and geopotential) in an atmospheric column. Due to its strong dependence on moisture, θe decreases rapidly with height above the boundary layer, reaching a minimum in the middle troposphere, then θe increases again into the upper troposphere. The maximum vertical θe differential from the boundary layer to the middle troposphere is a useful quantity in calculating microburst potential, etc.

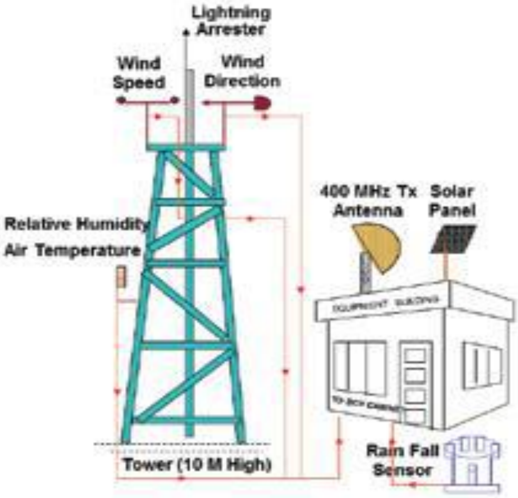
Total precipitable water: TPW may be used to monitor mesoscale to synoptic-scale convective activity, monsoonal activity, and moisture gradients. It has shown significant improvement in precipitation forecasts when TPW is incorporated into numerical weather prediction models.

Chapter 5: Data Relay Transponder (DRT) and Satellite Aided Search and Rescue (SAS & R) Transponder of INSAT 3DR/DS

The INSAT-3DR and INSAT-3DS satellites are equipped not only with meteorological observation payloads but also with specialized communication payloads designed to support data collection and emergency response services. These additional payloads significantly enhance the operational utility of the INSAT satellite system by enabling real-time environmental monitoring from remote locations and facilitating rapid response during distress situations. The two major communication payloads onboard INSAT-3DR/3DS are the Data Relay Transponder (DRT) and the Satellite Aided Search and Rescue (SAS & R) Transponder. These payloads play an important role in strengthening disaster management, environmental monitoring, and safety services across the Indian region and surrounding oceanic areas.

5.1 Data Relay Transponder (DRT)

Data Relay Transponder (DRT) on-board **INSAT-3DR/3DS** is used for receiving meteorological, hydrological and oceanographic data from remote, uninhabited locations over the coverage area from Data Collection Platforms (DCPs) like Automatic Weather Station (AWS), Automatic Rain Gauge (ARG) and Agro Met Stations (AMS). The data is relayed back for down linking in extended C-Band.



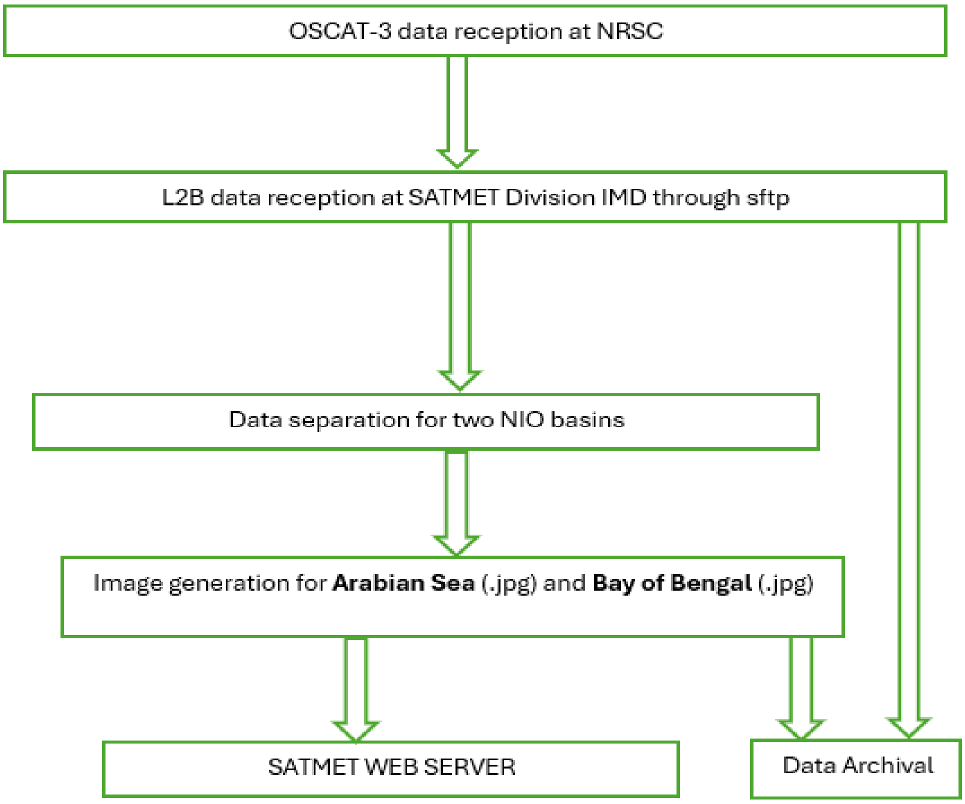
5.2 Satellite Aided Search and Rescue (SAS & R) Transponder

