वार्षिक प्रतिवेदन

ANNUAL REPORT

2024

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

INDIA METEOROLOGICAL DEPARTMENT

(MINISTRY OF EARTH SCIENCES)

(GOVT. OF INDIA)

MAUSAM BHAWAN, LODI ROAD, NEW DELHI – 110 003, INDIA

TELEFAX : 91-11-24623220

Website :https://mausam.imd.gov.in

e mail:mausam.imd@imd.gov.in

Published in India

by

Information Science & Knowledge Resource
Development Division (IS&KRDD)
(Formerly Publication Section)
India Meteorological Department, New Delhi – 110 003 (India)

e mail : mausam.imd@imd.gov.in

Dialing Code : 011-24344298, 24344522

Telefax : 91-11-24699216, 91-11-24623220

Website : https://mausam.imd.gov.in/

INDIA METEOROLOGICAL DEPARTMENT ORGANIZATION CHART

Dr. Jitendra Singh

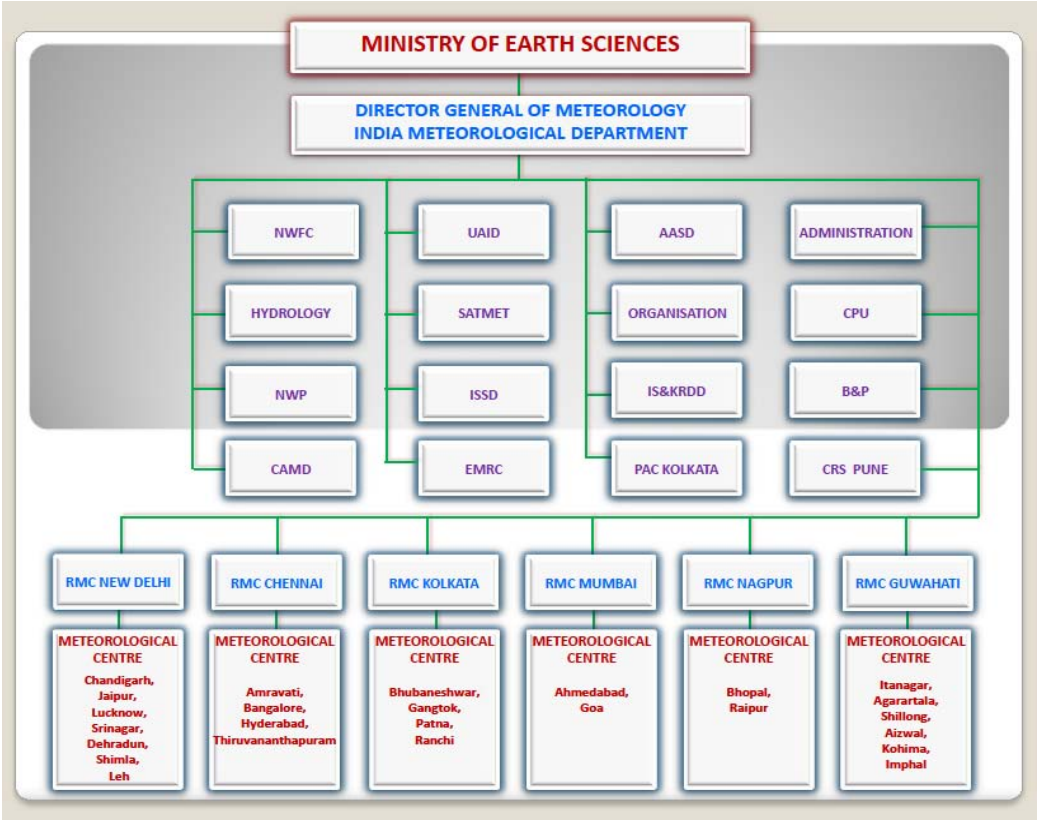
Minister of State (Independent Charge) of the Ministry of Earth Sciences, Minister of State (Independent Charge) of Science & Technology, Minister of State in the Prime Minister's Office, Minister of State in the Ministry of Personnel, Public Grievanc

Dr. M. Ravichandran

Secretary
Ministry of Earth Sciences

Dr. Mrutyunjay Mohapatra

Director General of Meteorology
India Meteorological Department



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

FOREWORD

It is a great privilege to present the Annual Report of India Meteorological Department (IMD) for the year 2024. The report highlights significant activities of the department during the year. The department has been playing a leading role in the field of Earth and Atmospheric Sciences by providing services in meteorology and allied fields.

During 2024, the IMD progressively strode towards modernization of scientific infrastructure in the fields of meteorological observations, information systems, numerical modelling and weather forecasting. It helped to render better services in areas of disaster management, agriculture, aviation, shipping, fisheries, energy and transport etc. IMD's services of very short range (up to 6 hrs), short range (up to 3-days in advance), medium range (up to 4-10 days in advance), extended range (up to 4 weeks in advance) and long range (monthly and seasonal) forecast alongwith severe weather (cyclones, thunderstorms, heavy rainfall, heat wave, cold wave, fog, etc.) warnings continuously improved to meet the demands of the user agencies, disaster managers, emergency response groups, stakeholders and general public.

India Meteorological Department celebrated an extraordinary milestones commencing from 15th January, 2024 the 150th year of its establishment and service to the nation. The inaugural function was organized at Vigyan Bhawan, New Delhi on 15th January, 2024. Hon'ble Vice President of India graced the occasion as Chief Guest. Major highlights of the event are:

- Release of Souvenir on Evolution of IMD and its services since 1875
- Launch indigenously developed Decision Support System (DSS)
- Launch of Panchayat Mausam Seva for farmers (PMS)
- Launch of IMD's mobile app and Mausamgram – MAUSAM
- Launch of National Framework of Climate Services (NFCS)

In order to celebrate this mementos occasion, a series of activities planned for one year starting from 15th January, 2024 as a curtain raiser and culuminating on 15th January, 2025. This year also marks the 75th anniversary of Mausam, a journal that has continuously served as a platform for researchers, scientist and academicians to share their findings, discoveries and perspectives. Over the decades, through the Collaborative efforts of our authors, reviewers and editorial team. Mausam has fostered an environment of intellectual exchange and scientific advancement. Today, it stands as a premier scientific journal among its contemporaries in the fields of meteorology, hydrology and geophysics. The scientists in IMD have published 128 research papers in peer reviewed national and International journals during the year 2024.

IMD monitors the climate parameters and provides annual climate statement to the country, WMO and IPCC. The year 2024 is termed by WMO as the warmest year in the 175-year observational record with a global mean surface temperature of 1.55±0.13 °C above the 1850-1900 average. The annual mean land surface air temperature averaged over India during 2024 was +0.65°C above the long-term average (1991-2020 period). This marked the warmest year since nationwide records began in 1901, surpassing the previous highest temperature observed in 2016, which had an anomaly of +0.54°C. The all-India mean temperature was above normal, with anomalies of

+0.37°C, +0.56°C, +0.71°C and +0.83°C during the winter (January to February), pre-monsoon (March to May), southwest monsoon (June to September) and post-monsoon (October to December) seasons, respectively. Heatwave conditions were observed over most parts of the east coast in April, most parts of northwest India in May and most parts of Northern and central India in the month of June.

The 2024 annual rainfall over the country as a whole was 104% of its Long Period Average (LPA) value for the period 1971-2020. The monsoon season rainfall over the country as a whole was 108% of its LPA. The seasonal rainfall during the Northeast monsoon season (October - December) over the NE Monsoon core region of the south peninsula was 122% of its LPA. In 2024, four cyclonic storms formed over the North Indian Ocean. Of these, two were severe cyclonic storms (REMAL and DANA), and two were cyclonic storms. One of these cyclones ASNA formed over the Arabian Sea (as remnant from the Bay of Bengal). REMAL formed during the pre-monsoon season (May 24-28) over the Bay of Bengal, ASNA during the monsoon season (August 25 to September 2) over the Arabian Sea and DANA (October 22-26) and FENGEL (November 25 to December 2) formed during the post-monsoon season over the Bay of Bengal. In addition to these cyclones, extreme weather events such as extremely heavy rainfall, floods, landslides, lightning, thunderstorms, droughts and others were also experienced in various parts of the country.

As IMD celebrates 150 years of service, it continues to expand its reach and impact across all sectors, contributing significantly to India's socio-economic development. With advancements in forecasting, IMD has extended its lead time for weather predictions from three days to a full week, aiding better planning for stakeholders. Agrometeorological Advisory Services (AAS) already benefit 28 million farmers through various platforms, including state IT systems, mobile apps, and WhatsApp groups.

A standout initiative, "Har Har Mausam, Har Ghar Mausam" ensures that weather forecasts are accessible to people anywhere and anytime in the country. Through the Mausamgram platform, users can access forecasts by entering a location name, Postal Index Number (pin) code, or Panchayat / Block / Tehsils / District / City / Town name. Starting from 24th October, 2024, daily gram panchayat-level forecasts are available for nearly all 2.6 lakh panchayats across India, covering parameters like temperature, rainfall, humidity, wind and cloud cover. Forecasts include hourly updates for up to 36 hours, 3-hourly forecasts for five days and 6-hourly forecasts for up to 10 days, helping farmers optimize crop management and enhance productivity. The Panchayat level forecast is also available on Panchayat Mausam Sewa portal https://mausam.imd.gov.in/greenalerts of IMD. The Panchayat level forecast is also disseminated to Panchayat Secretary, Ward member and Sarpanch.

IMD, MoES and Ministry of Rural Development (MoRD) are working together to disseminate the weather and climate information, as well as agrometeorological advisories through the village-level network of ‘Krishi Sakhi’ and ‘Pashu Sakhi’ under the Deendayal Antyodaya Yojana-National Rural Livelihoods Mission (Day-NRLM) of MoRD. This partnership seeks to equip farmers with actionable weather data, crop planning, water management, and risk mitigation. IMD data will support developing action plan for the Self Help Group (SHG) network, where trained members will act as weather information disseminators in their villages. SHG members will get timely alerts on floods, cyclones, and other hazards.

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

Finally, I sincerely thank all the employees of IMD for their support and commitment throughout the last year and I look forward to your continued support in our journey towards setting higher levels of excellence. My special thanks to Dr. D. S. Pai, Scientist 'G', Dr. V. K. Soni, Scientist 'F' and Mr. Sunny Chug, Scientist 'D', Information Science & Knowledge Resource Development Division (IS&KRDD) (Formerly Publication Section) and their team in the division for their sincere efforts in compilation, editing and publication of this Annual Report 2024.

Dr. Mrutyunjay Mohapatra
Director General of Meteorology

Document Control Sheet

India Meteorological Department

Ministry of Earth Sciences (MoES)

1.	Document Title	Annual Report 2024
2.	Document type	Technical
3.	Issue No.	MoES/IMD/Annual Report -2024/2024(01)/04
4.	Issue Date	31.03.2024
5.	Security Classification	Open
6.	Control Status	Open
7.	No. of Pages	202
8.	No. reference	Nil
9.	Distribution	Open
10.	Language	English & Hindi
11.	Originating Division/Group	India Meteorological Department, New Delhi [Information Science & Knowledge Resource Development Division (IS&KRDD) (Formerly Publication Section)]
12.	Reviewing and Approving Authority	Director General of Meteorology
13.	End Users	Open to all
14.	Abstract	This report highlights the progress made by the India Meteorological Department during the year 2024. The Department is continuously augmenting its observational, forecasting and information systems to render improved services in areas of agriculture, aviation, shipping, fisheries, environment, water, health, energy, transport etc. India's diverse topography necessitates enhanced radar coverage. To address these gaps and ensure comprehensive weather monitoring, a strategic plan has been proposed to install additional radars: C-band Radars: Installation of 12 radars aimed at improving coverage in the plains, where radar coverage is currently insufficient. X-band Radars: Installation of 10 radars to strengthen the network in the northeastern states, which face frequent severe weather events and have complex terrain and installation of 08 radars under 'urban meteorology scheme'. S-Band Radars: Installation 04 radars for improving the coverage of the coastal India. INSAT-3DR and INSAT-3DS are dedicated geostationary meteorological satellites and located at 74-degree and 82-degree East longitude, respectively. This year marked the launch of the INSAT-3DS mission which was launched successfully on 17th February,2024 using GSLV-F14 launch vehicle and by June 2024, INSAT-3DS was maneuvered into its final geostationary slot at 82°E, replacing INSAT-3D, which ceased operations. This milestone enhanced India's capabilities in satellite meteorology and improved the accuracy and timeliness of weather-related

		services.INSAT-3D Slike 3DR carries a multispectral 6 channel Imager, 19 channel Sounder, Data Relay Transponder (DRT), and Satellite Aided Search & Rescue Transponder (SAS&R). Surface Ozone monitoring network using electro-chemical method with IMD make instrument. Two more stations (Shillong and Ranichauri) have been added in the network and now network comprises total 11 surface monitoring stations including Maitri and Bharati stations. IMD issues AQ Early Warning bulletins based on different models. This year the air quality forecast services were extended to other cities. As of now, the services are being provided to 46 cities. It is now planned to extend the air quality forecast services to all the 131 non-attainment cities of India by 2025. IMD has prioritized Urban Meteorological Services due to increasing demand. This initiative aims to offer specific severe weather alerts for the capital by leveraging dense observational networks, detailed forecasts, early warning systems for multiple hazards, and climate services that support Sustainable Development Goals. As urban centers, including smart cities and megacities, continue to grow in India, there is a crucial requirement to enhance infrastructure and deliver comprehensive environmental and weather services. Year 2024 witnessed the formation of 12 cyclonic disturbances (CDs) against normal of 11.2 per year based on the data during the period 1965-2023. It included 8 depressions/deep depressions (maximum sustained wind speed (MSW): 32 – 61 kmph), 2 cyclonic storms (MSW: 62-91 kmph) and 2 severe cyclonic storms (92-117 kmph). All the 4 cyclones had recurving tracks. Out of 4 cyclones, 3 were landfalling cyclones (Remal, Dana and Fengal) and the depression over northwest Madhya Pradesh moved westwards, emerged into northeast Arabian Sea, intensified into cyclonic storm Asna over northeast Arabian Sea.
15.	Key words	IMD Annual Report 2024, MoES, Publication, Mausam, Weather.

CHAPTER 1

INDIA METEOROLOGICAL DEPARTMENT - OVERVIEW

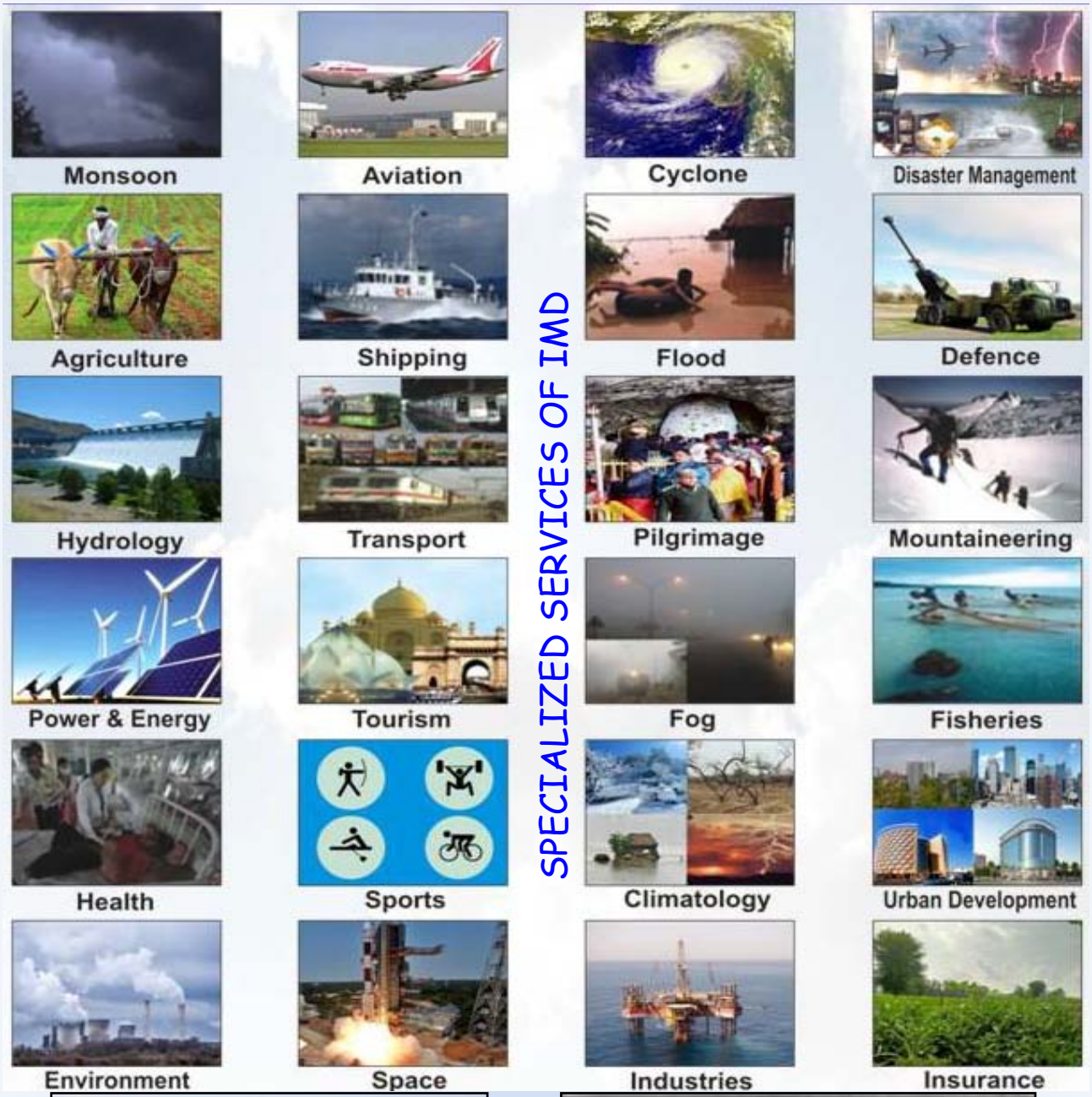
India Meteorological Department, Ministry of Earth Sciences is the National Meteorological Service of the country and the principal Government agency in all matters relating to Meteorology, Seismology and allied discipline and provides weather and climate services to the public and specialized sectors (Fig. 1).

It's mandate is:

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

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

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



India Meteorological Department (IMD)

Alipore Observatory, Kolkata founded in 1877

Fig. 1. Specialized services of IMD

India had some of the oldest meteorological observatories of the world and the first astronomical and meteorological unit started at Madras in 1793. Thus, meteorological observation in India was taken even prior to the establishment of the department in 1875. Since then IMD has achieved many milestones during the period from 1793 to 2024 (Fig. 2).

Fig. 2. IMD milestones during the period from 1793 to 2024

The Director General of Meteorology is the Head of the India Meteorological Department, with headquarters at New Delhi. For the convenience of administrative and technical control, there are 6 Regional Meteorological Centres (RMCs) (Fig.3), with regional headquarters at Mumbai, Chennai, New Delhi, Kolkata, Nagpur and Guwahati. Under the Head of RMCs, there are different operational units such as Meteorological Centres, Forecasting Offices, Agromet. Advisory Centres, Flood Meteorological Offices and Cyclone Detection Radar Stations.

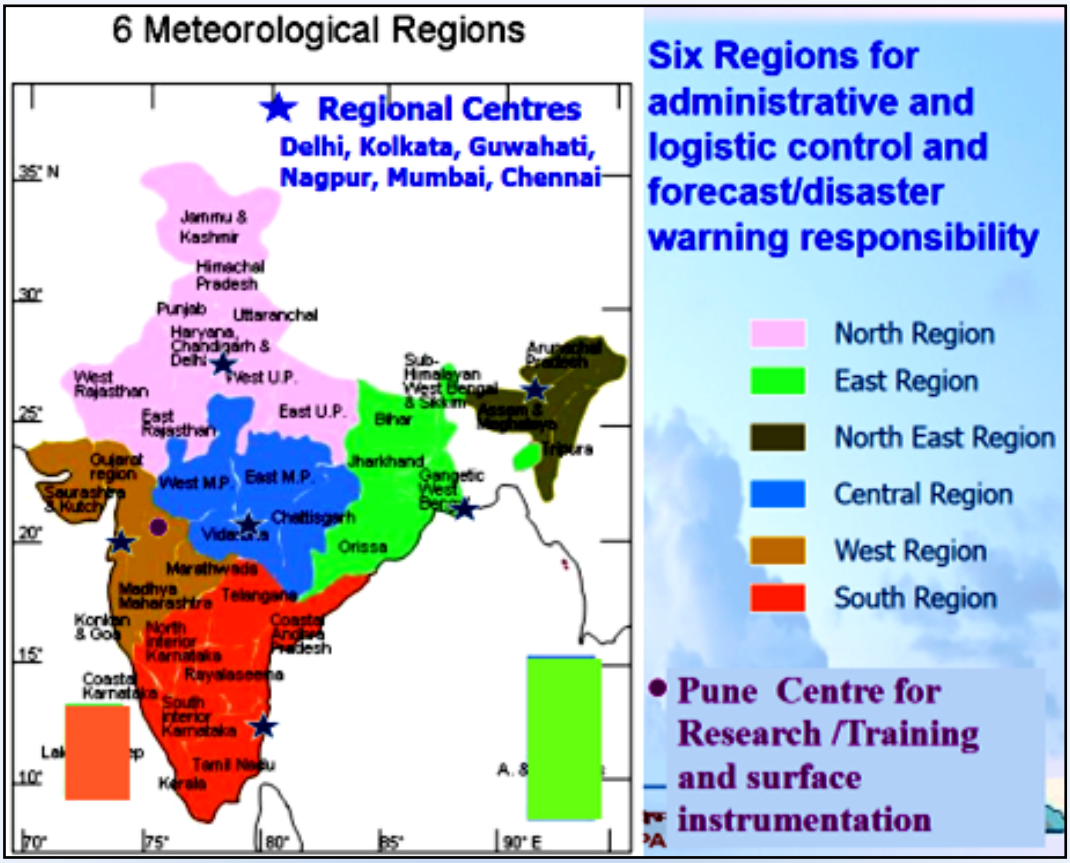


Fig. 3. Six(6) Meteorological regions

India Meteorological Department has continued its efforts for the improvement of observing, warning and dissemination mechanism/systems all through 2024. Its improved services rendered in respect of very short (up to 6 hrs), short (up to 3-days in advance), medium (up to 7-10 days in advance), extended (up to 15 to 20 days in advance), long (monthly and seasonal) range and severe weather (cyclones, thunderstorms, extreme rainfall) forecasts have been built to meet the demands of the user agencies, disaster managers, emergency response groups and other stakeholders in an organized manner in 2024. Its short, medium, extended & long range and cyclone forecasts were appreciated all over the world.

The annual mean land surface air temperature averaged over India during 2024 was +0.65 °C above the long-term average (Period 1991-2020). This marked the warmest year since nationwide records began in 1901, surpassing the highest temperature observed in 2016, which had an anomaly of +0.54 °C. The all-India mean temperature was above normal, with anomalies of +0.37 °C, +0.56 °C, +0.71°C, and +0.83 °C during the winter (January to February), pre-monsoon (March to May), southwest monsoon (June to September), and post-monsoon (October to December) seasons, respectively. Heatwave conditions were observed over most parts of the east coast in April, most parts of northwest India in May, and most parts of Northern and central India in June.

During 2024, mean, minimum and maximum temperature anomalies over many parts of the country were generally above normal or near normal. Mean temperature over parts of Himachal Pradesh, Uttarakhand, East Madhya Pradesh, West Bengal state, Sikkim state, Jharkhand, Chattisgarh, South Interior Karnataka, North Interior Karnataka, Madhya Maharashtra, Odisha, Bihar, Rayalaseema and Kerala & Mahe was above normal by about 1°C. Maximum temperature over parts of Jammu, Kashmir & Ladakh, Himachal Pradesh, Uttarakhand, West Bengal state, Assam & Meghalaya, South Interior Karnataka and Kerala & Mahe was above normal by about 1°C. However, the maximum temperature over parts of East Uttar Pradesh and East Madhya Pradesh was below normal by about 1°C. The minimum temperature over parts of Punjab, Bihar, and East Madhya Pradesh was above normal by about 2°C.

The 2024 annual rainfall over the country as a whole was 104% of its Long Period Average (LPA) value for the period 1971-2020. The monsoon season rainfall over the country as a whole was 108% of its LPA. The seasonal rainfall during the Northeast monsoon season (October - December) over the NE Monsoon core region of the south peninsula was 122% of its LPA.

Rainfall activity over the country as a whole was 104% of LPA during the year. Out of 36 meteorological subdivisions, 1 subdivision Saurashtra & Kutch received large excess rainfall, 30 received excess/normal rainfall and the remaining 5 subdivisions (Arunachal Pradesh, Bihar, Punjab, Himachal Pradesh, Jammu & Kashmir, and Ladakh) received deficient rainfall. At the end of the year, out of the four homogeneous regions, South Peninsular India received 115% of its LPA, Central India received 117% of its LPA, Northwest India received 95% of its LPA, while East & Northeast India received 88% of its LPA rainfall.

In 2024, four cyclonic storms formed over the North Indian Ocean. Of these, two were severe cyclonic storms (REMAL and DANA) and two were cyclonic storms (ASNA and FENGAL). Three of these cyclones-REMAL, DANA and FENGAL-formed over the Bay of Bengal, while ASNA formed over the Arabian Sea (as remnants from the Bay of Bengal).

Among these systems, REMAL formed during the pre-monsoon season (May 24-28), ASNA during the monsoon season (August 25 to September 2) and DANA (October 22-26) and FENGAL (November 25 to December 2) formed during the post-monsoon season. In addition to these cyclones, extreme weather events such as extremely heavy rainfall, floods, landslides, lightning, thunderstorms, droughts, and others were also experienced in various parts of the country.

Various parts of the country also experienced extreme weather events like extremely heavy rainfall, floods, landslide, lightning, thunderstorm, heat wave, cold wave, hailstorm, etc. which caused more than 3680 deaths, out of which more than 1640 were due to lightning and thunderstorm.

1. Summary of Major achievements in 2024

1.1. Launch of the new scheme 'Mission Mausam'

The Union Cabinet approved the central sector scheme Mission Mausam on September 11, 2024, with a budget outlay of 2,000 crores over two years (2024-25 to 2025-26) with the goal of making Bharat a "Weather-ready and Climate-smart" nation. The mission seeks to exponentially enhance the country's weather and climate observations, understanding, modelling and forecasting, leading to better, more useful, accurate and timely services. The previously approved sub-scheme ACROSS under the PRITHVI scheme is merged with the current scheme.

1.2. The objectives of the scheme "Mission Mausam" includes:

- Develop Cutting Edge Weather Surveillance Technologies & Systems
- Implement Higher resolution atmospheric observations with better temporal and spatial sampling/coverage
- Implement Next-generation radars, and satellites with advanced instrument payloads
- Implement High-Performance Computers (HPC).
- Improve understanding of weather and climate processes and prediction capabilities
- Develop improved earth system models, and data-driven methods (use of AI/ML)
- Develop Technologies for weather management
- Develop state-of-art dissemination system for last mile connectivity
- Capacity building

The Mission Mausam will be implemented by IMD and other institutes of MoES. IMD will mainly focus on the observations, services, decision support system and dissemination. Major IMD activities under Mission Mausam include:

- Commissioning of 53 Doppler Weather Radars
- Establishment of 60 RS/RW stations
- Commissioning of 100 Disdrometers
- Commissioning of 10 Wind profilers
- Commissioning of 25 Microwave Radiometers
- Augmentation of Solar Radiation Monitoring Network- 55 Nos.
- Commissioning of 10 Aerosol / Raman LiDARs
- Procurement of 20 Skyradiometers
- Expansion of BC Aerosol Network (BC, EC/OC)- 25 stations
- Ozonesonde Network (3 India+ Maitri+ Bharati)
- Total Columnar Ozone (TCO3)- 5 Nos.
- Commissioning of Visualization and Decision Support System (mini HPCS)
- Collaboration with various agencies and startups for the indigenous development of met instruments / sensors and software and provide useful outputs for enhancing precipitation forecasting, validation of weather forecasting models, and dissemination of information and products
- Establishment of Radar data centre, R&D Labs for Tropical Cyclones, severe weather events, Aviation Meteorology, Mountain weather and Augmentation of Training centre.

CHAPTER 2

Weather Summary during 2024

1. Winter Season (January-February)

1.1. Highlights

During the winter season, in India, the minimum temperature was (13.50°C with an anomaly of 0.86°C) the highest since 1901. The mean temperature was 19.74°C with an anomaly of 0.37°C and it was 14th highest since 1901. The mean temperature over South Peninsular India (26.23°C with an anomaly of 1.10°C) was the highest and Central India (22.37°C with an anomaly of 0.92°C) was the 3rd highest since 1901.

Among the four homogeneous regions, over South Peninsular India the maximum temperaturewas the 2nd highest (31.79°C with an anomaly of 0.62°C) and minimum temperature was highest (20.66°C with an anomaly of 1.58°C) since 1901.Over Central India the minimum temperature was the highest (15.41°C with an anomaly of 1.65°C) since 1901.

1.2. Cold wave / Fog conditions

In January 2024, the cold wave/severe cold wave conditions were observed mainly over parts of East Madhya Pradesh, Rajasthan state, Uttar Pradesh state, Himachal Pradesh, Jharakhand, Punjab, Sub Himalayan West Bengal & Sikkim, Haryana, Chandigarh & Delhi and Uttarakhand.

In February 2024, Cold wave conditions prevailed for 4-5 days over Punjab and Haryana during first 10 days in February 2024.

1.3. Rainfall Features

Rainfall realized during the season was 67% of its LPA. It was 42% of its LPA during January and 87% of its LPA during February. Except many subdivisions from south peninsula, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Jharakhand, Odisha, East Uttar Pradesh and West Madhya Pradesh all the remaining sub-divisions received deficient/large deficient rainfall.

During the season, out of 36 meteorological subdivisions, 5 received large excess rainfall, 3 received excess rainfall, 5 subdivision received normal rainfall, 17 received deficient rainfall, 6 received largely deficient rainfall (Fig. 1). Table 1 shows the subdivision-wise rainfall statistics (mm) for the season.

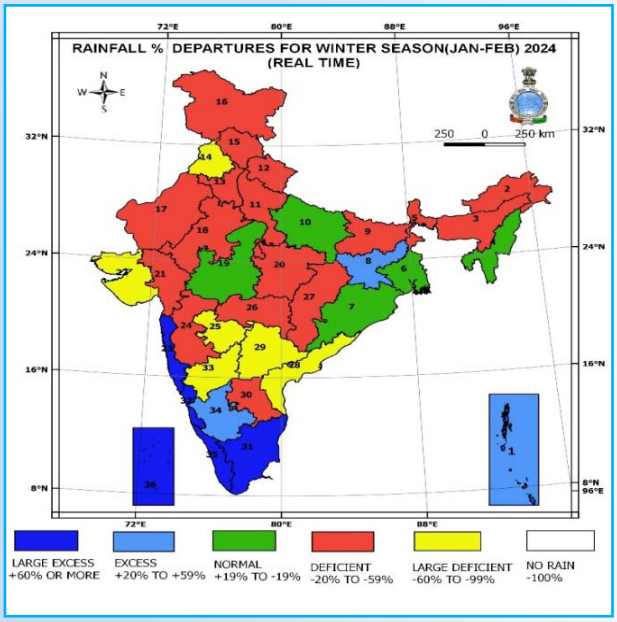


Fig. 1. Sub-divisionwise rainfall percentage departures for winter (January-February) 2024

Fig. 2(a) shows the spatial pattern of rainfall (mm) received during the winter season. Parts of Arunachal Pradesh, Jammu & Kashmir & Ladakh, Uttarakhand, Tamilnadu, Puducherry & Karaikal, Kerala & Mahe, Himachal Pradesh and both the islands received more than 100 mm rainfall.

Fig. 2(b) shows the spatial pattern of rainfall anomaly (mm) during the winter season. Rainfall anomaly was generally negative over most parts of the country except, extreme east and northeastern parts, northern parts and peninsular part. Rainfall anomaly more than 50 mm was observedover parts of Jammu & Kashmir & Ladakh, Tamilnadu, Puducherry & Karaikal, Kerala & Mahe and both the islands. The magnitude of negative rainfall anomaly was more than 50 mm over parts of

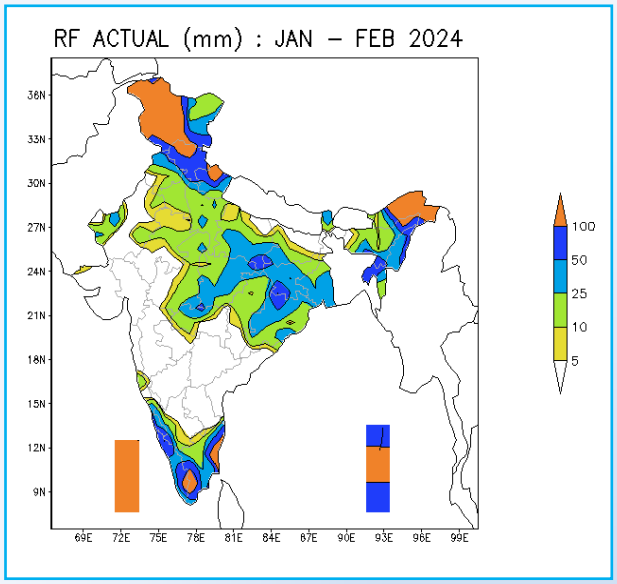


Fig. 2(a). Seasonal rainfall actual (mm) winter (January-February 2024)

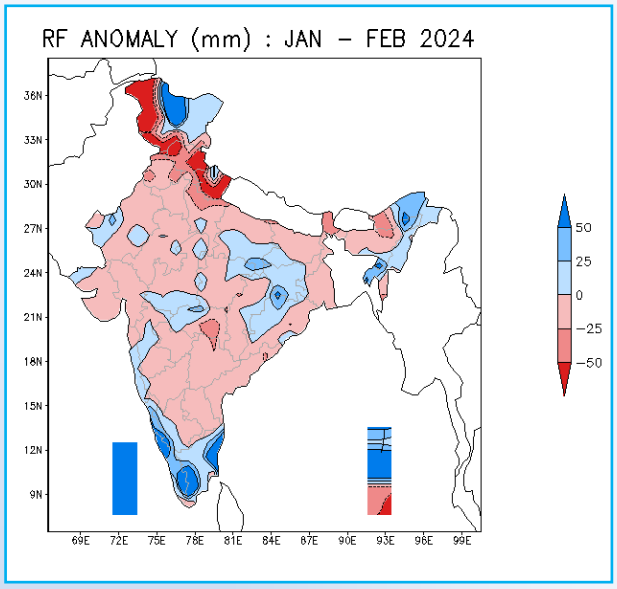


Fig. 2(b). Seasonal rainfall anomaly (mm) for winter (January-February 2024)

Jammu & Kashmir & Ladakh, Himachal Pradesh, Uttarakhand and West Uttar Pradesh.

Fig. 3 shows the time series of area weight averaged rainfall over all Indiaand four homogeneous regions for the winter season since 1951. Seasonal rainfall realized over all India was 67 % of its LPA. Considering homogeneous region wise it was 77% of its LPA over Central India, 120% of its LPA over South peninsula, 83% of its LPA over East & North East India, and 54% of its LPA over Northwest India.

1.4. Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for measuring drought and is based on only precipitation. This index is negative for drought and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive respectively. Figs. 4(a&b) show the SPI values for the winter season (January-February) 2024 (2 months cumulative) and period from June 2023-February 2024 (nine months cumulative) respectively.

Cumulative SPI values of the past two months indicate extremely wet/severely wet conditions over parts of Saurashtra & Kutch, Jammu & Kashmir & Ladakh, while extremely dry/severely dry conditions were observed over parts of A & N Islands, Assam & Meghalaya, S.H. West Bengal & Sikkim, Haryana, Chandigarh & Delhi, Jammu & Kashmir and Ladakh, Tamil Nadu, Kerala and Mahe, Lakshadweep.

Cumulative past nine months SPI values indicate extremely wet/severely wet conditions over parts of A & N Islands, Nagaland, Manipur, Mizoram & Tripura, West Uttar Pradesh, Haryana, Chandigarh & Delhi, Himachal Pradesh, West Rajasthan, Saurashtra & Kutch, Chhattisgarh and Tamil Nadu, while extremely dry/severely dry conditions were observed over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Odisha, Bihar, Uttar Pradesh state, Punjab, Jammu & Kashmir and Ladakh, Madhya Maharashtra, Chhattisgarh, Andhra Pradesh state, Telangana, South Interior Karnataka and Kerala & Mahe.

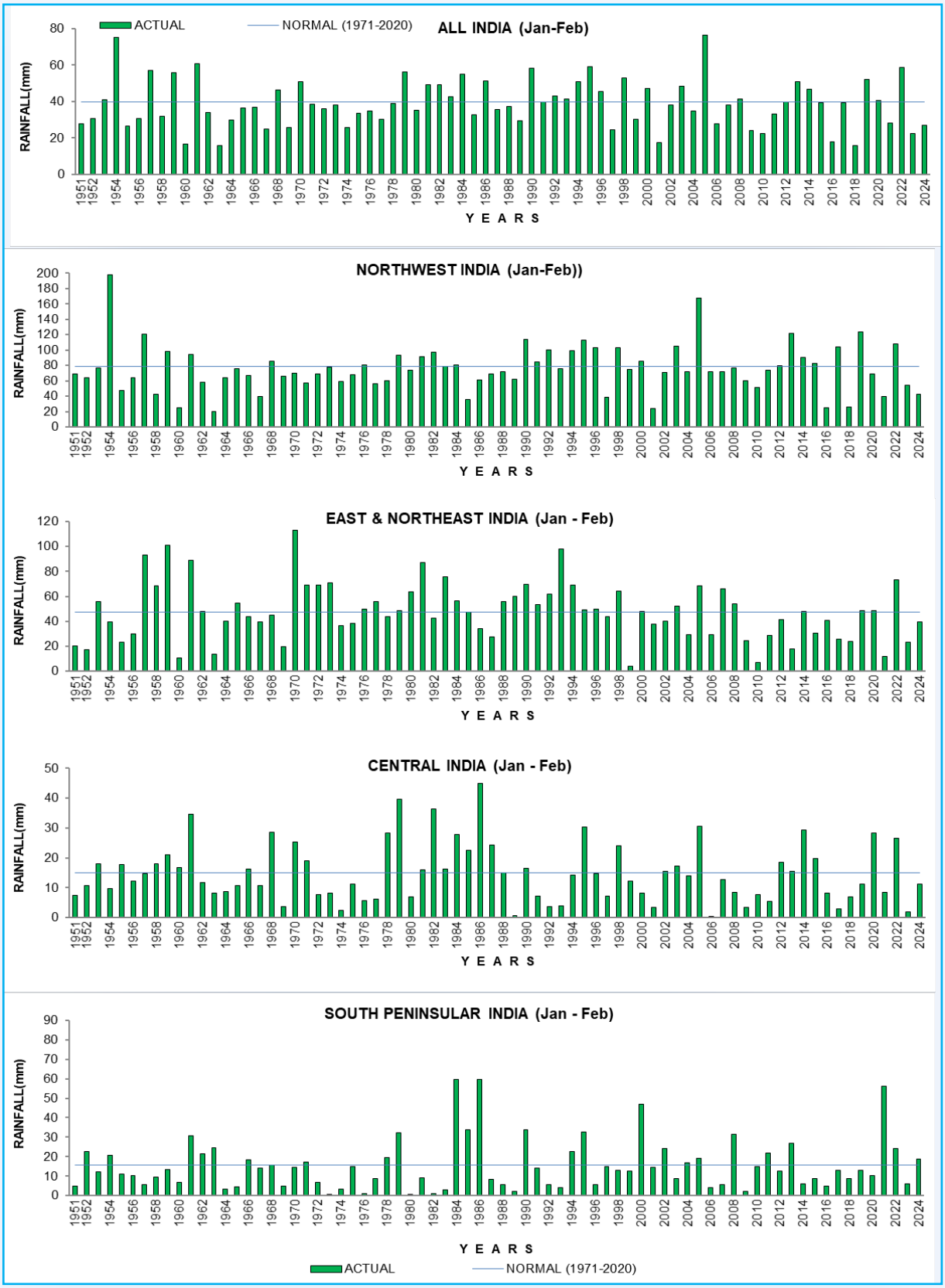


Fig. 3. Time series of area weight averaged rainfall over all India and four homogeneous regions for the winter season (1951 - 2024)

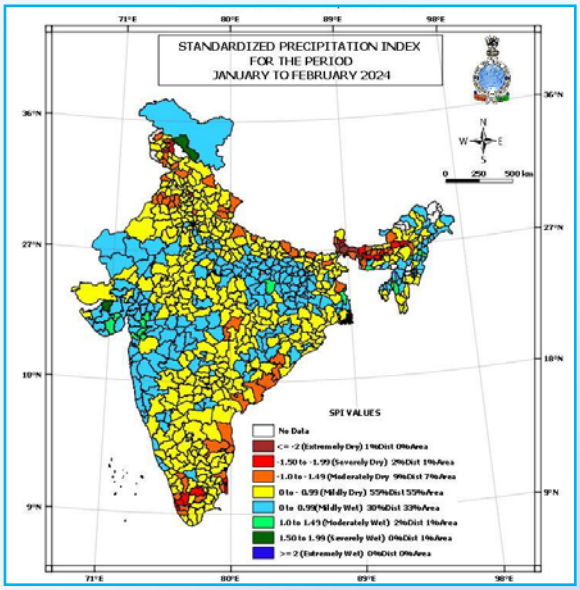


Fig. 4(a). Standardized precipitation index (SPI) for Two Months (January- February 2024)

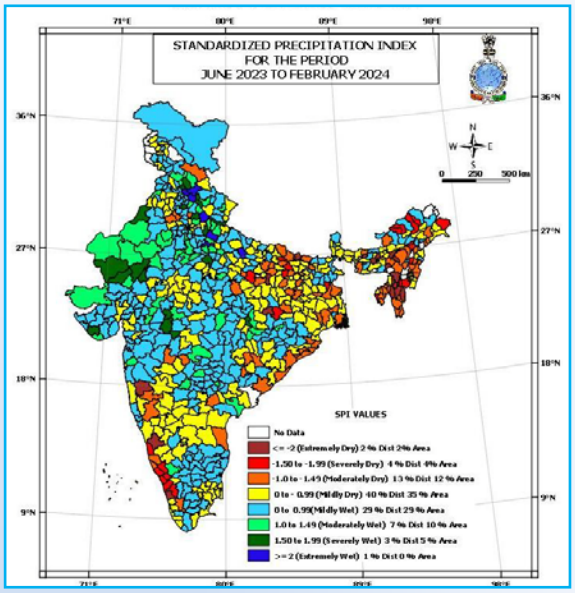


Fig. 4(b). Standardized precipitation index (SPI) for Nine Months (June 2023 - February 2024)

1.5. Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) during winter season over the Indian region and neighborhoods is shown in Fig. 5. OLR anomaly was negative over most parts of the country, Arabian Sea, and adjoining parts of Bay of Bengal and was within 0 to -10W/m^2. OLR anomaly was positive over northwestern parts of the country and was within 0 to 10W/m^2.

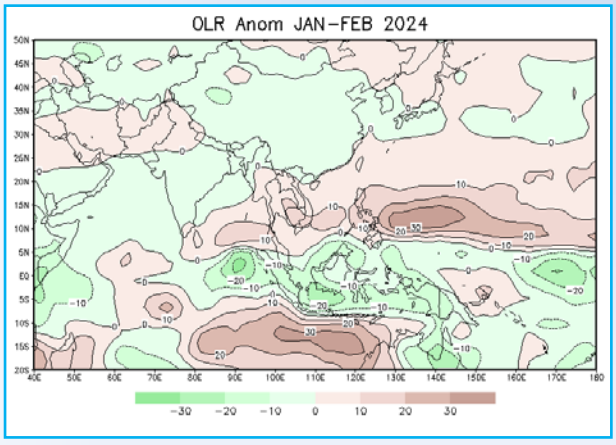


Fig. 5. OLR Anomaly (W/m^2) For Winter (January-February) 2024 (Source Data : CDC / NOAA, USA) (Based on 1991-2020 Climatology)

1.6. Temperature

Mean seasonal maximum and minimum temperature anomalies during winter 2024 are shown in Figs. 6(a&b) respectively. The maximum temperature was below normal over most parts of the country, except some parts of north India, central India, south peninsular India and both the islands. The maximum temperature anomaly was more than 2°C over parts of Jammu, Kashmir & Ladakh. The maximum temperature anomaly was less than -3°°C over parts of West Uttar Pradesh, Haryana, Chandigarh & Delhi and West Rajasthan.

The minimum temperature was above normal over most parts of the country, except for some parts of northwest India and East & Northeast India. The minimum temperature anomaly was more than 3°C over parts of Odisha, Chhattisgarh and northern Madhya Maharashtra. The minimum temperature anomaly was more than 2°C over parts of Gujarat region, Madhya Maharashtra, Chhattisgarh, Telangana, Rayalaseema, North Interior Karnataka, South Interior Karnataka and Tamil Nadu, Puducherry & Karaikal. The minimum temperature anomaly was less than -1°C over parts of Haryana, Chandigarh & Delhi, Uttar Pradesh state, Assam state and West Rajasthan.

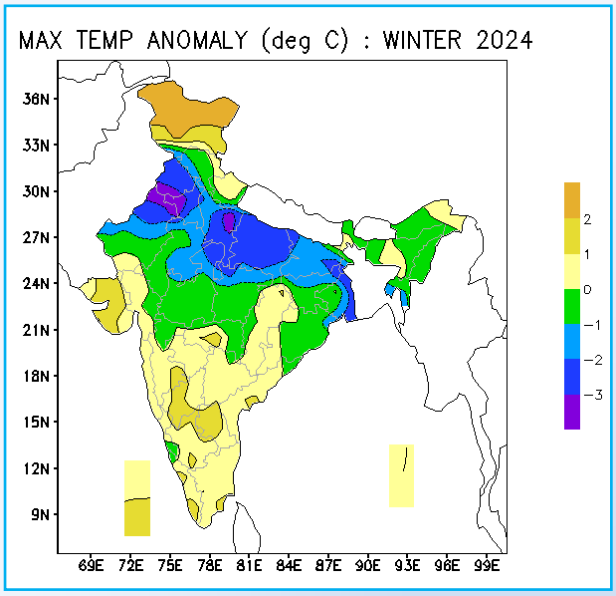


Fig. 6(a). Mean seasonal temperature anomalies (°C) for winter (January-February) 2024, (a) maximum (Based on 1991-2020 Normals)

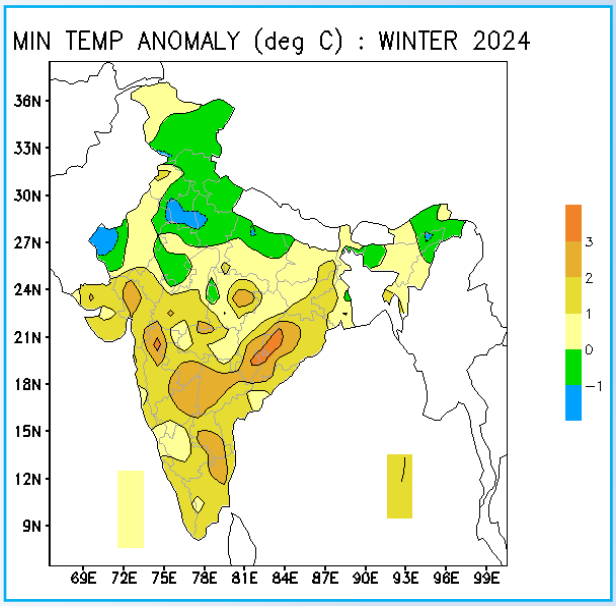


Fig. 6(b). Mean seasonal temperature anomalies (°C) for winter (January-February) 2024, (b) minimum (Based on 1991-2020 Normals)

1.7. Percentage of Warm days/Cold nights

Figs. 7(a&b) show the percentage of days when the maximum (minimum) temperature was more (less) than the 90th (10th) percentile. Over parts of Lakshdweep maximum temperature was greater than the 90th percentile for more than 50% of the days of the season. For minimum temperature no such significant distribution was observed.