INSAT-3DR/3DS is equipped with a Search and Rescue payload (operating in 406 MHz) that picks up and relays the alert signals originating from the distress beacons of maritime, aviation and land-based users to the Indian Mission Control Centre (INMCC) located at ISRO Telemetry, Tracking and Command Network (ISTRAC), Bangalore. The major users of Satellite Aided Search and Rescue service in India are the Indian Coast Guard, Airports Authority of India (AAI), Directorate General of Shipping, Defence Services and fishermen. The Indian service region includes a large part of the Indian Ocean region covering India, Bangladesh, Bhutan, Maldives, Nepal, Seychelles, Sri Lanka and Tanzania for rendering distress alert services.

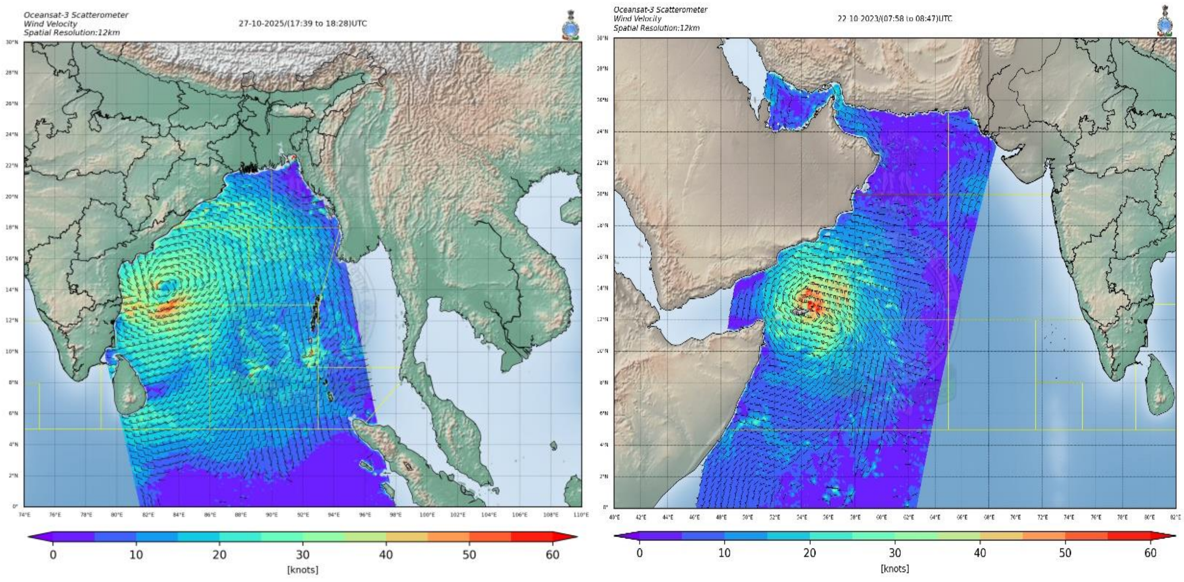
Chapter 6: OceanSat-3 (EOS-06)

6.1 Overview of OceanSat-3 Mission

OceanSat-3, also designated as EOS-06, represents a significant advancement in India's ocean observation satellite programme. While the INSAT series primarily focuses on geostationary meteorological observations, OceanSat-3 provides complementary oceanographic and marine meteorological observations from a polar orbit. The integration of OceanSat-3 observations with geostationary satellite data and numerical weather prediction models strengthens the overall operational meteorological framework. Oceansat-3 (EOS-06) on November 26, 2022, an advanced Earth observation satellite to provide wind vector data products over ocean for weather forecasting, cyclone detection and tracking services to the users. The satellite carries Ku-band Scatterometer similar to the one flown onboard Oceansat-2. SRO has launched the EOS-06(Oceansat-3) satellite on 26 Nov 2022 in a polar sun-synchronous orbit at 740 km altitude.



The OSCAT-3 (Scatterometer for Oceansat-3) is a Ku-band microwave radar instrument designed to measure sea-surface wind vectors over the global oceans. Wind products are generated at multiple spatial resolutions of 12.5 km, and 25 km, allowing flexibility for both operational and research applications. With this configuration, OSCAT-3 achieves near-global ocean coverage on a daily basis, making it a key instrument for marine meteorology, ocean state monitoring, and numerical weather prediction.



Wind speed and direction from OceanSat-3 during Cyclone Dana (2025) and Tej (2023)

Chapter 7: Foreign Satellites

7.1 EUMETCast

EUMETCast is a multi-service dissemination system based on multicast technology sustained by EUMETSAT. IMD has established a dedicated terrestrial EUMETCast system at NCMWRF Noida through a MoU with EUMETSAT to receive the Geostationary and Polar meteorological satellites data for assimilating in NWP models and Weather forecasting.

7.2 Meteosat-9 (Indian Ocean Data Coverage, IODC)

Meteosat-9 is a Meteosat Second Generation (MSG) spin-stabilized Geostationary Meteorological satellite located at 45.5 °E and consist of 12 spectral channels with capability to performed 'Full-Earth Scan' in 15 minutes. The scan region for Full-Earth scanning is covered up the area from approximately 40°W to 120°E i.e., it cover up the full European continent, Africa and central Asia. It carried the 12-channel imager, known as the spinning enhanced visible and infrared imager (SEVIRI). It also provides for better retrieval of wind fields which are obtained from the tracking of clouds, water vapour and ozone features.

7.3 Himawari Satellite

Himawari-9 is a Geostationary Meteorological satellite located at 140.7° E longitude of JMA with capability to performed 'Full-Earth Scan' in 10 minutes. The scan region for Full-Earth scanning is covered up the area of the East Asia and Western Pacific. It carried the 16-channel imager, known as the Advanced Himawari Imager (AHI) for multi-purpose imagery for weather watch, NWP utilization and environment monitoring and wind derivation by tracking clouds and water vapour features.

Chapter 8: Global Navigation Satellite Systems (GNSS)

8.1 GNSS Network Infrastructure

Integrated Precipitable Water Vapour (IPWV) product derived from the IMD GNSS Network is utilised for continuous, near real-time monitoring of columnar atmospheric moisture and associated surface meteorological parameters, namely pressure, temperature and relative humidity. The IPWV product is generated at 15-minute intervals and disseminated through operational web-based platforms. At present, two GNSS processing systems are operational at IMD, namely the proprietary Trimble Pivot Platform (TPP) and an indigenously developed open-source processing system based on GAMIT/GLOBK. Both systems are operated in parallel to ensure operational continuity, redundancy and cross-validation of GNSS-derived IPWV products.

IMD initiated GNSS-based IPWV monitoring in 2005 with a pilot network of five stations located at Delhi, Mumbai, Chennai, Kolkata and Guwahati. The GNSS network was subsequently expanded to 25 GNSS meteorological stations by 2017. Under the legacy processing framework, the Trimble Pivot Platform continues to generate real-time IPWV and surface meteorological parameters from IMD GNSS stations, which are visualised through a dedicated TPP-based web interface. This system supports routine monitoring of atmospheric moisture fields and provides continuity of long-term GNSS IPWV datasets.