Fig. 8 shows the mean temperature for the country as a whole for the winter season since 1971. Five-

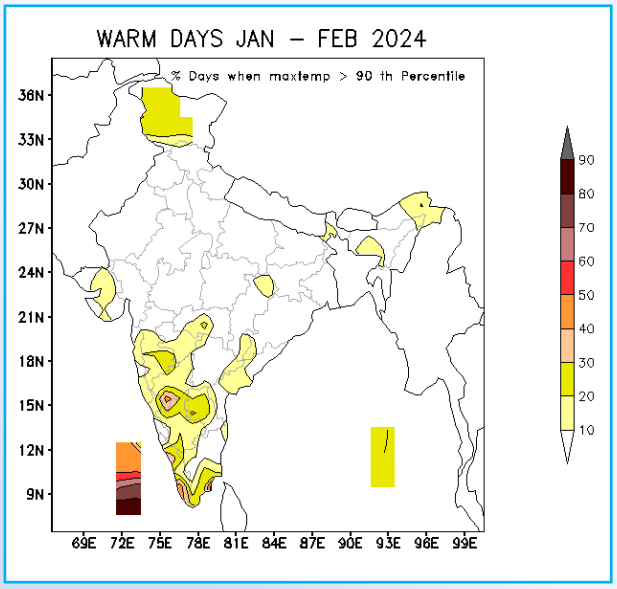


Fig. 7(a). Percntage of days when maximum temperature > 90th percentile

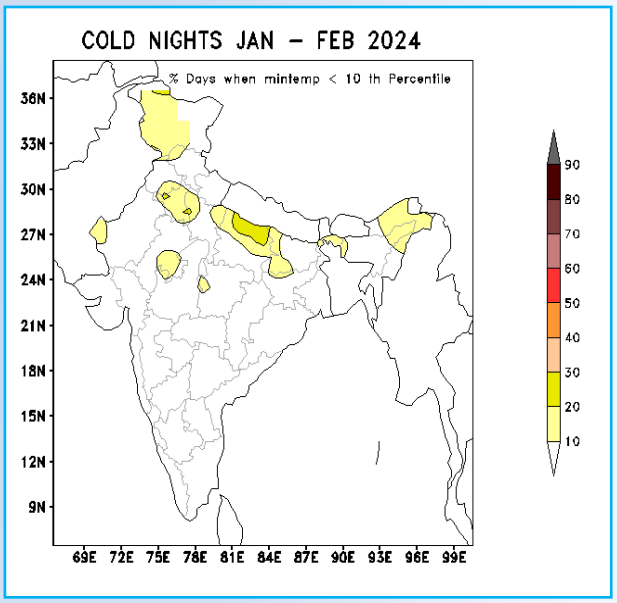


Fig. 7(b). Percentage of Days when minimum temperature < 10th percentile

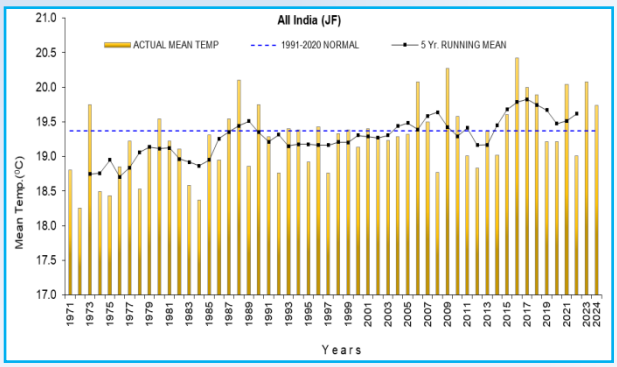
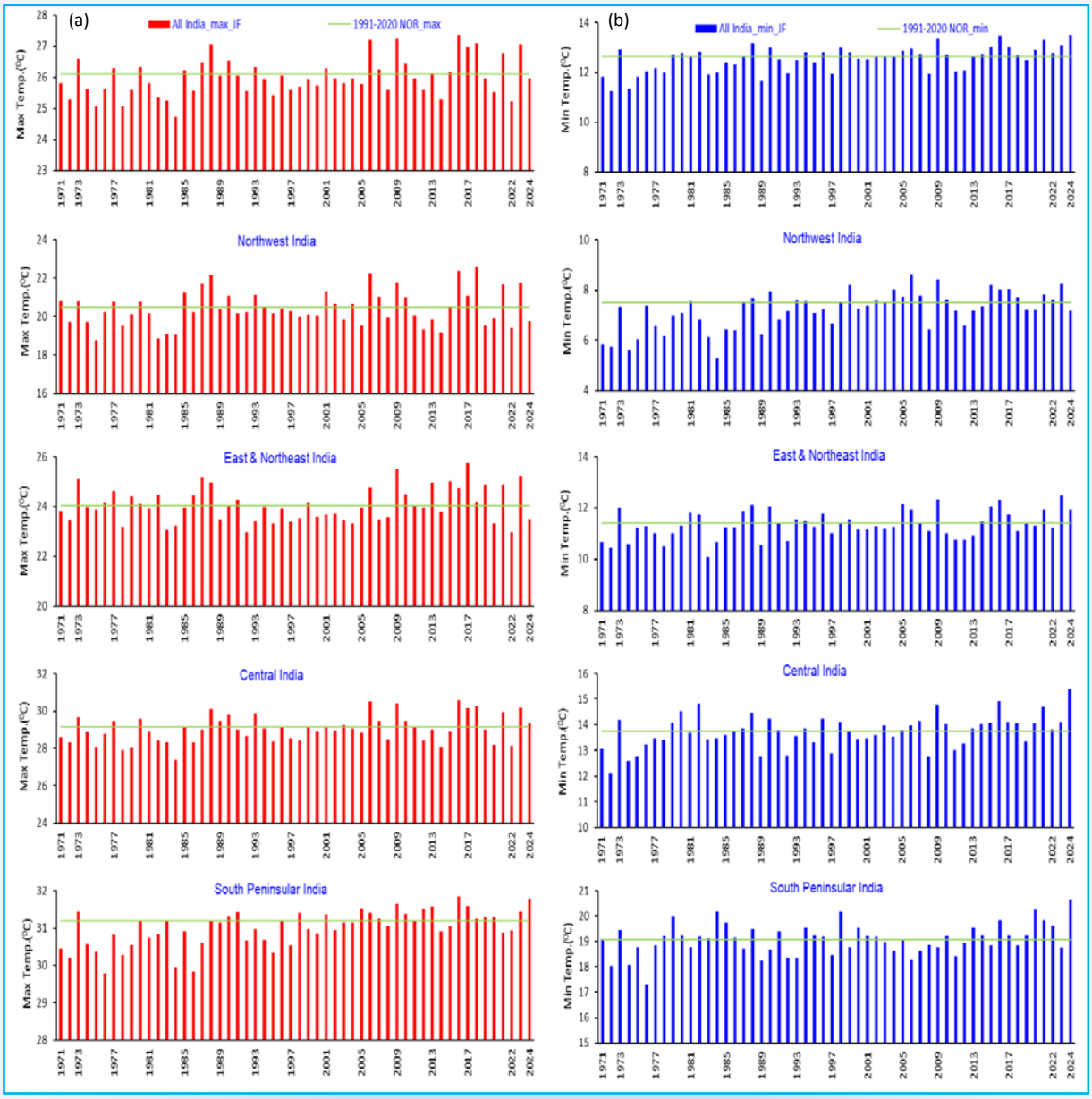


Fig. 8. Time series of mean temperature averaged over India (vertical bars) and five-year running mean (continuous line) for winter season (January-February) (1971-2024)



Figs. 9(a&b). Time series of temperature for the country as a whole and the four homogeneous regions for winter season(January-February) (1971-2024) (a) Maximum and (b) Minimum

year moving average values are also shown.The mean temperature for the winter season 2024 was 19.74 °C with an anomaly of 0.37°C and 14th highest since 1901. The mean temperature over South Peninsular India (26.23°C with an anomaly of 1.10 °C) was the highest and Central India (22.37 °C with an anomaly of 0.92 °C) was the 3rd highest after the years 2016 (22.74 °C), 2009 (22.59 °C) since 1901.

Figs. 9(a&b) shows the maximum and minimum temperature time series respectively for the country as a whole and the four homogeneous regions during the winter season since 1971.The maximum temperature was below normal/normal over all the homogeneous regions except South Peninsular India, while minimum temperature was above normal over all the homogeneous regions, except Northwest India. Over the country as a whole the maximum temperature was normal and minimum temperature was above normal during winterseason. Over South Peninsular India the maximum temperaturewas the 2nd highest (31.79 °C with an anomaly of 0.62 °C) after the year 2016 (31.84 °C) and minimum temperature was highest (20.66 °C with an anomaly of 1.58 °C) since 1901. Over Central India the minimum temperature was the highest (15.41 °C with an anomaly of 1.65 °C) since 1901. Over the country as a whole the minimum temperature was the

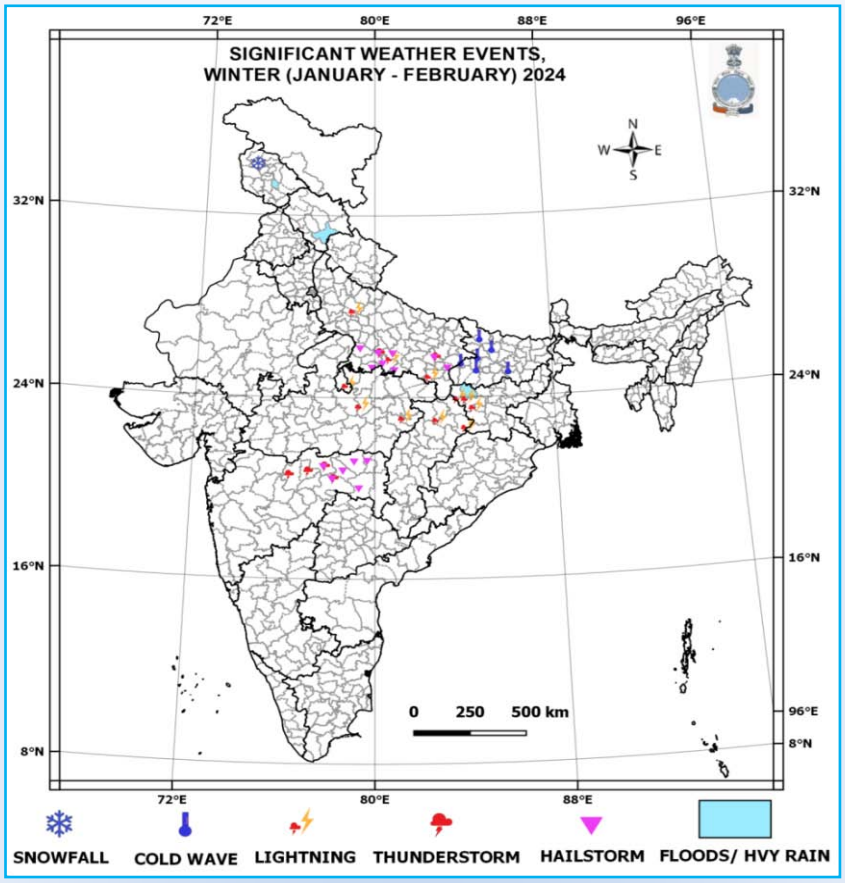


Fig. 10. Deaths due to significant weather events during winter (Jan- Feb) 2024 (Based on real time media report)

highest (13.50 °C with an anomaly of 0.86 °C) since 1901.

1.8. Significant Weather Events for Winter Season (January-February) 2024

During Winter Season, a total of 26 persons were reportedly claimed dead, 10 persons were injured, one missing & more than 180 livestock were perished. The details of causalities given below, which are based on real time media reports.

Fig. 10 shows deaths due to significant weather events during Winter Season (January-February) 2024. (Based on real time media reports).

Cold Wave: A total of 6 persons were reportedly claimed dead during winter 2024 because of Cold Wave.

Floods & Heavy Rains: A total of 4 persons were reportedly claimed dead, during winter 2024, because of Floods & Heavy Rains.

Lightning: A total of 12 persons were reportedly claimed dead, 10 persons were injured & more than180 livestock were perished, during winter 2024, because of Lightning.

Snowfall: Total one person reportedly claimed dead & one person missing, during winter 2024, because of Snowfall.

Thunderstorm: A total of 3 persons were reportedly claimed dead, during winter 2024, because of Thunderstorm. Hailstorm affected Amaravati, Bhandara, Chandrapur, Nagpur, Wardha, Yavatmal districts of Maharashtra on 10, 11, 15 February. Banda, Chitrakoot, Chandauli, Fatehpur, Hamirpur, Jalaun, Jaunpur, Mahoba districts of Uttar Pradesh on 13, 20 February, 2024.

Akola, Amaravati, Buldhana, Yavatmal districts of Maharashtra were affected due to Thunderstorm on 10, 26 February, 2024.

2. Pre-monsoon Season (March-May)

2.1. Highlights

During the pre-monsoon season, in India, the mean temperature was 28.35 °C with an anomaly of 0.56 °C and 7th highest since 1901. The minimum temperature was alsothe 7th highest (21.80 °C with an anomaly of 0.66 °C) since 1901.

Among the four homogeneous regionsover South Peninsular India, the maximum temperature was the 4th highest (36.16 °C with an anomaly of 0.53 °C) after the years 2016 (36.61 °C), 2019 (36.56 °C), 2017 (36.25 °C) and minimum temperature was the 2nd highest (24.82 °C with an anomaly of 0.78 °C) after the year 2016 (25.04 °C) since 1901. The mean temperature overSouth Peninsular India (30.49 °C with an anomaly of 0.66 °C) was the 3rd highest after the years 2016 (30.82°C), 2019 (30.65 °C) since 1901. Over East & Northeast India, the minimum temperature was the 2nd highest (21.02 °C with an anomaly of 0.97 °C) after the year 2022 (21.10 °C) since 1901.The mean temperature over East & Northeast India (26.67 °C with an anomaly of 0.94 °C) was the highest since 1901.

Southwest Monsoon set in over Kerala on the 30th of May.

2.2. Heat Wave Conditions

In March, heat wave conditions were not observed over any part of the country.

In April there were two spells of heat wave during the month. The first spell was from 5-7 April; during this period, heat wave / severe heatwave conditions were observed mainly over eastern India and the southeast Peninsula. The second spell of the heat wave was from 15-30 April, mainly over Odisha and WB, which later intensified and expanded to Bihar Jharkhand, Southeast Peninsular India and interior Karnataka from 24 April.

In May, during the first week, heat waves to severe heat waves were observed mainly over eastern parts of India, southeast Peninsular India, and interior parts of Karnataka. During the second week, no heat wave conditions developed over parts of India except at isolated pockets over the Gujarat region on 15th May. During the third week, most parts of northwest and adjoining central India, Gujarat state, and Delhi NCR experienced persistent spells of Heatwave to severe heatwave conditions from 17-22 May. During last week, heatwave to severe heatwave conditions, which already prevailed over northwest and adjoining central India and Gujarat state, continued to prevail on almost all dates during this week till 29 May, 2024 and also intensified and further extended to more parts of central and north India and eastern parts of India such as to Chhattisgarh, Bihar and Vidarbha.

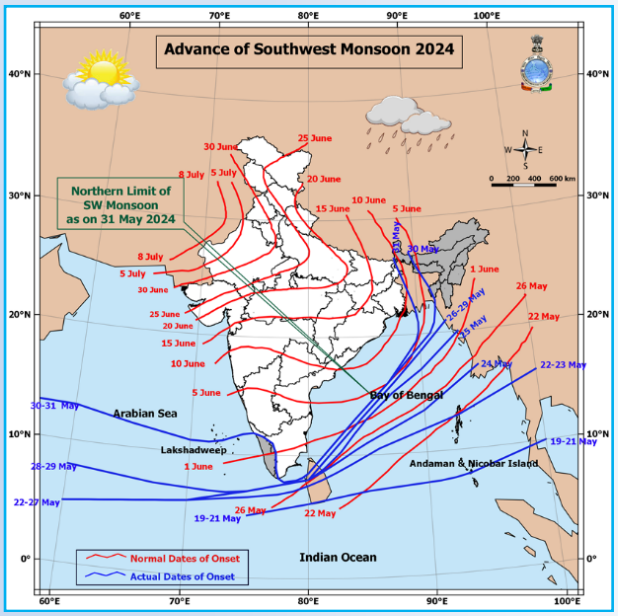


Fig. 1. Advance of Southwest Monsoon TILL 31 MAY 2024

2.3. Advance of Southwest Monsoon

In May, the Southwest Monsoon advanced into some parts of the Maldives & Comorin area and some parts of the South Bay of Bengal, Nicobar Islands, and South Andaman Sea on 19th May, 2024. The Northern Limit of Monsoon passed through 5° N/75° E, 6° N/80° E, 7° N/85° E, Nancowry and 10° N/100 °E on 19th May. It advanced into some parts of the Maldives & Comorin area, the south Bay of Bengal, the remaining parts of Andaman & Nicobar Islands, the Andaman Sea and some parts of the Eastcentral Bay of Bengal on 24th May. It gradually advanced over the Bay and the Arabian Sea and Maldives area on 28th May. Advancing further over the Arabian Sea, prominently Southwest Monsoon set in over Kerala on the 30thof May. It further advanced into the remaining parts of the northeast

Bay of Bengal and some parts of the northwest Bay of Bengal, the remaining parts of Tripura, Meghalaya, and Assam, and most parts of Sub-Himalayan West Bengal & Sikkim on 31st May.Northern Limit of Monsoon passed through 13° N/60° E, 12° N/65° E, 11° N/70° E, Amini, Kannur, Coimbatore, Kanyakumari, 8.5° N/80° E, 13° N/84° E, 16° N/87° E, 20° N/91° E, Agartala, Dhubri, 27° N/89.5° E on 30th May; through 13° N/60° E, 12° N/65° E, 11° N/70° E, Amini, Kannur, Coimbatore, Kanyakumari, 8.5° N/80° E, 13° N/84° E, 16° N/87° E, 18.5° N/89° E, 21° N/90° E, 23° N/89.5° E and Islampur on 31st May.

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

2.4. Rainfall Features

Rainfall realized during the season was 96% of its LPA. It was 95% of its LPA during March, 80% of its LPA during April and 108% of its LPA during May. During the season, most sub-divisions received large excess/excess/normal rainfall, except some sub-divisions from the northeast, north and Andaman & Nicobar Islands.

During the season, out of 36 meteorological subdivisions, 7 received large excess rainfall, 5 received excess rainfall, 14 subdivisions received normal rainfall, 9 received deficient rainfall, and 1 received large deficient rainfall (Fig. 2). Table 1 shows the subdivision-wise rainfall statistics (mm) for the season.

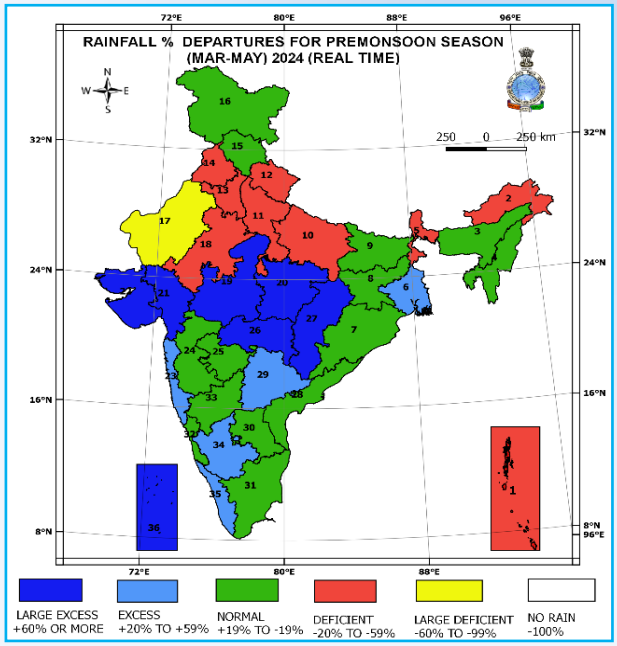


Fig. 2. Divisionwise rainfall percentage departures for pre-monsoon (Mar-May) 2024

Fig. 3(a) shows the spatial pattern of rainfall (mm) received during the season. Parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Sub Himalayan West Bengal & Sikkim, some isolated places from Jammu & Kashmir & Ladakh, Gangetic West Bengal, Kerala & Mahe and Andaman & Nicobar Islands received more than 400 mm rainfall.

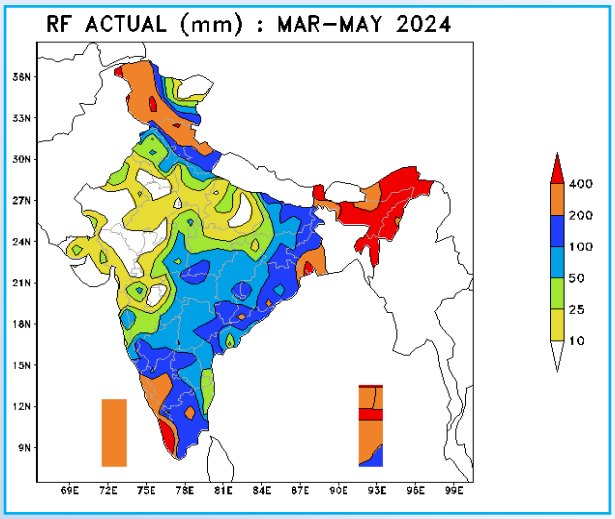


Fig. 3(a). Seasonal rainfall pre-monsoon (Mar-May) 2024

Fig. 3(b) shows the spatial pattern of rainfall anomaly (mm) during the season.Rainfall anomaly was more than 75 mm over parts of Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Gangetic West Bengal, Jammu & Kashmir & Ladakh, East Madhya Pradesh, Chhattisgarh, South Interior Karnataka, Tamilnadu, Puducherry & Karaikal,Kerala & Mahe and Lakshadweep. The magnitude of negative rainfall anomaly was more than 75 mm over parts of Arunachal Pradesh, Assam & Meghalaya, Sub Himalayan West Bengal & Sikkim and Andaman & Nicobar Islands.

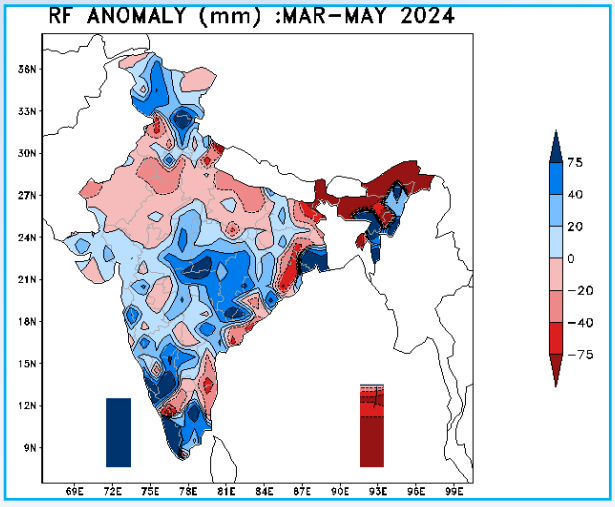


Fig. 3(b). Seasonal rainfall anomaly (mm) Pre-monsoon (Mar-May) 2024 (Based on 1971-2020 NOR)

Fig. 4 shows the area weight averaged rainfall series for the season over all of India and four homogeneous regions since 1951. Seasonal rainfall realized over all India was 96 % of its LPA.

Considering homogeneous region-wise, it was 156% of its LPA over Central India, 116% of its LPA over South peninsula, 84% of its LPA over East & North East India and 84% of its LPA over Northwest India.

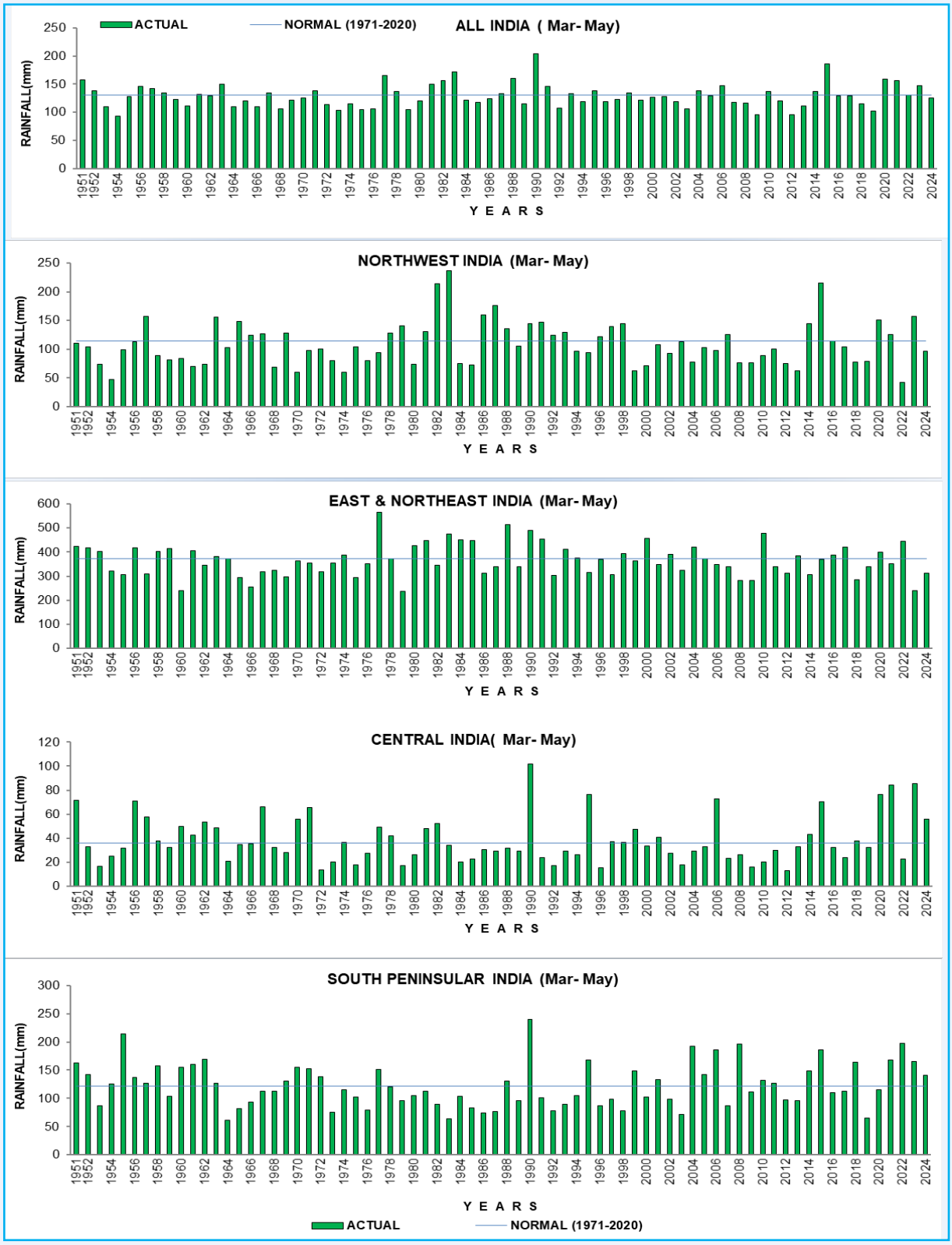


Fig. 4. Time series of area weighted rainfall over all India and four homogeneous regions for pre-monsoon (1951-2024)

2.5. Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is used for monitoring drought and is based only on precipitation. This index is negative for dry and positive for wet conditions. The index becomes more negative or positive as the dry or wet conditions become more severe. Figs. 5 (a&b) give the SPI values for the Pre-monsoon season this year and for the period from the past monsoon season, i.e., June 2023-May 2024 (12 months cumulative), respectively.

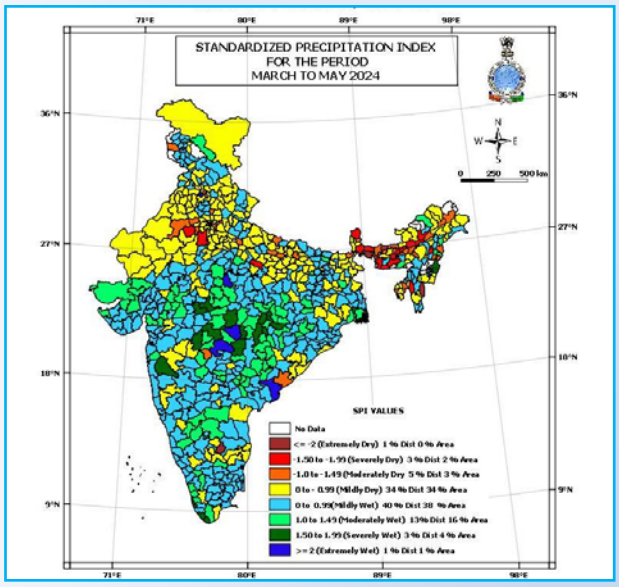


Fig. 5(a). Standardized Precipitation Index (SPI) for (3) Three Months

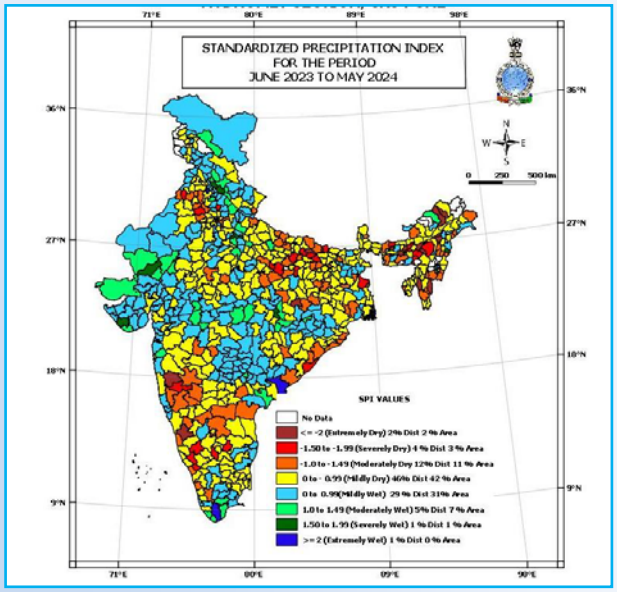


Fig. 5(b). Standardized Precipitation Index (SPI) for (12) Twelve Months

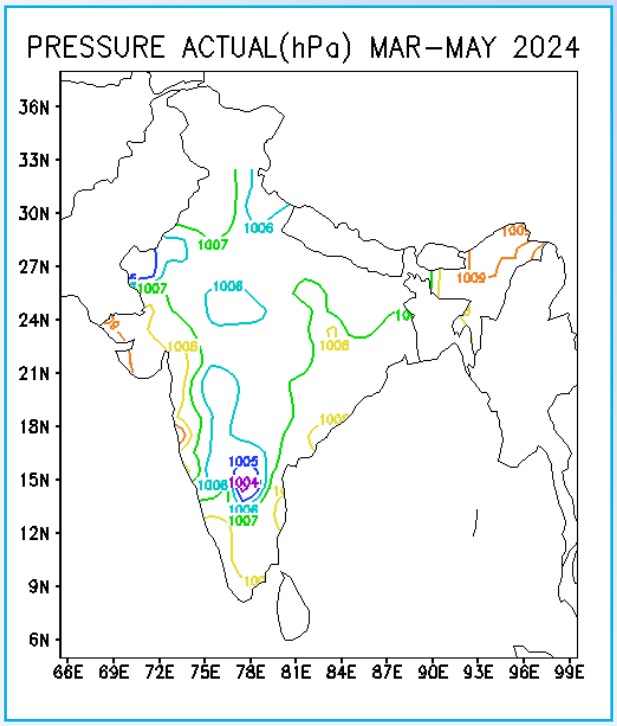


Fig. 6(a). Seasonal mean sea level pressure (hPa) mean (Based on 1991-2020 NORMALS)

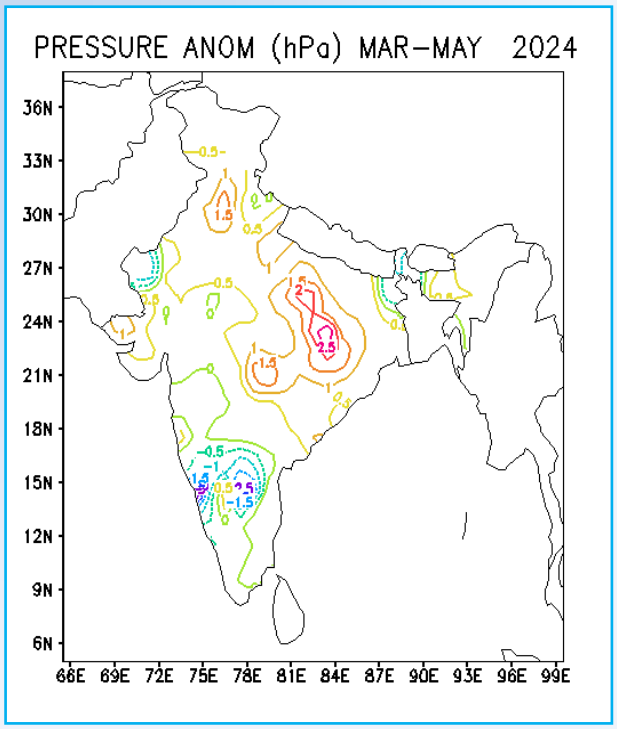


Fig. 6(b). Seasonal mean sea level pressure (hPa) Anomaly (Based on 1991-2020 NORMALS)

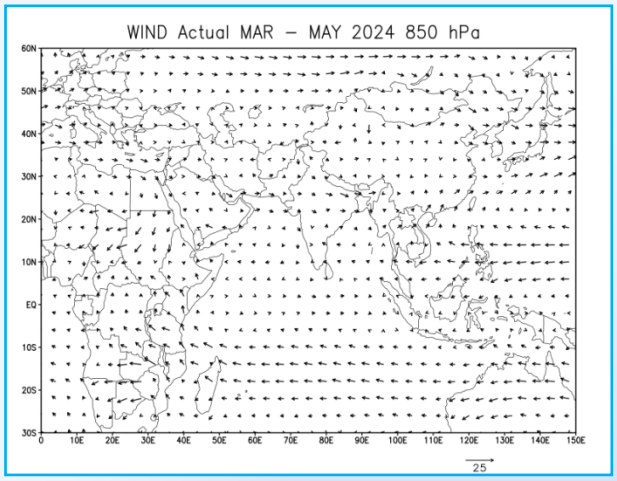


Fig. 7(a). Seasonal wind (m/s) Mean (OPERATIONAL NWP ANALYSIS OF IMDGFS T-574)

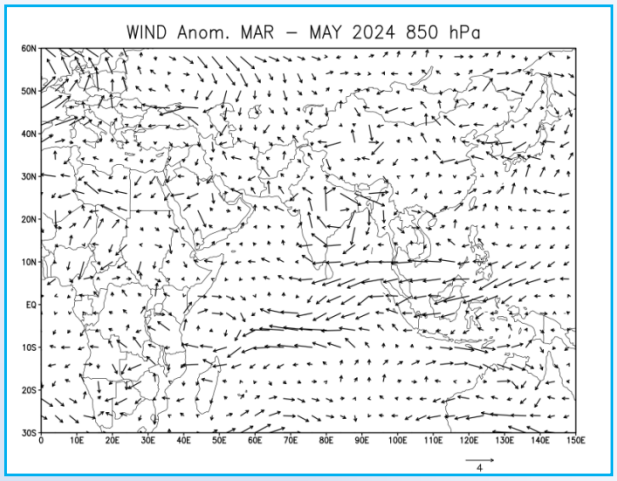


Fig. 7(b). Seasonal wind (m/s) anomaly at 850 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

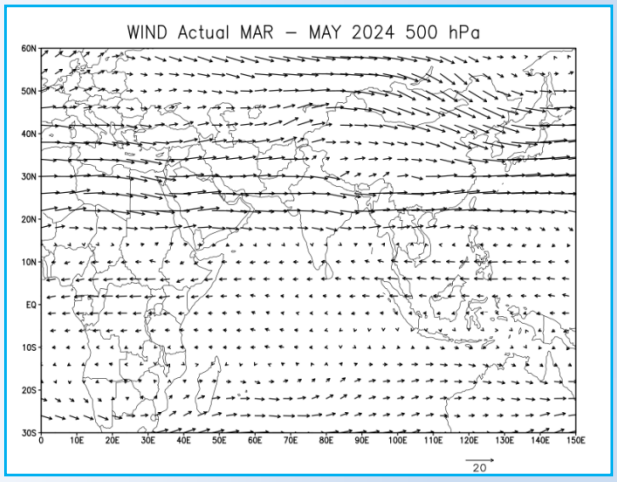


Fig. 8(a). Seasonal wind (m/s) Mean (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574)

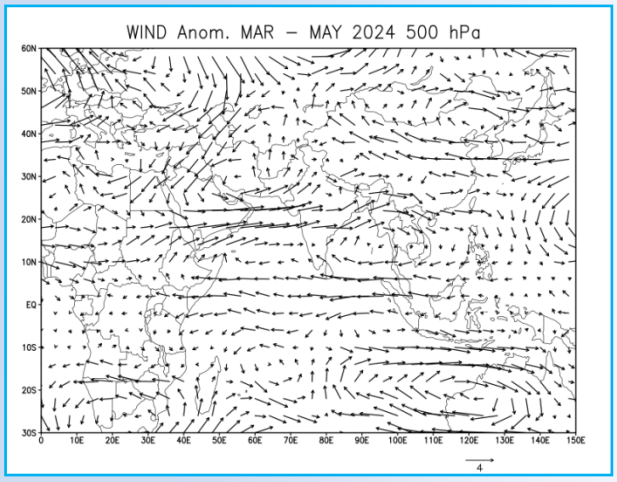


Fig. 8(b). Seasonal wind (m/s) anomaly at 500 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

Cumulative SPI values of the past three months show extremely wet/severely wet conditions over parts of Gangetic West Bengal, West Uttar Pradesh, Haryana, Chandigarh & Delhi, Punjab, Madhya Pradesh state, Gujarat Region, Madhya Maharashtra, Vidarbha, Chhattisgarh, Coastal Andhra Pradesh, Tamil Nadu and Kerala while, extremely dry/severely dry conditions were observed over parts of A & N Islands, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, S.H. West Bengal & Sikkim, East Uttar Pradesh, Haryana, Chandigarh & Delhi, Jammu & Kashmir and Ladakh, East Rajasthan and South Interior Karnataka.

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

2.6. Pressure & Wind

Figs. 6(a&b) show the mean sea level pressure & its anomaly respectively. The pressure anomaly was positive over the east-central, northern, and northeastern parts of the country. It was within 0 to 2.5 hPa. A negative pressure anomaly was observed mainly in the peninsular parts and western central parts. It was within 0 to -2.5 hPa.

Figs. 7(a&b), 8(a&b) and 9(a&b) show the mean circulation pattern and its anomaly at 850, 500 & 250 hPa levels, respectively. At 850 hPa level, an anomalous anti-cyclonic circulation was seen over central India and adjoining Bay. At 500 hPa level, an anomalous anti-cyclonic circulation was seen over the entire Bay of Bengal. At 250 hPa level, anomalous westerlies prevailed over central India.

2.7. Velocity Potential & Stream Function

Figs. 10(a&b) show the 250 hPa mean Velocity Potential & its anomalies. Similarly, Figs. 11(a&b) show the mean stream function & its anomalies at 850 hPa level. Dashed lines indicate negative values. Anomaly in the velocity potential at 250 hPa level was negative over the entire country except for extreme northeastern parts. In comparison, the anomaly in the stream function at 850 hPa level was positive over the entire country.

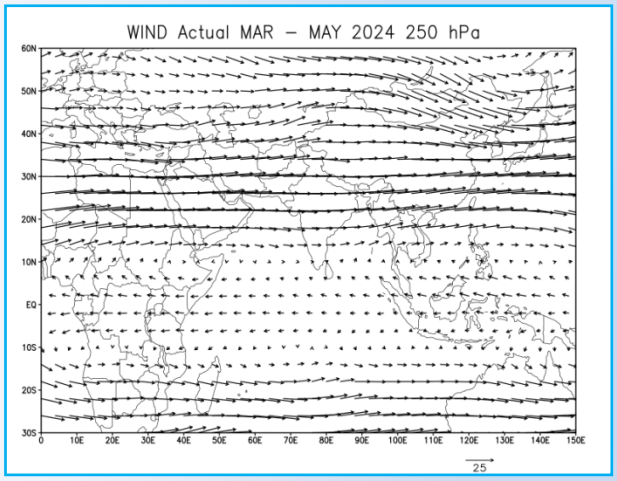


Fig. 9(a). Seasonal wind (m/s) mean at 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574)

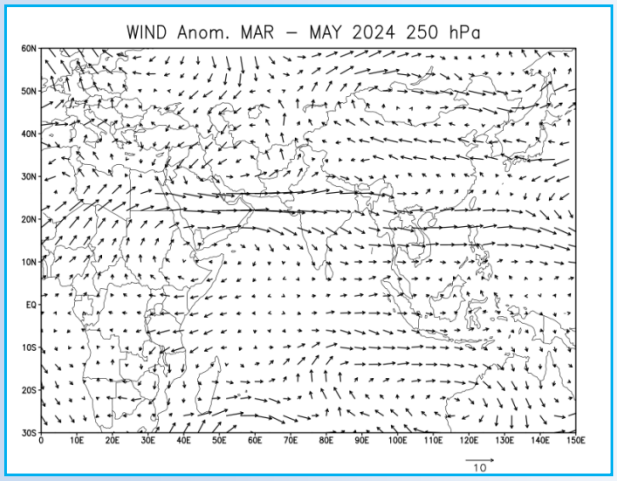


Fig. 9(b). Seasonal wind (m/s) anomaly at 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

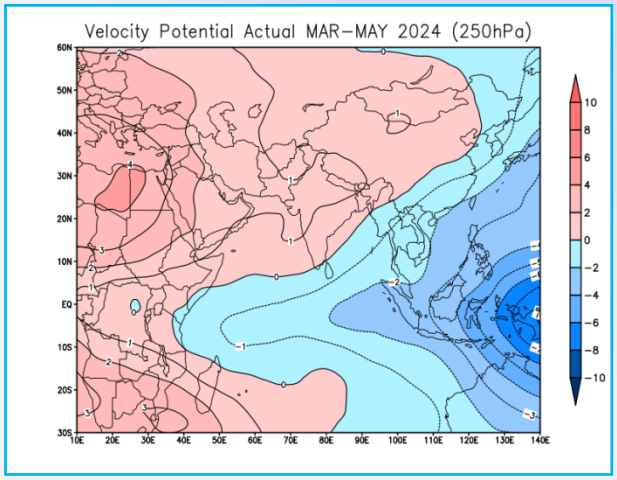


Fig. 10(a). Velocity potential ($106m^2/s$) Mean at 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574)

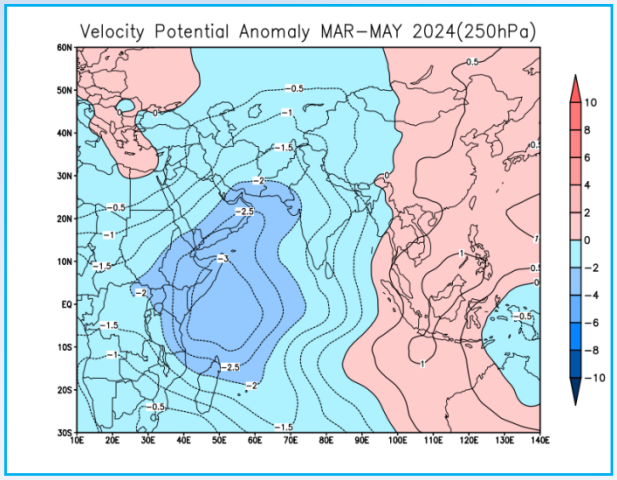


Fig. 10(b). Velocity potential ($106m^2/s$) Anomaly at 250 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

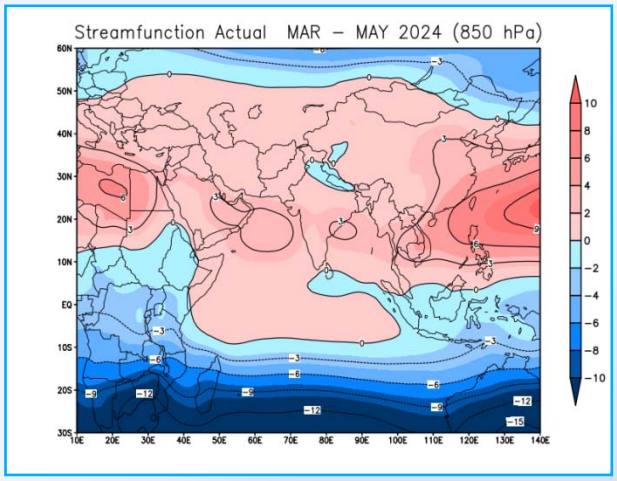


Fig. 11(a). Stream function (106m^2/s) Mean at 850 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574)

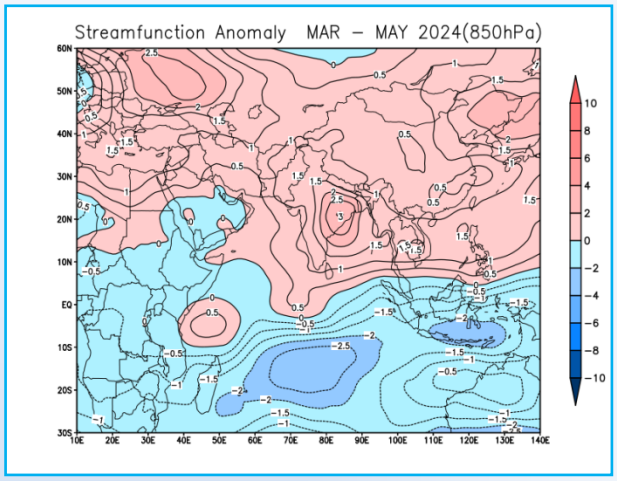


Fig. 11(b). Stream function (106m^2/s) Anomaly at 850 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (ANOMALY IS BASED ON 2000-2018 Climatology, Source : NCMRWF)

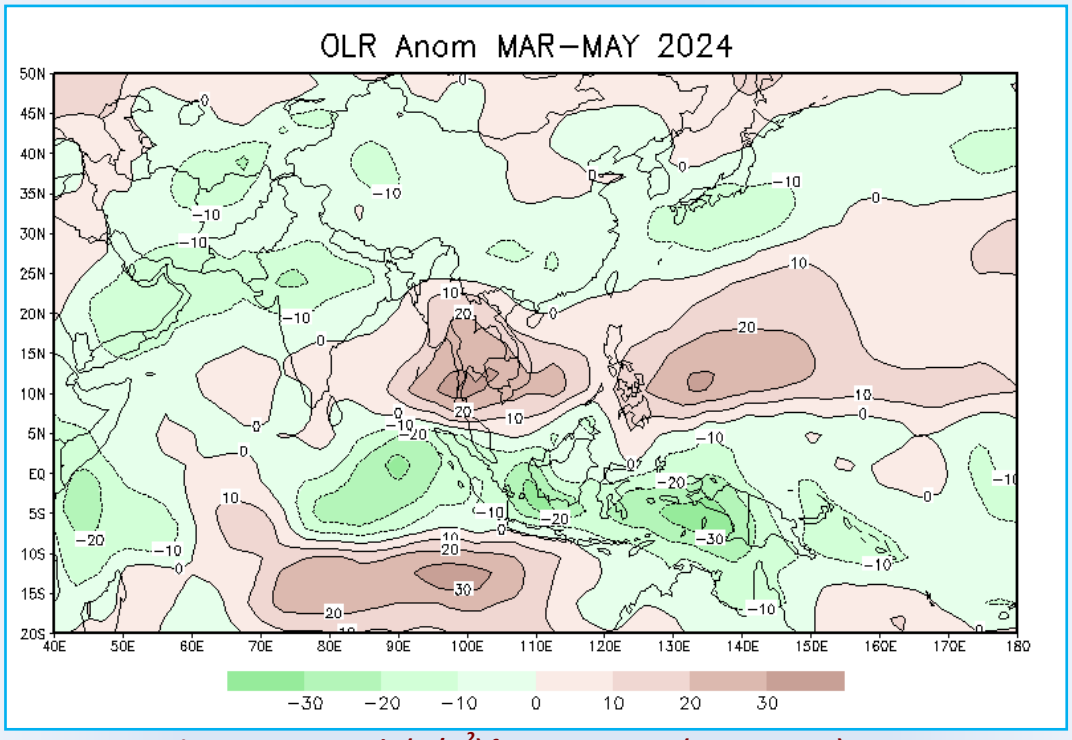


Fig. 12. OLR anomaly (w/m^2) for pre monsoon (MARCH-MAY) 2024 (Source : CDC / NOAA, USA) BASED ON 1991 - 2020 CLIMATOLOGY)

2.8. Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighborhood is shown in Fig. 12. OLR anomaly was negative over most parts of the country, except the south peninsula, the entire Bay, and some parts of the Arabian Sea. OLR anomaly was within 10 to -10 W/m^2.