In parallel, IMD has developed and operationalized an indigenous real-time and post-processed GNSS IPWV processing system using open-source GAMIT/GLOBK software. This system became operational on 5 June 2025 and currently processes data from approximately 55 GNSS stations, including IMD GNSS stations and Survey of India GNSS stations equipped with Trimble and Leica receivers. The indigenous system removes dependency on proprietary software, enables scalable processing, and provides enhanced flexibility for both real-time operations and retrospective reprocessing. IPWV products generated through this system are archived in database IMDDB (MariaDB) and displayed through an IMD-developed interactive dashboard in the form of station-wise charts and maps.

GNSS-derived IPWV products are used operationally for monitoring monsoon onset, advance and withdrawal, and for nowcasting and short-range forecasting of thunderstorms, cyclones, fog and heavy rainfall events. These products are also utilized for the development and refinement of IPWV threshold values associated with rainfall initiation and are disseminated to the National Centre for Medium Range Weather Forecasting (NCMRWF) for assimilation into Numerical Weather Prediction models.

8.2 GNSS Operational Access and Display

Real-time and post-processed GNSS-derived IPWV and surface meteorological parameters are made available through an interactive web-based dashboard developed by the GNSS Unit, Satellite Meteorological Division, IMD. The processed data are archived in IMDDB (MariaDB) and displayed in the form of tables and geospatial maps. The data can also be exported in CSV format for further analysis.

The dashboard additionally provides a map-based visualization of GNSS station health, indicating the availability of recent data at each station.

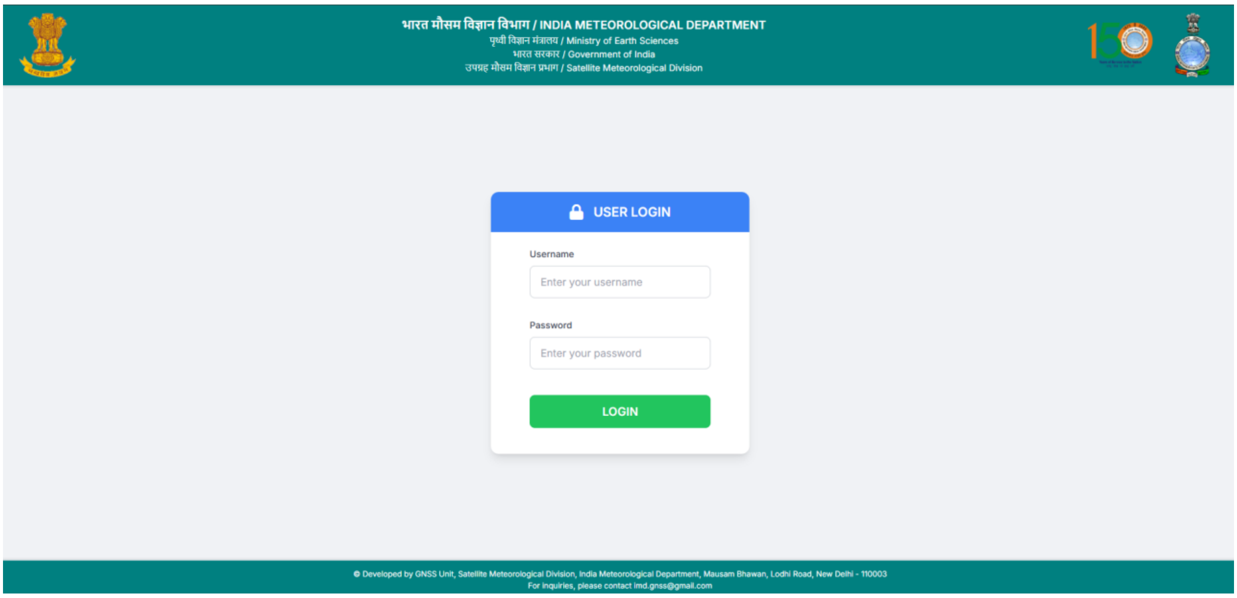
Procedure for Viewing GNSS-Derived Parameters

To access and visualise GNSS IPWV data, the user shall follow the steps given below:

Visit the GNSS IPWV Data Viewer URL: *http://192.168.18.86/*

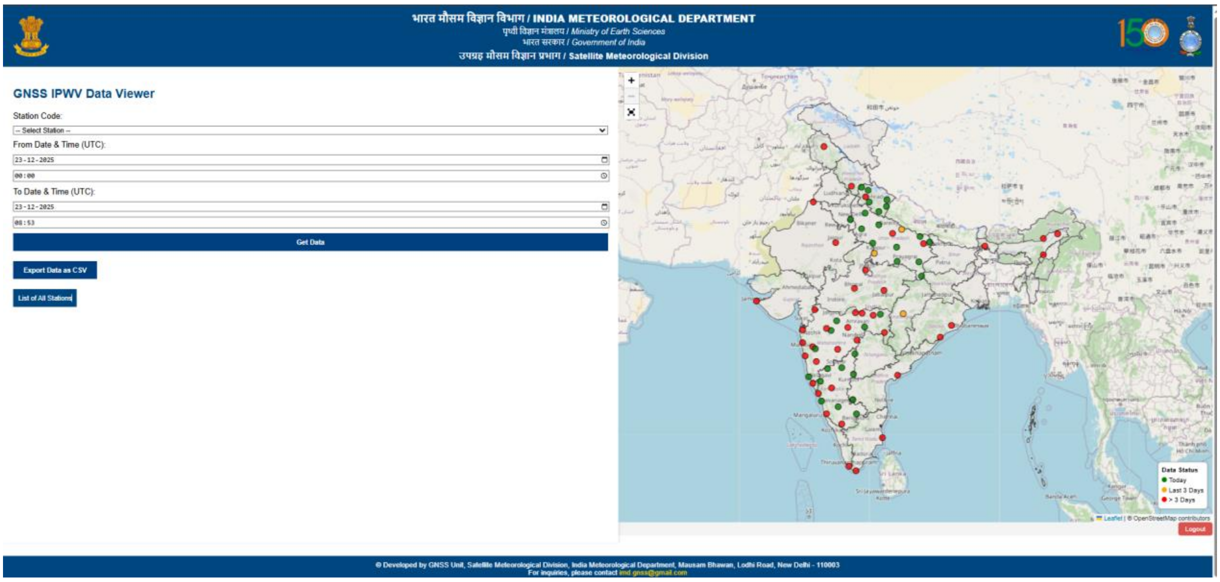
Enter the authorised user credentials on the login page to access the dashboard.
After successful login, select the required input details, namely:
Station name (specific station or All Stations),
From Date and Time (UTC), and
To Date and Time (UTC).
Click on "Get Data" to display the selected GNSS IPWV and related parameters in tabular form on the dashboard.

Alternatively, click on "Export Data as CSV" to download the selected data in CSV format.
The map panel displays the GNSS station health status based on the latest availability of data, where different colour codes indicate whether data have been received today, within the last three days, or beyond three days.



भारत मौसम विज्ञान विभाग / INDIA METEOROLOGICAL DEPARTMENT
पृथ्वी विज्ञान मंत्रालय / Ministry of Earth Sciences
भारत सरकार / Government of India
उपग्रह मौसम विज्ञान प्रभाग / Satellite Meteorological Division

© Developed by GNSS Unit, Satellite Meteorological Division, India Meteorological Department, Mausam Bhawan, Lodhi Road, New Delhi - 110003
For inquiries, please contact imd.gnss@gmail.com



भारत मौसम विज्ञान विभाग / INDIA METEOROLOGICAL DEPARTMENT
पृथ्वी विज्ञान मंत्रालय / Ministry of Earth Sciences
भारत सरकार / Government of India
उपग्रह मौसम विज्ञान प्रभाग / Satellite Meteorological Division

GNSS IPWV Data Viewer

Station Code: -- Select Station --
From Date & Time (UTC): 23-12-2025 00:00
To Date & Time (UTC): 23-12-2025 08:53

© Developed by GNSS Unit, Satellite Meteorological Division, India Meteorological Department, Mausam Bhawan, Lodhi Road, New Delhi - 110003
For inquiries, please contact imd.gnss@gmail.com

The following criteria of IPWV and surface temperature values may be used for predicting the rainfall occurrence associated with Synoptic system at Inland and Costal stations.