2.9. Temperature

Mean seasonal maximum and minimum temperature anomalies are shown in Figs. 13(a&b) respectively. The maximum temperature was above normal over most parts of the country, except some parts of northwest India, central India, east India and south peninsular India (Telangana and Coastal Andhra Pradesh & Yanam).

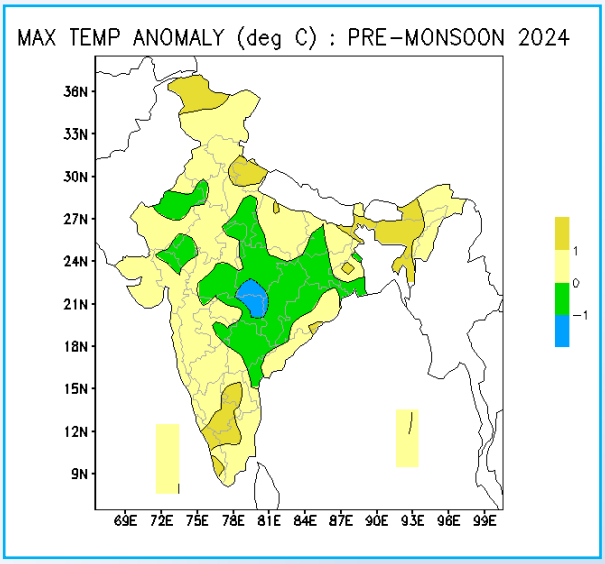


Fig. 13(a). Mean monthly temperature anomalies (°C) Maximum (Based on 1991-2020 Normals)

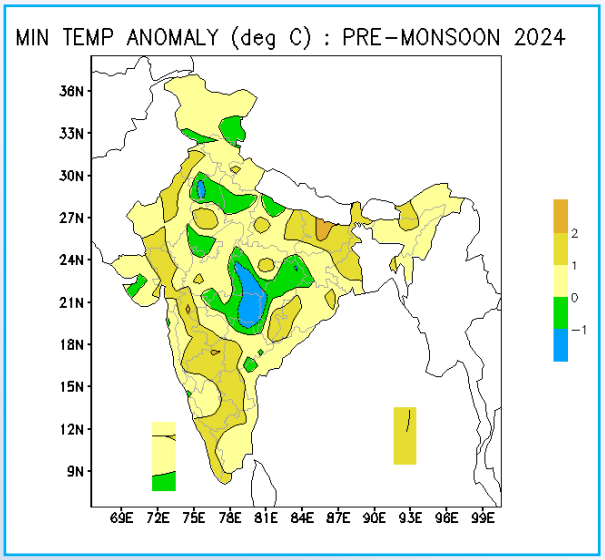


Fig. 13(b). Mean monthly temperature anomalies (°C) Minimum (Based on 1991-2020 Normals)

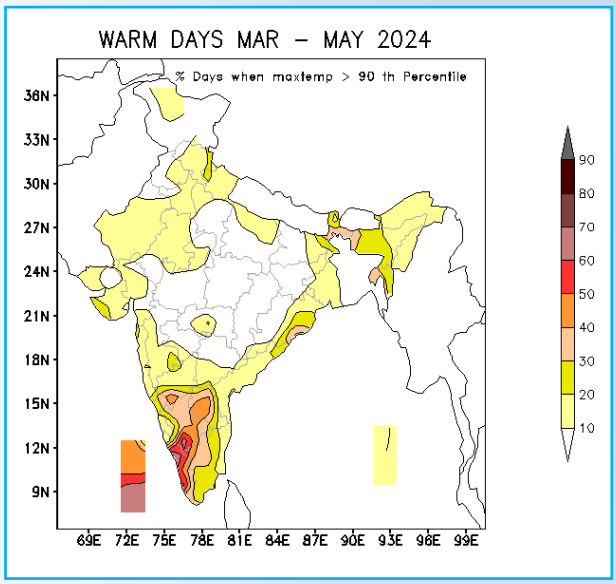


Fig. 14(a). Percentage of Days When Maximum Temperature > 90Th Percentile

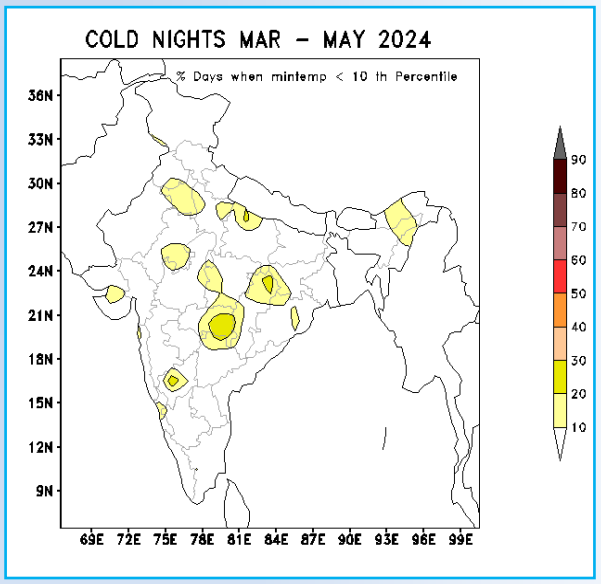


Fig. 14(b). Percentage of Days When Minimum Temperature < 10Th Percentile

The maximum temperature anomaly was more than 1°C over parts of Jammu, Kashmir state, Himachal Pradesh, Uttarakhand, SubHimalayan West Bengal & Sikkim, Gangatic West Bengal, Bihar, Odisha, Rayalaseema, South Interior Karnataka, Tamil Nadu, Puducherry & Karaikal, Kerala & Mahe. The maximum temperature anomaly was less than -1°C over parts of East Madhya Pradesh, Chhattisgarh and Vidarbha.

The minimum temperature was above normal in most parts of the country, except for some parts of northwest India, Central India and Lakshadweep. The minimum temperature anomaly was more than 2 °C over parts of Bihar, North Interior Karnataka, and northern Madhya Maharashtra.The minimum temperature anomaly was less than -1 °C over parts of Haryana, Chandigarh & Delhi, East Madhya Pradesh, Chhattisgarh, Telangana and Vidarbha.

2.10. Percentage of Warm Days/Cold Nights

Figs. 14(a&b) show the percentage of days when the maximum (minimum) temperature was more (less) than the 90th (10th) percentile. Over parts of Kerala & Mahe, Rayalaseema, South Interior Karnataka, and Lakshadweep, the maximum temperature was greater than the 90th percentile for more than 40% of the days of the season. For minimum temperature, no such significant distribution was observed.

Fig. 15 shows the mean temperature for the country as a whole for the season since 1971. Five-year moving average values are also shown. This year's mean temperature for the season was 28.35°C with an anomaly of 0.56°C and 7th highest since 1901. The mean temperature over East & Northeast India (26.67°C with an anomaly of 0.94°C) was the highest and South Peninsular India (30.49°C with an anomaly of 0.66°C) was the 3rd highest after the year 2016 (30.82°C), 2019 (30.65°C) since 1901.

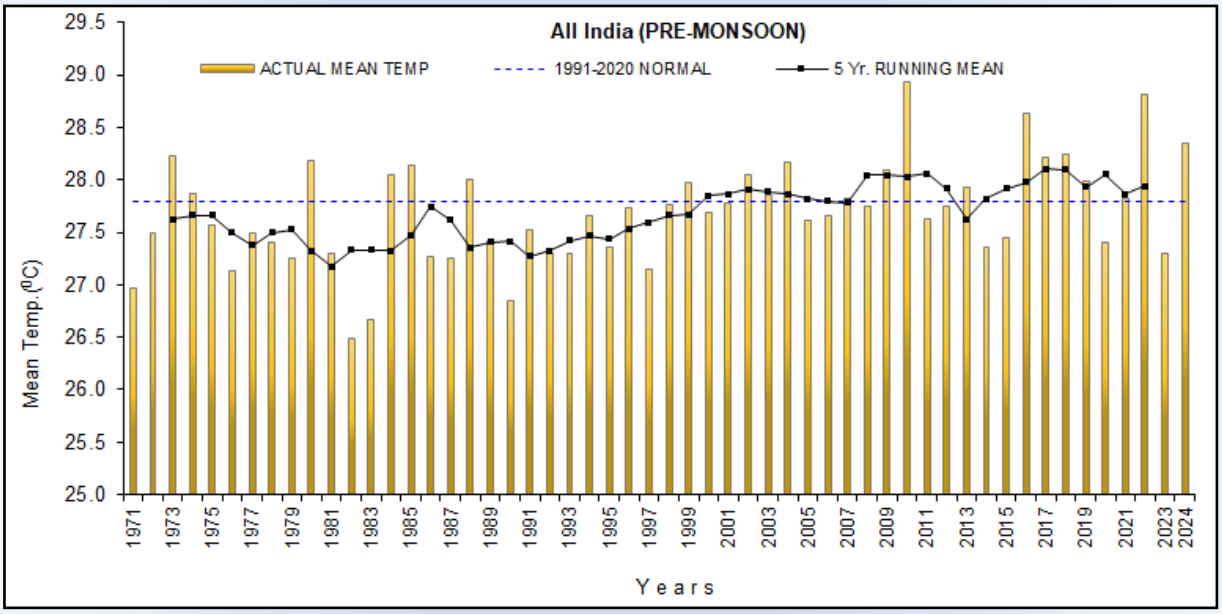
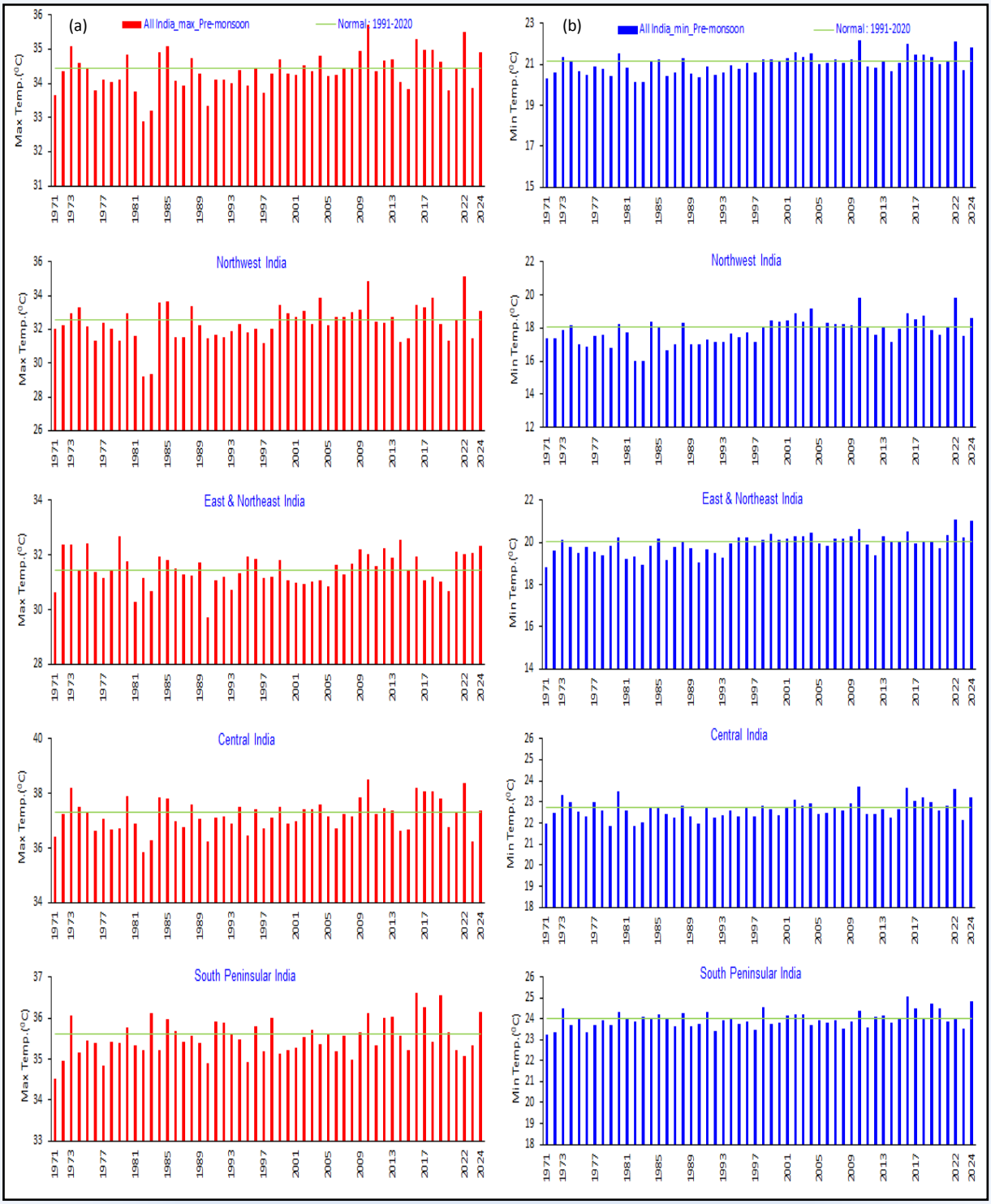


Fig. 15. Time Series of Mean Temperature Averaged Over India (Vertical Bars and Five Year Running Mean (Continous Line) For Mar-May (1971-2024)



Figs. 16(a&b). Time Series of Temperature for the Country as a whole and the four Homogeneous Regions for Mar-May (1971- 2024) (a) Maximum and (b) Minimum

Figs. 16(a&b) show the maximum and minimum temperature series for the country as a whole and the four homogeneous regions during the season since 1971. The maximum and minimum temperatures were above normal over all the homogeneous regions. Over South Peninsular India, the maximum temperature was the 4th highest (36.16°C with an anomaly of 0.53°C) after the years 2016 (36.61°C), 2019 (36.56°C), 2017 (36.25°C) and minimum temperature was the 2nd highest (24.82°C with an anomaly of 0.78°C) after the year 2016 (25.04°C) since 1901. Over East & Northeast India, the minimum temperature was the 2nd highest (21.02°C with an anomaly of 0.97°C) after the year 2022 (21.10°C) since 1901.

Over the country as a whole, the minimum temperature was the 7th highest (21.80°C with an anomaly of 0.66°C) and the maximum temperature was the 13th highest (34.90°C with an anomaly of 0.46°C) since 1901.

2.11. Low Pressure Systems

A severe Cyclonic storm, "Remal," formed over the Bay of Bengal during the season from 24 – 28 May, 2024. Along with this severe cyclonic storm, a low-pressure area formed over the Arabian Sea on 23 – 24 May. Fig. 17 shows the track of this system.

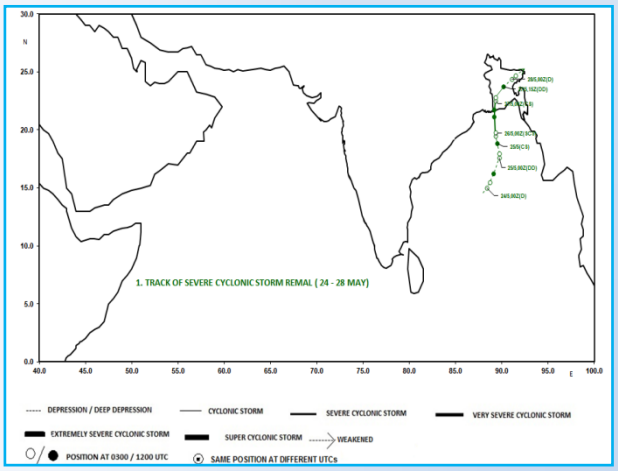


Fig. 17. Track of intense low-pressure system formed during premonsoon season 2024

2.12. Significant Weather Events for Pre-Monsoon Season (March-May) 2024

During the pre-monsoon season, a total of 497 persons reportedly died, more than 1000 persons were injured, about nine persons were reportedly missing & more than 270 livestock perished. The details of causalities are given below, based on real-time media reports. Fig. 18 shows deaths due to significant weather events during Pre Monsoon Season (March-May) 2024. (Based on real-time media reports).

2.13. Lightning

Total 144 persons reportedly died,more than 80 persons injured & 139 livestock perished, during Pre Monsoon Season, because of Lightning. Damage to the runway edge lights at the Manohar International Airport (MIA), Goa, on 22nd May and damage to house & household equipment on 23rd May in North Goa district reported.

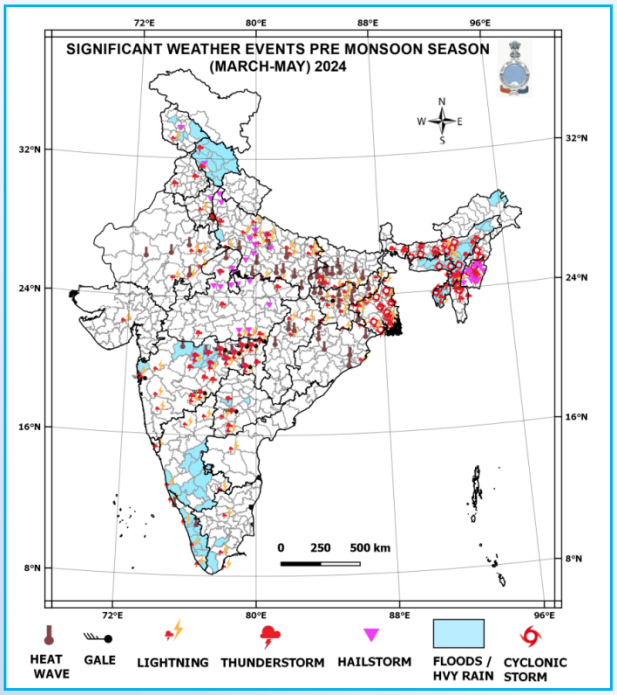


Fig. 18. Significant weather events during pre-monsoon (Mar-May) 2024 (Based on real time media report)

2.14. Thunderstorm

Total 56 persons reportedly died, more than 400 persons injured & 8 livestock perished during Pre Monsoon season, because of Thunderstorm.

2.15. Heavy Rains, Floods & Landslide

A total of 64 persons reportedly died, 25 persons were injured, two persons were reportedly missing & 14 livestock perished during the pre-monsoon season because of heavy rains, floods & Landslides.

2.16. Gale

Total four persons reportedly died, one person injured during Pre Monsoon Season, because of Gale.

2.17. Heat Wave

Total 176 persons reportedly died & more than 100 livestock including bats perished duringPre Monsoon Season, because of Heat Wave.

2.18. Hailstorm

A total of 2 persons reportedly died & 12 livestock perished during the pre-monsoon season due to the Hailstorm.

2.19. Cyclonic Storms

A total of 51 persons reportedly died, more than 500 persons were injured & 7 persons were reportedly missing during the pre-monsoon seasondue to the Severe Cyclonic Storm REMAL (24 May to 28 May).

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

3.1. Highlights

During Monsoon,over the country the mean temperature was 28.72 °C with an anomaly of 0.71 °C and the 2nd highest after the year 1987 (28.724 °C) since 1901. The maximum temperature was the 5th highest (32.80 °C with an anomaly of 0.59 °C) after the years 1987(33.35 °C), 2009 (32.92 °C), 2014 (32.83 °C) & 1979 (32.82 °C) and the minimum temperature was the highest (24.63°C with an anomaly of 0.82 °C) since 1901. Among the four homogeneous regions, over East & Northeast India, the maximum was the highest (32.45 °C with an anomaly of 1.28 °C) and the minimum temperature was also the highest (25.15 °C with an anomaly of 0.97 °C) since 1901. Over Northwest India, the maximum was the 3rd highest (33.93 °C with an anomaly of 0.80 °C) and the minimum temperature was the highest (24.42 °C with an anomaly of 1.15 °C) since 1901. The minimum temperature over Central India was the highest (24.85 °C with an anomaly of 0.65 °C) and South Peninsular India, it was the 3rd highest (24.18 °C with an anomaly of 0.49 °C) since 1901.

Rainfall over homogeneous region of east & northeast India (1178.7 mm) was 9th lowest since 1901.

3.2. Onset Advance and Withdrawal of Southwest Monsoon

Fig. 1(a) depicts the isochrones of the advance of the southwest monsoon and Fig. 1(b) depicts the isochrones of withdrawal of the southwest monsoon.

Southwest Monsoon advanced into some parts of Maldives & Comorin area and some parts of South Bay of Bengal, Nicobar Islands and South Andaman Sea on 19th May, 2024.

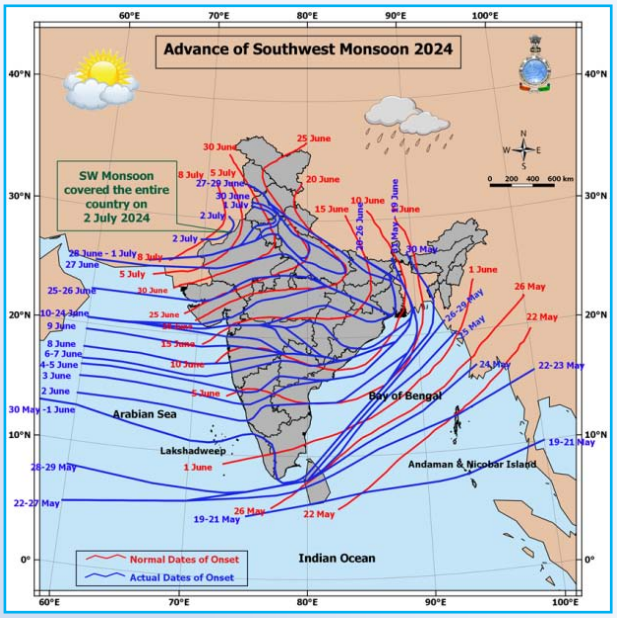


Fig. 1(a). Advance of Southwest Monsoon 2024

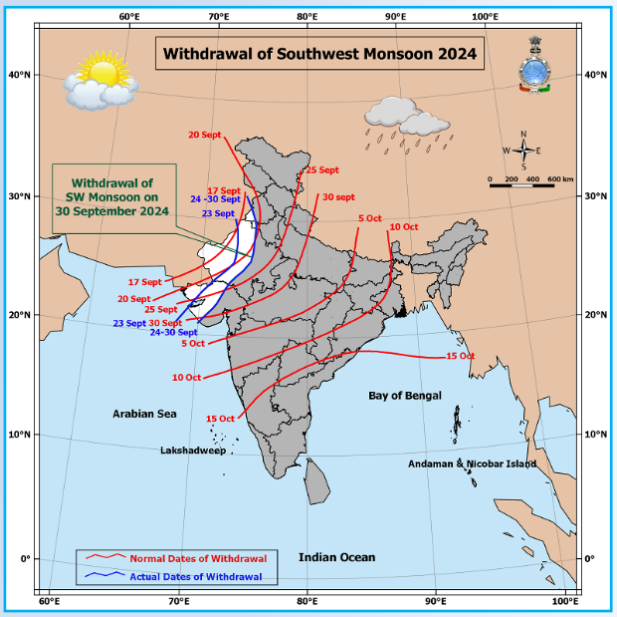


Fig. 1(b). Withdrawal of Southwest Monsoon 2024 Till 30th September

By 31st May it advanced into remaining parts of northeast Bay of Bengal and some parts of northwest Bay of Bengal, remaining parts of Tripura, Meghalaya and Assam and most parts of Sub-Himalayan West Bengal & Sikkim.

The monsoon continued advancing in early June, covering parts of central and northwest Bay of Bengal, coastal Andhra Pradesh, Telangana, Goa and Karnataka. By June 8, it reached southern Maharashtra, Telangana and Odisha. Between June 8 and 12, it extended further into the north Arabian Sea and Maharashtra, including Mumbai,

before a brief halt in its progress from June 12 to 19. On June 20, the monsoon resumed its advancement, reaching Vidarbha, Chhattisgarh, Odisha, Sub-Himalayan West Bengal and parts of Bihar. It spread into Madhya Pradesh, Jharkhand and Gujarat by June 23. By June 27, the monsoon had reached the northern Arabian Sea, Gujarat, Rajasthan and parts of Jammu & Kashmir, Himachal Pradesh and Punjab. The Southwest Monsoon entirely covered India by July 2, 2024, six days earlier than its normal date of July 8.

The withdrawal of the SW-monsoon 2024 began on 23th September against its normal date of 17th September [Fig. 1(b)].

3.3. Rainfall Features

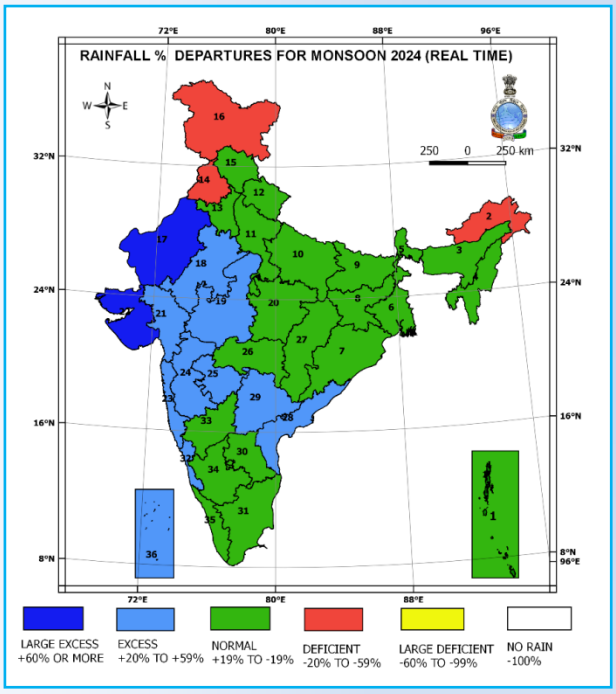


Fig. 2. Sub-divisionwise rainfall percentage departures for the monsoon 2023

Most sub-divisions of the country received large excess/excess/normal rainfall, except Arunachal Pradesh, Jammu & Kashmir & Ladakh and Punjab. During the season, out of 36 meteorological subdivisions, 2 sub divisions received large excess rainfall, 10 subdivisions received excess rainfall, 21 received normal rainfall and the remaining 3 subdivisions received deficient rainfall (Fig. 2). Table 1 shows the subdivision-wise rainfall statistics (mm) for the Southwest Monsoon Season 2024. Rainfall over East Rajasthan and Saurashtra & Kutch (920 mm, 942.7 mm respectively) was third highest since 1901. Rainfall over West Rajasthan, Madhya Maharashtra and Coastal Andhra Pradesh (486.0mm, 1035.8mm, 800.7mm respectively) was 4th highest since 1901. Rainfall over Konkan & Goa (3710.6mm) was 5th highest since 1901.

Fig. 3 shows the subdivision-wise distribution of rainfall percentage departures for the four months of the monsoon season (June to September) 2024.

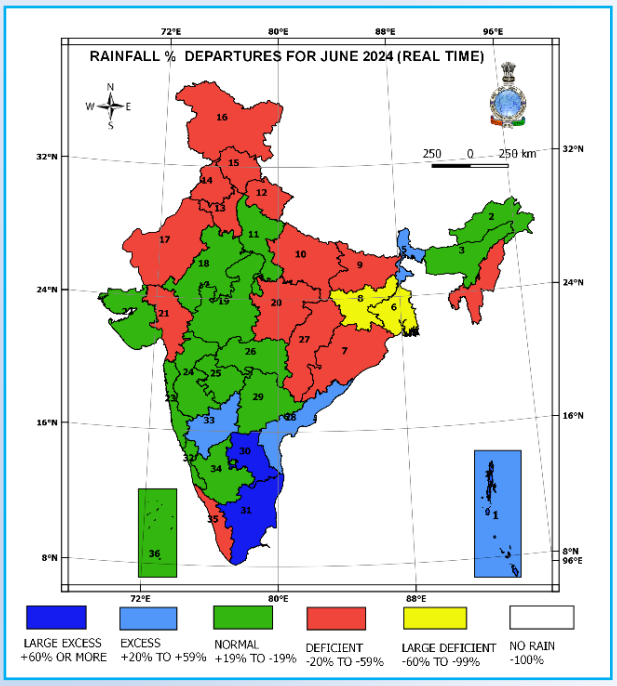


Fig. 3(a). Monthly sub-divisionwise distribution of rainfall percentage departures (June, 2024)

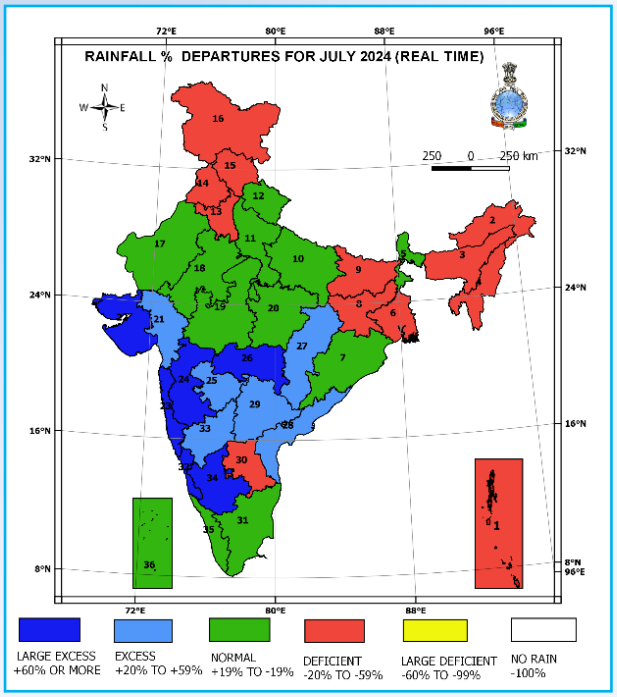


Fig. 3(b). Monthly sub-divisionwise distribution of rainfall percentage departures (July, 2024)

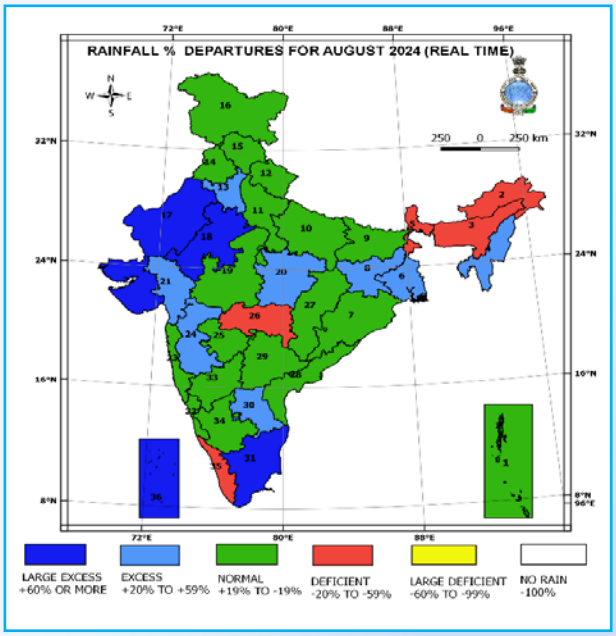


Fig. 3(c). Monthly sub-divisionwise distribution of rainfall percentage departures (August, 2024)

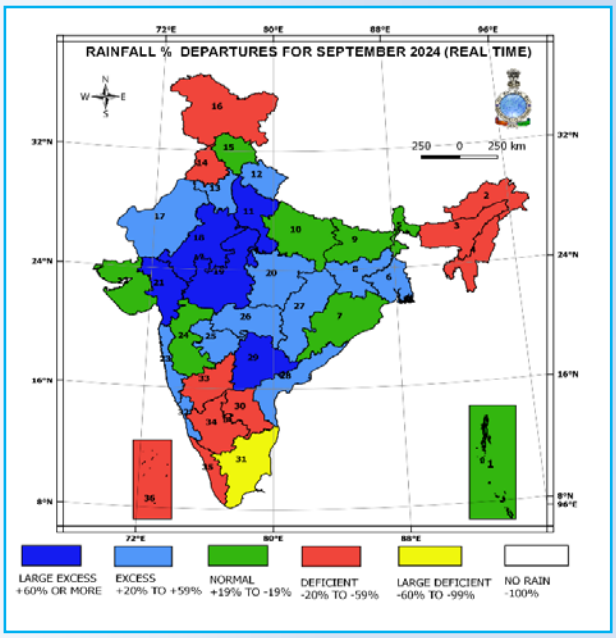


Fig. 3(d). Monthly sub-divisionwise distribution of rainfall percentage departures (September, 2023)

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

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

Positive rainfall anomaly of more than 400 mm was observed over Assam & Meghalaya, Tripura, Uttarakhand, West Uttar Pradesh, East Rajasthan, West Madhya Pradesh, Coastal Andhra Pradesh, Odisha, Telangana, Chhatisgarh, Gujarat Region Saurashtra & Kutch, Konkan & Goa, Madhya Maharashtra, Coastal Karnataka and Andaman & Nicobar Island. The magnitude of negative rainfall anomaly was more than 300 mm over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Bihar, Odisha, Kerala and adjoining North Interior Karnataka.

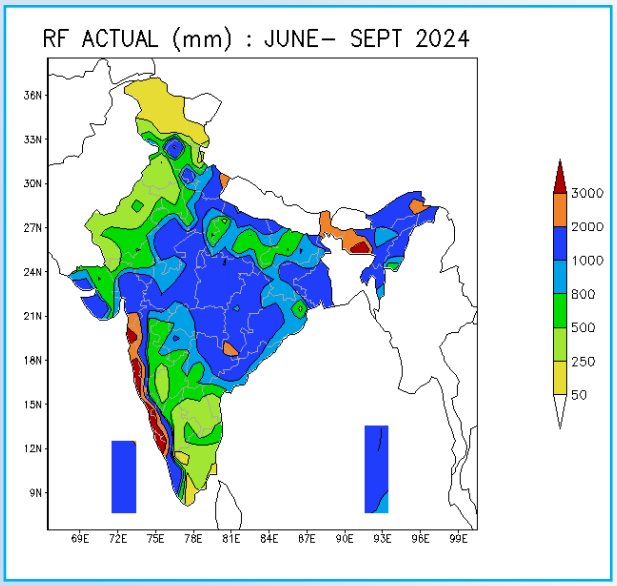


Fig. 4(a). Seasonal rainfall (mm)

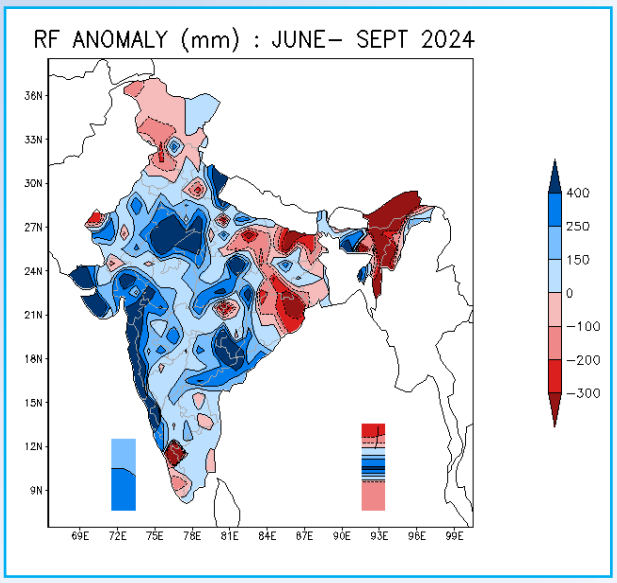


Fig. 4(b). Seasonal rainfall anomaly (mm) (based on 1971-2020 normals)

The number of subdivisions that received excess, normal, deficient, or scanty rainfall during each

month of the season, actual and Long Period Average (LPA) rainfall, and the percentage of LPA for the country as a whole for each month and season is given in the following table:

MONTH		JUN	JUL	AUG	SEP	SEASON
Number of sub-divisions in different categories	Large Excess	2	6	5	5	2
	Excess	4	6	8	12	10
	Normal	14	12	18	8	21
	Deficient	14	12	5	10	3
	Large Deficient	2	0	0	1	0
	No Rain	0	0	0	0	0
Actual (mm)		147.2	305.8	293.9	187.3	934.7
LPA (mm)		165.3	280.5	254.9	167.9	869
Rainfall (% of LPA)		**89**	**109**	**115**	**112**	**108**

Fig. 5 shows the daily area-weight averaged rainfall (in mm) and its long-term normal over the country as a whole and the four homogeneous regions during the season. For the country as a whole, the average rainfall was above or near normal on 9 days during June, 20 days during July, 20 days during August and 15 days during September.

On almost 17 occasions including the continuous periods of 1 – 3 August, 24 – 27 August, 10 – 11 September and 26 – 28 September it was more than or equal to one and a half times its normal value. It was below normal at a stretch on 8 – 18 June, 20 – 26 June, 12 – 19 August and 13 – 23 September.

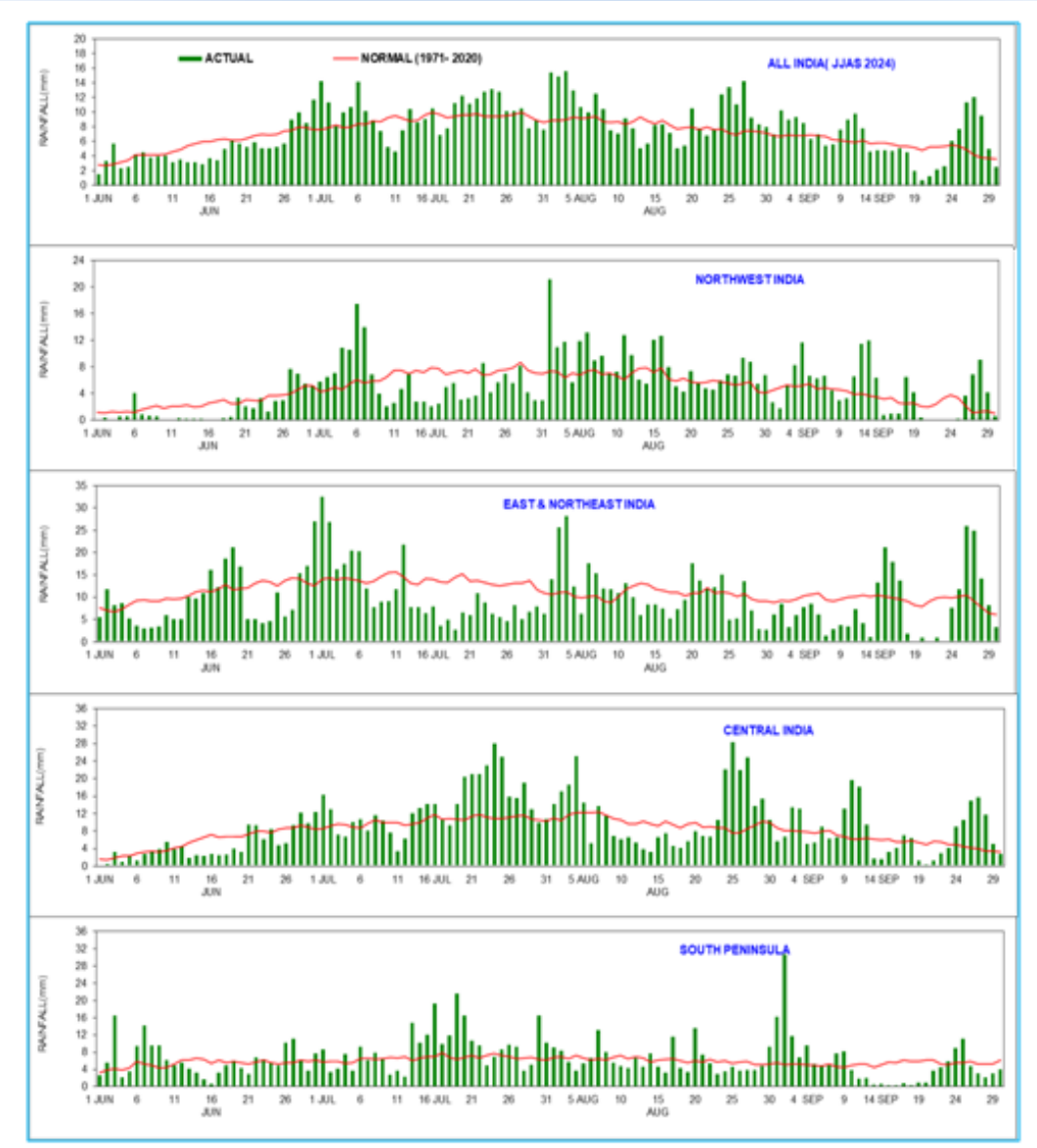


Fig. 5. Daily area weighted rainfall (mm) and its long term normal for the country as a whole and the four homogeneous regions (1st June - 30th September)

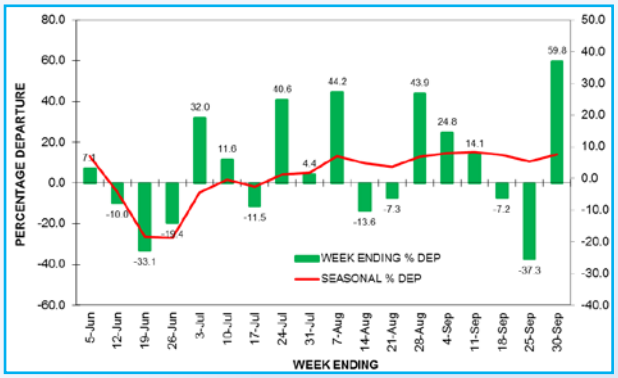


Fig. 6. Week wise and cumulative percentage departure of area weighted rainfall over the country as a whole during June to September 2024

Fig. 6 shows the area weight averaged weekly and cumulative rainfall percentage departure respectively for the country as a whole during the season. Of the seventeen weeks of monsoon season, rainfall was above normal (>+10%) on seven occasions, below normal (<-10%) on five occasions and near normal on five occasions. Cumulative rainfall departure was negative till July end and turned positive during August and remained positive till end of the season. **The area-weight averaged rainfall for the monsoon season for All India this year was 108% of its LPA value.** The realized rainfall for the season this year was 107% of its LPA over northwest India, 119% of its LPA over central India, 86% of its LPA over east & northeast India and 114% of its LPA over south peninsula. Rainfall over homogeneous region of east & northeast India (1178.7 mm) was 9th lowest since 1901. Fig. 7 shows area weighted rainfall series for the monsoon season over all India and four homogeneous regions since 1951.

Fig. 7. Time series of area weighted rainfall over all India and four homogenous regions for the monsoon season during the period 1951-2024

3.4. Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for monitoring drought and is based only on precipitation. This index is negative for dry and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. Figs. 8 (a&b) give the SPI values for the monsoon season (four months) and the year since January 2024 (nine months) respectively.

Cumulative past four months SPI values indicate, extremely wet/severely wet conditions over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, S.H.West Bengal & Sikkim, Gangetic West Bengal, Odisha, Uttar Pradesh state, Haryana, Chandigarh & Delhi, Punjab, Rajasthan state, Madhya Pradeshstate, Gujarat state, Konkan & Goa, Madhya Maharashtra, Chhattisgarh, Coastal Andhra Pradesh, Telangana, Tamil Nadu, Coastal Karnataka and South Interior Karnatakawhile, extremely dry/severely dry conditions were observed over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Jharkhand, Bihar, West Uttar Pradesh, Punjab, Jammu & Kashmir and Ladakh and Chhattisgarh.

Cumulative SPI values of the nine months indicate, extremely wet/severely wet conditions over parts of Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, S.H. West Bengal & Sikkim, Gangetic West Bengal, Odisha, West Uttar Pradesh, Uttarakhand, Haryana, Chandigarh & Delhi, Punjab, Jammu & Kashmir and Ladakh, Rajasthan state, Madhya Pradesh state, Gujarat state, Konkan & Goa, Madhya Maharashtra, Chhattisgarh, Coastal Andhra Pradesh, Telangana, Tamil Nadu, Coastal Karnataka, South Interior Karnataka and Lakshadweep while, extremely dry/severely dry conditions were observed over parts of A & N Islands, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Jharkhand, Bihar, Uttar Pradesh state, Punjab, Himachal Pradesh, Jammu & Kashmir and Ladakh, Chhattisgarh and South Interior Karnataka.