Inland Stations

Month	Surface Temperature (approximately)	IPWV (with Synoptic system)
Jan	10 – 15-degreeCelcius	15 – 18 mm
Feb	15 – 20 C	18 – 22 mm
March	15 - 25 C	20 – 25 mm
April	25 - 35	25 – 30 mm
May	35-40	>40 mm (less than this value dust storm)
June	38 – 45 Degree Celsius	>45 mm (less than this value dust storm)
Monsoon	30-38 degree	>60 mm
Break Monsoon		40 – 45 mm
Post Monsoon	30-35	30 – 40 mm

Costal station: South Peninsular India

Month	Surface Temperature	IPWV
JAN - FEB	20 – 30 C	40 mm and more
MAR - APRIL	30 – 35 C	45 and above
MAY,JUN,JULY,AUG,SEP, OCT	35 – 40 C	55 and above
NOV, DEC	30 - 35	60 and above

Operational experience indicates that IPWV thresholds, when interpreted in conjunction with surface temperature and prevailing synoptic conditions, provide useful guidance for rainfall forecasting. For inland stations, IPWV values of 15–18 mm in January, 18–22 mm in February, 20–25 mm in March and 25–30 mm in April are generally associated with rainfall occurrence under synoptic influence. During May and June, IPWV values exceeding 40 mm and 45 mm respectively are indicative of rainfall potential, while lower values during these months may be associated with dust storm conditions. During the monsoon season, IPWV values exceeding 60 mm are commonly observed, while values in the range of 40–45 mm are typical during break monsoon conditions. Post-monsoon rainfall over inland stations is generally associated with IPWV values in the range of 30–40 mm.