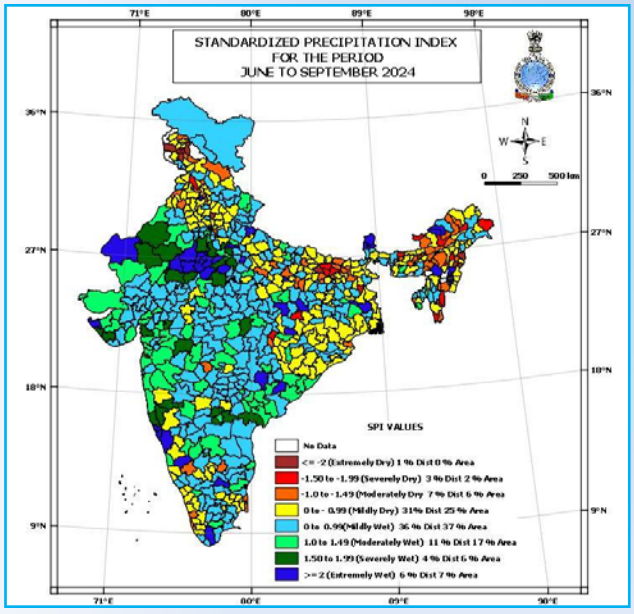


Fig. 8(a). Standardized Precipitation Index (SPI) For Four Months (June-September 2024)

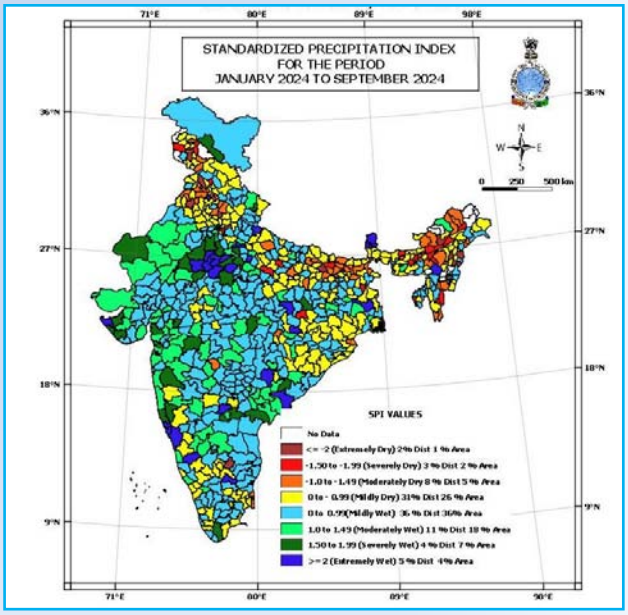
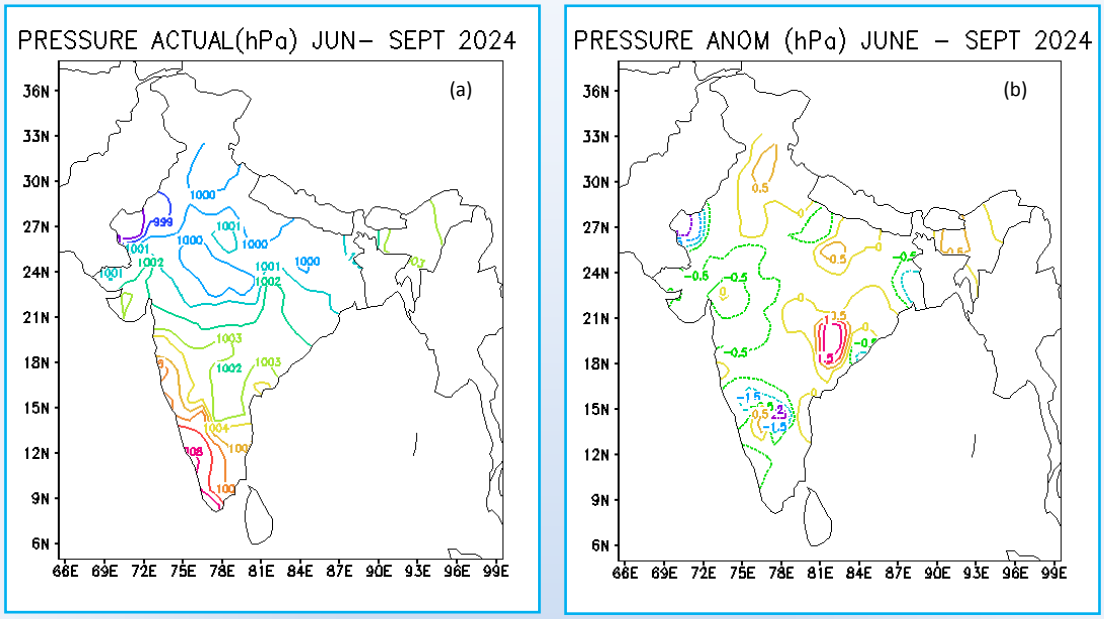


Fig. 8(b). Standardized Precipitation Index (SPI) For Nine Months (January 2024-September 2024)

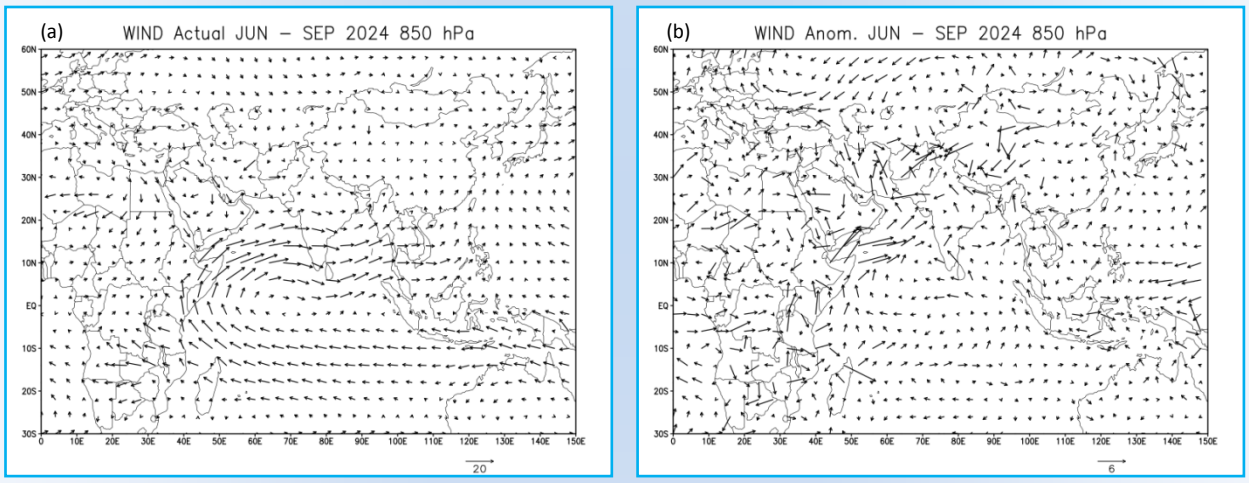
3.5. Pressure & Wind

Figs. 9(a&b) show the mean sea level pressure & its anomalies respectively. The pressure anomaly was within normal range over most parts of the country. Positive pressure anomaly was within range 0.5 hPa to 1.5 hPa.

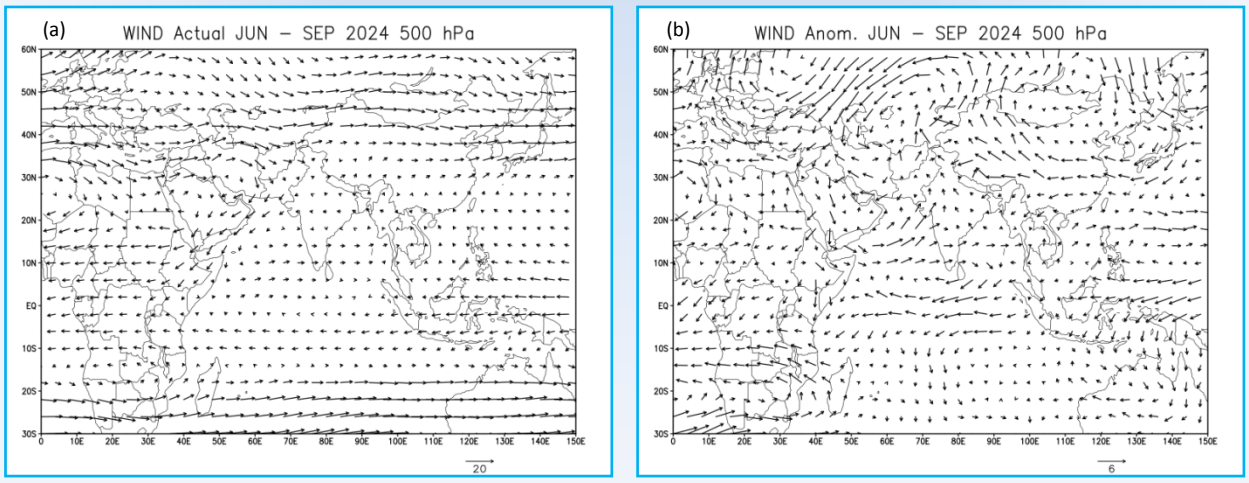
Figs. 10(a&b), 11(a&b) and 12(a&b) Show the mean circulation pattern and its anomalies at 850, 500 and 250 hPa levels respectively. At 850 hPa level, anomalous strong low level westerly jet was observed. At 500 hPa level, an anomalous anti cyclonic circulation was observed over south peninsula and adjoining north Indian Ocean.



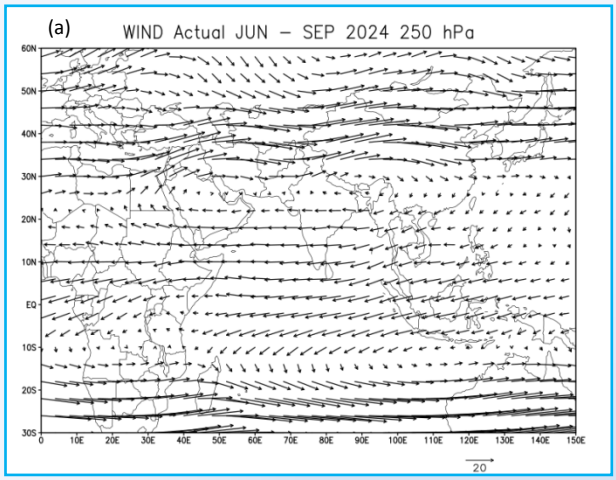
Figs. 9(a&b). Mean Sea Level Pressure (hPa) For Monsoon 2024 (a) Mean Sea Level Pressure (MSLP) (b) MSLP Anomaly (Based on 1991-2020 Normals)



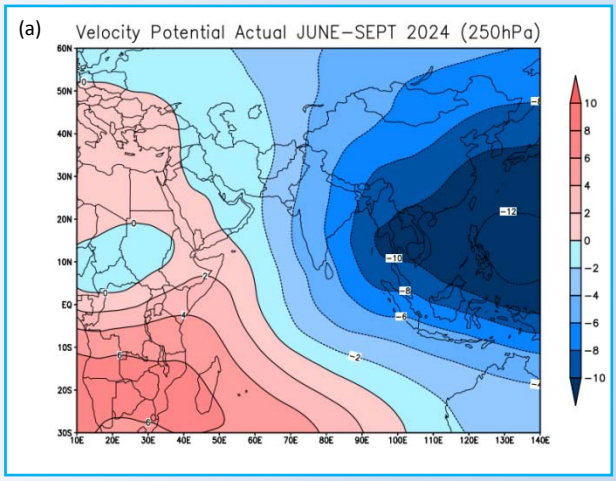
Figs. 10(a&b). Seasonal Wind (m/s) For Monsoon 2024 (a) Mean (b) Anomaly at 850 hPa (Operational NWP Analysis of IMD GFS T-574 (Anomaly Is Based on 2000-2018 Climatology, Source : NCMRWF)



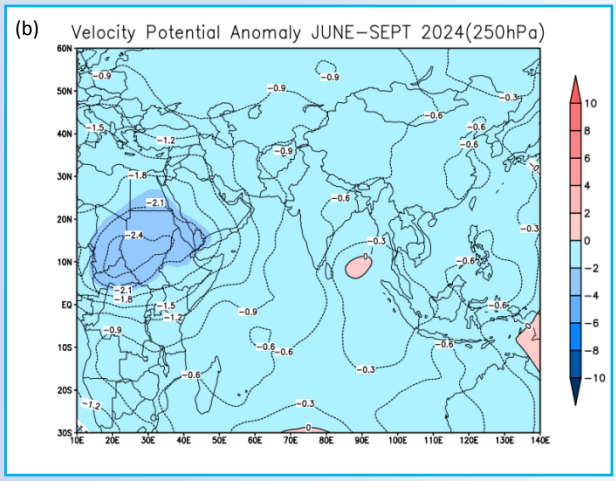
Figs. 11(a&b). Seasonal wind (m/s) for monsoon 2024 (a) mean (b) anomaly at 500 hPa (operational NWP analysis of IMD GFS t-574) (anomaly is based on 2000-2018 climatology, Source : NCMRWF)



Figs. 12(a&b). Seasonal Wind (m/s) For Monsoon 2024 (a) Mean (b) Anomaly at 250 hPa (Operational NWP Analysis of IMD GFS T-574) (Anomaly Is Based On 2000-2018 Climatology, Source : NCMRWF)



Figs. 13(a). Velocity potential (106M^2/S) for monsoon 2024 Mean at 250 hPa (Operational NWP Analysis of IMD GFS T-574)



Figs. 13(b). Velocity Potential (106m^2/s) For Monsoon 2024) Anomaly at 250 hPa (OperationaL NWP Analysis Of IMD GFS T-574) (Anomaly is based on 2000-2018 Climatology, Source : NCMRWF)

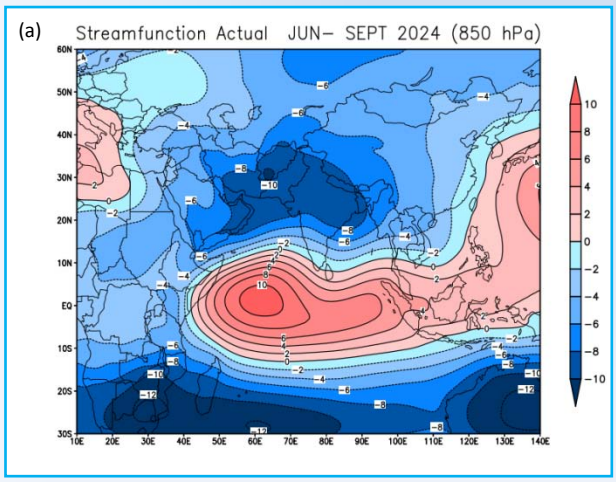


Fig. 14(a). Stream function (106m^2/s) for monsoon 2023 mean at 850 hPa (OperationaL NWP analysis of IMD GFS T-574)

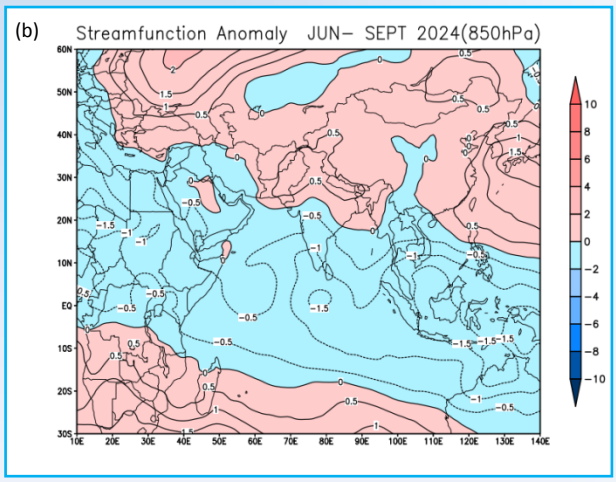


Fig. 14(b). Stream function (106m^2/s) for monsoon 2023 Mean Anomaly At 850 hPa (OPERATIONAL NWP ANALYSIS OF IMD GFS T-574) (Anomaly is based on 2000-2018 Climatology, Source : NCMRWF)

3.6. Velocity Potential & Stream Function

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

3.7. Outgoing Long Wave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighborhood is shown in Fig. 15. OLR anomaly was negative throughout the country, except extreme northeastern parts. Negative OLR anomaly less than - 30 W/m^2 was observed over northwestern parts.

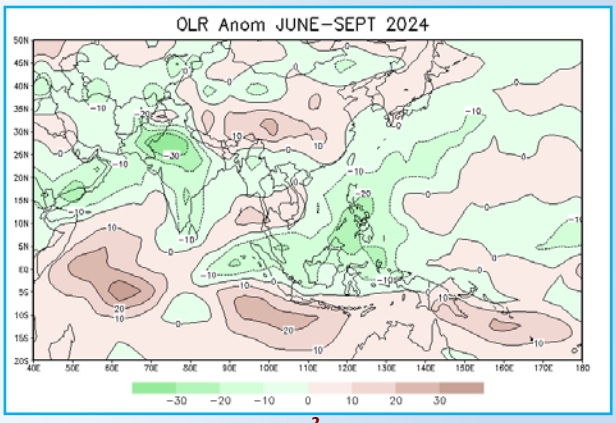


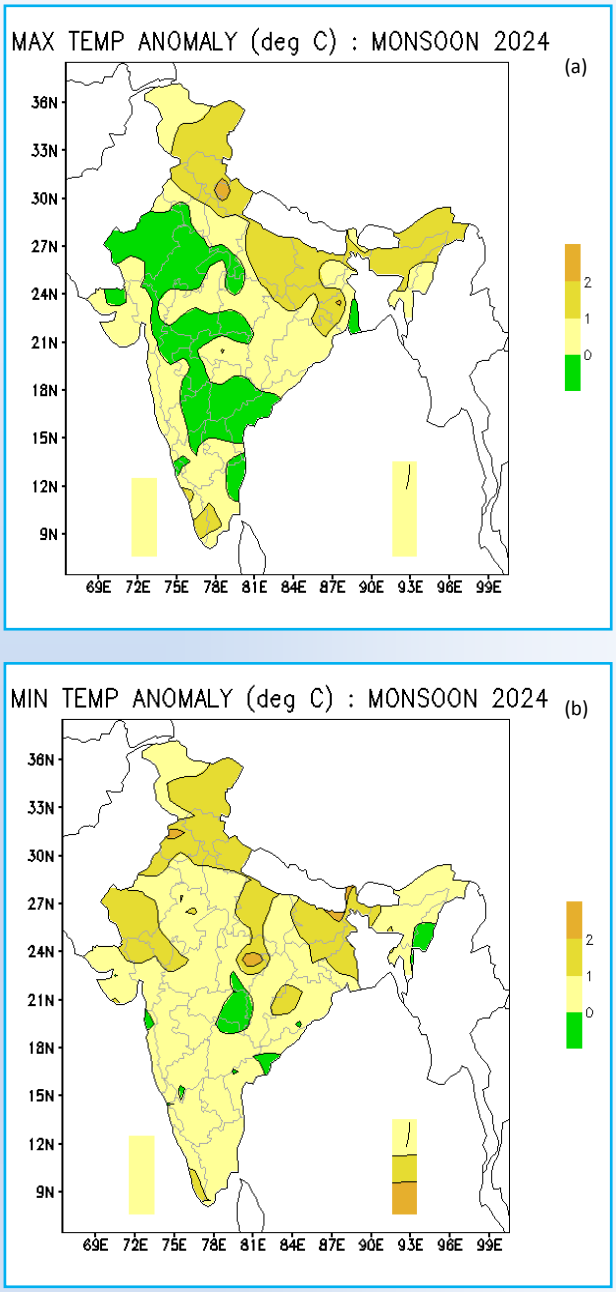
Fig. 15. OLR anomaly (w/m^2) for the monsoon season 2024 (DATA SOURCE : CDC / NOAA, USA) (Based on 1991-2020 climatology)

3.8. Temperature

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

Maximum temperature was above normal/near normal over most parts of the country, except some parts of northwest India, central India and south peninsular India. Maximum temperature anomaly was more than 2°C over parts of Uttarakhand and Gangatic West Bengal.

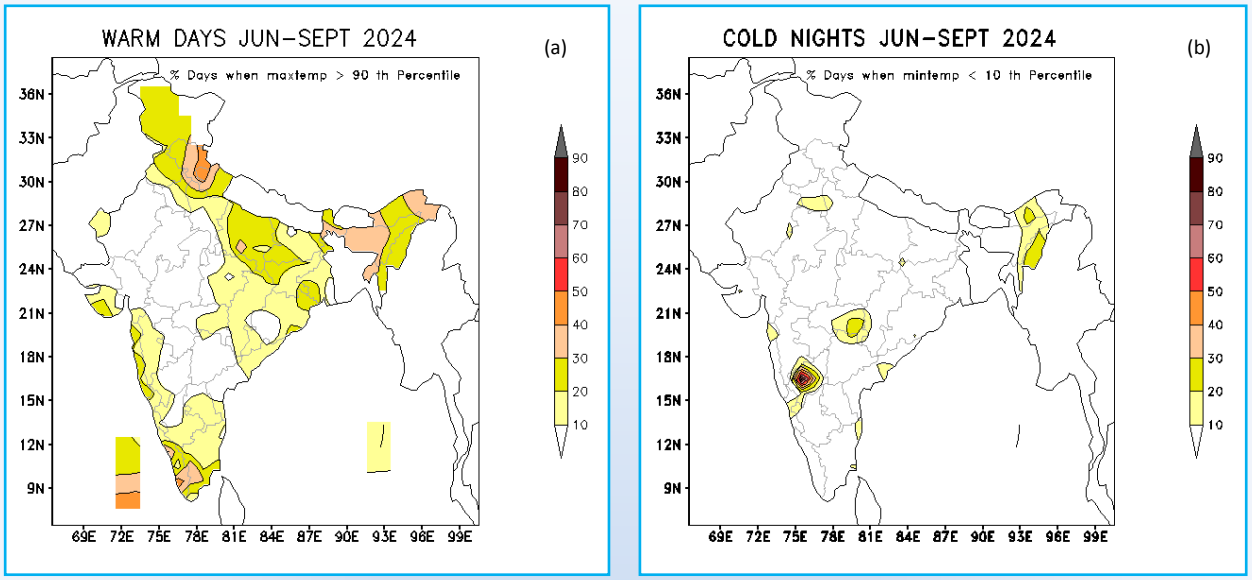
Minimum temperature was above normal/normal over the country. Minimum temperature anomaly was more than 2°C over parts of Punjab, Bihar, Sikkim state, East Madhya Pradesh and Andaman & Nicobar Islands.



Figs. 16(a&b). Mean seasonal temperature anomalies (°C) for monsoon 2024 (a) Maximum and (b) minimum (Based on 1991-2020 normals)

3.9. Percentage of Warm days / Cold nights

Figs. 17(a&b) show the percentage of days when the maximum (minimum) temperature was more (less) than the 90^{th} (10^{th}) percentile. Over parts of Uttarakhand, West Uttar Pradesh, Kerala & Mahe and Lakshadweep maximum temperature was greater than 90^{th} percentile for more than 40% of the days of the season. The minimum temperature was less than the 10^{th} percentile for more than 40% of the days of the month over parts of North Interior Karnataka.



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

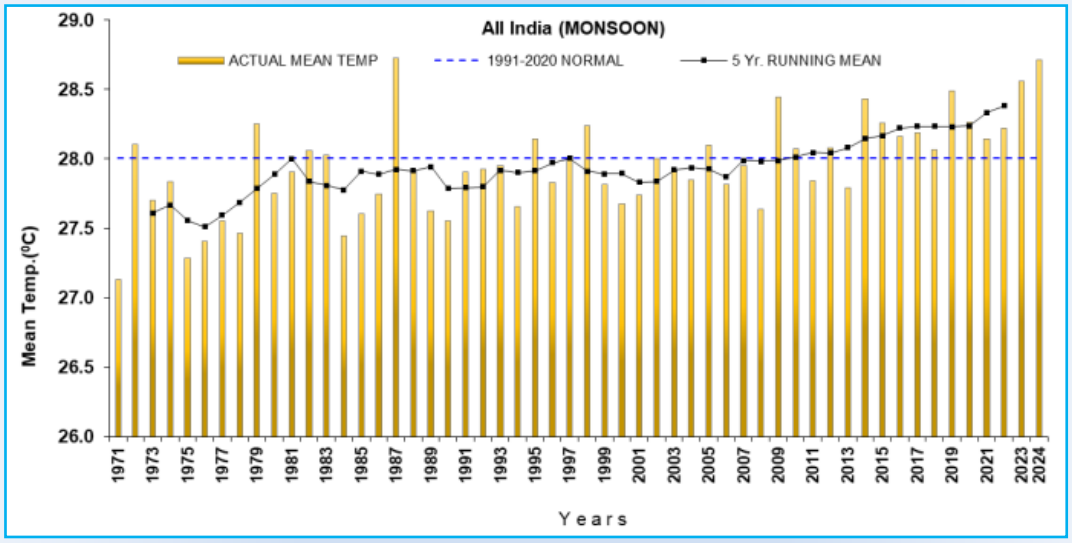


Fig. 18. Time series of mean temperature averaged over India (vertical bars and five year running mean (continous line) for the monsoon season (1971-2024)

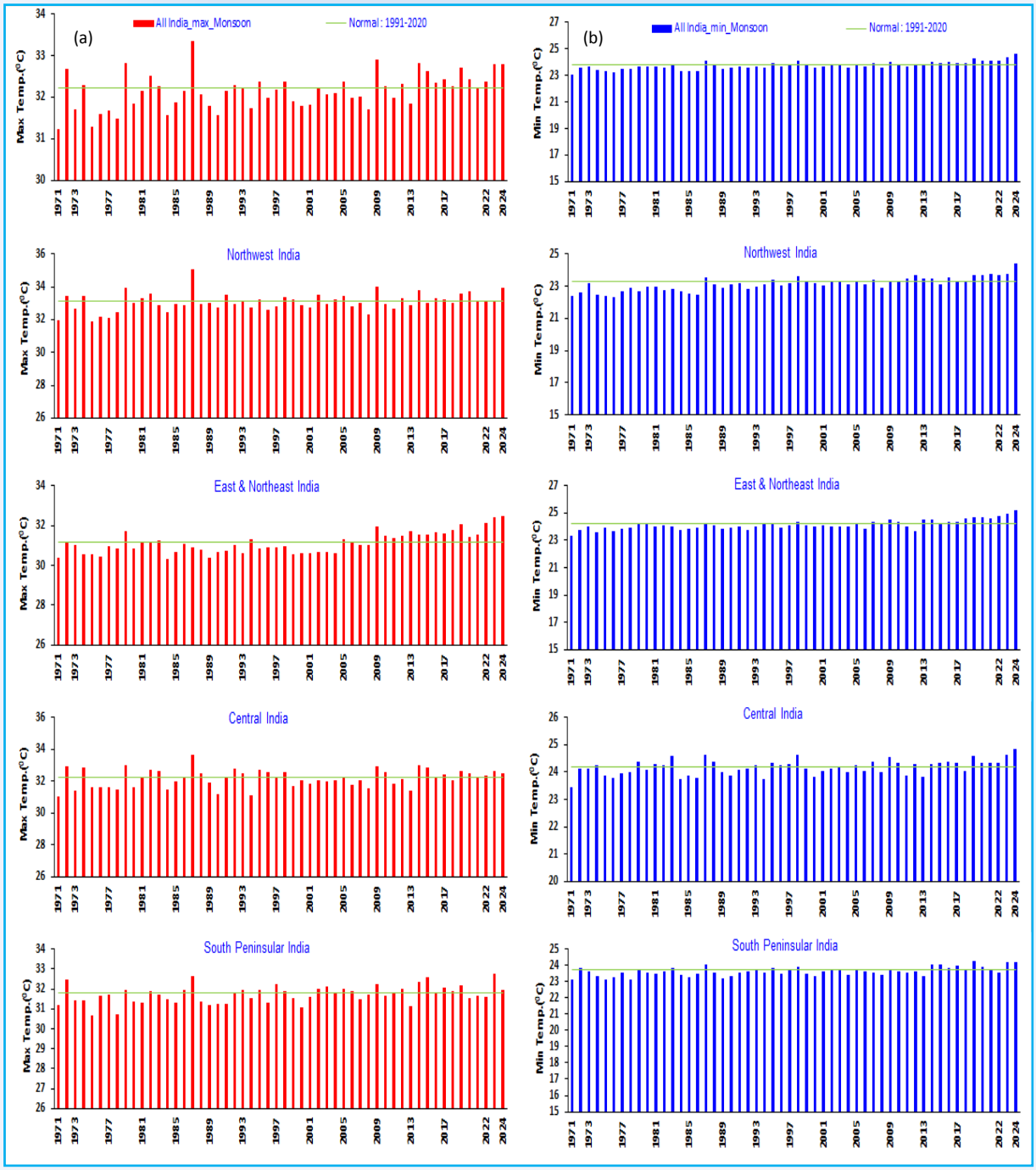
Fig. 18 the mean temperature time series for the country as a whole for Monsoon season since 1971. Five year moving average values are also shown. The mean temperature for the season this year over the country as a whole was 28.72 °C with an anomaly of 0.71°C and the 2nd highest after the year 1987(28.724 °C) since 1901. Among the four homogeneous regions, the mean temperature over East & Northeast India was the highest (28.80 °C with an anomaly of 1.13 °C), Northwest India, itwas the 2nd highest (29.18°C with an anomaly of 0.98 °C) after the year 1987 (29.32 °C) and Central India, it was the 5th highest (28.68 °C with an anomaly of 0.47 °C) after the years 1987 (29.15 °C), 2009 (28.73 °C), 1979 (28.70 °C) and 1915 (28.69 °C) since 1901.

Figs. 19(a&b) shows, the maximum and minimum temperature series respectively for the country as a whole and the four homogeneous regions during Monsoon 2024 since 1971. Both the maximum and minimum temperatures were above normal over all the homogeneous regions. Over the country as a whole both the maximum and minimum temperatures were above normal during Monsoon 2024. Among the four homogeneous regions, over East & Northeast India, the maximum was the highest (32.45°C with an anomaly of 1.28°C) and

the minimum temperature was also the highest (25.15°C with an anomaly of 0.97°C) since 1901. Over Northwest India, the maximum was the 3rd highest (33.93°C with an anomaly of 0.80°C) and the minimum temperature was the highest (24.42°C with an anomaly of 1.15°C) since 1901. The minimum temperature over Central India was the highest (24.85°C with an anomaly of 0.65°C) and South Peninsular India,it was the 3rd highest (24.18°C with an anomaly of 0.49°C) since 1901.

Over the country as a whole the maximum temperature was the 5th highest (32.80°C with an anomaly of 0.59°C) after the years 1987 (33.35°C), 2009 (32.92°C), 2014 (32.83°C) & 1979 (32.82°C) and the minimum temperature was the highest (24.63°C with an anomaly of 0.82°C) since 1901.

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



Figs. 19(a&b). Time series of temperature for the country as a whole and the four homogeneous regions for the monsoon season (1971 - 2024) (a) Maximum and (b) minimum

TABLE 2

TEMPERATURE ANOMALIES OVER INDIA AND FOUR HOMOGENEOUS REGIONS DURING MONSOON 2024

MONSOON 2024		Max Temp (^{0}C)	Min Temp (^{0}C)	Mean Temp (^{0}C)
ALL INDIA	ACTUAL	32.80	24.63	28.72
	NORMAL	32.21	23.81	28.01
	ANOMALY	0.59	0.82	0.71
NORTHWEST INDIA	ACTUAL	33.93	24.42	29.18
	NORMAL	33.13	23.27	28.20
	ANOMALY	0.80	1.15	0.98
EAST & NORTHEAST INDIA	ACTUAL	32.45	25.15	28.80
	NORMAL	31.17	24.18	27.67
	ANOMALY	1.28	0.97	1.13
CENTRAL INDIA	ACTUAL	32.52	24.85	28.68
	NORMAL	32.22	24.20	28.21
	ANOMALY	0.30	0.65	0.47
SOUTH PENNINSULAR INDIA	ACTUAL	31.98	24.18	28.08
	NORMAL	31.82	23.70	27.76
	ANOMALY	0.16	0.49	0.32

3.10. Low-Pressure Systems

During the season, thirteen low-pressure systems (one cyclonic storm, three Deep Depressions, two Depressions, two well-marked low-pressure areas, four low-pressure areas and one land low-pressure area) were formed. The frequency and place of origin of these low-pressure systems formed over the Indian region during the monsoon season are shown in the table below.

Month /Systems	CS and above	DD	D	WML	LPA	LAND D/DD	LAND LPA	TOTAL
June	0	0	0	0	1 (BOB)	0	0	1
July	0	0	1 (BOB)	1(BOB)	1(BOB)	0	0	3
August	1(BOB)	0	1 (BOB)	1(BOB)	1(AS)	1	1	6
September	0	2(BOB)	0	0	1(BOB)	0	0	3
	(AS : Arabian Sea)				**(BOB: Bay of Bengal)**			

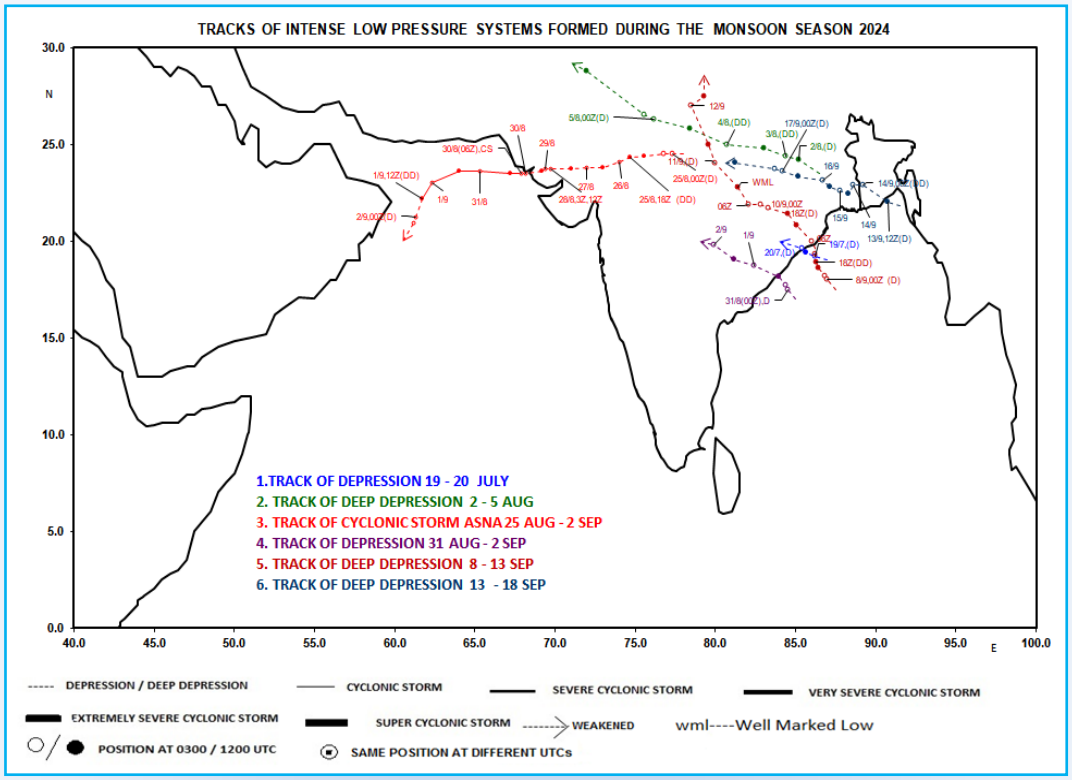


Fig. 20. Tracks of intense low pressure systems formed during the monsoon season

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

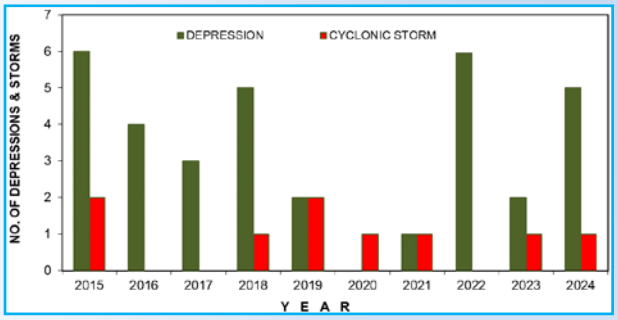


Fig. 21. Number of depressions & cyclonic storms formed during the southwest monsoon season (2015 - 2024)

Fig. 21 shows the number of depressions and cyclonic storms formed during the monsoon season since the last 10-year period (2015-2024).

3.11. Significant Weather events during Monsoon season

During Monsoon Season, total 2106 persons reportedly claimed dead, more than 880 persons injured, more than 240 persons missing & more than 14140 livestock perished. The details of causalities given below, which are based on real time media reports.

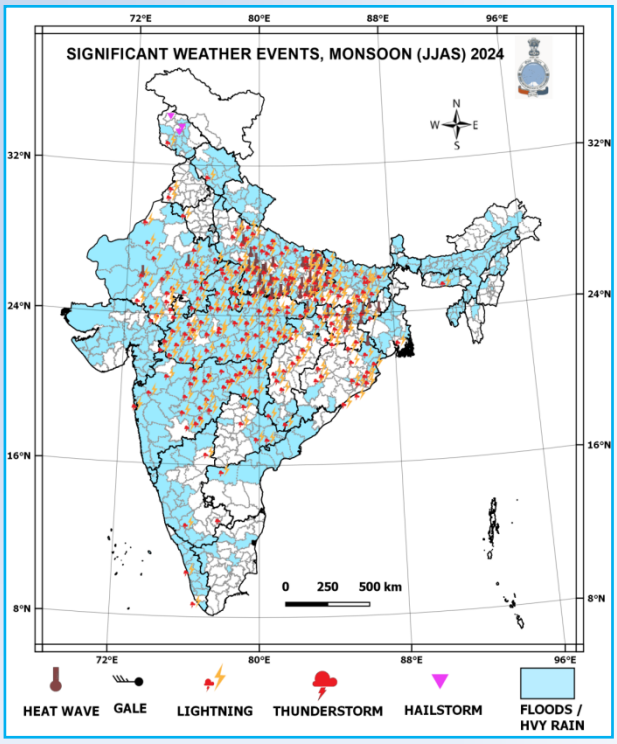


Fig. 22. Significant weather events during the season monsoon 2024 (Based on real time media report)

Fig. 22 shows deaths due to significant weather events during Monsoon Season (June-September) 2024. (Based on real time media reports).

3.12. Lightning

Total 713 persons reportedly claimed dead, more than 440 persons injured & more than 6050 livestock perished, during Monsoon Season because of Lightning.

3.13. Thunderstorm

Total 22 persons reportedly claimed dead, 4 persons injured & 4 livestock perished during Monsoon season, because of Thunderstorm.

3.14. Heavy Rains, Floods & Landslide

Total 1158 persons reportedly claimed dead, more than 420 persons injured, more than 240 persons missing & more than 8085 livestock perished, during Monsoon season, because of heavy rains, floods & Landslide.

3.15. Heat Wave

Total 213 persons reportedly claimed dead because of Heat Wave during Monsoon season.

3.16. Gale

Total 8 persons injured in Surguja district of Chhattisgarh on 13 June because of Gale.

3.17. Hailstorm

Damage to Apple, Walnut, Cherry, vegetable crops and orchards in Kupwara, Pulwama, Shopian districts of UT-Jammu & Kashmir on 6, 7 June, 2024; 2 September, 2024 reported.

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

4.1. Highlights

During Post-monsoon, over the country the mean temperature was 23.17 °C with an anomaly of 0.83 °C and the highest since 1901. Over the country as a whole the maximum temperature was the 6th highest (29.04 °C with an anomaly of 0.40 °C) and the minimum temperature was the highest (17.31 °C with an anomaly of 1.26 °C) since 1901.

Among the four homogeneous regions,Over Northwest India, the minimum temperature was the highest (13.0 °C with an anomaly of 1.17 °C), East & Northeast India, it wasalsothe highest (17.19 °C with an anomaly of 1.24 °C), Central India, it was the 2nd highest (18.22 °C with an anomaly of 1.33 °C) after the year 1979 (18.49 °C) and South Peninsular India, it was also the 2nd highest (21.91 °C with an anomaly of 1.26 °C) after the year 2023 (21.94 °C) since 1901.

4.2. Northeast Monsoon Activity

The southwest monsoon withdrew from the entire country on 15th October and northeast monsoon rains commenced from same date. Rainfall activity over core region of the South Peninsular India (comprising of 5 subdivisions, viz., Coastal Andhra Pradesh & Yanam, Rayalaseema, Tamil Nadu, Puducherry and Kariakal, South Interior Karnataka and Kerala & Mahe) during the season as a whole was 122% of its LPA. It was 118% of its LPA during October, 64% of its LPA during November and 293% of its LPA during December.

4.3. Cold Wave/ foggy conditions

During the season in the month of December, subdued cold wave/dense fog were observed across plains of northwest and central India. However, cold wave was mainly observed over Punjab during 13-18 Dec and Himachal Pradesh during 19-27 Dec. Dense fog/low cloud across Indo Gangetic Plains only was observed during 29-31 December, 2024.

4.4. Rainfall Features

Rainfall realized over the country as a whole during the season was 97% of LPA During the season many subdivisions received large excess/ excess/normal rainfall, except Nagaland, Manipur, Mozoram & Tripura, Jharkhand, Bihar, East & West Uttar Pradesh,Uttarakhand, Himachal Pradesh, Jammu & Kashmir, West Rajasthan, East Madhya Pradesh, Marathawada, Vidarbha, Chhatisgarh and Telangana. During the season, out of 36 meteorological subdivisions, 2 received large excess rainfall, 6 received excess rainfall, 14 received normal rainfall, 10 received deficient rainfall and 4 sub divisions received large deficient rainfall (Fig. 1).

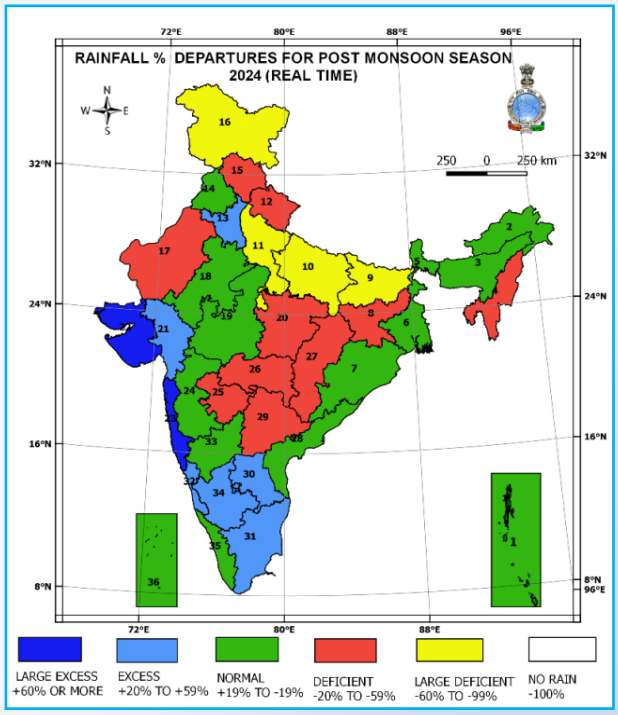
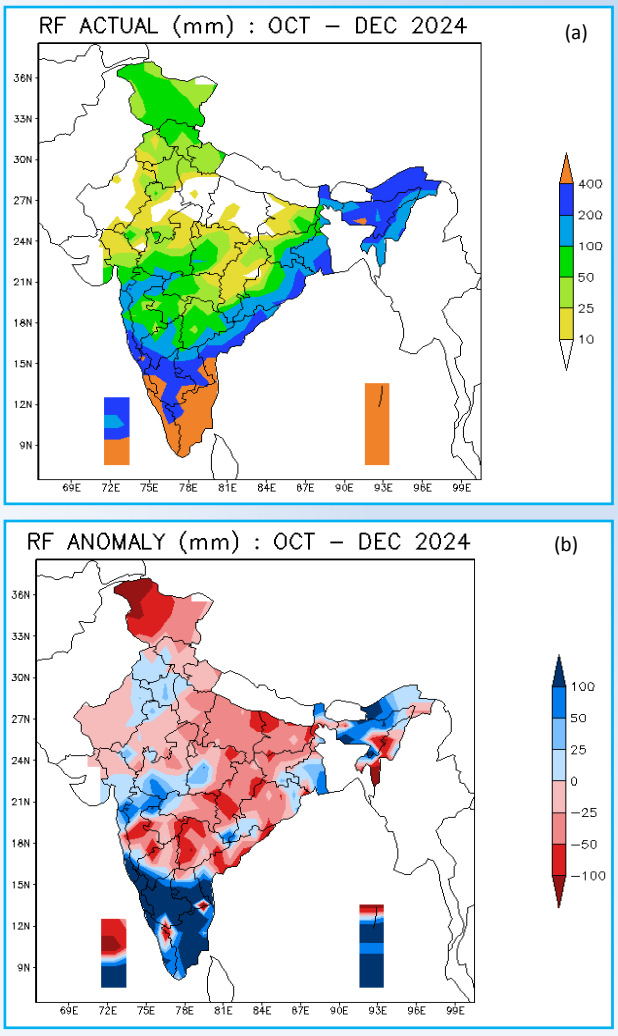


Fig. 1. Subdivisionwise rainfall percentage departure for post-monsoon season 2024



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

Figs. 2(a&b) show the spatial pattern of rainfall (mm) received during the season and its anomaly respectively. Parts of Coastal Andhra Pradesh, Tamilnadu, Puducherry & Karaikal, Coastal Karnataka, South Interior Karnataka, Kerala & Mahe, some pockets of Assam & Meghalaya and both the islands received more than 400 mm of rainfall.

Rainfall anomaly was more than 100 mm over parts of Arunachal Pradesh, Assam & Meghalaya, Coastal Andhra Pradesh, Rayalaseema. Tamilnadu, Puducherry & Karaikal, Konkan & Goa, Coastal Karnataka, North and South Interior Karnataka, Kerala & Mahe and both the islands. Magnitude of negative rainfall anomaly was more than 100 mm over parts of Nagaland, Manipur, Mizoram & Tripura, Jammu & Kashmir & Ladakh and Lakshdweep.

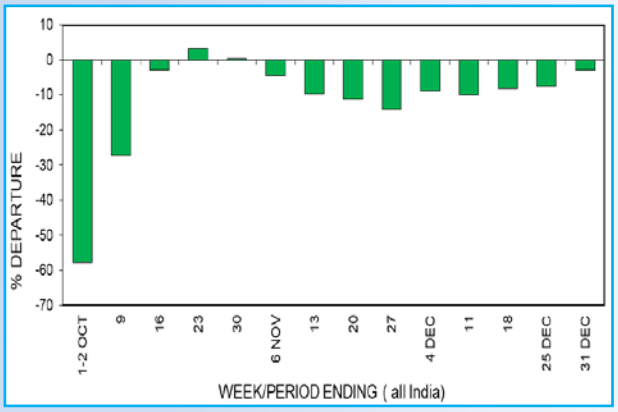


Fig. 3(a). Accumulated percentage departure of area weight averaged cumulative rainfall for post-monsoon (October - December) over the country as a whole

Fig. 3(a) shows the area weight averaged cumulative weekly rainfall percentage departure during the season for the country as a whole. Cumulative rainfall departure was negative during all the weeks of the season. At the end of the post-monsoon season 2024, the rainfall for the country as a whole was 97 % of its LPA. Fig. 3(b) shows the area weight averaged cumulative weekly rainfall percentage departure during the season for the northeast monsoon core region of south peninsula. At the end of the post-monsoon season 2024, the rainfall over the northeast monsoon core region of south peninsula was 122% of its LPA.

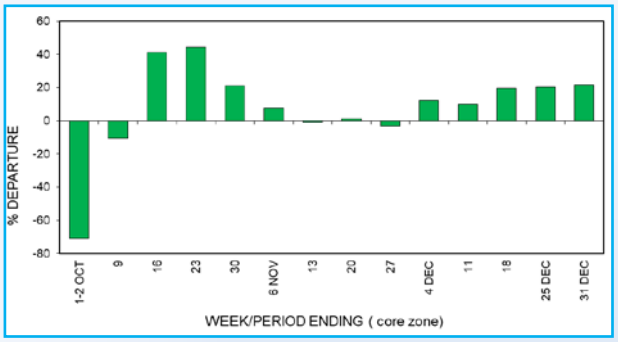


Fig. 3(b). Accumulated percentage departure of area weight averaged cumulative rainfall for post-monsoon (October - December) over the core zone of peninsula

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

Fig. 4 shows area weight averaged rainfall series for post-monsoon season over all India and four homogeneous regions since 1951. Rainfall realized over the country as a whole was 97% of its LPA during the season. It was 45% of its LPA over northwest India, 90% of its LPA over central India, 97% if its LPA over east & northeast India and 116% of its LPA over south peninsula.

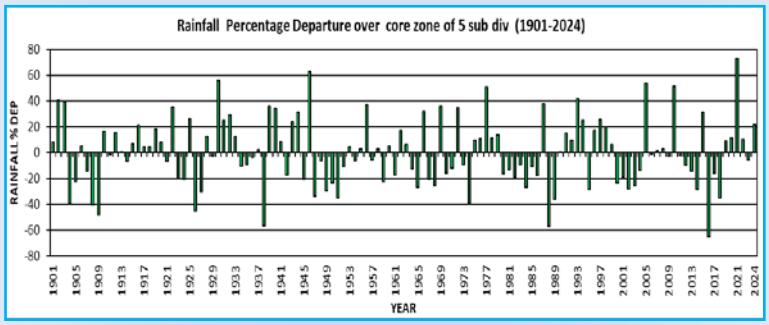


Fig. 3(c). Time series of area weight averaged post - monsoon (October - December) (1901-2024) rainfall over the core zone of peninsula

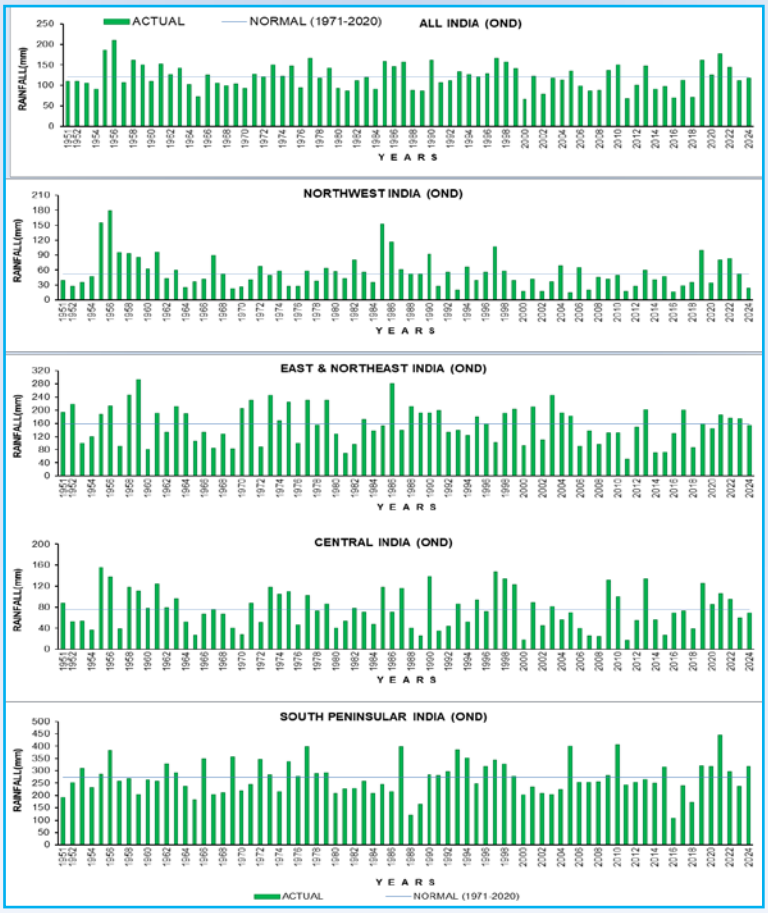
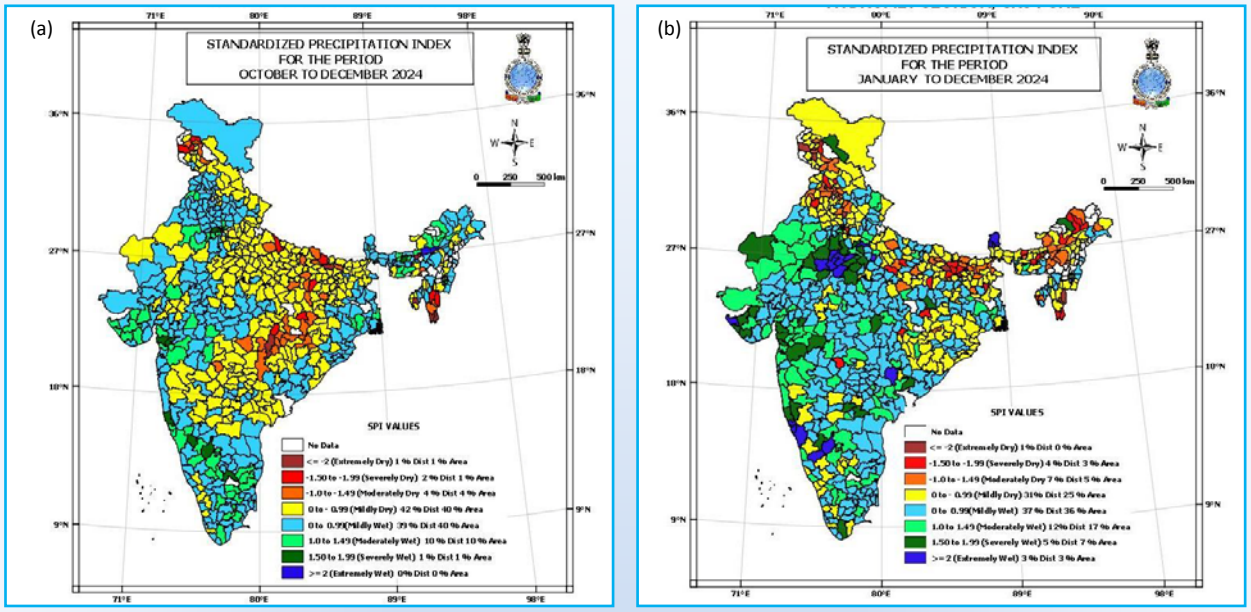
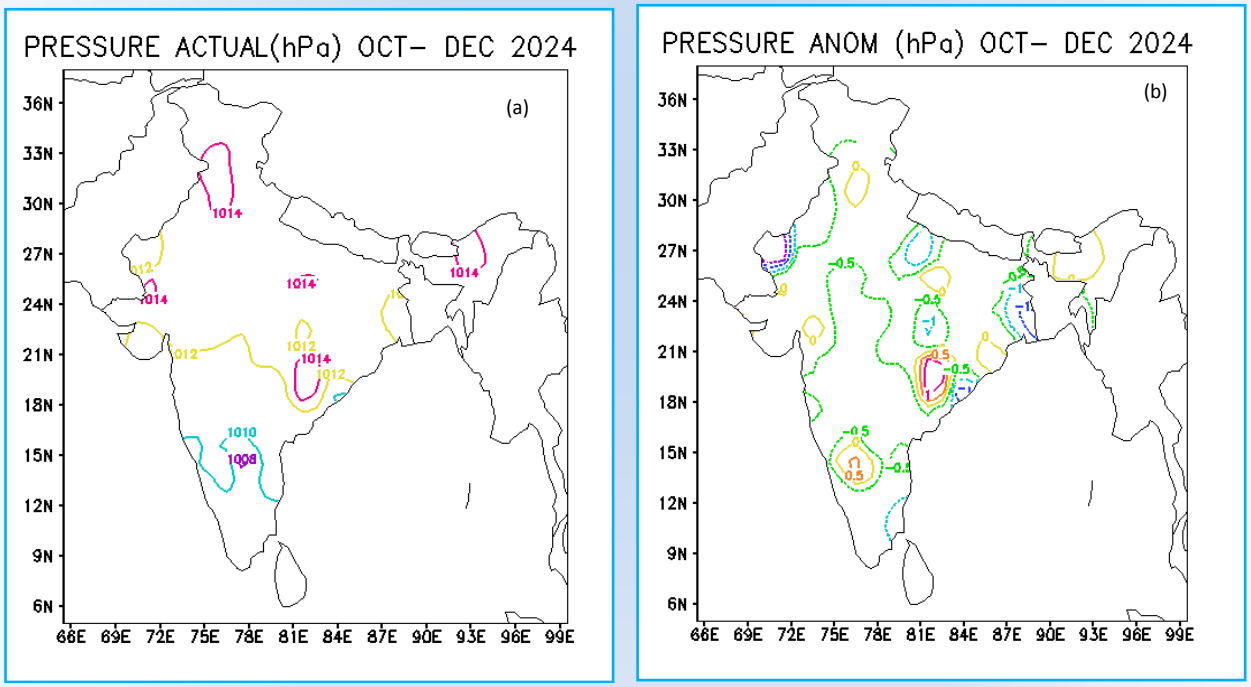


Fig. 4. Time series of area weight averaged rainfall over all India and four homogeneous regions for post - monsoon season (1951-2024)



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



Figs. 6(a&b). Mean Sea Level Pressure (hPa) For Post-Monsoon 2024(a) Mean (b) Anomaly (Based on 1991 - 2020 Normals)

4.5. Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for measuring drought and is based only on precipitation. This index is negative for dry and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. Figs. 5 (a&b) give the SPI values for the northeast monsoon season (October to December 2024, i.e., 3 months cumulative) and the year (January-December 2024, i.e., 12 months cumulative) respectively.

Cumulative SPI values of the past three months indicate extremely wet-severely wet conditions over parts of Assam & Meghalaya, Haryana, Chandigarh & Delhi, Gujarat Region, Konkan & Goa, Tamil Nadu, North Interior Karnataka and South Interior Karnataka, while extremely dry-severely dry conditions were observed over parts

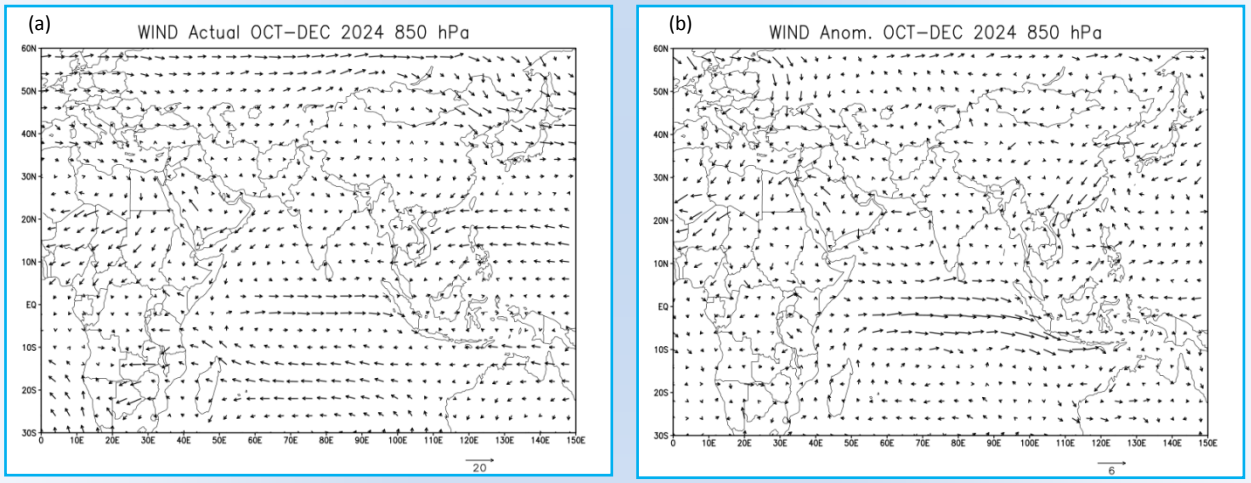
of Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Bihar, East Uttar Pradesh, Jammu & Kashmir and Ladakh and Chhattisgarh.

Cumulative SPI values of the past twelve months indicate extremely wet-severely wet conditions over parts of Arunachal Pradesh, Nagaland, Mani., Mizo. & Trip., Sub Himalayan West Bengal & Sikkim, Odisha, West U.P., Haryana, Chandigarh & Delhi, Jammu & Kashmir and Ladakh, Rajasthan state, Madhya Pradesh state, Gujarat state, Konkan & Goa, Madhya Maharashtra, Chhattisgarh, Telangana, Tamil Nadu, Coastal Karnataka and South Interior Karnataka, while extremely dry-severely dry conditions were observed over parts of Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Jharkhand, Bihar, Uttar Pradesh state, Punjab, Himachal Pradesh, Jammu & Kashmir and Ladakh, Marathawada and Chhattisgarh.

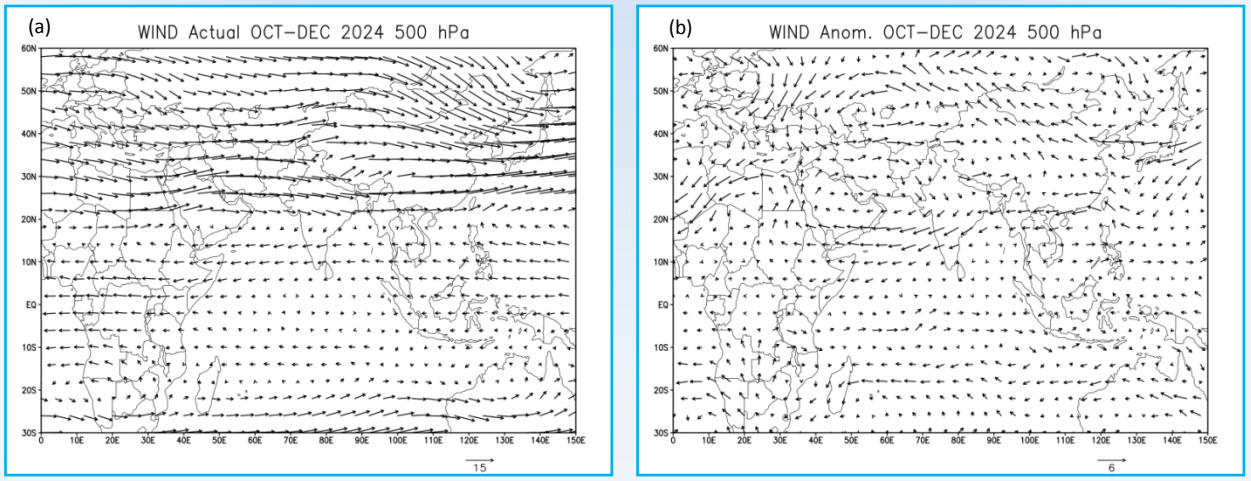
4.6. Pressure & Wind

Figs. 6(a&b) show the mean sea level pressure & its anomaly respectively.The pressure anomaly was negative over most parts of country, except some extreme northeastern parts. The negative pressure anomaly was within 0 to -1.0 hPa over most parts of the country.

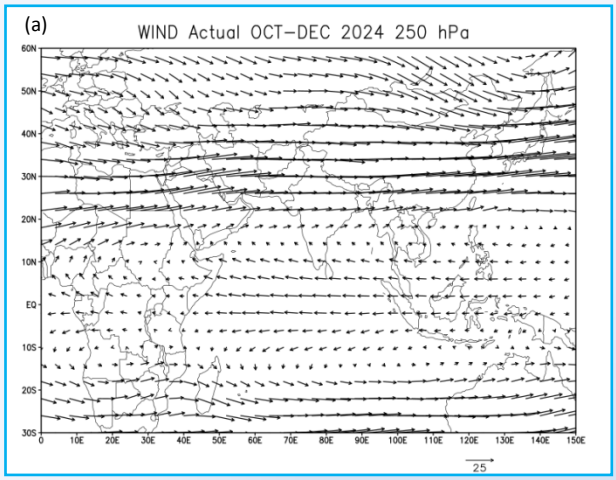
Figs. 7(a&b), 8(a&b) and 9(a&b), show the mean circulation pattern and its anomaly at 850, 500 & 250 hPa levels respectively. At 850 hPa level, an anomalous cyclonic circulation was observed over entire Arabian Sea. At 500 hPa level, an anomalous anti-cyclonic circulation was observed over north Arabian Sea and adjoining Indian region and west Asian region. This pattern was also seen at 250 hPa level also.



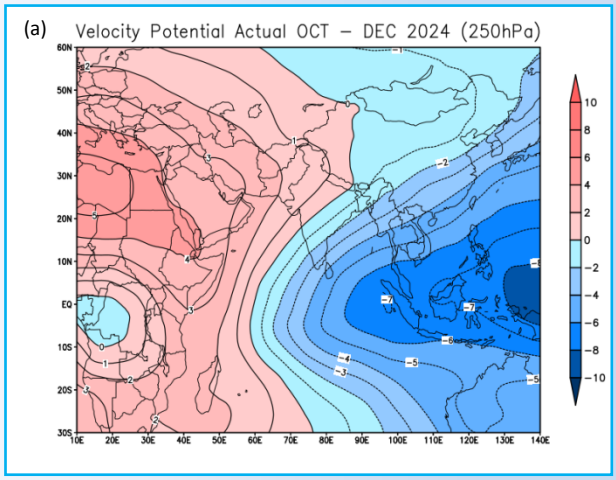
Figs. 7(a&b). Seasonal wind (m/s) for post-monsoon 2024 (a) mean (b) anomaly at 850 hPa (operational nwp analysis of IMD GFS T-574) (Anomaly is based on 2000-2018 Climatology, Source : NCMRWF)



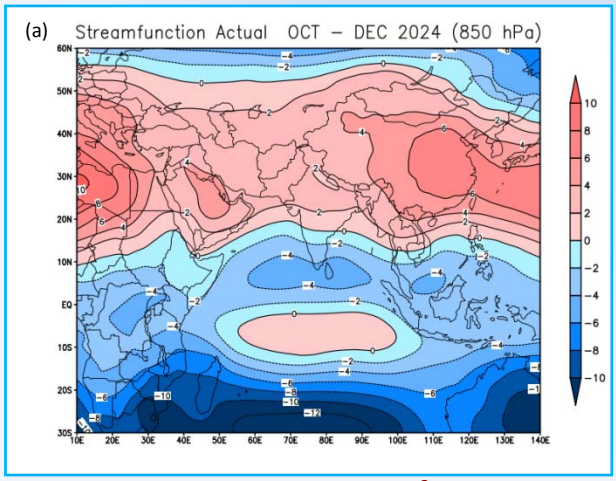
Figs. 8(a&b). Seasonal Wind (m/s) For Post-Monsoon 2024(a) Mean (b) Anomaly at 500 hPa (Operational NWP Analysis of IMD GFS T-574) (Anomaly is based on 2000-2018 Climatology, Source : NCMRWF)



Figs. 9(a&b). Seasonal wind (m/s) for post-monsoon 2024 (a) mean (b) anomaly at 250 hPa (operational NWP analysis of IMD GFS T-574) (Anomaly Is Based on 2000-2018 Climatology, Source : NCMRWF)



Figs. 10(a&b). Velocity Potential ($106m^2/s$) For Post-Monsoon 2024 (a) Mean and (b) Anomaly at 250 hPa (operational NWP analysis of IMD GFS T-574) (Anomaly is based on 2000-2018 Climatology, Source : NCMRWF)



Figs. 11(a&b). Stream function ($106m^2/s$) for post-monsoon 2024 (a) Mean (b) Anomaly at 850 hPa (Operational NWP analysis of IMD GFS T-574) (anomaly is based on 2000-2018 Climatology, Source : NCMRWF)

4.7. Velocity Potential & Stream Function

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

4.8. Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighborhood is shown in Fig. 12. During the season OLR anomaly was within normal range within ±10 W/m^2over most parts of the country and adjoining seas.

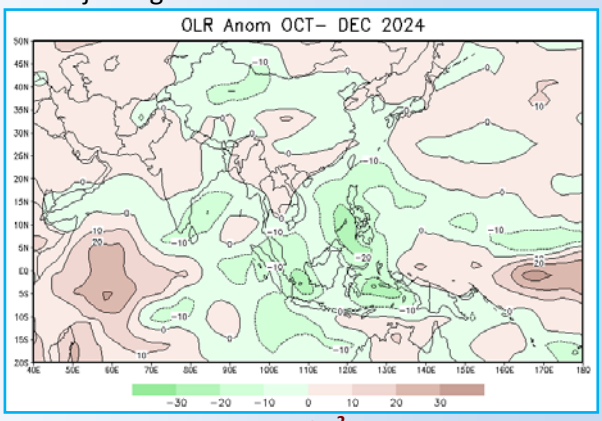


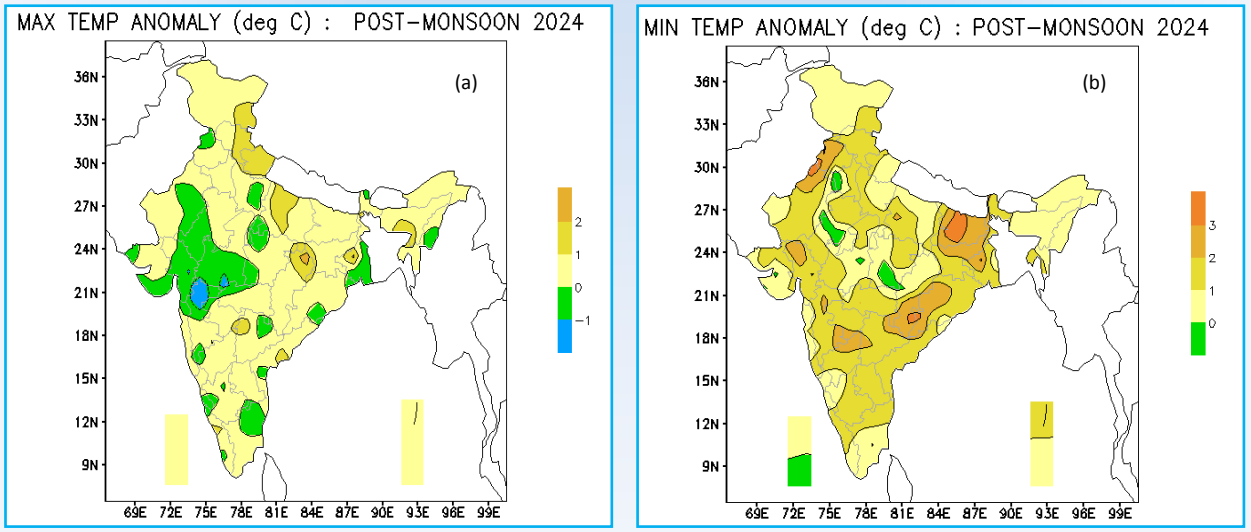
Fig. 12. OLR ANOMALY (W/m^2) FOR POST-MONSOON 2024 (DATA SOURCE : CDC / NOAA, USA) (BASED ON 1991-2020 CLIMATOLOGY)

4.9. Temperature

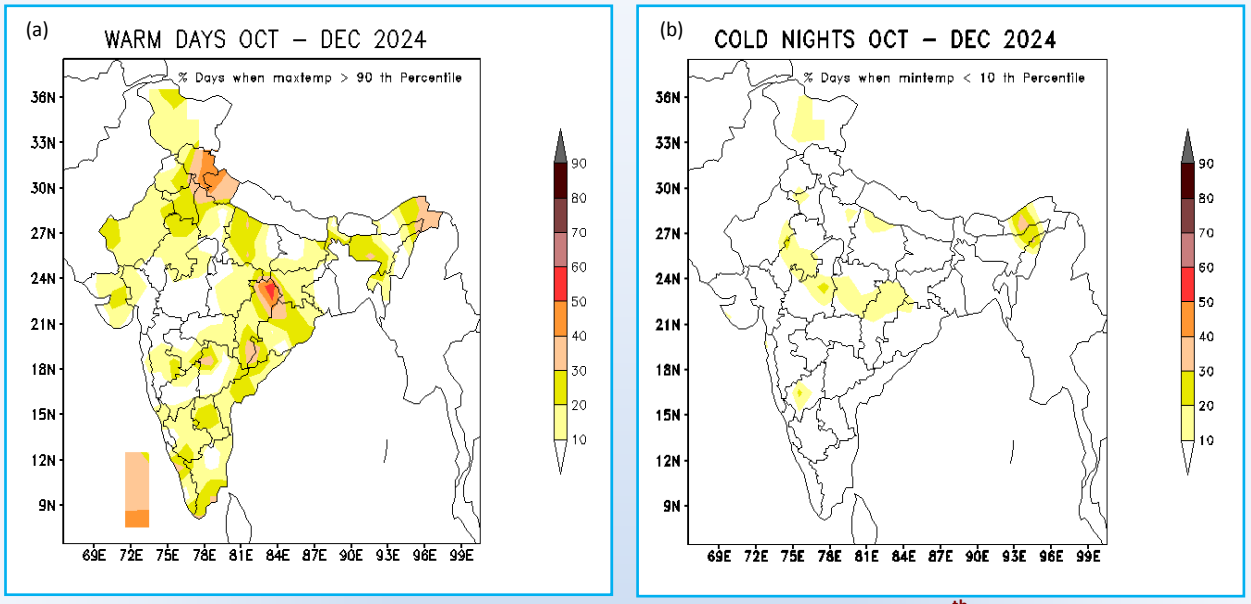
Mean seasonal maximum and minimum temperature anomaly is shown in Figs. 13(a&b) respectively.

Maximum temperature was above normal over most parts of the country except some parts of northwest India, central India and south peninsular India.Maximum temperature anomaly was more than 2°C over parts of northern Chhattisgarh. Maximum temperature anomaly was more than 1°C over parts of Ladakh, Himachal Pradesh, Uttarakhand, East Uttar Pradesh, Jharkhand, Chhattisgarh, Assam & Meghalaya, West Bengal state, Telangana, Coastal Andhra Pradesh & Yanam and Kerala & Mahe.

Minimum temperature was above normalover the country.Minimum temperature anomaly was more than 3°C over parts of extreme southwestern Punjab, northern West Rajasthan, Bihar and Chhattisgarh.Minimum temperature anomaly was more than 2°C over parts of Punjab, West Rajasthan, Gujarat region, Madhya Maharashtra, Bihar, Jharkhand, West Bengal state, Odisha, Chhattisgarh, Vidarbha, Marathawada, North Interior Karnataka, Coastal Andhra Pradesh & Yanam and Telangana.



Figs. 13(a&b). Mean seasonal temperature anomalies (°C) for post-monsoon 2024 (a) Maximum and (b) minimum (Based on 1991-2020 normals)



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

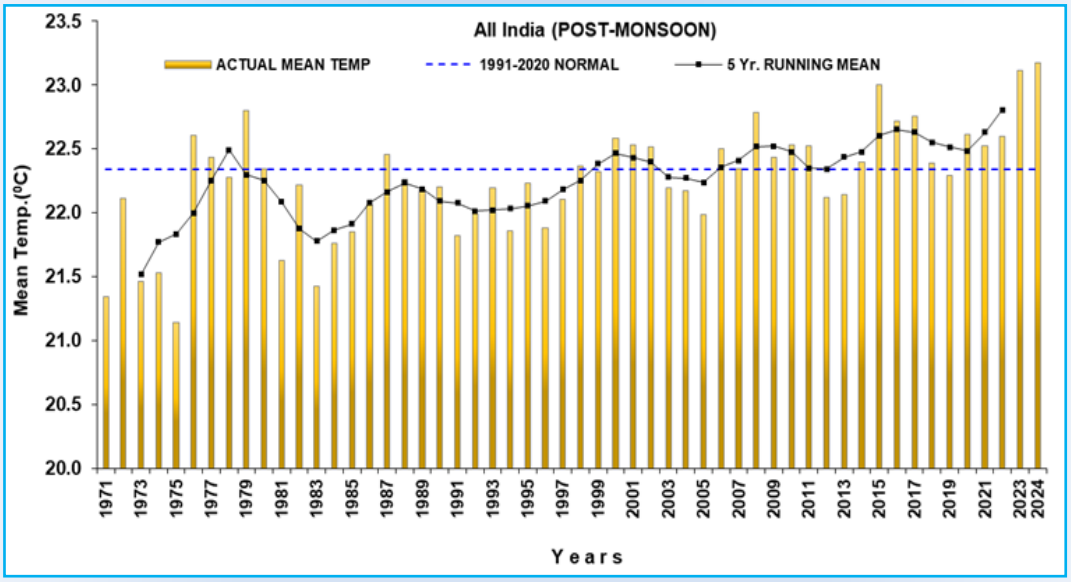


Fig. 15. Time series of mean temperature averaged over India (vertical bars and five-year running mean (continuous line) for the post-monsoon during the period 1971-2024

4.10. Percentage of Warm days/Cold nights

Figs. 14(a&b) show the percentage of days when maximum (minimum) temperature was more (less) than 90th (10th) percentile. During the season over parts of Uttarakhand, Himachal Pradesh, Chhatisgarh and Lakshdweep maximum temperature was greater than 90th percentile for more than 40% of the days of the season. For minimum temperature no such significant distribution was observed.

Fig. 15 the mean temperature time series for the country as a whole for Post-monsoon since 1971. Five year moving average values are also shown.The mean temperature for the season this year over the country as a whole was 23.17°C with an anomaly of 0.83°C and the highest since 1901. Among the four homogeneous regions, the mean temperature over Northwest India was the highest (19.83°C with an anomaly of 0.92°C), East & Northeast India, it was the 2nd highest (22.49°C with an anomaly of 0.93°C) after the year 2023

(22.67°C), South Peninsular India, it was also the 2nd highest (26.26°C with an anomaly of 0.78°C) after the year 2023 (26.50°C) and Central India, it was the 4th highest (24.60°C with an anomaly of 0.70°C) after the years 2015 (24.97°C), 1976 (24.72°C) and 1979 (24.63°C) since 1901.

Figs. 16(a&b) show, the maximum and minimum temperature series respectively for the country as a whole and the four homogeneous regions during Post-monsoon 2024 since 1971. Both the maximum and minimum temperatures were above normal over all the homogeneous regions and country as a whole. Among the four homogeneous regions, over East & Northeast India, the maximum was the 6th highest (27.79°C with an anomaly of 0.61°C) and the minimum temperature was the highest (17.19°C with an anomaly of 1.24°C) since 1901. Over Northwest India, the minimum temperature was the highest (13.00°C with an anomaly of 1.17°C), Central India, it was the 2nd highest (18.22°C with an anomaly of 1.33°C) after

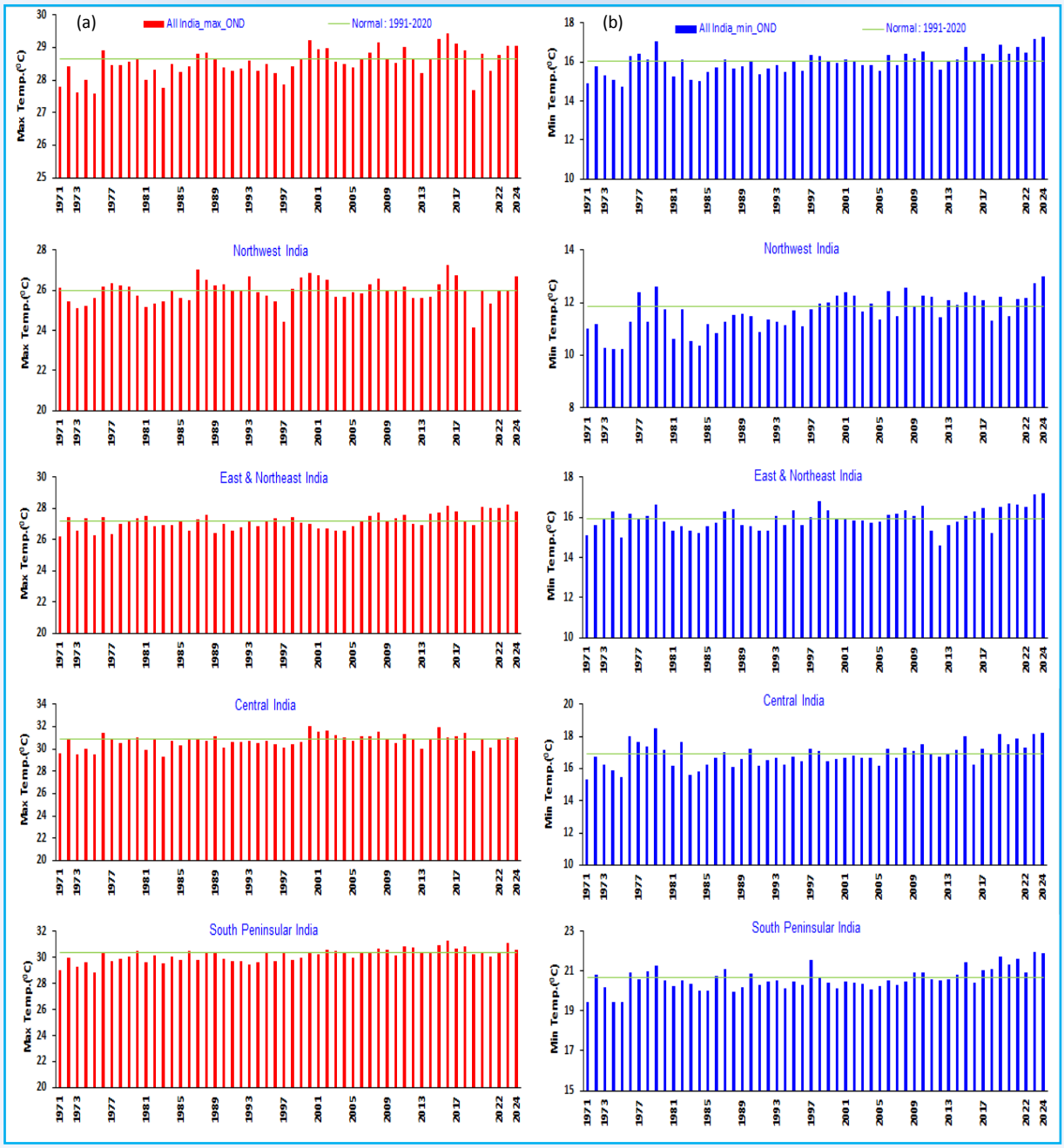


Fig. 16(a&b). Time series of temperature for the country as a whole and the four homogeneous regions for post-monsoon season ofthe period 1971-2024 (a) Maximum and (b) Minimum

the year 1979 (18.49°C) and South Peninsular India, it was also the 2nd highest (21.91°C with an anomaly of 1.26°C) after the year 2023 (21.94°C) since 1901.

Over the country as a whole the maximum temperature was the 6th highest (29.04°C with an anomaly of 0.40°C) and the minimum temperature was the highest (17.31°C with an anomaly of 1.26°C) since 1901.

4.11. Low Pressure Systems

During the post monsoon season, nine low pressure systems (1 SCS, 1 CS, 3 depressions, 2 well marked low pressure areas and 2 low pressure area) were formed. The frequency and place of origin of these low pressure systems formed over the Indian region during the post monsoon season is shown in the table below.

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

CS: Cyclonic Storm, **DD:** Deep Depression, **D:** Depression, **WML:** Well Marked low, **LPA:** Low Pressure Area

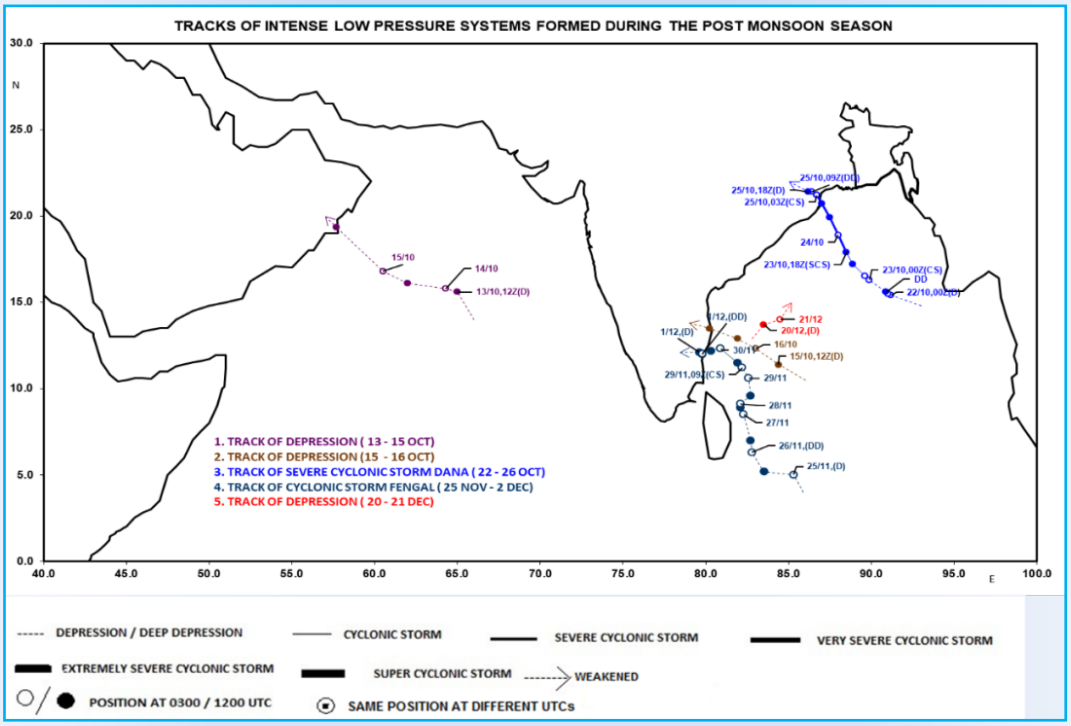


Fig. 17. Tracks of intense low pressure systems formed during post-monsoon season of 2024

During October three low pressure systems formed (one was severe cyclonic storm DANA during the period 22 – 26 October over Bay of Bengal and two were depressions one over Bay of Bengal during 15 – 16 October and another over Arabian Sea during the period 13 – 15 October). Besides these three intense low-pressure systems, a low-pressure area formed over the Bay ofBengal from 4 – 5 October and a well-marked low-pressure area formed over the Arabian Sea from 18 – 23 October.

During November 2024, cyclonic storm "**FENGAL**" formed over Bay of Bengal during 25 Nov – 2 Dec. Besides this cyclone a low pressure area formed over Bay of Bengal during 11 – 13 November.

During December one depression formed over Bay of Bengal during 20 – 21 December. Besides this depression a well- marked low pressure area formed over Bay of Bengal during 7 – 15 December. Fig. 17 shows tracks of these systems formed during season.

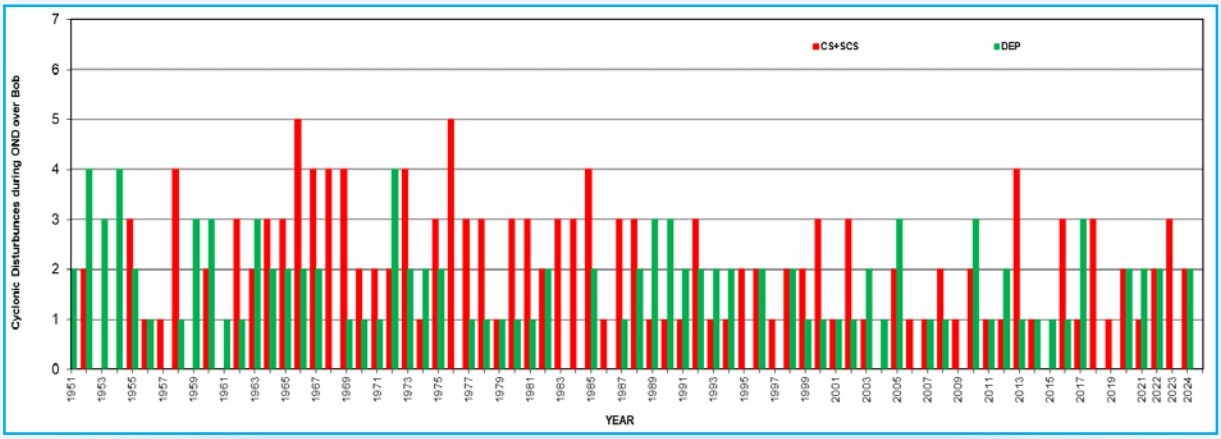


Fig. 18. Time series of frequency of depressions/cyclonic storms formed over Bay of Bengal during the post monsoon season Oct-Dec (1951- 2024) (Source : Cyclone eAtlas RSMC IMD New Delhi) based on real time data

Fig. 18 shows the number of depressions & storms formed over Bay of Bengal during the post - monsoon season (1951-2024).

4.12. Significant Weather Events during Post Monsoon Season 2024

During Post Monsoon Season, total 94 persons reportedly died, more than 55 persons injured & about 70 livestock perished. The details of causalities given below, which are based on real time media reports. Fig. 19 shows deaths due to significant weather events during Post Monsoon Season (October-December) 2024. (Based on real time media reports).

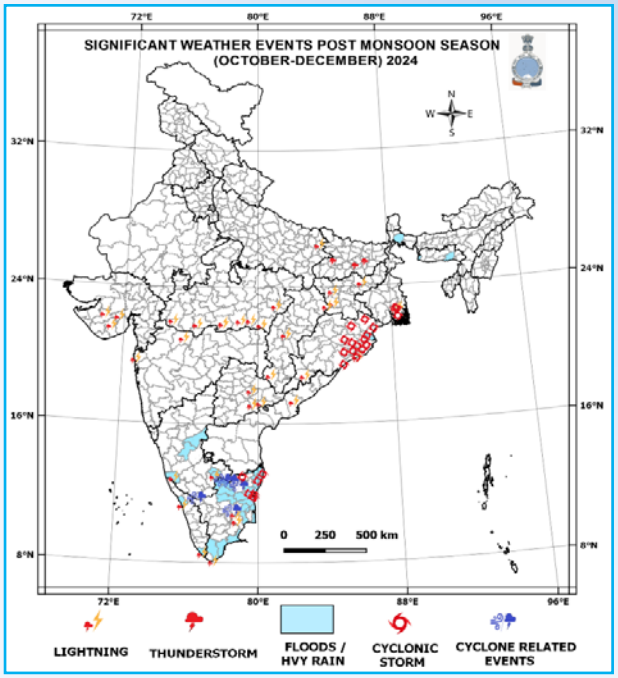


Fig. 19. Significant weather events during post-monsoon season 2024 (Based on real time media report)

4.13. Heavy Rains, Floods & Landslide

Total 22 persons reportedly died, 10 persons injured, during Post Monsoon season, because of heavy rains, floods & Landslides.

4.14. Thunderstorm

Total 3 persons reportedly died, during Post Monsoon season, because of Thunderstorm.

4.15. Lightning

Total 50 persons reportedly died, more than 45 persons injured & more than 45 livestock perished, during Post Monsoon Season, because of Lightning.

4.16. Cyclonic Storm

Total 19 persons reportedly died, & 23 livestock during Post Monsoon Season, due to the Severe Cyclonic Storm DANA (22 October to 26 October) and Cyclonic Storm FENGAL (25 November to 2 December).

4.17. Hailstorm

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

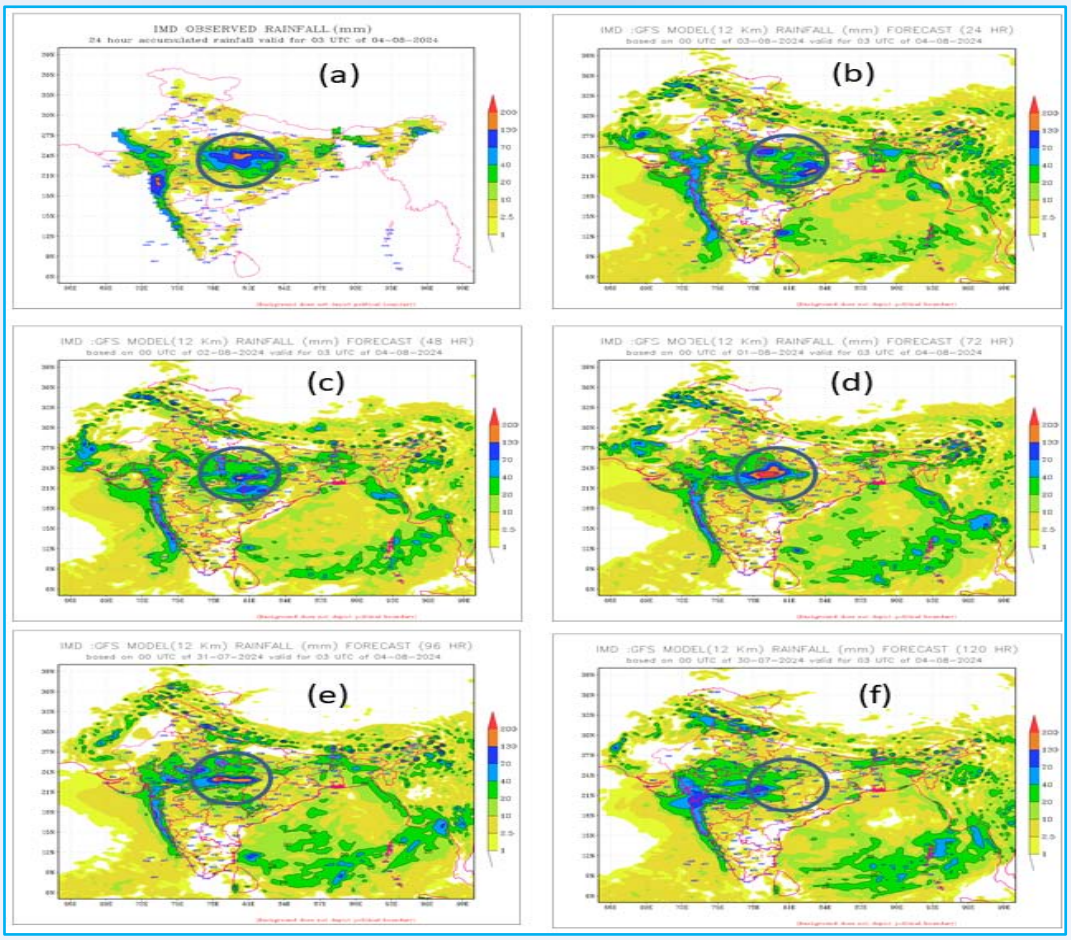
CHAPTER 3

NUMERICAL WEATHER PREDICTION

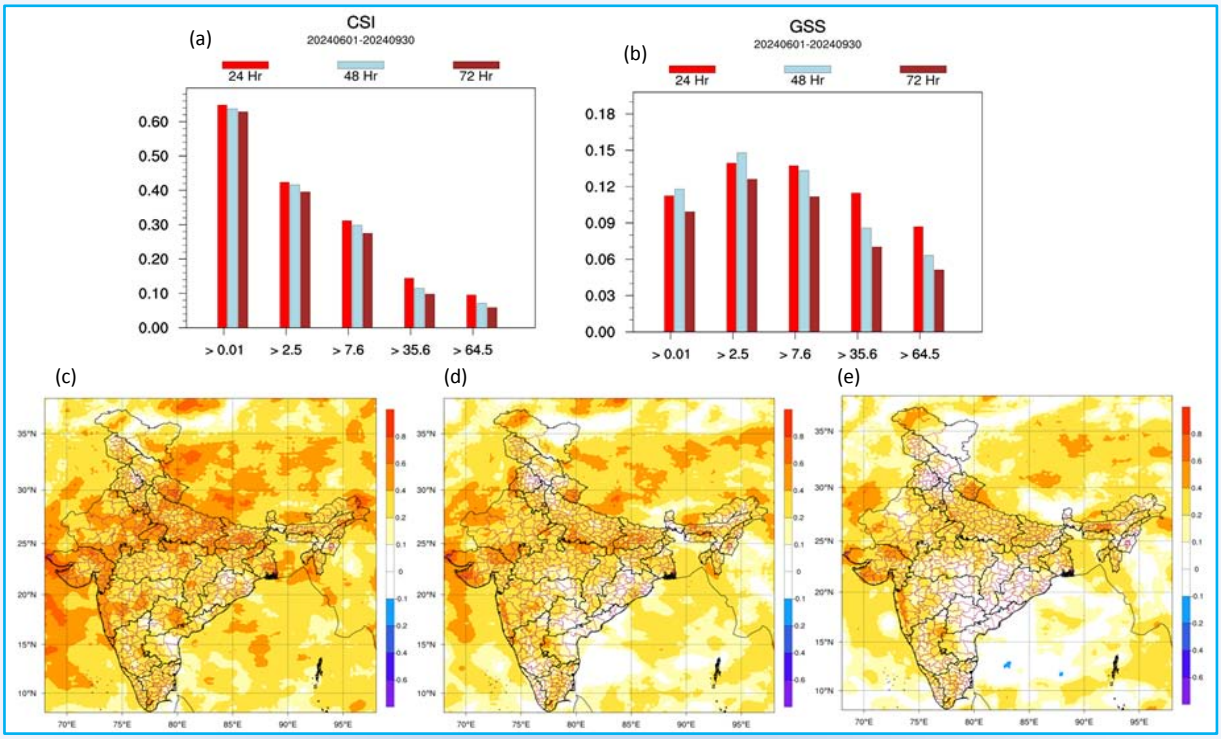
3. Global and Regional Modelling (NWP)

3.1. Global Forecasting System

Global Forecasting System (GFS T1534L64) model is run operationally at India Meteorological Department (IMD) four times in a day (0000, 0600, 1200 & 1800 UTC) to give deterministic forecast in the short to medium range upto 10 days. The forecast model has a resolution of approximately 12 km in horizontal and has 64 levels in the vertical. The initial conditions for this GFS model is generated from the four-dimensional (4D) ensemble-variational data assimilation (DA) system (4DEnsVar) building upon the grid point statistical interpolation (GSI)-based hybrid Global Data Assimilation System (GDAS) run on High Performance Computing Systems (HPCS) at National Center for Medium Range Weather Forecasting (NCMRWF). The real-time GFS T1534L64 model outputs are generated daily at IMD. This 4DEnsVar data assimilation system has capabilities to assimilate various conventional as well as satellite observations including radiances from different polar orbiting and geostationary satellites. The real-time outputs are made available to operational weather forecasters and various users through the national web site of IMD. Fig. 1 shows the forecast and observed heavy rainfall event of 4th August, 2024 during south west monsoon 2024.