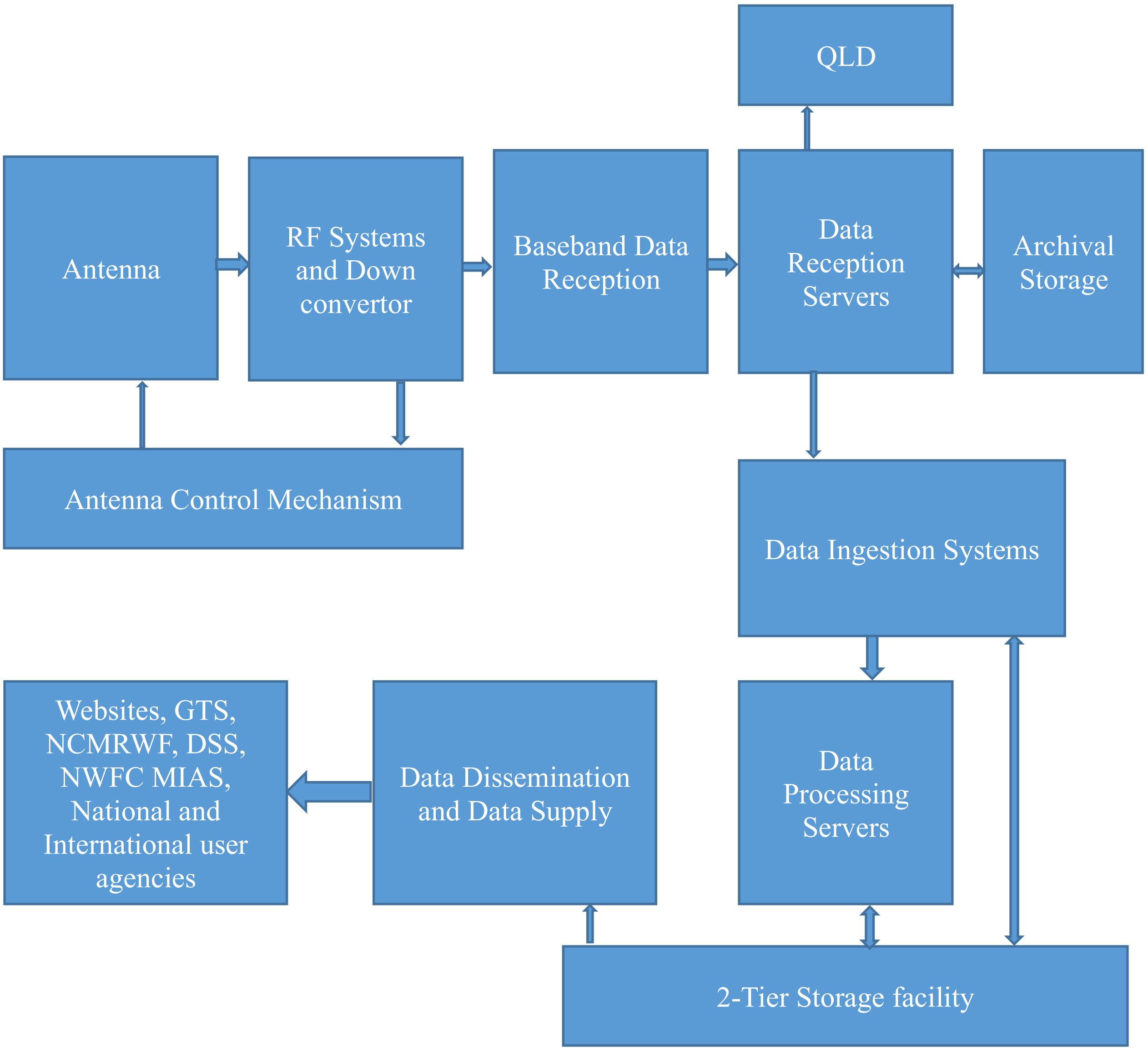
For coastal stations over South Peninsular India, IPWV values of 40 mm or more during January–February, 45 mm or more during March–April, 55 mm or more during May to October, and 60 mm or more during November–December are generally associated with rainfall occurrence. Sustained IPWV values of 60 mm or more for two to three consecutive days may be considered a favorable indicator for monsoon onset at a given location. IPWV values in the range of 65–68 mm, when associated with synoptic systems, are indicative of heavy rainfall over coastal stations, while values exceeding 70 mm, if maintained at synoptic timescale, are indicative of heavy to very heavy rainfall. During severe convective thunderstorm activity, IPWV values may exceed 80 mm, particularly over Northeast India, Bihar, Uttar Pradesh, Delhi and Jharkhand.

Over hilly and elevated regions, IPWV threshold values are comparatively lower than those over plains and vary with elevation. For example, Bengaluru typically exhibits monsoon onset signals around IPWV values of approximately 40 mm, while Shimla shows threshold values in the range of 30–35 mm. The IPWV thresholds provided are indicative and station-specific, and forecasters may further refine these thresholds for different weather events, seasons and stations based on local climatology, synoptic conditions and operational experience to improve forecast accuracy.

Chapter 9: Data Flow and Dissemination of MMDRPS

9.1 Multi-Mission Data Reception and Processing System (MMDRPS) System Architecture

The Meteorological and Oceanographic Multi-Mission Data Reception and Processing System (MMDRPS) serves as the central operational satellite earth segment for processing meteorological satellite data in the India Meteorological Department (IMD). The system ensures seamless acquisition, processing, storage, and dissemination of satellite observations required for operational weather forecasting and research applications. The data flow architecture of MMDRPS is designed with redundancy and automation to ensure uninterrupted availability of satellite-derived meteorological products.Fig: Block diagram of one chain of data flow at MMDRPS (each met payloads have main and redundant chains)



All satellite channels, specialized imagery, and derived meteorological products generated by the Satellite Meteorology Division of the **India Meteorological Department (IMD)** are disseminated through dedicated web portals to ensure timely and wide accessibility for operational forecasters, researchers, and other stakeholders. The primary dissemination platforms include the official IMD satellite websites:

- **https://satellite.imd.gov.in**
- **https://satmet.imd.gov.in**

These portals host a comprehensive suite of real-time and near-real-time satellite products, including visible, infrared, water vapour imagery, derived meteorological parameters, and specialized diagnostic products. In addition to the products displayed on the main webpages, users can further explore an expanded range of datasets and value-added products by navigating through embedded links, which provide access to additional imagery and analyses not directly visible on the homepage.