Figs. 1(a-f). (a) IMD Observed rainfall for 04th August, 2024 and IMD-GFS forecast for (b) 24 hours, (c) 48hours, (d) 72 hours, (e) 96 hours and (f) 120 hours valid for 4th August, 2024



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

TABLE 1

Coupled HWRF-HYCOM Track and intensity forecasts Error Statistics for cyclone DANA

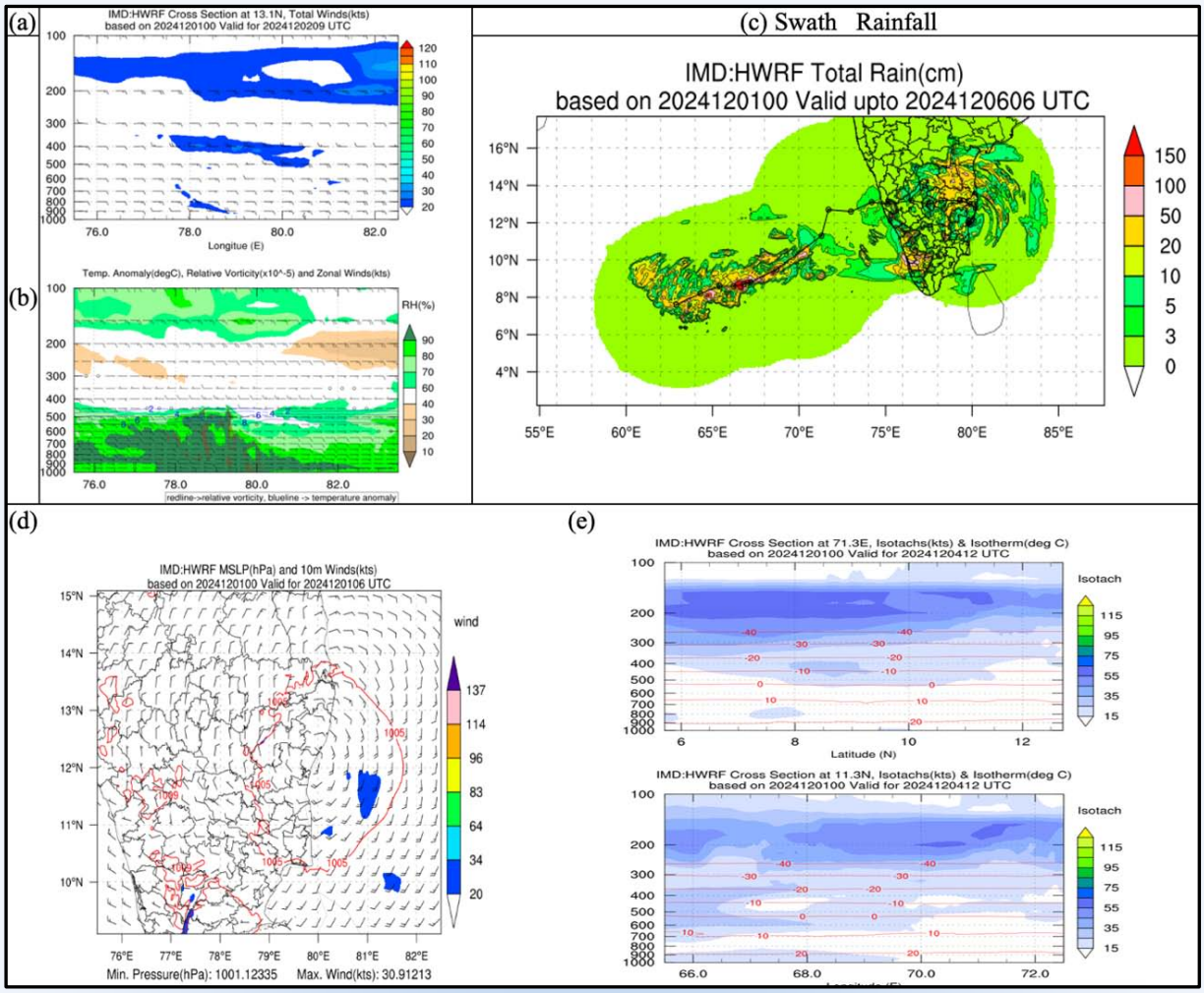
Lead Time Errors	12 Hr	24 Hr	36 Hr	48 Hr	60 Hr
Direct Position Errors (DPE) (km)	32	40	51	55	118
Along Track Errors (AT) (km)	-69	-69	-63	-42	-55
Cross track Errors (CT) (km)	4	17	14	9	28
Landfall Point Errors (km)	11	16	145	NA	NA
Landfall Time Errors (hr)	-1	3	-6	NA	NA
Average Absolute Intensity Errors (AAE) (kts)	9	8	6	14	12
Root Mean Square Intensity Errors (RMSE) (kts)	11	8	8	19	16

3.2. WRF model

During southwest monsoon season 2024, the WRF model (ARW) delivered three days forecasts at 3 km horizontal resolution four times daily at 0000, 0600, 1200 and 1800 UTC with hourly interval. The data assimilation component, regional GSI (Global Statistical Interpolation) takes global GFS analysis and all other conventional quality-controlled observations as its input and generates mesoscale analysis at 3 km resolution. The model produced forecasts over a domain spanning about 5° S to 41° N in north-south and 49° E to 102° E in east-west directions respectively. Fig. 2 portrays skill scores (a) critical success index and (b) Gilbert skill scores for different rainfall thresholds whereas lower row exhibits seasonal averaged spatial correlation coefficient for (c) 24 hours, (d) 48 hours and (e) 72 hours rainfall forecasts with observation.

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

During pre-monsoon and post-monsoon cyclone seasons of 2024, the movable triple nested HWRF-

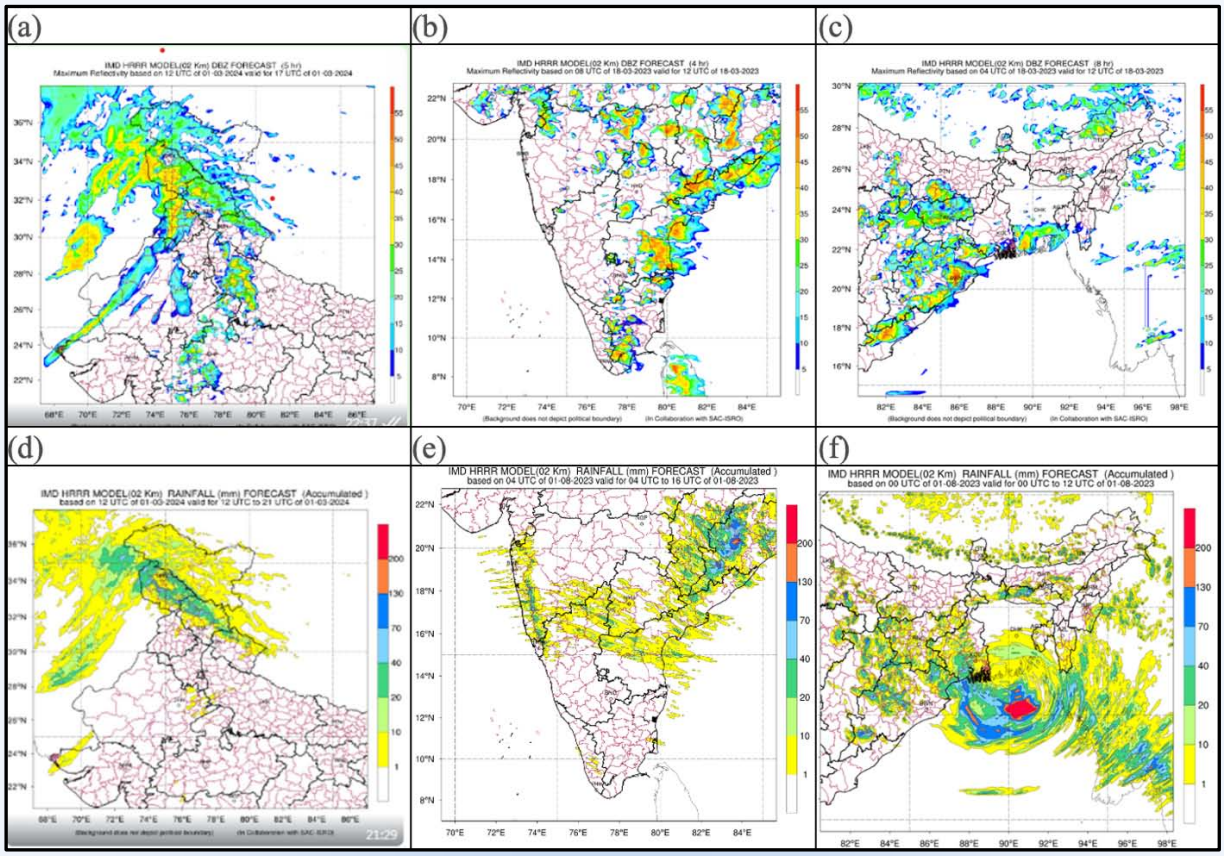


Figs. 3(a-e). SCS DANA Zonal Cross-section of (a) Total wind & (b) Humidity and temperature, (c) Swaths of Rainfall (d) 10m wind and MSLP of 2 km core domain and (e) X-Sect : Isotherm and Isotachs

Ocean (HWRF/POM-TC) coupled model with horizontal resolutions of 18 km, 6 km and 2 km delivered five days forecasts four times a day at 0000 UTC, 0600 UTC, 1200 UTC and 1800 UTC for tropical cyclones formed over north Indian Ocean (NIO). The data assimilation component of HWRF, regional GSI Data Assimilation, generated mesoscale analysis for intermediate and innermost nests which are then merged to generate analysis for all three domains. The model parent domain (18 km horizontal resolution) remained stationary whereas the intermediate domain (6 km horizontal resolution) and the inner most domains (2 km horizontal resolution) moved to track the storm centre. The verification (error) score for SCS DANA formed during 2024 is presented in Table 1. The Fig. 3 represents the different product generated from operational HWRF-HYCOM coupled model for the Cyclonic Storm (CS) FENGAL during November 2024.

3.4. High Resolution Rapid Refresh (HRRR) MODEL

The HRRR model is based on Weather Research and Forecasting (WRF) Model's ARW core and takes the initial and boundary condition from the IMD-GFS global model. Utilising the WRF Data Assimilation system (WRF-DA), the RADAR data is assimilated in HRRR model every 10-15 min over a 1-h period. The HRRR is hourly updated, cloud-resolving, convection-allowing atmospheric model, with horizontal resolution of 2km and provides reflectivity and rainfall forecast for next 12 hours. The HRRR model is run in cyclic mode every hour for three domains covering entire mainland of India viz. North-West Domain, East & North-East Domain and South Peninsular India domain and forecast products are updated on the NWP website after every two hours. The forecast product from HRRR model is shown in Fig. 4.



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

3.5. Extended Range Forecasts

A coupled model with a suite of models from CFSv2 coupled model has been developed, implemented, and operationalized in IMD in 2017 for generating operational Extended Range Forecast products for different users. This suite of models are (i) CFSv2 at T382 (≈ 38 km) (ii) CFSv2 at T126 (≈100 km) (iii) GFSbc (bias corrected SSTfrom CFSv2) at T382 and (iv) GFSbc at T126. The Multi-model ensemble (MME) of the above suite is run operationally for 32 days based on every Wednesday initial condition with 4 ensemble members to give forecast for 4 weeks for days 2-8 (week1; Friday to Thursday), days 09-15 (week2; Friday to Thursday), days 16-22 (week3; Friday to Thursday) and days 23-29 (week4; Friday to Thursday). The observed weekly rainfall departure over India during monsoon 2024 indicating the weak phase in June, middle of July, middle of August and middle of September are shown in Fig. 5. The corresponding weekly rainfall anomalies in forecast are also shown in Fig. 5. As it is seen from Fig. 5 the model could capture these active

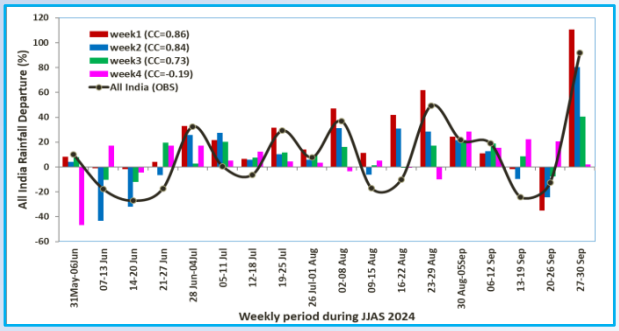
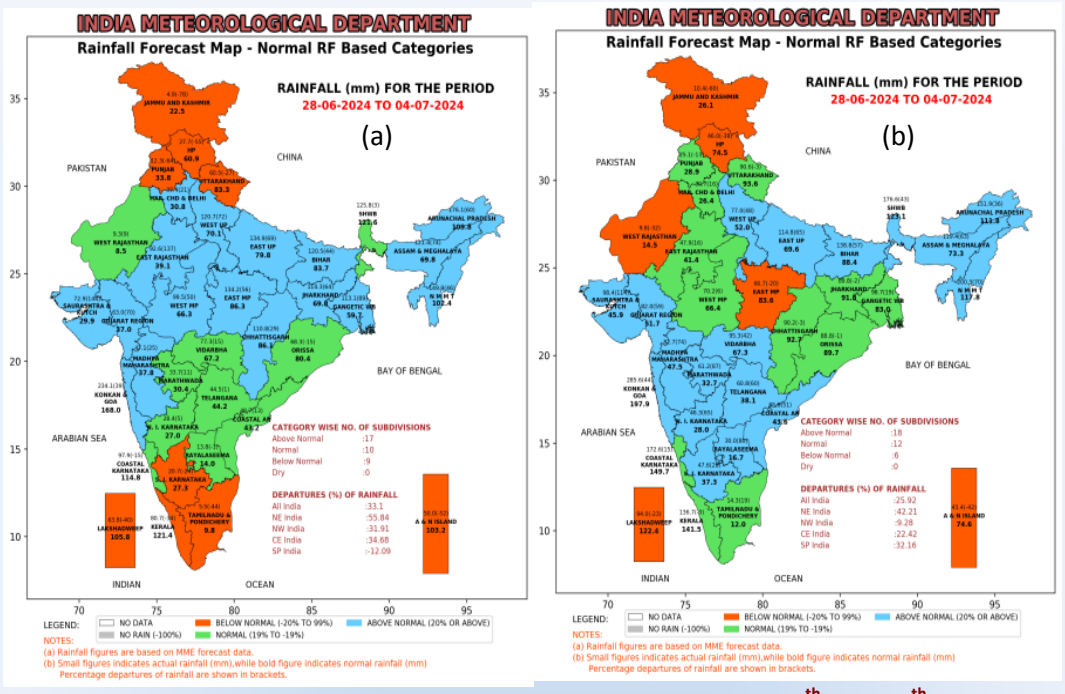


Fig. 5. Weekly observed and forecast rainfall departure during the monsoon season 2024 with 4 weeks lead time

phases of monsoon along with the normal monsoon periods. However, the weak phase of monsoon in middle of July and 2nd week of August were not very well captured as the model slightly over predicted the actual departure of rainfall. On smaller spatial scales (homogeneous regions and met subdivision levels) the forecast shows useful skill up to two weeks. On met subdivision level the category forecasts up-to two weeks are being used for agro-advisory purpose.



Figs. 6(a&b). Met-subdivision wise forecast for target week 28th June - 4th July (a) week 1 forecast based on 26th June, 2024 IC and (b) week 2 forecats based 19th June, 2024

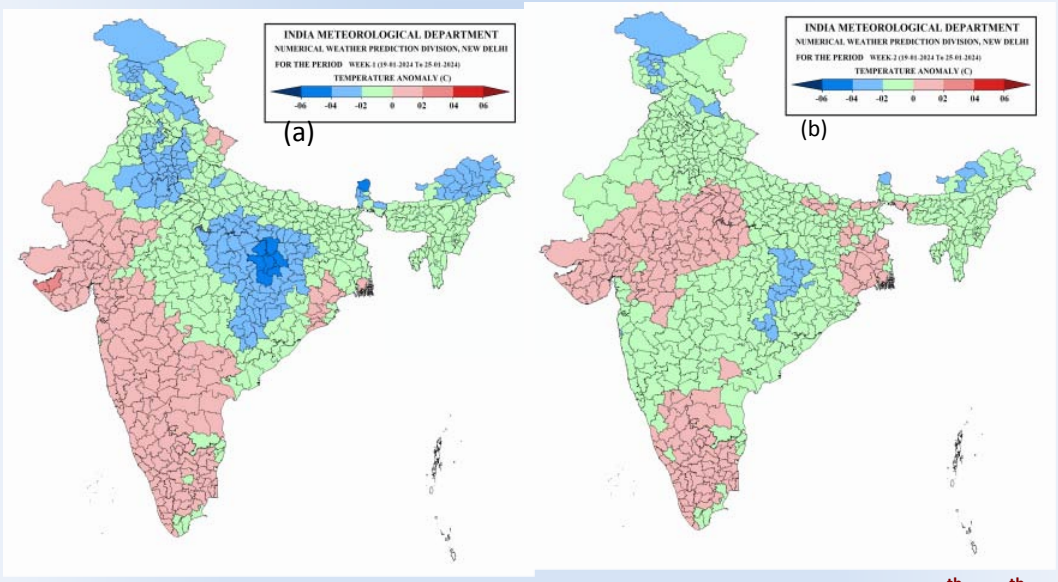


Fig. 7. Shows the District wise minimum temperature anomaly forecast for target week 19th - 25th January (a) week 1 forecast based on IC (17th January) and (b) week 2 forecast based on IC (10th January, 2024)

For agromet applications forecast for 36 met subdivisions of India is prepared for two weeks with categorising the subdivisions as below normal, normal, or above normal category depending on the rainfall departure during the week. The two weeks forecast on met-subdivision level is widely used for application in Agriculture for farmers' advisory. The active phases of monsoon for the target weeks of 28th June - 4th July 2024 with two weeks lead time is shown in Figs. 6(a&b). The transition of monsoon from above normal to below normal is well captured in the extended range forecast, which is being used widely for Agromet advisory purpose.

3.6. Districts level extended range forecast

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

Agriculture and veterinary sector (The winter frost forecast and extreme low temperature will be used

for crop advisory; high temperature for veterinary sector like poultry firm will be used)

Water sector/Disaster management (The ERF forecast of active and break phases of monsoon, heavy rainfall, severe weather like cyclone etc will be generated for application in hydrological models and reservoirs operations).

Health sector (indices like heat index, transmission windows for vector borne diseases, cold wave etc will be generated for services in health sector).

Energy sector (The extreme high and low temperature forecasts products are being generated for potential use in power/energy sector) as shown in the Fig. 7.

3.7. Verification of Multi-Model Ensemble (MME) and individual model Forecasts using Observations from Buoys and Ships

The NWP division of IMD generates MME products to support marine weather services. These products are operationally available to forecasters and serve as critical guidance tools for providing forecasts to the marine community. The MME products include computations for 10-meter wind, visibility, weather conditions and sea state.

Forecast data from five global operational models-Global Forecast System (GFS), Global Ensemble Forecast System (GEFS), Japan Meteorological Agency (JMA) model, National Centers for Environmental Prediction (NCEP) model and the National Centre for Medium Range Weather Forecasting (NCMRWF) Unified Model (NCUM)-are utilized daily for up to seven days. Both individual model outputs and MME-based graphical products are generated twice daily, based on 0000 UTC and 1200 UTC data and updated on the IMD website to aid in marine forecasting and bulletin preparation.

The MME forecast wind speeds are visually represented with a color-coded scheme that indicates various wind speed ranges according to the legend. These visualizations extend to a seven-day forecast and are valuable tools for operational forecasters. Observational data are also incorporated, with buoy wind speed and direction displayed as blue wind bars and ship observations shown as black wind bars. Fig. 8 provides an example of the Day-1 MME forecast overlaid with real-time buoy and ship observations.

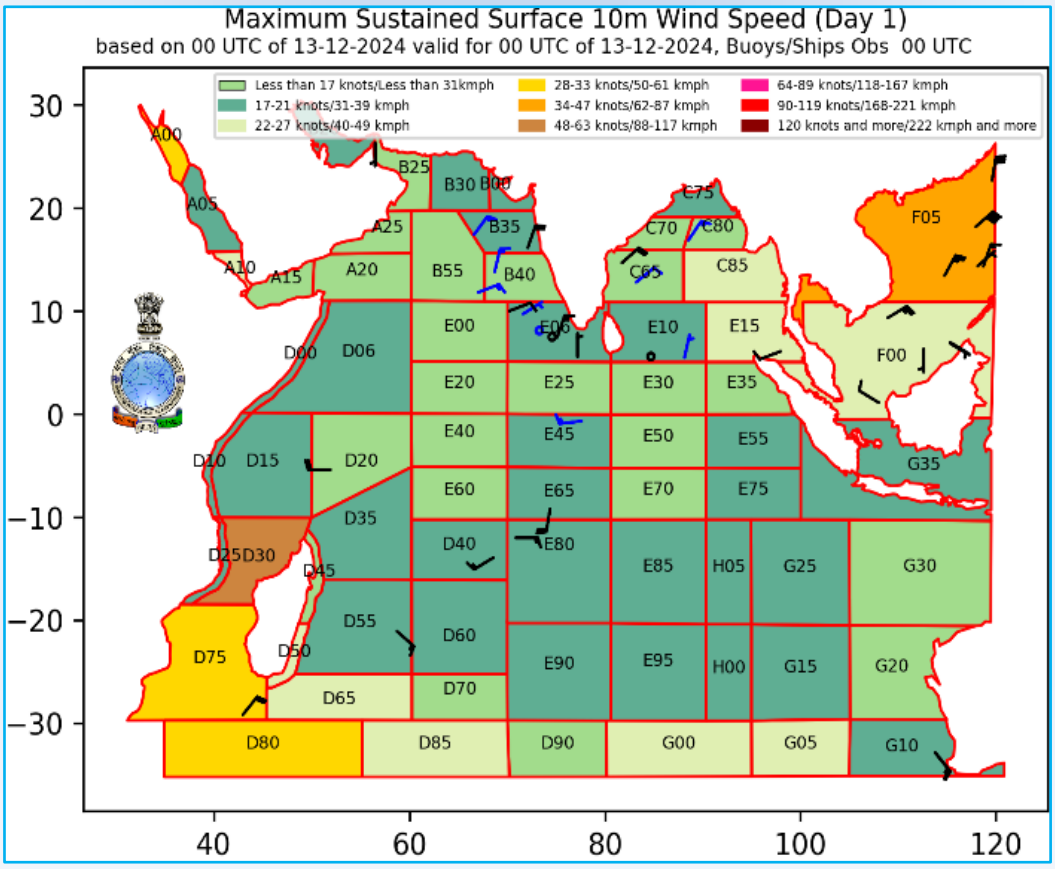


Fig. 8. Extended Fleet Forecast domain including buoys and ships observation for day 1 forecast

3.8. The real-time verification of individual models for forecasts up to five days is carried out using buoy observations

Forecasts from individual models, generated daily at 0000 UTC and 1200 UTC, are validated against observations from buoys and ships. The figure below provides valuable information for forecasters, serving as a guidance tool to identify and assess biases in the individual models and incorporate value-added adjustments into the final forecasts. The comparison highlights that individual models exhibit larger errors compared to buoy observations, emphasizing the need for logarithmic correction when comparing model-derived 10m wind speeds. Similarly models wind speed data also validated with respect to the ships observation. The comparison shows that wind speed from the ships observation has large bias compare to the individual models. The error for 00 UTC based models vsbuoys and ships observation are shown in the below Fig. 9.

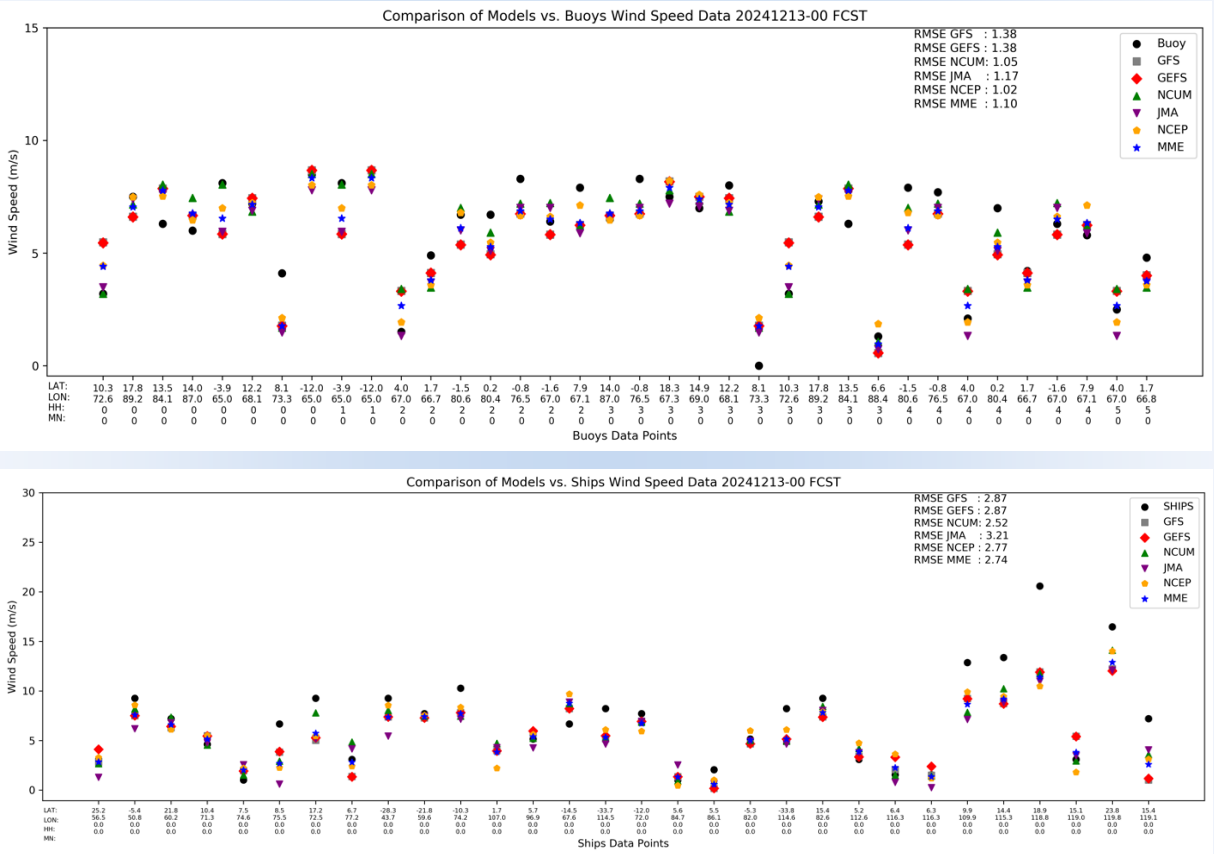


Fig. 9. Root mean Square error of the individual model, MME vs buoys (black dots) and ships (black dots)

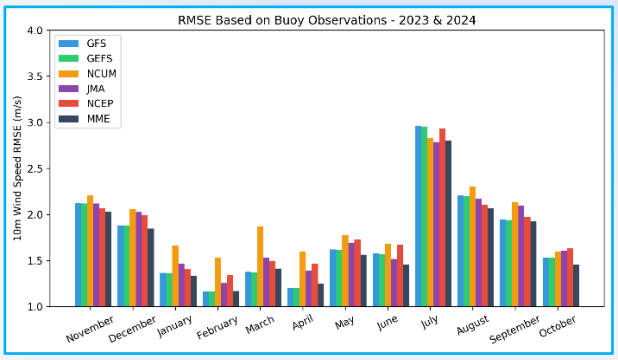


Fig. 10. Representing the monthly 10m wind speed root mean square error (m/s) for the individual models with respect to buoys observation

3.9. Monthly Models Verification Based on Buoys Observation

Fig. 10. shows the monthly statistical computations of models based on buoy observations. Daily data for the months as per x-axis are used to calculate the RMSE and this same data is made available to forecasters in real-time for specific locations of buoys. The figure conveys crucial information to forecasters, indicating that MME products offer greater reliability compared to individual models. This is further emphasized in the RMSE, where the

black-colored MME exhibits lower errors in comparison to any individual model.

3.10. Scatter plot of individual models with respect to the buoys observations

The scatter plot analysis of 10m wind speed models against observations reveals crucial insights into their performance as show in Fig. 11. Points along the 45-degree line (dark black dotted line) indicate perfect agreement, serving as a benchmark for model accuracy. Clusters around this line signify accurate predictions, while deviations above or belowsuggest positive or negative biases, respectively. The spread of points reflects variability in model performance, with a tight cluster indicating consistency and accuracy. Comparative analysis between models highlights those with consistent biases and the Multi-Model Ensemble (MME) can be assessed against individual models. In summary, the scatter plot visually captures agreement, biases and variability,

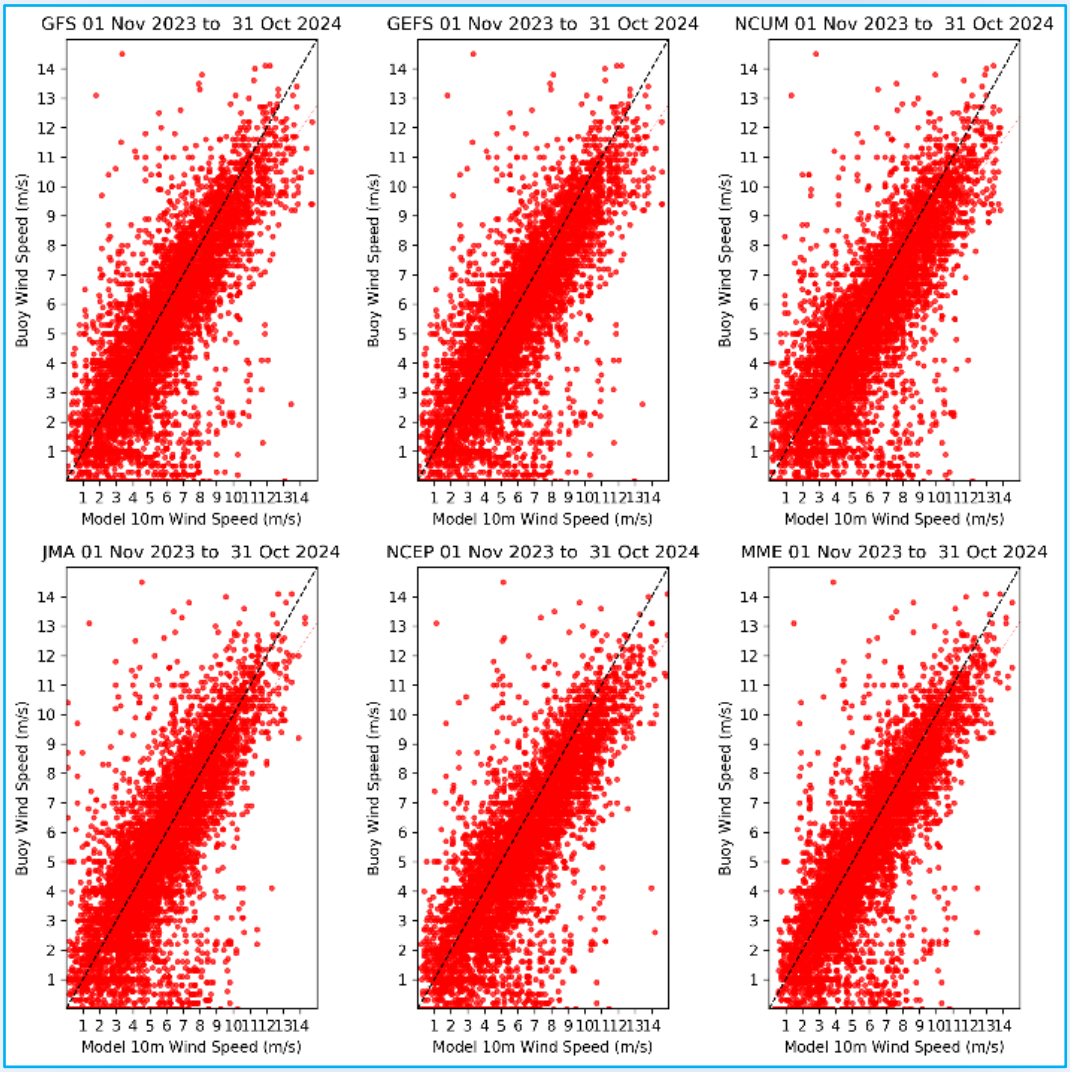


Fig. 11. Representing the scatter plot for 10m wind speed root mean square error (m/s) for the individual models with respect to buoys observation

offering valuable information for model evaluation and enhancement strategies. In addition, incorporating a regression line with its corresponding R-squared value and slope enhances the scatter plot analysis, providing a quantitative measure of the relationship between model predictions and observations. Most red dots lie to the right of the lines, indicating a model overestimation bias. MME exhibits less bias, and a narrower spread compared to other models. Also, the higher R-squared value observed for the Multi-Model Ensemble (MME) in the scatter plot

indicates a stronger correlation between the ensembles predictions and buoy observations.

3.11. Monthly Models Verification Based on Ships Observation

Fig. 12. shows the monthly statistics of models based on ships observations. Daily data for the months as per x-axis are used to calculate the RMSE for each locations of ships. The figure conveys that MME products offer greater reliability compared to individual models. This is further emphasized in the RMSE, where the black-colored MME exhibits lower errors in comparison to any individual model.

3.12. Scatter plot of individual models with respect to the ships observations

The Scatter plot in Fig. 13. illustrate the ships vs models (GFS, GEFS, NCUM, JMA, NCEP and MME) wind speed. The points in red dots above the black

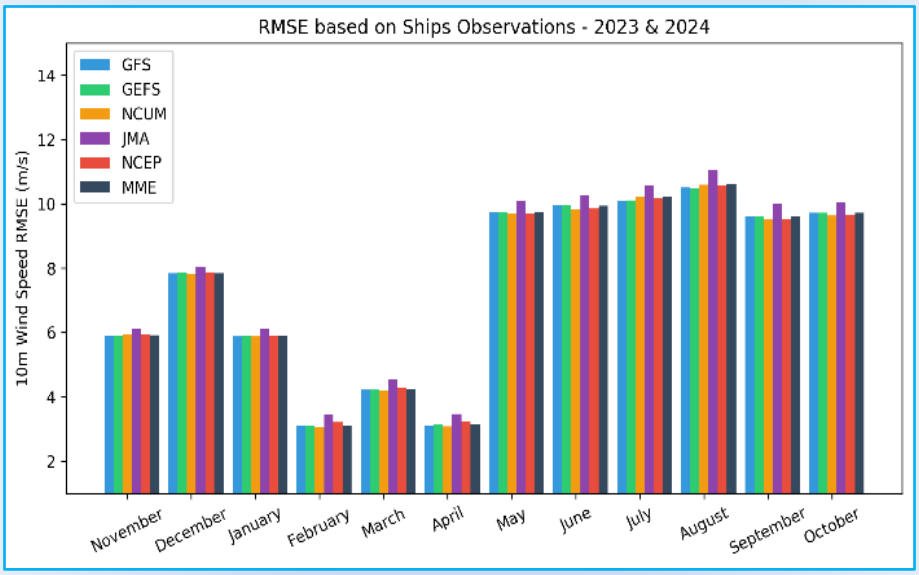


Fig. 12. Representing the monthly 10m wind speed root mean square error (m/s) for the individual models with respect to ships observation

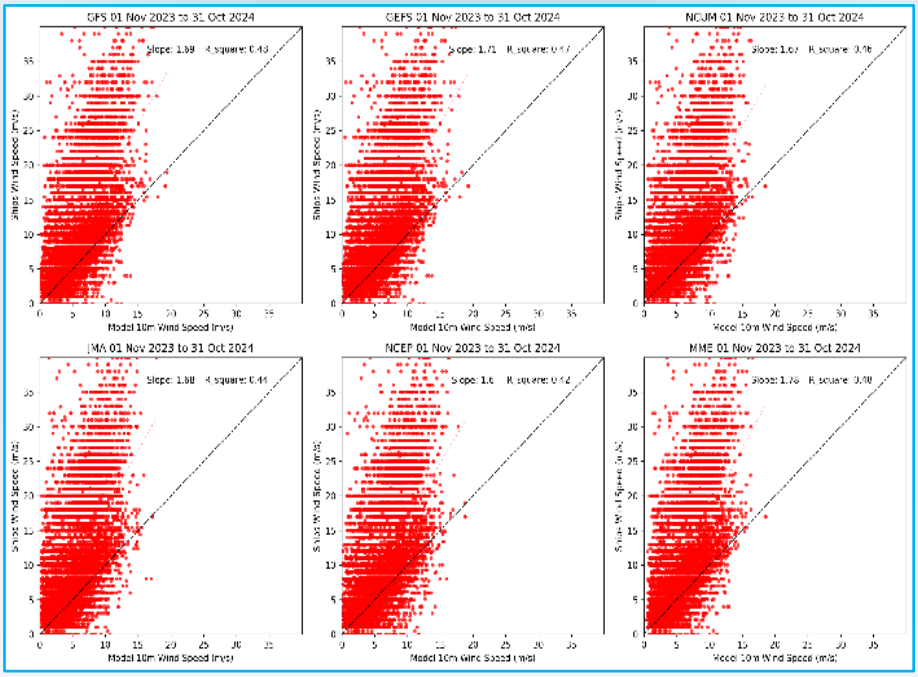


Fig. 13. Representing the monthly 10m wind speed root mean square error (m/s) for the individual models with respect to buoys observation

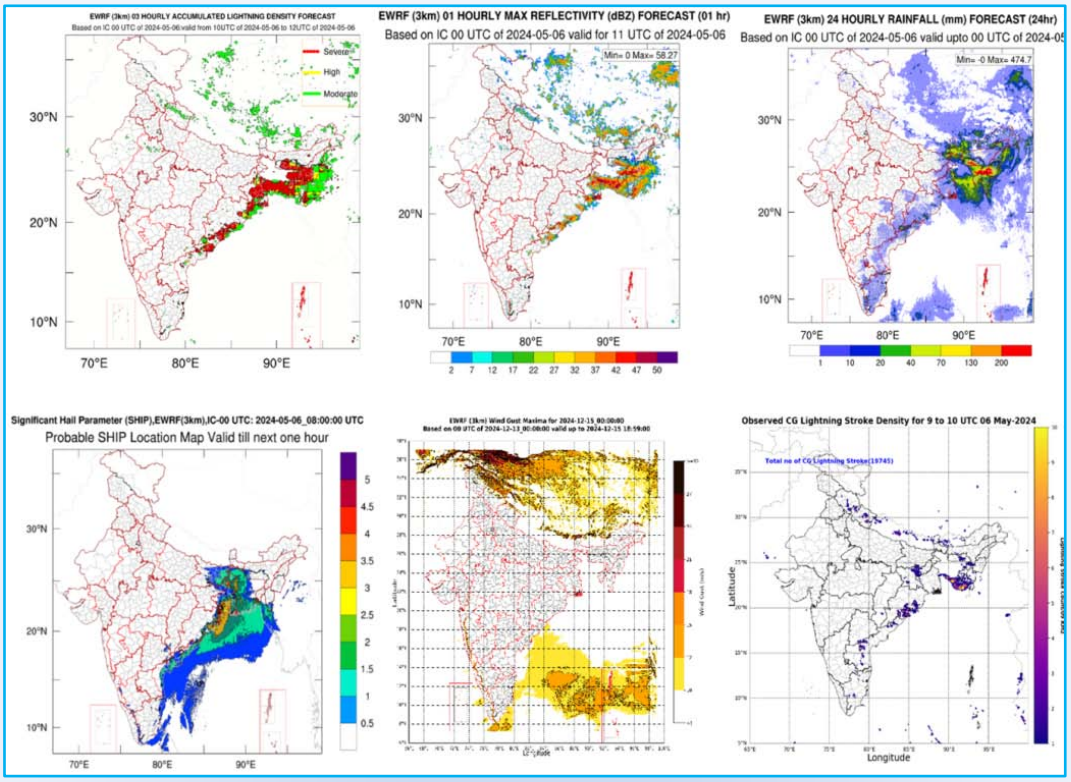


Fig. 14. EWRF simulated (top left to right) Lightning Flash Origin Density, Max Reflectivity, Rainfall and (bottom left to right) Significant Hail Parameter (SHIP), Wind Gust, and Observed Lightning density products

dotted line suggest model underestimation, while points below imply overestimation. The spread around the line signifies variability in model performance. In below figure, most red dots lie to the left of the regress line (light red), indicating a model under estimate the observed values. In other words, the model predicts lower values than what is observed via ships. MME exhibits less bias and a narrower spread compared to other models.

3.13. Electric WRF (E-WRF) Operationalization

Recently during March 2022, IMD NWP division has operationally implemented the model EWRF. Presently three different products (Lightning Flash Density, Max Reflectivity and Hourly rainfall) from the Electric-WRF model have been updated in the IMD NWP internal website on the experimental basis for the kind feedback of forecasters. In the E-WRF modelling system, ground-based lightning flash rate has been assimilated for the improvement of the model forecast.

The details of these products available in the NWP website (https://nwp.imd.gov.in/) are depicted below. Recently, IMD has extended the model forecast for 72 hours for 0000 UTC run. The 1200 UTC run is still forecasted for next 36 hours. Each run utilizes the latest lightning data assimilation that helps to improve the forecast effectively.

Early Run is based on the 0000 UTC IMD-GFS initial conditions with the validity of the forecast being for 72 hours at hourly intervals. The Early run products will be available on the website around 0500-0530UTC (10:30 to 11:00 IST onward).

Second run is based on the IMD-GFS 1200 UTC initial condition with the validity of the forecast being for 36 hours at hourly intervals. The Third run products will be available on the website around 1730 UTC (11:00 to 1200 IST; midnight).

This Electric WRF model is based on the proper and explicit cloud electrification physics mechanism through which the model generates the electric field over the different grid points of the domain. This electrification mechanism has separate charging and discharging schemes based on different laboratory experiments. In the charging mechanism, Inductive and no-inductive processes have been introduced. Few plots of the products are given below for the understanding of the forecasters (Fig. 14).

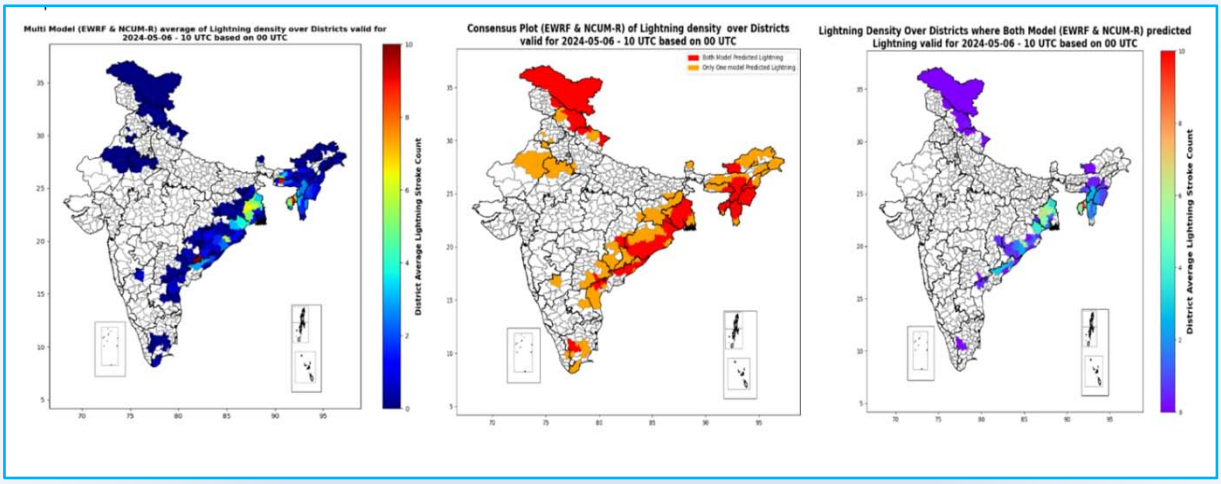


Fig. 15. Multimodel average Lightning count (MMA) over districts of India based on EWRF and NCUM-R model lightning flash count. (left to right) left most plot in Multi model average of lightning count over Districts, middle plot is the consensus plot to show how many models predicted lightning over Districts and right most plot is lightning density over districts where both models indicated lightning

IMD also introduces district wise hourly Multi Model Average of lightning count. Presently, we are using EWRF and NCUM-R models are utilizing for generating the district wise multi model average lightning count. Hourly basis we are generating Multi Model average over all districts of India daily two times 0000 UTC and 1200 UTC based for next 24 hours. We will soon implement the Multi model average for 72 hours for all districts of India (Fig. 15).

3.14. Wind Speed Probabilities

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

3.15. Multi Model Ensemble Tropical Cyclone Tracker

ECMWF IFS TC Tracker: The European Centre for Medium-Range Weather Forecasts (ECMWF) developed the Integrated Forecasting System (IFS) model for the global numerical weather prediction at medium range timescale and developed Tropical Cyclone tracker (IFS-TC-Tracker).

The ECMWF IFS-TC-Tracker source code has been modified by the NWP division of IMD, to feedin multi-model global forecasts outputs and made the individual model TC-tracker lines plot along with multi-model-mean and the verifications of TC-Tracker both the visual and statistical outputs are discussed. By using 7 global model (IMDGFS, NCMRWF-G, ECMWF, NCEP, CMC, UKMO, IMDGEFS-Mean, NEPS-Mean) and the IFS-TC-Tracker outputs and 2 regional model (NCMRWF-R, HWRF) tracker outputs have been made over north Indian Ocean, operationally at NWP, IMD. All model outputs are being interpolated to T159 Gaussian Grid horizontal resolution before running the IFS-TC-Tracker. Last 4 years (2021-24) this method is being operationally implemented and made significant improvement in landfall location & time prediction in well advance. Here showed this year first Severe Cyclonic Storm named 'REMAL' during 2024-05-24-00Z to 2024-05-27-12Z over the Bay of Bengal (BoB) has been explored (Fig. 11) & verified [Fig. 16(b)].