During extreme weather events such as cyclones, severe thunderstorms, and heavy rainfall episodes, **Rapid Scan** observations are activated to enhance temporal monitoring of rapidly evolving atmospheric systems. Rapid Scan imagery is made available through a dedicated webpage:

- **https://www.satellite.imd.gov.in/rapid/rapid_scan.htm**

To further support real-time analysis and interactive visualization, the **RAPID Tool** (https://rapid.imd.gov.in) provides advanced capabilities for accessing and analyzing high-frequency satellite observations, particularly during high-impact weather situations.

In parallel with web-based dissemination, the Satellite Meteorology Division operates multiple automated scripts and dedicated data pipelines to share satellite data and products in near real time with national and international agencies. These include dissemination through the **Global Telecommunication System (GTS)** as well as direct data sharing with organizations such as **NCMRWF**, the **Indian Air Force (IAF)**, and other collaborating agencies, ensuring seamless integration into operational forecasting and decision-support systems.

For archival and reference purposes, the division maintains a secure **Satellite Image Archive**, which provides access to historical satellite imagery through a username- and password-protected interface:

- **https://satellite.imd.gov.in/ImageArchive/index.html**

Additionally, an **FTP server** is maintained to facilitate on-demand sharing of satellite data and specialized products as per user requirements, supporting research activities, case studies, and collaborative projects.

9.2 Satellite Data Dissemination Mechanisms

INSAT Data products and images are being disseminated to user clients such as NCMRWF, WMO's GTS, RSMC New Delhi, NFWC, IMD's public website, and international agencies in real-time through dedicated transfer scripts and tools. SATMET hosts websites for the real-time dissemination of hundreds of images every 15 minutes, a dedicated Web-based GIS platform to analyze the past 7 days of data, webpages for archived images for IMD’s internal users, sectoral applications, real-time district-level T-phi grams for clear-sky pixels derived from INSAT data, etc.

Near Real-Time Satellite Data/Imageries Dissemination from MMDRPS

Together, these dissemination mechanisms ensure robust, timely, and user-oriented access to satellite observations and products, strengthening IMD’s capability to support weather monitoring, forecasting, disaster management, and research applications at national and international levels.

References:

- (https://mosdac.gov.in/docs/ INSAT˙3D˙ATBD˙MAY˙2015.pdf).
- (https://mosdac.gov.in/docs/Incremental-ATBD12Feb2020.pdf).
- Mitra, A. K., Kaushik, N., Singh, A. K., Parihar, S., & Bhan, S. C. (2018). Evaluation of INSAT-3D satellite derived precipitation estimates for heavy rainfall events and its validation with gridded GPM (IMERG) rainfall dataset over the Indian region. *Remote sensing applications: Society and environment*, *9*, 91-99.
- Varma, A. K., and R. M. Gairola. "Algorithm Theoretical Basis Document: Hydro-Estimator (Modified)." *Document No. SAC/EPSA/AOSG/SR/04* (2015).
- Saikrishna, T. S., Ramu, D. A., & Osuri, K. K. (2021). Inter-comparison of high-resolution satellite precipitation products over India during the summer monsoon season. *Meteorology and Atmospheric Physics*, *133*(6), 1675-1690.
- Mahesh, C., Prakash, S., Sathiyamoorthy, V., & Gairola, R. M. (2014). An improved approach for rainfall estimation over Indian summer monsoon region using Kalpana-1 data. *Advances in Space Research*, *54*(4), 685-693.
- Mitra, A. K., Parihar, S., Peshin, S. K., Bhatla, R., & Singh, R. S. (2019). Monitoring of severe weather events using RGB scheme of INSAT-3D satellite. *Journal of Earth System Science*, *128*(2), 36.