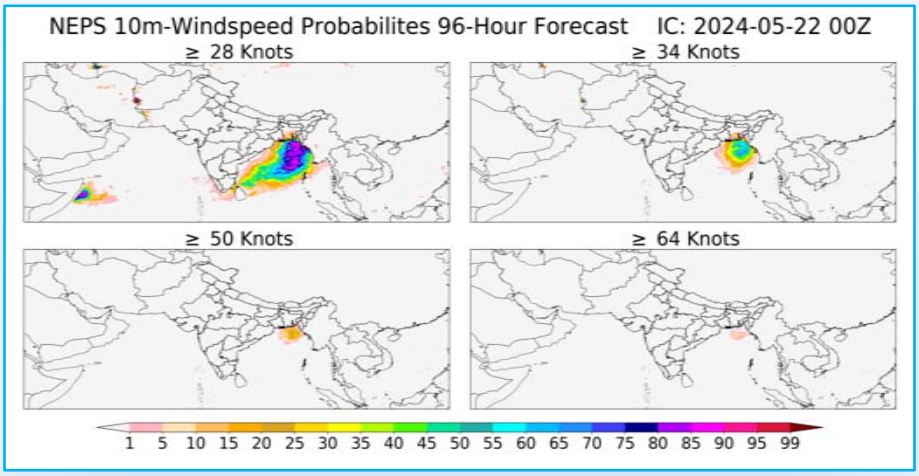


Fig. 16(a). 10-meter wind speed probability at threshold ≥ 28 Knots, ≥ 34 Knots, ≥ 50 Knots, and ≥ 64 Knots using NEFS (20 ensemble members + 1 Control run) based on initial condition as on 2024-05-22 00 UTC valid for 96th hour forecast

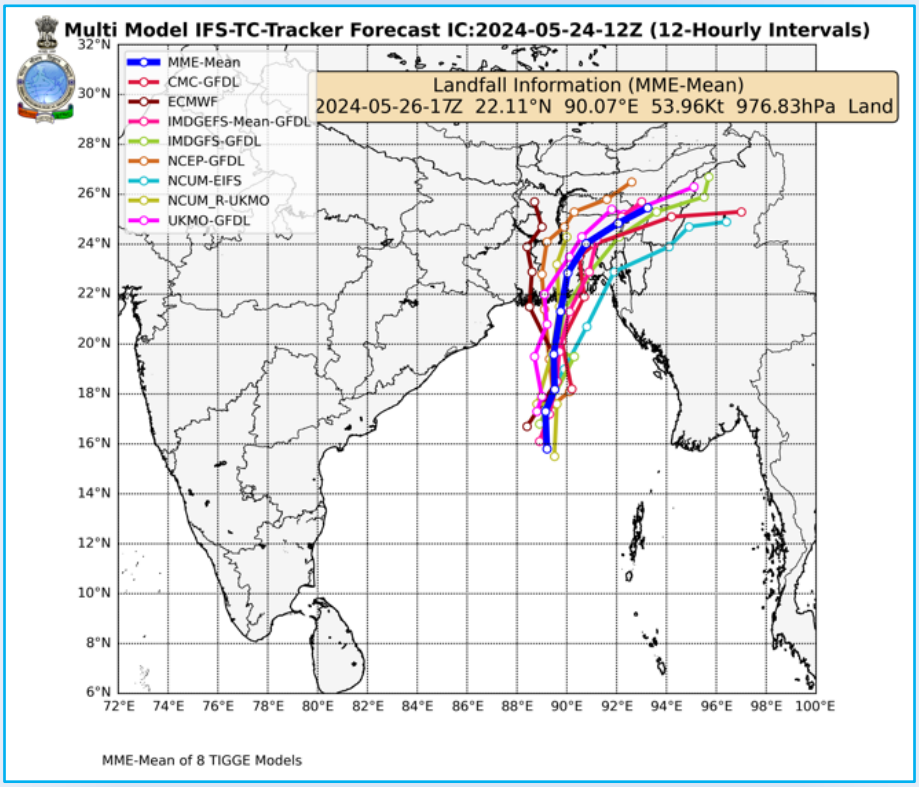


Fig. 16(b). Real-time production of tropical cyclone tracker outputs ('REMAL' Severe Cyclonic Storm) using ECMWF's IFS-TC-Tracker. The Multi Model Mean is shown in dark blue line. The TC tracker outputs are at 12-hourly intervals which are marked in open circles over individual model-colored lines and also over the MM mean blue line. The number of different models used to compute the Multi Model Mean cyclone track details are mentioned in the figure legend

The verification of severe cyclonic storm 'REMAL' (Fig. 17) using 7 TIGGE global models and multi-model mean outputs fed into the IFS-TC-Tracker at different forecast lead times (upto 72 hours by 6 hourly intervals). In Fig. 12 shows the distance position error (DPE) of the IFS-TC-Tracker outputs of the nine TIGGE models and MMMean, during different initial conditions from 2024-05-24-00Z and 2024-05-27-12Z at both 0000 and 1200 UTC, and upto 240 hours forecast lead time. The MMEM

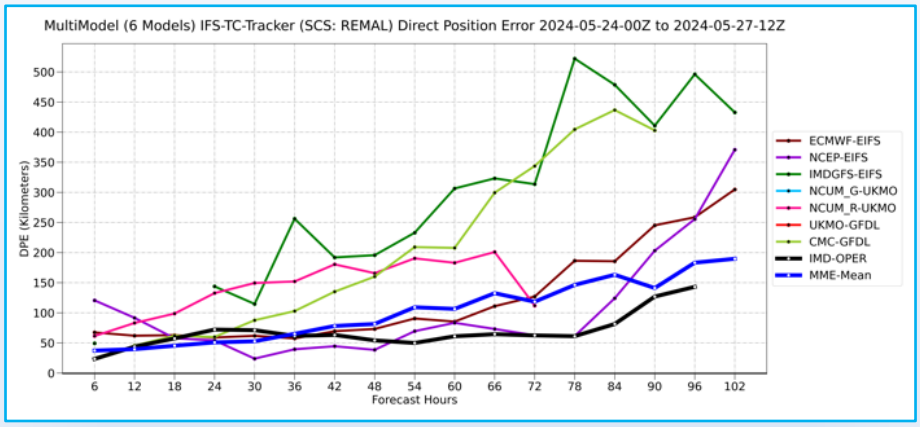


Fig. 17. Verification of REMAL Severe Cyclonic Storm predicted by the ECMWF IFS-TC-Tracker using 7 TIGGE multi model outputs (shown in multiple colored lines) and MMMean (shown in thick blue line) during 2024-05-24-00Z to 2024-05-27-12Z. X-axis shows forecast lead hours and Y-axis shows Distance Position Error (DPE) in Kilometers

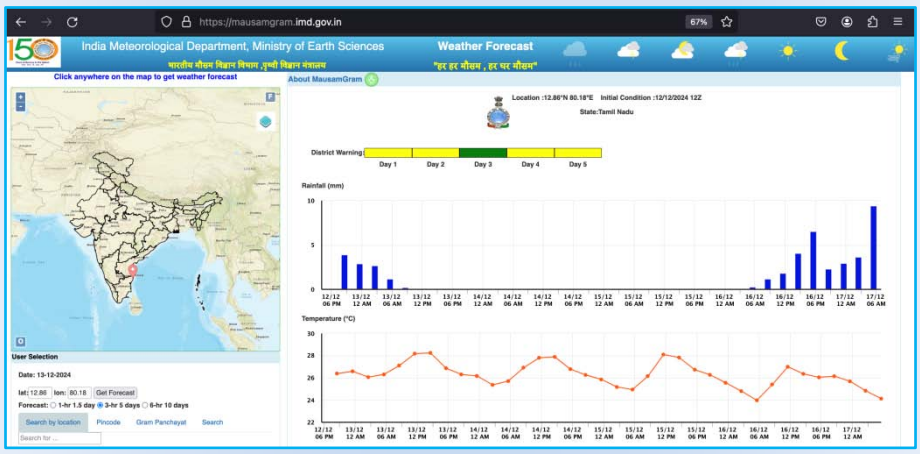


Fig. 18(a). Screenshot of Mausamgram Webpage where multi model ensemble mean generated from 5 global and 2 regional NWP model outputs for public use https://mausamgram.imd.gov.in, where user can click anywhere on the Map (left side) including Ocean, and the corresponding Meteograms are dynamically generated and displayed as interactive meteograms (on right side). User can select or search location or area pincode or Gram Panchayats provided provision at the bottom left panel of the website, and instant response will be generated in interactive graphics over the right side of the interface. Also, the color coded weather warning over the respective districts are marked just above meteogram. Finally, user can download the meteogram as image or csv or pdf

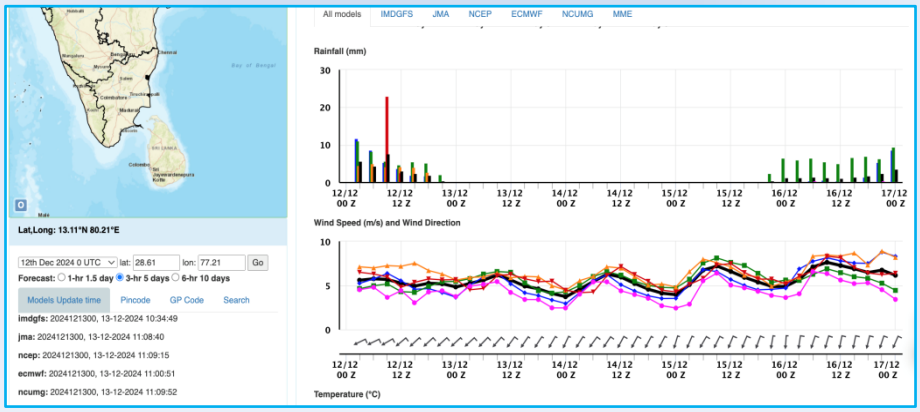


Fig. 18(b). Screenshot of Dynamic Meteogram Webpage https://meteogram.imd.gov.in/forecaster.html, for forecasters where multi model ensemble mean along with individual 5 global and 2 regional NWP model outputs where user can click anywhere on the Map (left side) including Ocean, and the corresponding Meteograms are dynamically generated and displayed as interactive meteograms (on right side). User can select or search location or area pincode or Gram Panchayats provided provision at the bottom left panel of the website, and instant response will be generated in interactive graphics over the right side of the interface. Also, user can download the meteogram as image or csv or pdf

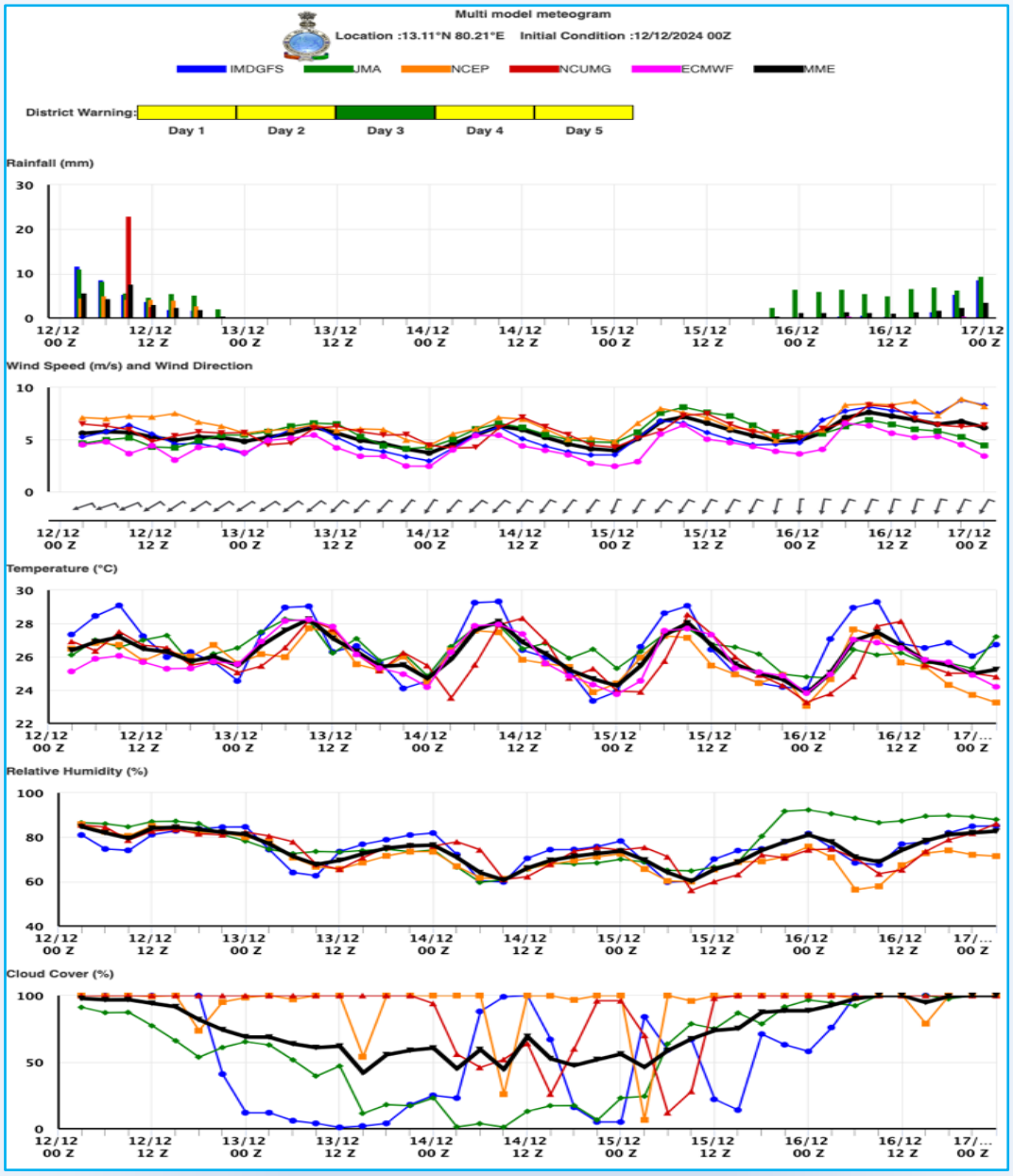


Fig. 19. Downloaded multimodel (all models) meteogram as image (by click download icon shown in Fig. 17 top right corner)

(blue line) model track error is less than 150 Km at 102 hour lead forecast, but reduced errors less than 75 Km at 48 hours lead forecast, and less than 50 Km at 24 hours lead forecast. The IMD's Operational Forecast error (black line) much less than any of the model forecast at long lead time and better performed than any of the model by utilizing the guidance from the above MMEM.

3.16. Dynamic & Interactive Multi Model Meteogram (Mausamgram)

The NWP division jointly with ISSD division, developed, designed and deployed **Mausam Gram** web portal [Figs. 18(a&b)] at NWP division - Post Processing of Multi Model Ensemble (MME) and generating mean of it (MMEM) by using IMDGFS, NCUM-G, ECMWF, NCEP, JMA, NCUM-R, WRF to produce dynamic & interactive meteogram (Fig. 19) over GIS map (https://meteogram.imd.gov.in/ forecaster.html for forecasters use and https://mausamgram.imd.gov.in for public use), mobile app, APIs. It provide instant responses for any given location on the GIS map, or search through any location name or Area Pincodes (> 6 Lakhs) or Gram Panchayats Name or GP codes (> 2.5 Lakhs). The multi model mean dynamic meteogram website was released to the public by the Hon'ble Vice President of India, Shri Jadgeep Dhankhar during 150th IMD Foundation

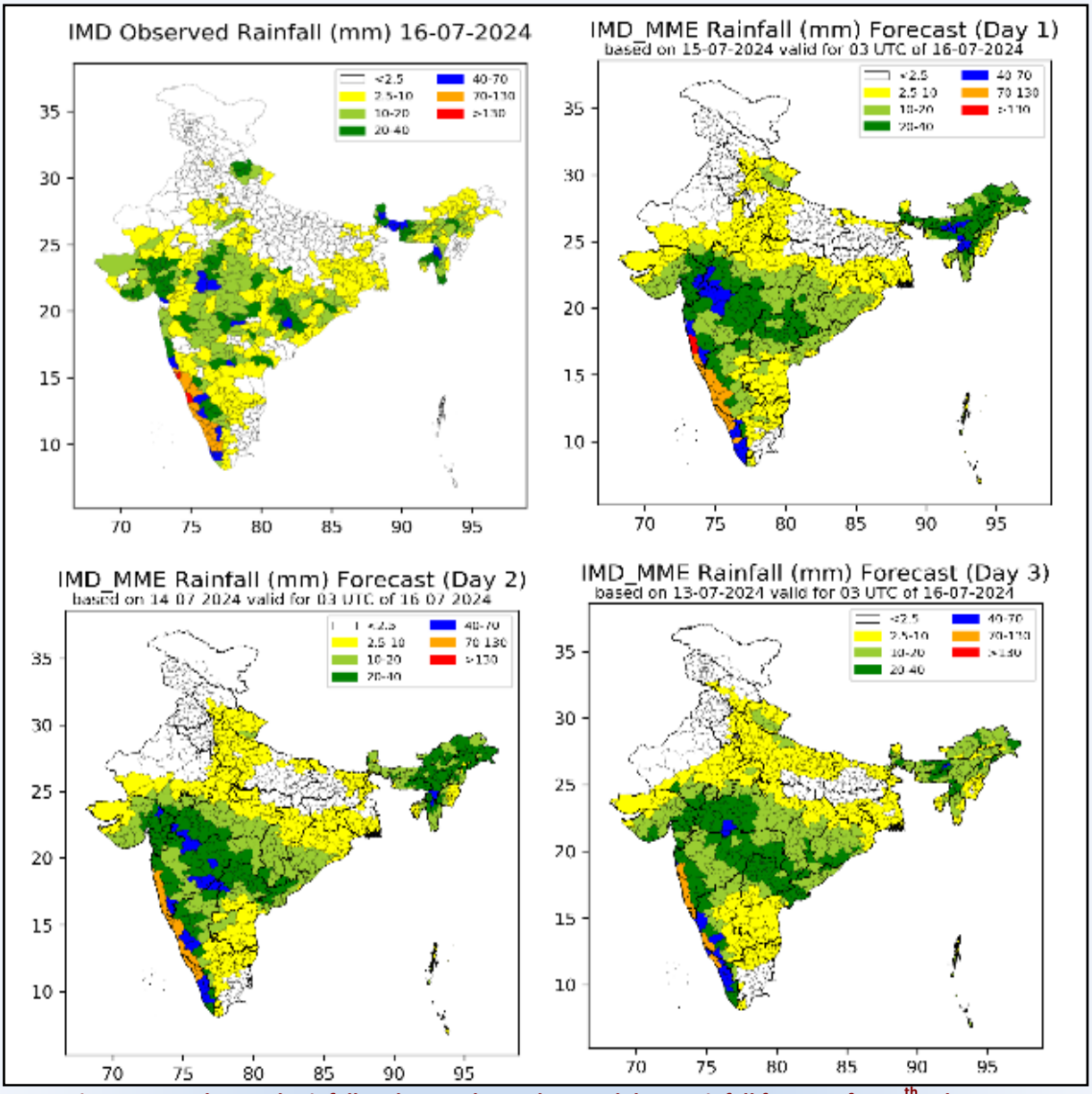


Fig. 20. IMD observed rainfall and MME day 1, day 2and day 3 rainfall forecast for 16th July, 2024

Day Celebration on 15th Jan, 2024. Released next version of multi models dynamic meteogram along Gram Panchayats location specific forecasts, by the Ministers of MoES and MoPRon 24 Oct, 2024 for farmers use.

3.17. Generation of MME forecast for Indian cities, districts and meteorological sub-divisions

IMD generates location based as well as area averaged forecast from seven models also its MME in real time for decision support. The NWP model forecasts available with IMD is of different spatial resolution (Table 2).

TABLE 2

Operational Global models

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

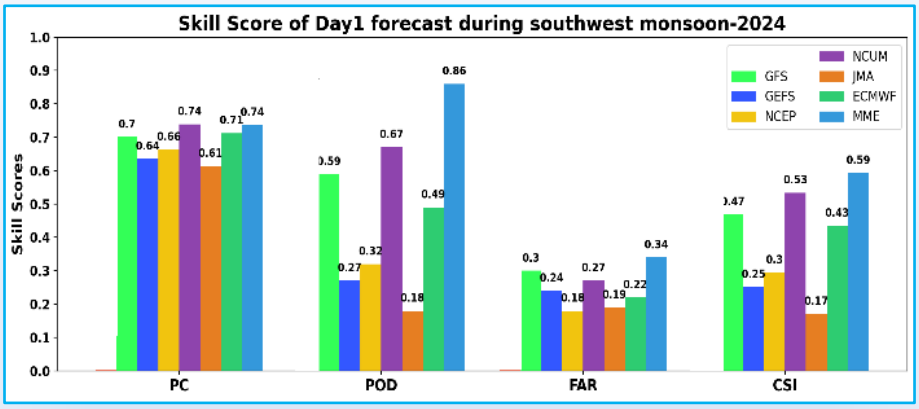


Fig. 21. Percentage correction (PC), Probability of detection, False Alarm Ratio (FAR), Threat Score (TS) of day 1 rainfall forecast against IMD observations for heavy, very heavy and extremely heavy rainfall categories during 2024 monsoon

Seven days of location based forecast of rainfall, maximum temperature, minimum temperature, wind speed, wind direction, relative humidity (at 0300 UTC and 1200 UTC) and cloud cover from each model is generated for Indian cities, followed by MME-mean forecasts have been generated. Currently forecast for 1854 cities are generating. Additionally, meteograms from above models are also generating for these stations.

Area-averaged forecast of rainfall, maximum temperature, minimum temperature, wind speed, wind direction, relative humidity (at 0300 UTC and 1200 UTC), and cloud cover from each model are also generated for Indian districts for next 7 days, followed by MME-mean forecasts have been generated. Currently, forecast over 748 districts are generating in real time. Over these spatial domains, forecast of rainfall distribution also calculated by estimating the percentage of grids reporting a rainfall amount greater than 2.5 mm/day. Similarly, rainfall distribution and intensity forecast are generating for 36 meteorological sub divisions are a decision support to the forecasters. In addition, a heavy rainfall warning system is developed for districts and meteorological sub-divisions based on MME forecast. These forecasts are disseminating to the operational forecasters at RMCs and MCs as a decision support while issuing forecast. These forecasts (as digital values) and figures are also available at NWP division's website.

An impact-based forecasting tools also developed for heavy rainfall and heavy winds (for marine areas) for the RSMC region using the MME approach. With the help of this forecast, Impact Based Forecast (IBF) is issuing regularly for entire RSMC countries.

The district rainfall forecast from different NWP model and MME are compared against IMD observation during the south-west monsoon 2024. A case study is presented in this report to evaluate the performance of MME forecast qualitatively over Indian districts. In order to assess the performance of MME forecast, a case study during 16th July, 2024 is shown in the Fig. 20. The extremely heavy rainfall observed over west coast region of India (Kerala, coastal Karnataka) during 16th July, 2024 is well predicted in MME up to day 5.

Assessment of heavy rainfall warning system is presented (Fig. 21) in terms of Percentage correction (PC), Probability of detection, False Alarm Ratio (FAR), Threat Score (TS) of heavy, very heavy and extremely heavy rainfall from seven models during monsoon 2024. From the Fig. 21, it is clear that MME have good skill in predicting extreme rainfall events than the individual models.

CHAPTER 4

OBSERVATIONAL NETWORK

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

4.1. Upper Air Observational Network

4.1.1. Radiosounding Radiowind (RS/RW) network

India Meteorological Department (IMD) has 56 operational Radiosonde radiowind stations in their upper air network (Fig. 1), as a part of global observing system (GOS) network of WMO. These stations take observations for measuring the vertical profile of the Atmosphere, viz., Temperature, Pressure, humidity, Wind Speed and Direction, the upper air observations are taken by using balloon borne soundings. These stations are engaged in taking the radiosounding observations twice a day at 0000 UTC and 1200 UTC hours (Fig. 2).

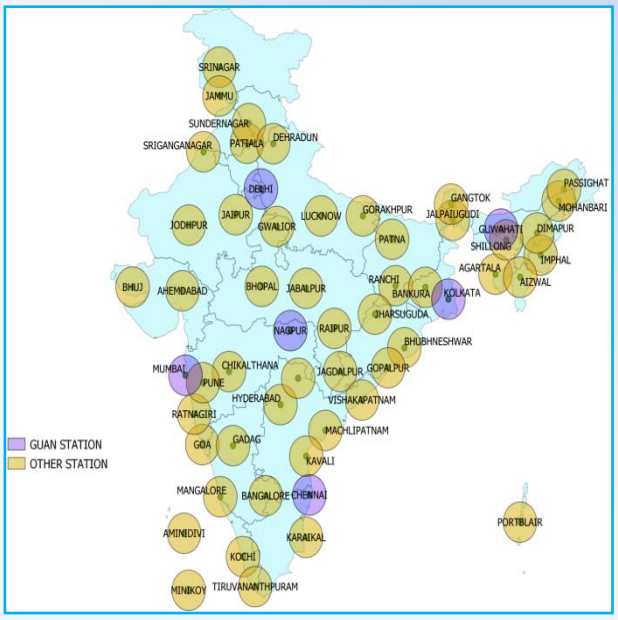


Fig. 1. Existing RS/RW Network of India Meteorological Department

Fig. 2. Balloon release for GPS sonde ascent at Kavali, Andhra Pradesh

As a subset of Global Observing System (GOS) network, World Meteorological Organization (WMO) in collaboration with the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU) established Global Climate Observing system (GCOS) network in 1992, as an outcome of 2nd World Climate Conference. In the upper air domain of GCOS, aiming on further improvement of upper air data quality, IMD established GUAN standard radiosounding observations at its 6 Regional Meteorological Centres (New Delhi, Mumbai, Kolkata, Chennai, Guwahati and Nagpur). The performance of these stations was presented at WMO Technical Conference on Instruments and Methods of Observations (TECO-2016) and a

formal claim was made to Secretary General WMO for inclusion of these stations into the GCOS Upper Air Network (GUAN). **Based on the sustained performance, these stations have been included in the WMO-GUAN standard network by GCOS Secretariat, and their performance indicators figures in the summary of NOAA's monthly report with effect from June 2017 on regular basis.**

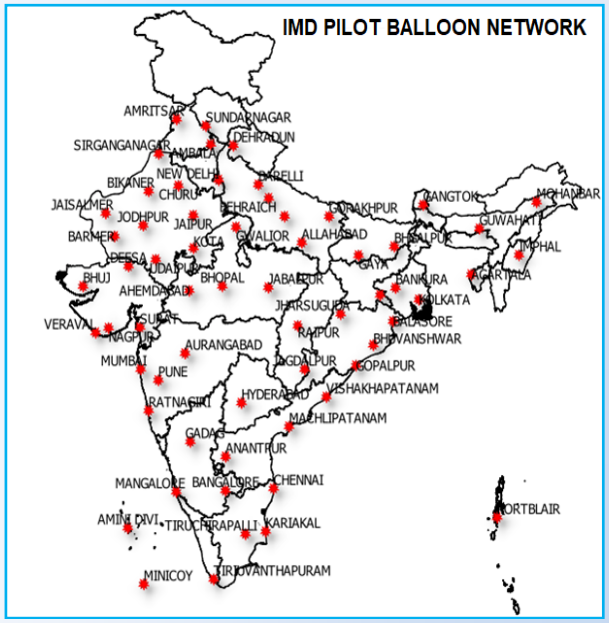


Fig. 3. Upper Air Pilot Balloon (PB) Network of IMD

4.1.2. Pilot Balloon (PB) Network

IMD is operating 63 PB observatories (Fig. 3) taking 2 to 4 observations for upper air wind profiles at 0000, 0600, 1200 and 1800 UTC hrs of observations. PB stations were using optical theodolites for balloon tracking manually. Efforts have been made now to switch over to GPS based fully automatic PB systems from conventional optical theodolite-based observations. For this, GPS based pilot-sonde has been developed and being manufactured in-house in IMD Workshop. In the line of this, 25 stations of PB network now havebeen upgraded and equipped with GPS-based fully automatic PB systems. Among these, five stations are equipped with IMD-manufactured systems, namely Jammu, Jaipur, Jodhpur, Sundernagar, and Dehradun, while the remaining 20 are outsourced from Indian manufacturers, namely Aminidivi, Amritsar, Allahabad, Bangalore, Bhuj, Churu, Deesa, Gaya, Gangtok, Gopalpur, Gwalior, Karaikal, Lucknow, Minicoy, Mohanbari, Port Blair, Raipur, Sriganganagar and Thiruvananthapuram.

4.2. Surface Observational Networks

Automated weather stations measure all the important surface weather observations (Figs. 4, 5 & 6). These weather stations provide accurate and frequent readings, have low power requirements, and can operate practically anywhere. The weather monitoring system able to provide localized information on the weather conditions. These are very useful during severe weather conditions and current weather data made available to all in real time even at 1 minute interval also.

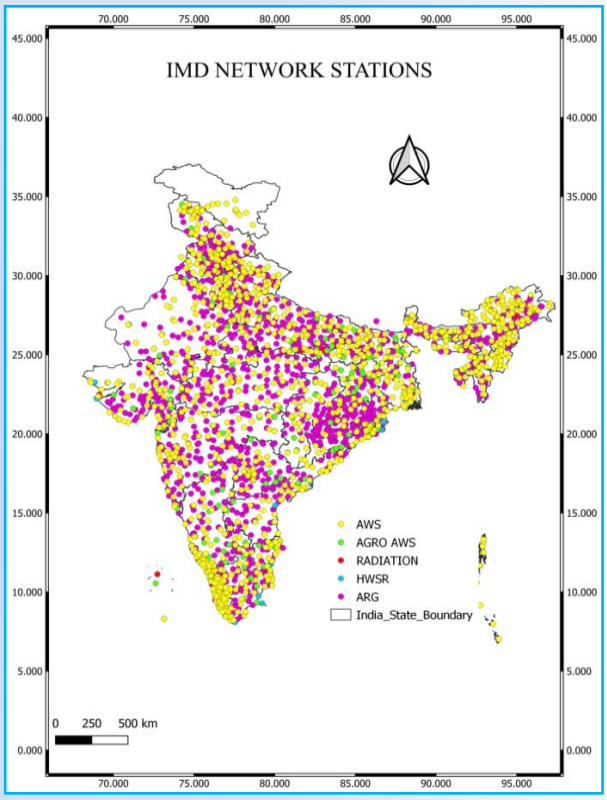


Fig. 4. Surface observation network

Fig. 5. Automatic weather station at Nungambakkam Observatory, Chennai

IMD operates 1,008 Automatic Weather Stations (AWS), 1,382 Automatic Rain Gauge (ARG) stations, 200 Agro-AWS, 5 Automatic Snow Gauge (ASG) stations, 37 High Wind Speed Recorders (HWSR), (Fig. 9) and 47 Solar Radiation Stations, as depicted in the below(Fig. 7).

Fig. 6. Mast of Automated Weather Observing System (AWOS) (Carrying Wind Sensor, ATRH Sensor and Pressure Sensor)

4.2.1. Solar Radiation network

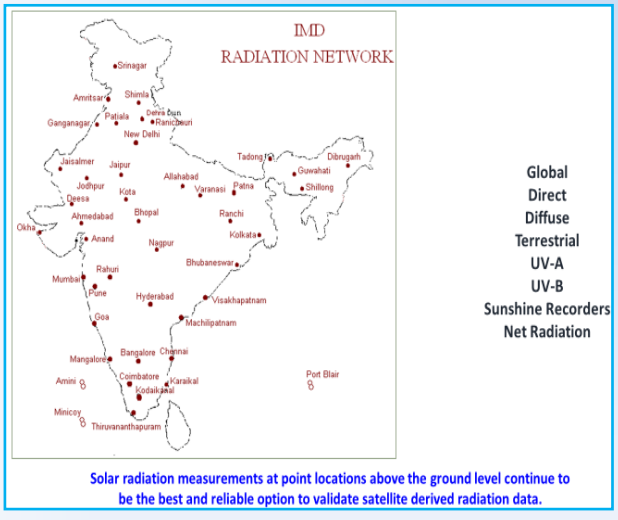


Fig. 7. IMD Radiation Network

IMD is an augmentation is solar radiation network with AWS and established network of 47 Solar Radiation stations all over India (Figs. 7 & 8).

Fig. 8. Solar radiation instruments, Meenambakkam Observatory, Chennai

Fig. 9. A network of 37 HWSR has been established all over India

4.3. Atmospheric Sciences

4.3.1. Environment Monitoring and Research Center (EMRC)

4.3.1.1. Environmental Meteorology Services

IMD conducts monitoring and research related to atmospheric constituents that are capable of forcing change in the climate of the Earth and may cause depletion of the global ozone layer and play key roles in air quality from local to global scales. IMD also provides specific services to Ministry of Environment and Forest & Climate Change and other Government Agencies in the assessment of air pollution impacts. IMD contributes in the field of atmospheric environment to the World

Meteorological Organization (WMO) Global Atmosphere Watch (GAW) programme. The main objective of GAW is to provide data and other information on the chemical composition & related physical characteristics of the atmosphere and their trends, required to improve understanding of the behaviour of the atmosphere and its interactions with the oceans and the biosphere.

4.3.1.2. Ozone Monitoring Network

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

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

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

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

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

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

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

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

(iii) Multi-wavelength Integrating Nephelometer Network : IMD has established a network for measurement of aerosol scattering coefficient at New Delhi, Ranichauri, Varanasi, Nagpur, Pune, Port Blair, Visakhapatnam, Guwahati, Kolkata, Jodhpur, Bhuj, Thiruvananthpuram.

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

4.3.1.3. Air Quality Forecasting and Research

The latest version of Air Quality forecast model “System for Integrated modelling of Atmospheric composition (SILAM v5.8)” has been

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

Further, to strengthen the forecasting services, the Air Quality Early Warning System (AQ-EWS) was developed under the aegis of Ministry of Earth Sciences in 2018, jointly by the scientists of Indian Institute of Tropical Meteorology (IITM), Pune, India Meteorological Department (IMD), National Centre for Medium-Range Weather Forecasting (NCMRWF). IMD issues AQ Early Warning bulletins based on different models. This year the air quality forecast services were extended to other cities. As of now, the services are being provided to 46 cities.

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

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

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

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

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

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

4.3.1.4. Performance Verification of Air Quality Model

Fig. 10 shows the performance diagram summarizing the Success Ratio, POD, bias, and CSI

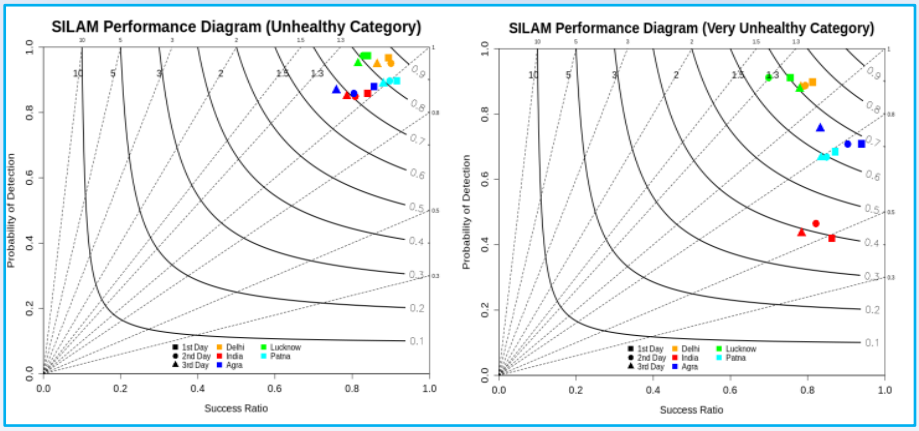


Fig. 10. Performance diagram summarizing the Success Ratio, POD, bias, and CSI skill scores for (a) Unhealthy category and (b) Very Unhealthy category of study periods. The labelled dashed lines represent bias scores, while labelled solid contours represent the CSI values. Appropriate symbols for different cities and days of forecast are present in the figure legends

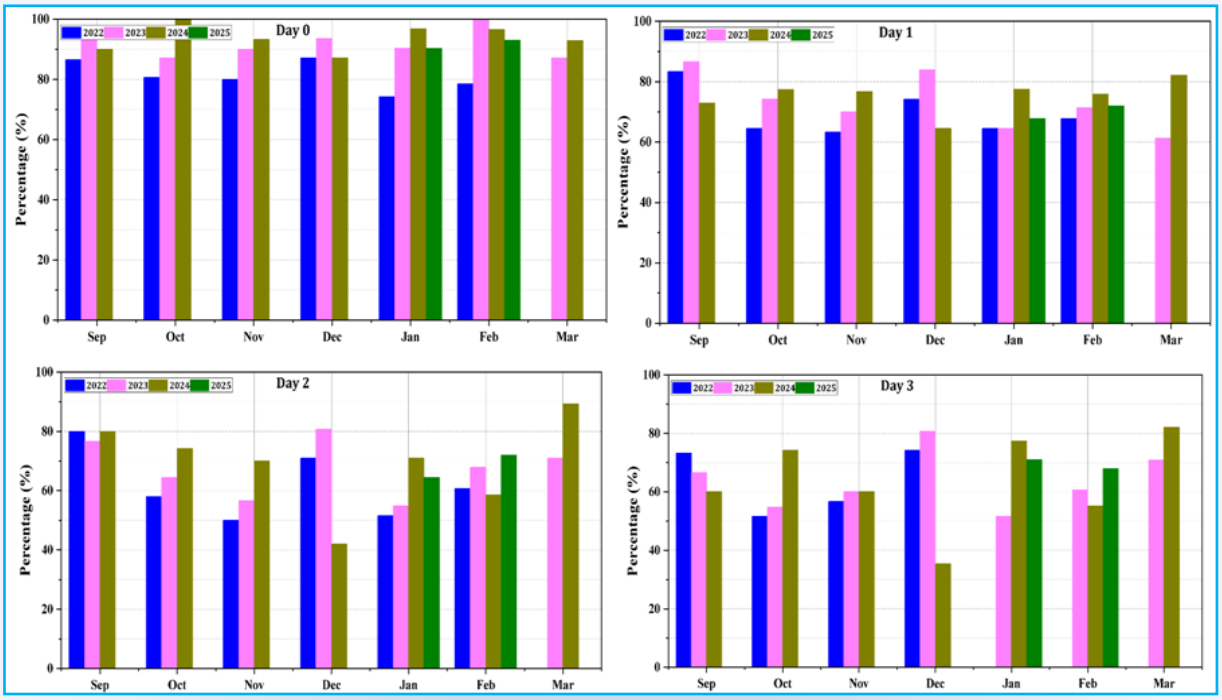


Fig. 11(a). Performance of IMD Air quality forecast bulletin percentage of correct forecast for Good, Satisfactory, Moderate, Poor, Very Poor and Severe categories over Delhi

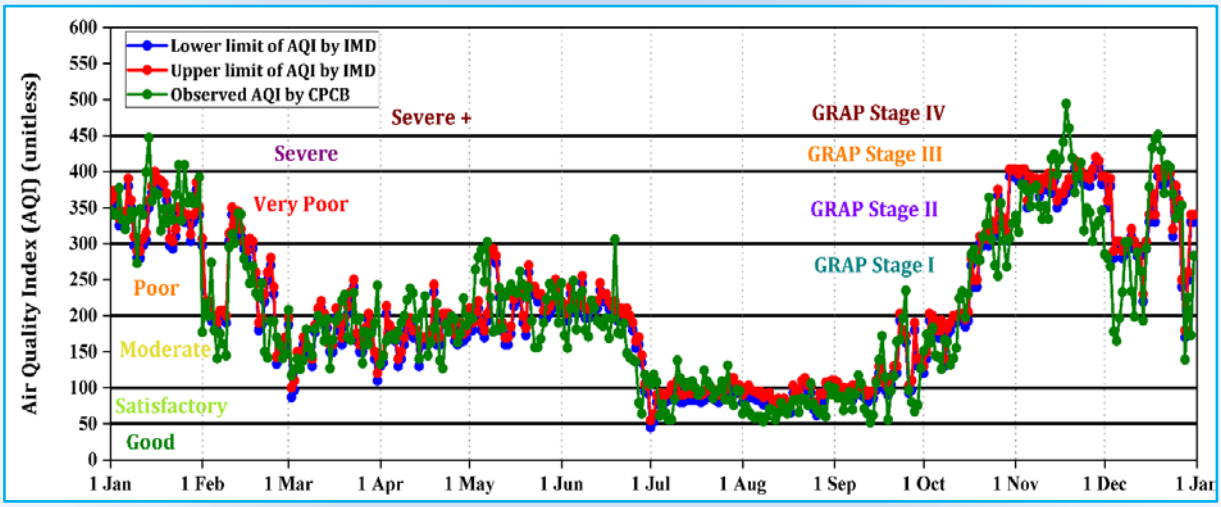


Fig. 11(b). Performance of IMD 3rd day air quality forecast bulletin lower limit AQI (blue) & upper limit AQI (red) by IMD and CPCB observed AQI (green) over Delhi

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

4.3.1.5. Performance of skill of IMD Air Quality Forecast Bulletin for Delhi

Fig. 11(a) shows the performance of IMD Air quality forecast bulletin percentage of correct forecast for Good, Satisfactory, Moderate, Poor, Very Poor and Severe categories over Delhi for last 3 years. Fig. 11(b) shows the performance of IMD 3rd day air quality forecast bulletin lower limit AQI (blue) & upper limit AQI (red) by IMD and CPCB observed AQI (green) over Delhi during 2024.

4.3.1.6. Air Mass Trajectories

Air Mass trajectories using IMD-WRF-HYSPLIT model forecast as well as analysis are available with forward and backward trajectories for 33

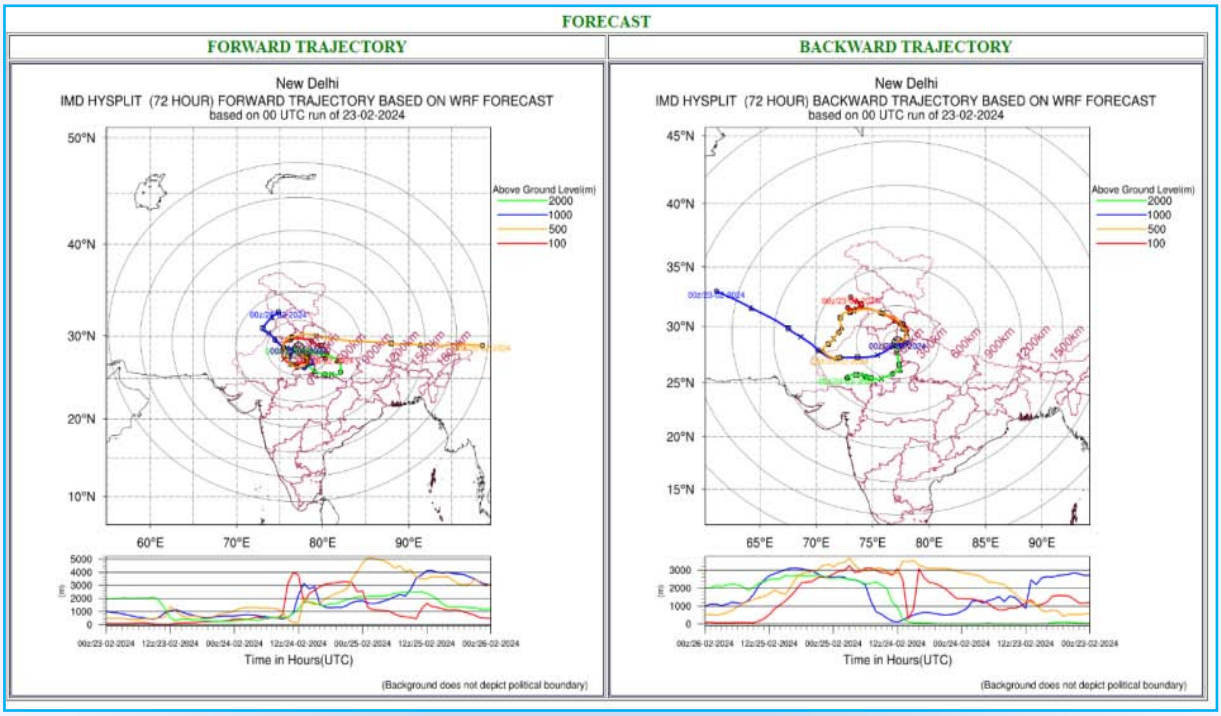


Fig. 12. Air Mass trajectories using IMD-WRF-HYSPLIT model

cities all over India at 100, 500, 1000 and 2000m for next 24, 48 and 72 hours. Fig. 12 shows the Air Mass trajectories using IMD-WRF-HYSPLIT model.

4.3.1.7. High Altitude Background Climate Monitoring Station

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

4.3.2. POLAR METEOROLOGICAL RESEARCH DIVISION (PMRD)

4.3.2.1. Polar Meteorological Research

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

Latest version of Polar WRF model has been operationalized to provide day-to-day 72 hours weather forecast at 3 km resolution for the Maitri and Bharati region in the Antarctica. The NWP products are routinely made available on the IMD web site to support of Antarctic Expedition. Two IMD officials each at Maitri and Bharati have proceeded as expedition member of 43 ISEA. Figs. 13 and 14 are showing spatial plot and meteogram respectively.

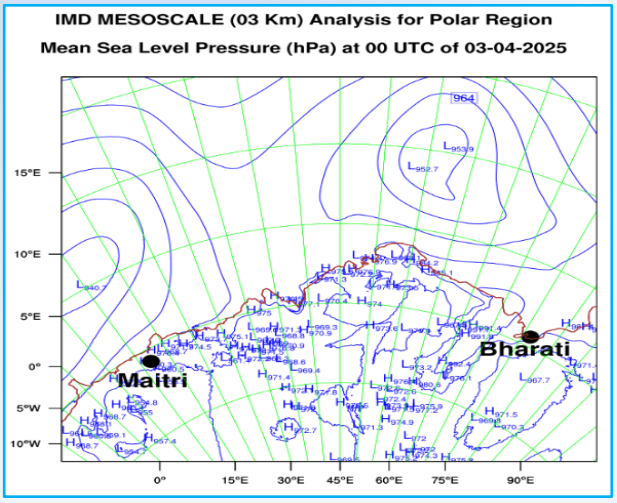


Fig. 13. Spatial plot of mean sea level pressure (hPa) over polar region

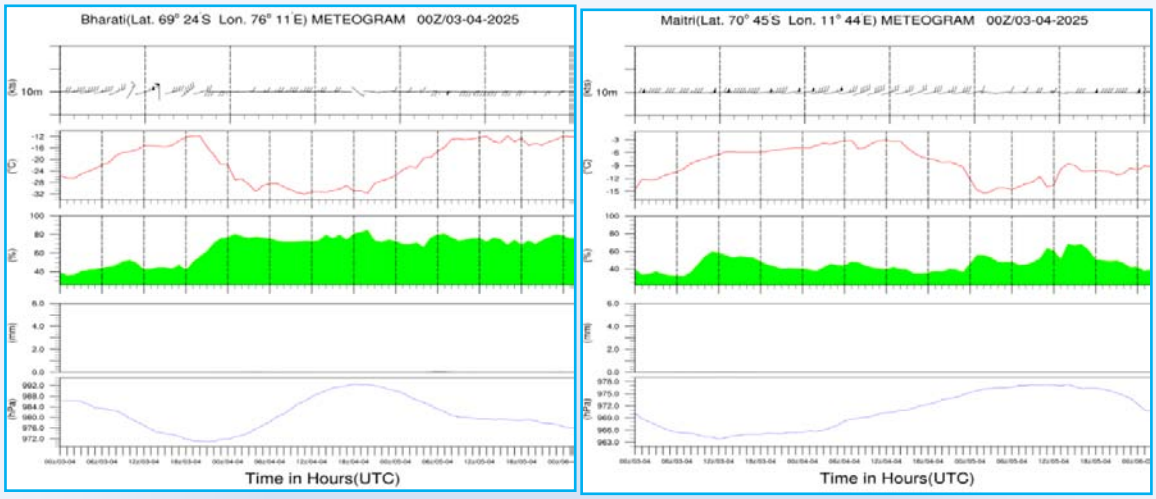


Fig. 14. Meteogram of T2m (oc), RH at 2m (%), Wind (Kts), MSLP (hPa) and Snow (mm) over Bharati and Maitri stations

4.3.3. Urban Meteorological Services

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

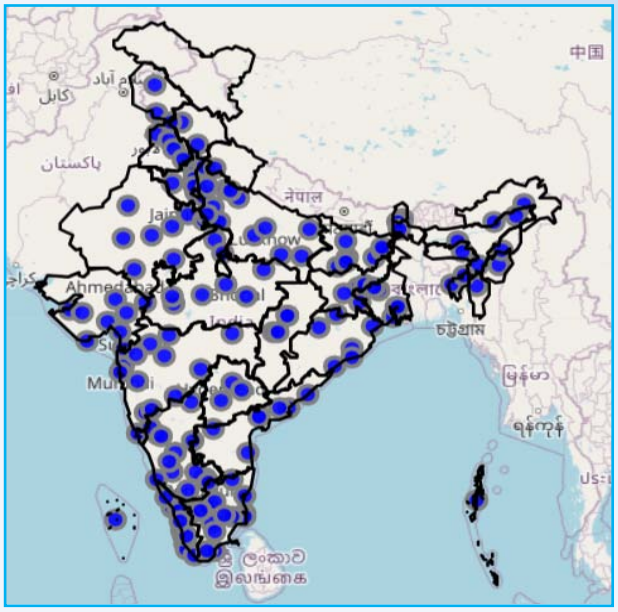


Fig. 15. List of cities covered under IMD UMS

The India Meteorological Department (IMD) has created Urban Meteorological Services for over 150+ urban regions across various city types in India to enhance its Early Warning System (https://internal.imd.gov.in/pages/city_weather_main_mausam.php; Fig. 15). These Urban Integrated Services include the incorporation of detailed urban data observations, urban canopy models, urban vegetation analysis and land use assessment to evaluate exposure, vulnerability, and soil permeability impact on hazards. Additionally, these systems involve ensemble prediction, uncertainty quantification, and a multi-disciplinary approach to model initialization processes effectively.

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

Heat waves and cold wave
Fog
Cyclone
Floods
Drought
Strong winds and Squalls

Hailstorms
Thunderstorms and lightning
Impact-based warnings for localized convective activities

4.3.3.1. R&D efforts in Urban Meteorological Services

Urban Heat Island (UHI) phenomenon, characterized by significantly warmer temperatures in urban areas compared to their rural surroundings, is intricately linked with climate change. It is a localized phenomenon that occurs when a particular part of a city receives more heat than the rest of the city on the same day. The differences are primarily due to heat trapped within environments resembling concrete jungles. Urbanization contributes to the UHI effect. The increase in heat effect can be seen due to altered surface characteristics, heat-trapping structures, waste heat generation, reduced vegetation and green spaces, heat-retaining materials used in infrastructure, etc.; this extreme heat effect is caused by a sudden rise in population and unplanned development. The increase in the urban population leads to the large-scale modification of the urban land use/land cover (LU/LC) pattern, which eventually results in a number of ecological and environmental problems. The changing LU/LC pattern in urban areas also affects the quality of life in urban areas by altering their environment, deteriorating air quality and increasing the frequency of extreme climatic events like high-intensity rainfall and the development of UHI. The haphazard changes in urban LU/LC patterns in the cities of developing countries lead to changes in the thermal properties of the land surface, which leads to an increase in the UHI intensity over the urban areas.Causes: Dark surfaces, human gathering, increased use of air conditioners, destruction of trees, urban canopy, and air pollutants. Effects: Discomfort and danger to human health, Increased Energy Consumption.

The rapid urbanization of cities has led to the development of Urban Heat Island, where urban areas experience significantly higher temperatures compared to their rural surroundings. The increase in impervious surfaces, reduction in vegetation cover, and heat generated by human activities contribute to the UHI effect.Delhi, the second-largest city in India, has grown significantly throughout time in terms of population and area, becoming a worldwide metropolis with a thriving economy. Delhi is situated in northern India, at 28.40° N to 28.88° N latitude and 76.84° E to 77.34° E longitude. The state of Haryana borders it on three sides (north, west, and south) and by Uttar Pradesh to the east. Delhi's National Capital Territory (NCT) covers an area of 1485 sq km. According to the Census of India (2011), Delhi's total population was 11.03 million, and the population density was about 11,320 persons per sq km. Delhi is experiencing the UHI effect. Urban Heat Island is one of the urban climatological problems that is developing in the city. Reduced vegetation cover and increased built-up surfaces made of concrete, asphalt, etc., are to blame for the excess heat in metropolitan areas. This phenomenon causes some city metropolitan areas to become exceedingly hot during the day, especially in the summer, which is quite uncomfortable for the population.

For the present study, the following methodology is adopted, which involves satellite data collection, classification of the imagery, development of land use/Land cover maps, change detection analysis, retrieval of Land Surface Temperature (LST) maps by utilizing raster calculator tool in the ArcGIS software, modeling of UHI stack profile and identification of Urban Hotspots (UHS). Cloud Free Landsat satellite data from 1980, 1990, 2000, 2010, and 2020 with a decadal gap has been downloaded from the United States Geological Survey (USGS) Earth Explorer website. The optical bands of Landsat 4-5 Thematic Mapper (TM), Landsat-7 Enhanced Thematic Mapper Plus (ETM+), and Landsat-8 Operational Land Imager/Thermal Infrared Sensor (OLI/TIRS) were used for the land use land cover maps. In contrast, the thermal bands were used to retrieve the LST. All the data are pre-processed and projected to the Universal Transverse Mercator (UTM) projection system.

While analyzing Landsat data of Delhi in 1980 and 2020, it was found that built-up covers the maximum area. From 1980 to 2020 there is a rapid change in built-up, due to urbanization and industrialization (Fig. 16). Other classes, viz., Waterbodies / wetlands, dense vegetation, cropland, open green land, and wasteland/ fallow land show a decline. The drastic increase in built-up areas and the corresponding loss of green spaces and water bodies have significant environmental implications. Reduced vegetation

cover and increased impermeable surfaces contribute to higher temperatures, poor air quality, and urban heat island effects. There is an increase of 30% in the built-up area while a decrease of 2%, 10%, 5%, 9%, and 4% from Water bodies, Dense Vegetation, Cropland, Green land, and wasteland (Fig. 17). This shows the rapid increase of urbanization in the region.

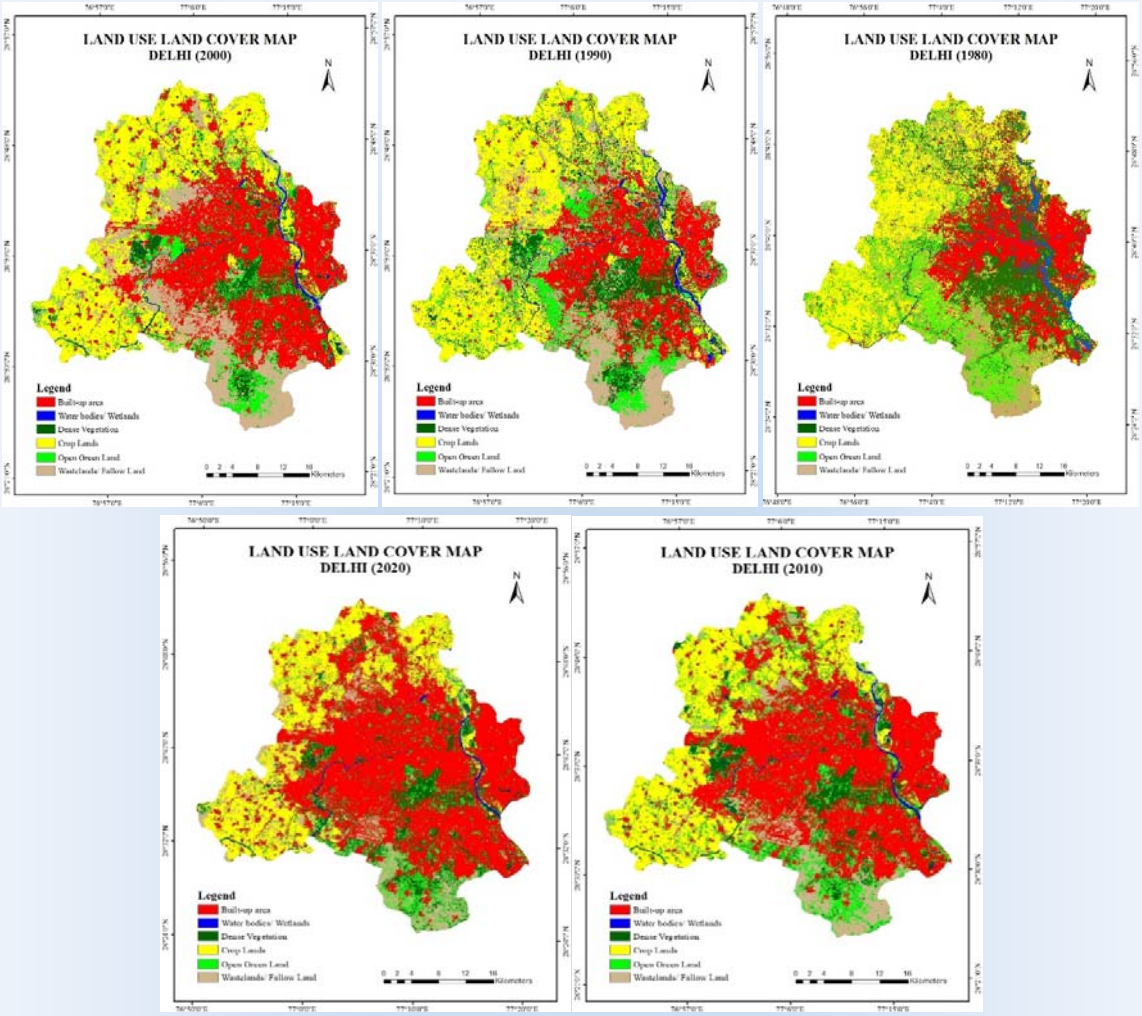


Fig. 16. LULC changes over Delhi for the years 1980, 1990, 2000, 2010 and 2020

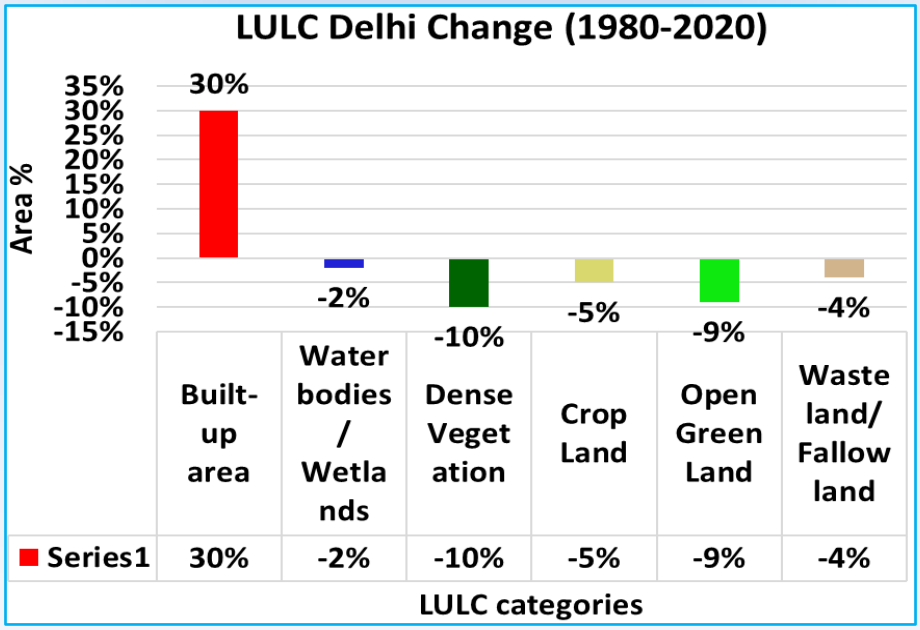


Fig. 17. LULC difference for 1980 to 2020

Over time, the changing patterns of Land Surface Temperature (LST) and Urban Heat Island (UHI) effects in Delhi reflect significant impacts of urbanization, climate change, and land use practices. The LST images clearly showed that the land surface temperature is inversely proportional to the vegetation cover. Higher values of LST were observed only at built-up surfaces. The LST is increasing from peri-urban areas to urban areas. With the increase in built-up area, LST was found to increase,as is evident from the LST map for 2020.The pattern of LST in Delhi showed an increasing trend in the spatial coverage of higher LST during 1990 - 2000, mainly in the southern and southwestern parts of Delhi. During 2000 - 2010, there was a heterogeneous pattern of higher LST (increasing pattern in the northwest and decreasing pattern in the south). During 2010 - 2020, the LST increased towards Delhi's northern and western parts.

From Fig. 18, the UHI zones are the areas with higher LST than the mean LST. In 1990, the UHI zones in Delhi were mainly concentrated in central and southern parts, while the small zones of UHI were clustered in northern and eastern parts. In 2000, the UHI zones remained concentrated in the eastern parts of Delhi, increased in the northern parts of Delhi, and decreased in the southern parts of Delhi. In 2010, there was a westward shift in UHI zones, and it declined in the southern part of the city. In 2020, the UHI zones covered most parts of western and north-western Delhi. The LST and UHI both increase from 1990 to 2020 with a westward and northward shift. It is seen that both higher LST and UHI were concentrated in areas where there was heavy build-up and barren land. This shows that as the dense vegetation, cropland and open green area decreases, LST rises and increases in UHI intensity due to a decrease in vegetation cover.

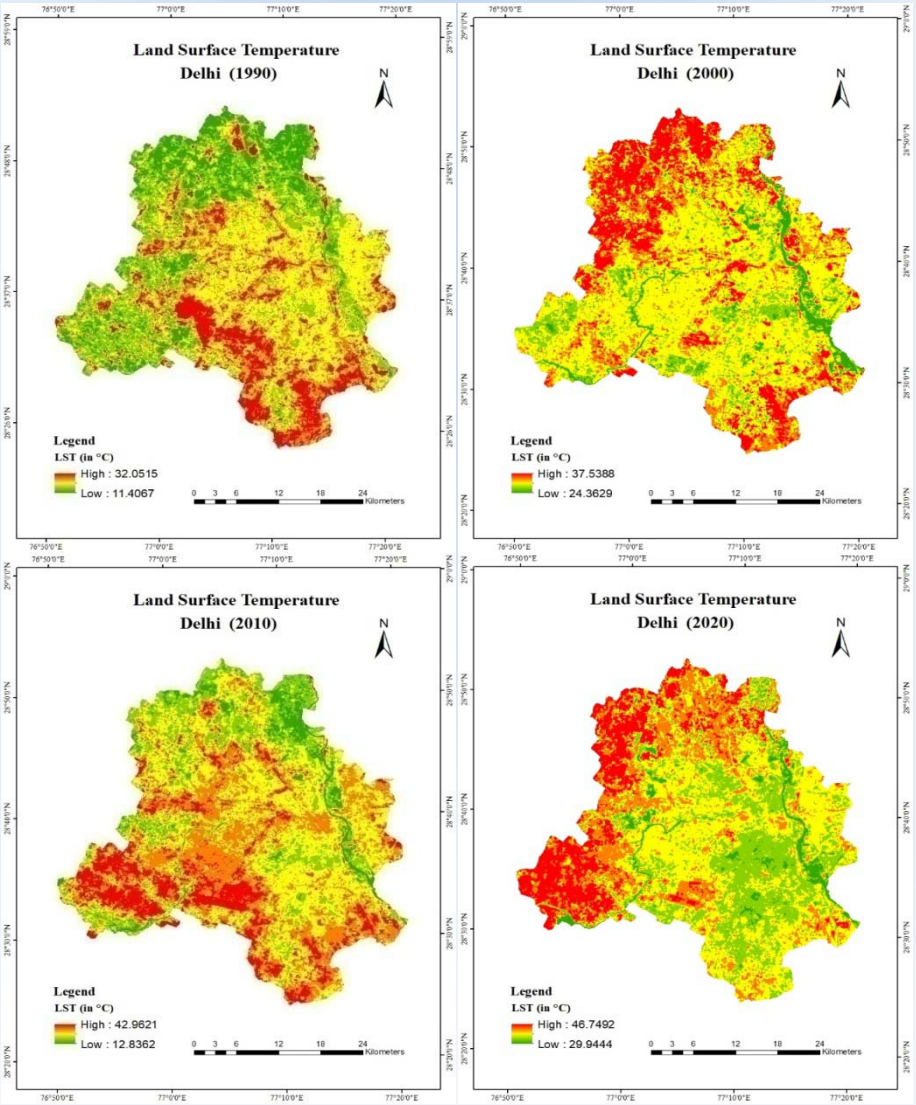


Fig. 18. LST changes for the various decades

The analysis of the result of LULC shows a rapid increase in built-up area, which is due to an increase in urbanization. It was seen in LULC maps that from 2000 to 2020, there was a drastic shift in built-up class. Change detection analysis from 1980 to 2020 shows that the built-up area has increased by 30% of the total area. The dense vegetation, cropland and open green land show a continuous decline from 1980 to 2020. Similarly, due to the increase in built-up area, there was an increase in land surface temperature (LST) which subsequently led to an increase in UHI. The LST of 1990 shows the highest temperature of 32°C which increases to 46°C in 2020.

4.4. Radar Observations

4.4.1. India Meteorological Department Doppler Weather Radar Network:

The **India Meteorological Department (IMD)** manages a comprehensive weather radar network in India (Fig. 19). This network includes **Forty-Doppler Weather Radars (DWRs)** positioned to monitor weather conditions across the country. Additionally, radar data is integrated from **five ISRO radars** and **one IITM radar**, enhancing the overall capability.

4.4.2. Distribution of IMD Radars:

1. **S-band RADARs:** Detect severe weather phenomena such as thunderstorms and cyclones. Installed in Chennai, Kolkata, Machilipatnam, Visakhapatnam, Paradip, Hyderabad, Nagpur, Patna, Lucknow, Patiala, Karaikal, Bhopal, Agartala, Mohanbari, Delhi (Palam) and Goa.

2. **C-band Polarimetric RADARs:** Differentiate between precipitation types. Installed at Delhi (HQ), Jaipur and Raipur.

3. **S-band Polarimetric RADARs:** Provide precise data for severe weather monitoring. Located in Kochi and Gopalpur.

4. **X-Band Polarimetric RADARs:** High-resolution short-range monitoring. Installed at Ayanagar, Jammu, Kufri, Mukteshwar, Surkanda Devi, Banihal Top, Murari Devi, Jot, Lansdowne and one mobile radar in Leh.

4.4.3. Coastal Radar Coverage:

- **East Coast:** Eight radars at Chennai, Kolkata, Machilipatnam, Visakhapatnam, Paradip, Gopalpur, SHAR and Karaikal.

- **West Coast:** Five radars at Kochi, Goa, Mumbai, Bhuj, and VSSC.

Recent Additions:

- **X-band DWR at Lansdowne, Uttrakhand**

- **C-band DWR at Raipur, Chhattisgarh**

4.4.4. Collaboration with ISRO:

- Utilizes data from ISRO radars located at VSSC Thiruvananthapuram (C-Band), Sohra/Cherrapunji (S-Band) and SHAR (Sriharikota-S Band).

This extensive network enhances India's ability to monitor severe weather events, providing vital data for accurate weather forecasting and disaster management. The integration of various radar types ensures comprehensive coverage and precise detection of weather patterns.

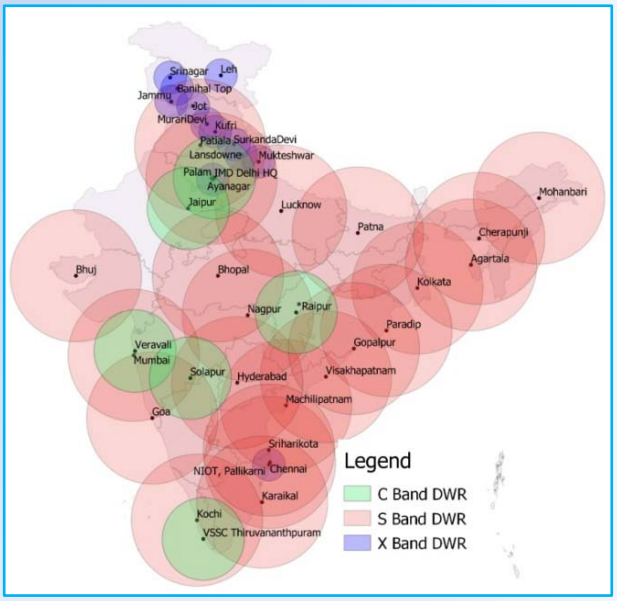


Fig. 19. Existing IMD DWR Network

4.4.5. IMD DWRs Operations:

The **IMD** operates a network of **DWRs** that play a vital role in detecting and monitoring weather phenomena such as rainfall, hailstorms, thunderstorms, and cyclonic storms (Fig. 21).

Radars use electromagnetic waves to measure precipitation intensity and distribution, predict hailstorms, and track cyclones. Complex algorithms generate meteorological and hydrological products, providing data on storm centres, movement, structure and intensity.

Radars deliver near real-time data to supercomputers for numerical weather prediction (NWP) models, enhancing short-range forecasts. Data is formatted in scientific standards like **NetCDF**, **HDF5** and **Opera BUFR** and managed by the **National Radar Data Centre** in New Delhi. Radar data is visualized on open-source GIS platforms, integrating with lightning data and satellite imagery for a unified display. This extensive network significantly improves weather forecasting and disaster preparedness in India.IST time stamp was also included inall the DWR Product images in addition to UTC time Stamp based on the request from stakeholders w.e.f September 2024.

4.4.6. Addressing Coverage Gaps:

India's diverse topography necessitates enhanced radar coverage. To address these gaps and ensure comprehensive weather monitoring, a strategic plan has been proposed to install additional radars(Fig.20 & 21):

- **C-band Radars:** Installation of 12 radars aimed at improving coverage in the plains, where radar coverage is currently insufficient.

- **X-band Radars:** Installation of 10 radars to strengthen the network in the northeastern states, which face scheme'.

- **S-Band** frequent severe weather events and have complex terrain and installation of 08 radars under 'urban meteorology **Radars**: Installation 04 radars for improving the coverage of the coastal India.

The proposed layout ensures that these additional radars will be strategically placed to provide enhanced meteorological observation capabilities, especially in regions that are currently underserved. This expansion aims to improve real-time weather monitoring and forecasting, thereby bolstering disaster management and preparedness efforts across India.

Strategic Expansion Plan

Following the success of the Integrated Himalayan Meteorological Project, IMD has set an ambitious goal to further expand its radar network:

- **Upgradation of 2 existing DWRs:** Two DWRs namely Mumbai, Bhuj wereupgraded through M/s BEL, Bangalore in May and September 2024 respectively.

- **Installation of 34 Additional DWRs:** By 2026, IMD plans to install 34 new DWRs across major parts of the country. This will increase the total number of radars in IMD's network to 73, providing more comprehensive coverage.

- **Targeted Areas:** The new installations will focus on areas with inadequate radar coverage, including regions prone to severe weather phenomena such as cyclones, thunderstorms, and heavy rainfall.

- **Enhanced Coverage:** This expansion will ensure that even remote and previously underserved areas are included in the radar network, improving the accuracy of weather predictions and providing timely warnings for severe weather events.

By integrating these additional radars into the existing network, IMD aims to enhance its ability to monitor weather patterns in real-time, contributing to improved disaster preparedness and response across the country.

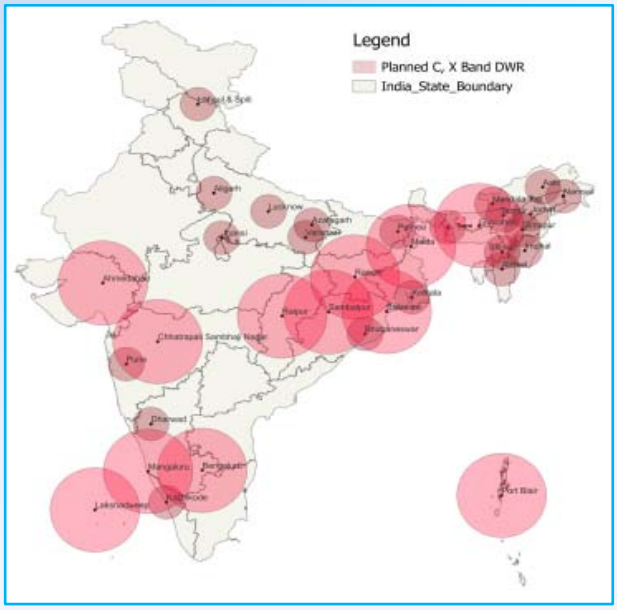


Fig. 20. Proposed C and X Band DWR

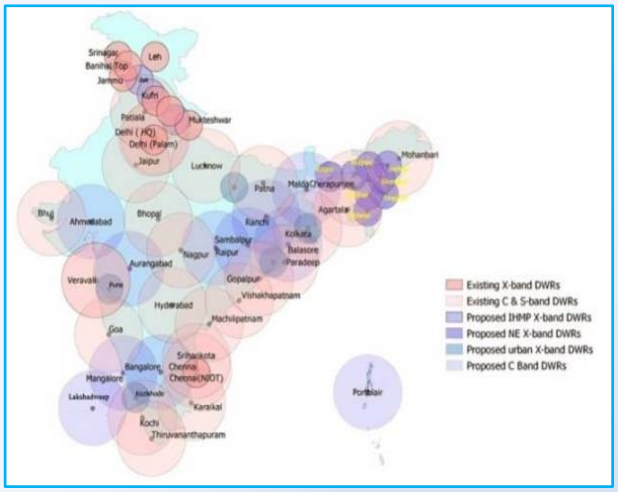


Fig. 21. IMD DWR Network after addition of 34

4.4.7. Mission Mausam

The **IMD** aims to enhance its radar network under **Mission Mausam** by installing additional **DWRs** (Fig. 22).

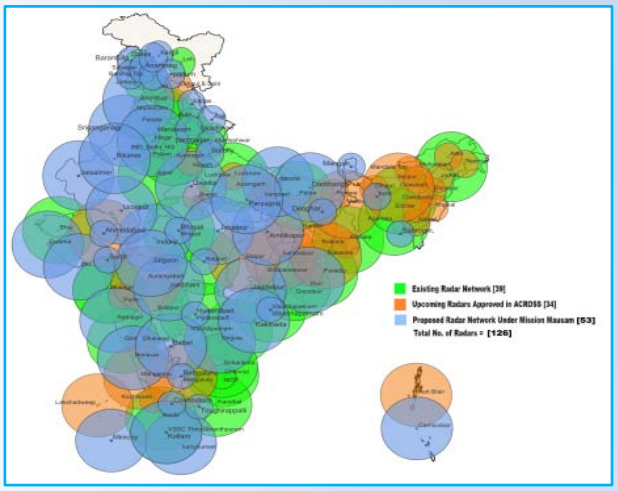


Fig. 22. Proposed DWR network after addition of Mission Mausam DWRs

X-Band (25 DWRs):

- **Purpose:** High-resolution monitoring for localized weather phenomena and adaptation to complex terrains.

C-Band (20 DWRs):

- **Purpose:** Versatile for various weather applications, effective in precipitation measurement and useful for hydrological purposes.

S-Band (8 DWRs):

- **Purpose:** Long-range detection, severe weather monitoring and robust performance in various weather conditions.

Proposed Locations:

- **Cyclone-Prone Areas:** To provide early warnings and detailed tracking.
- **Key Strategic Locations:** To ensure reliable and continuous radar coverage in vulnerable regions.

This initiative aims to improve weather monitoring and forecasting across different regions of India (Fig. 24).

4.4.8. Wind Profiler

The IMD has strategically planned to procure wind profilers as part of a collaborative effort under a Memorandum of Understanding (MoU) with the Indian Space Research Organisation (ISRO), Bangalore. This collaboration aims to enhance the accuracy of weather predictions, particularly in tropical regions, where wind profiles are critical for understanding atmospheric dynamics. IMD also planned 10 nos of additional wind profiler under Mission Mausam project (Fig. 23).

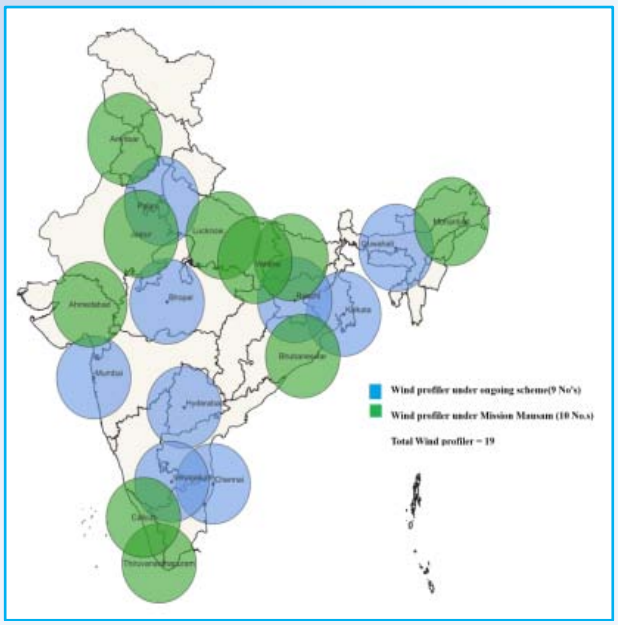


Fig. 23. Proposed Wind Profiler

4.5. Satellite Observations

4.5.1. 14th Asia Oceania Meteorological Satellite Users' Conference (AOMSUC-14)

The Honorable Minister of Earth Sciences Dr.Jitendra Singh inaugurated the 14th Asia Oceania Meteorological Satellite Users' Conference (AOMSUC-14) at Vigyan Bhavan, New Delhi on 4thDecember, 2024 (Fig. 24). The conference was hosted by the India Meteorological Department (IMD), Ministry of Earth Sciences from December 4th to 6th December 2024 that featured high-quality oral and poster presentations, panel discussions, and a training workshop focused on applying satellite data for meteorological and climatological applications.

Fig. 24. The Honorable Minister of Earth Sciences Dr.Jitendra Singh inaugurated the 14thAsia Oceania Meteorological Satellite Users' Conference (AOMSUC-14) at Vigyan Bhavan, New Delhi on 4th Dec, 2024

The conference aimed to promote the importance of satellite observations, advance satellite remote sensing science, provided a platform for dialogue and collaboration between satellite operators and users and informed the community about the current status and future plans of international space programs while engaging young scientists in the field.

There were about 150 participants from different countries, including national participantson. Other dignitaries who attended the conference included:

- Dr. M. Ravichandran, Secretary, Ministry of Earth Sciences
- Dr. M. Mohapatra, Director General of Meteorology, IMD
- Shri Nilesh M. Desai, Director, Space Application Centre (ISRO)
- Dr. Allen Huang, Chair, AOMSUC
- Dr. Ben Churchill, Director, Regional Office for Asia and the South-West Pacific, WMO

The 14th Asia-Oceania Meteorological Satellite Users' Conference proved to be highly beneficial event for advancing the use of satellites in weather, climate and environmental applications. The AOMSUC-14 was preceded by a two-day international training workshop on the 2nd and 3rd of December at Satellite Meteorology Division, IMD, New Delhi. There were 70 trainees from different countries, including India.

The AOMSUC-14 was followed by an international coordination meeting of members of Regional Association RA-II and RA-V countries at Arnav Hall, Prithvi Bhavan, on the 7th of December 2024. All these events helped in international coordination and capacity building for the important application of satellite products in weather and climate forecasting and services.

4.5.2. Achievements

4.5.2.1. Launch of INSAT-3DS Geostationary eteorological Satellite

INSAT-3DR and INSAT-3DS are dedicated geostationary meteorological satellites and located at 74-degree and 82-degree East longitude, respectively. This year marked the launch of the INSAT-3DS mission which was launched successfully on 17th February, 2024 using GSLV-F14launch vehicle and by June 2024, INSAT-3DS was maneuvered into its final geostationary slot at 82°E, replacing INSAT-3D, which ceased operations. This milestone enhanced India's capabilities in satellite meteorology and improved the accuracy and timeliness of weather-related services. INSAT-

3DSlike 3DR carries a multispectral 6 channel Imager, 19 channel Sounder, Data Relay Transponder (DRT) and Satellite Aided Search & Rescue Transponder (SAS&R).

INSAT 3DS (Fig. 25) has been successfully incorporated in the existing Multi-Mission Meteorological Data Receiving and Processing System (MMDRPS) facilityof the India Meteorological Department (IMD). The needed adjustment in the tuning of Antenna and the RF system along with the new data reception applications have been implemented to facilitate the continuous reception of data streams from meteorological payloads of the satellite. Virtualization of the data processing servers, servers for hosting of the divisions websites and dissemination servers have been implemented to integrate the additions. Data reception applications have been modified and integration of various meteorological data products have been added to MMDRPS with the help of Space Application Center, ISRO, Ahmedabad.

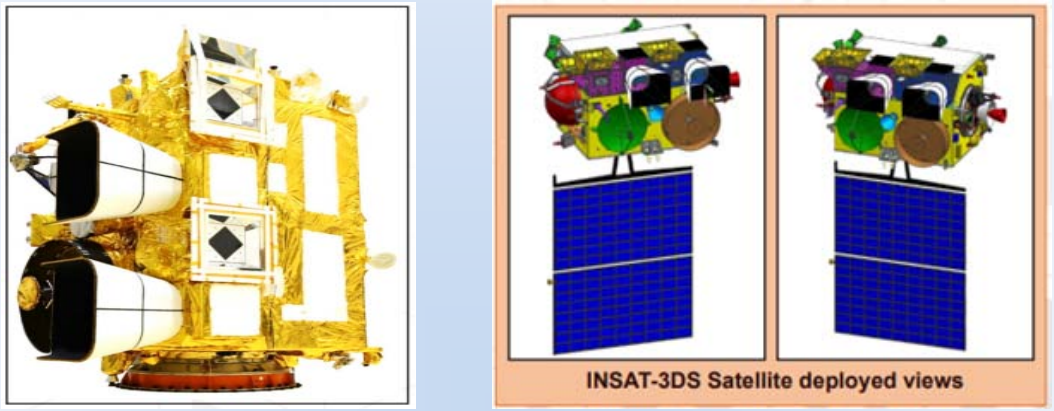


Fig. 25. INSAT -3DS Satellite deployed views

Fig. 26. Data receiving, processing, storage anddissemination chain of MMDRPS system

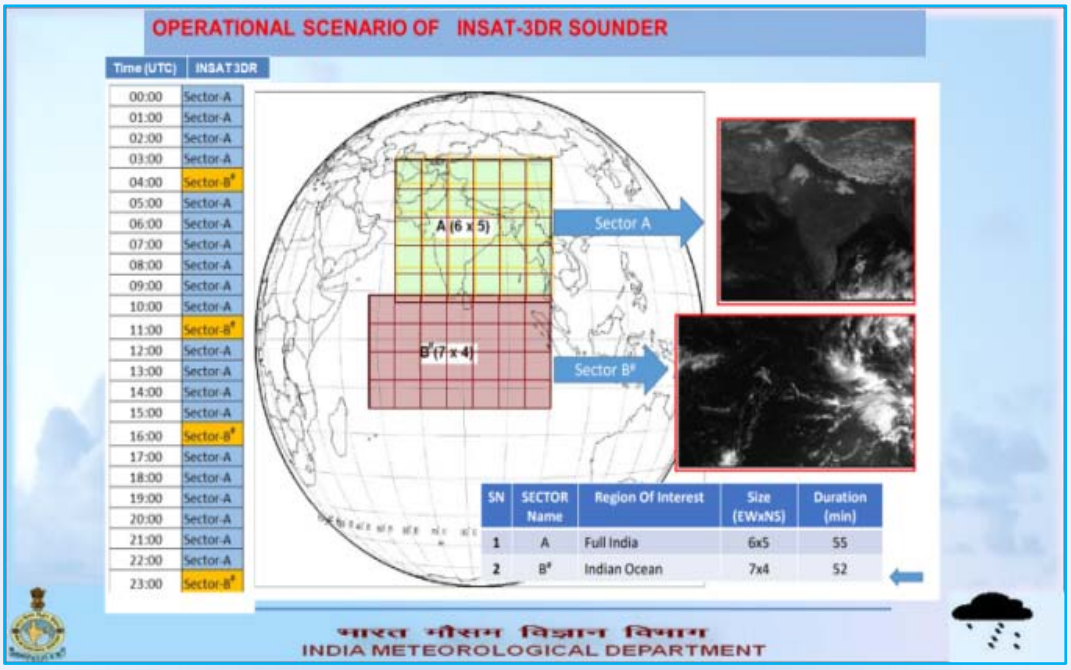


Fig. 27. Scan strategy of INSAT-3DR sounder

4.5.2.2. Multi-Mission Meteorological Data Receiving and Processing System (MMDRPS)

IMD has established Multi-Mission Meteorological Data Receiving and Processing System (MMDRPS) for INSAT-3DR, INSAT-3DS. Three numbers new earth stations have been setup under MMDRPS Project, which have the capability to receive the data from INSAT3D, INSAT-3DR and upcoming INSAT-3DS satellite. MMDRPS systems (Fig. 26) consist ofadvanced & latest state of art servers capable to process the complete set of data within 7 minutes after completion of scan along with the storage capacity of order 2.0/2.0PB (Main/Mirror) & 324 TB SSD which will facilitate online sharing of processed data for all Indian meteorological satellites to the registered users as per IMD data policy through Web-based secured satellite Data Supply System.

4.5.2.3. Operational Scan Strategies

The Imager payload of INSAT-3DR (Fig. 27) and INSAT-3DS is being used in the staggered mode so that a 15 minutes temporal resolution is achieved. During extreme weather events, the INSAT 3DR imager is used for RAPID scanning. Rapid scan has been conducted during major cyclonic events like Remal and Dana.

The sounder payload of INSAT-3DR is operated in such a way that Iindia land region sector data is covered up twenty times and the Indian Ocean region data is covered up four times (0400, 1100, 1600 & 2300 UTC) on an hourly basis.

4.5.2.4. Operational Products generated from INSAT 3DR/3DS satellites

The products derived from the satellite data include: Cloud images in the Visible, Short wave Infra-red, Mid Infra-red, Thermal Infra-red, Water Vapour Channels; and special enhanced images, Atmospheric Motion Vectors (IR Wind, Water Vapour Winds, MIR/Visible Winds), Sea Surface temperature, Outgoing Long-wave radiation, Land Surface Temperature (LST), Insolation, Quantitative Precipitation Estimates, Nighttime Fog, Smoke, Fire, Snow Cover, Aerosol Optical Depth, Upper Tropospheric Humidity, Cloud top Temperature, Cloud top Pressure, Temperature & Humidity profiles, Total ozone, Total/Layer Precipitable Water Vapour, Stability Indices.In addition to these, IMD has also started a generation of Wind derived products such as Vorticity (at 850mb, 700mb, 500mb, 200mb levels), Wind Shear, Mid-level Wind Shear, Shear Tendency, Low-level Convergence, and Upper-Level Divergence using Imager Wind product and NCEP forecast file and T-phi gram at all district locations using Sounder

data. All these images and products are disseminated on a real-time basis through a dedicated IMD website. Satellite observed radiances and winds are now being assimilated in NWP models to improve their forecast ability. Satellite images are used in monitoring Cyclones. The intensity and position of cyclones are given to forecasters in real-time using the Dvorak technique. Satellite data and images are also used in monitoring various other significant weather phenomena such as Fog and thunderstorms. Two new types of satellite Imageries IR-1 BT Blended Image & IR-1 BT & Visible Sandwich Image has been made operational which are considered very useful for monitoring Thunderstorm events.

4.5.2.4. Satellite-based cyclone monitoring

During the year 2024, tropical cyclones Remal, Asna, Dana were monitored with INSAT 3DR and 3DS. Advanced Dvorak Technique (ADT) software customized for INSAT-3DS was implemented to determine the intensity of Tropical Cyclones. During extreme weather events, INSAT 3DR imager was used for Rapid Scanning (Table 1 & Fig. 28). Rapid scanswere conducted during major cyclonic events like Remal, Asna, Dana as per the schedule given below. The imageries of rapid scan conducted during cyclonic events are being disseminated through newly developed dedicated web page (http://satmet.imd.gov.in/rapid/rapid_scan.htm).

TABLE 1

INSAT-3DR Total Number of Rapid Scans during cyclonic storms

S. No.	Name ofcyclone	Duration	Total Numberof Rapid Scans
1.	SCS – Remal	24thto 28thMay 2024	572
2.	SCS – Dana	22nd to 26th Oct 2024	508

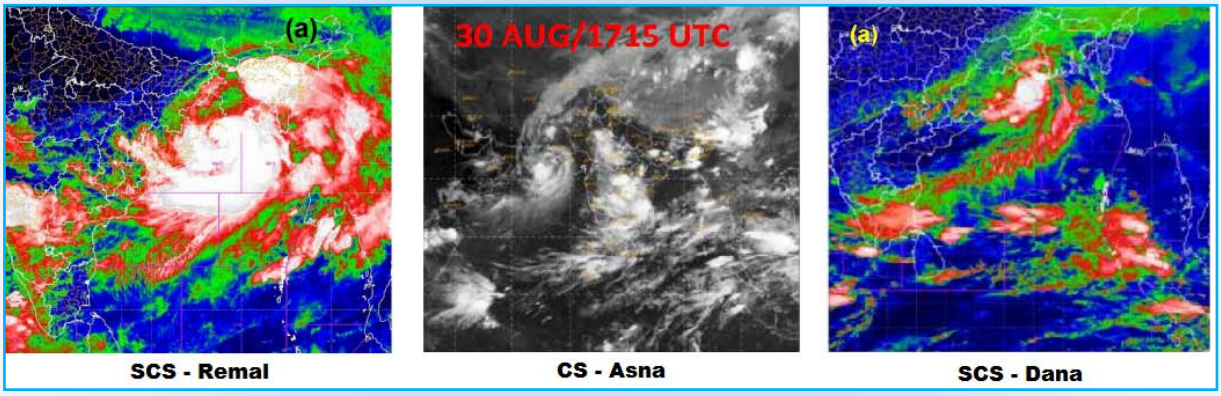


Fig. 28. INSAT-3DR Imager rapid scan during cyclonic storms

4.6. FDP STORM Report – 2024

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

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

This year also STORM Fields Experiments covered the whole India. The monitoring period was uniform for entire country from 1 March to 30 June, 2024.

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

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

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

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

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

A total of 122 FDP Bulletins were issued during the STORM Period-2024.

4.6.1. Nowcast Guidance Bulletins

In addition to FDP Bulletins during March to June - 2024, Nowcast Guidance Bulletins containing current Synoptic features and depicting potential areas for Severe Weather (Heavy Rainfall/ Thunderstorm & Associated Phenomenon/Fog) for next 24 hours, in text as well as visual form based on 0830 IST observations were issued once a day (updated in the afternoon if needed) throughout the year. These bulletins provide significant guidance to the forecasters working at different RMCs/MCs, in keeping a watch over their areas of responsibility as mentioned in the Guidance Bulletins & issue Nowcast Bulletins accordingly.

4.6.2. Location Specific three hourly Thunderstorm (TS) Nowcast

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

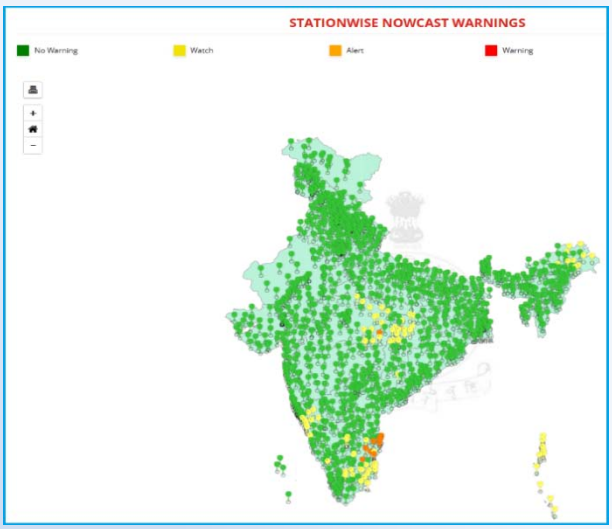


Fig. 29(a). Stationwise Nowcast Warning Page on IMD website Link:
https://mausam.imd.gov.in/responsive/stationWiseNowcast.php

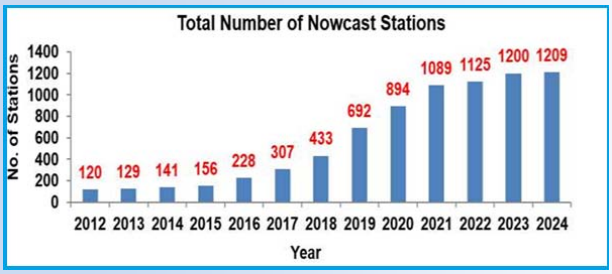


Fig. 29(b). Year-wise cumulative number of stations for three hourly thunderstorm Nowcast

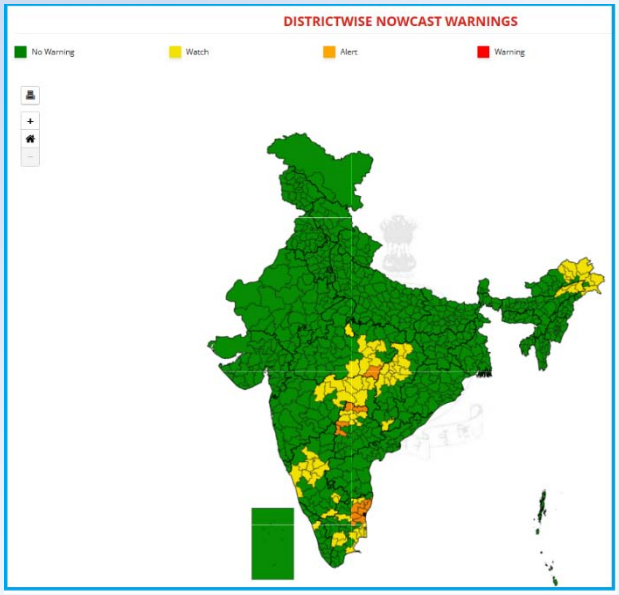


Fig. 29(c).Districtwise Nowcast Warning Web Page on IMD website Link:
https://mausam.imd.gov.in/responsive/districtWiseNowcast.php

Thunderstorm nowcast of major towns is uploaded every 3 hourly interval utilizing Synoptic Data, Model outputs, Satellite products and finally various Radar outputs by the respective RMCs/MCs/ RWFCs under whose jurisdiction these stations are situated. During the year-2024, 34 new stations were added on All India Nowcast Warning page of IMD website for issuing three hourly thunderstorm nowcast, thereby, increasing the total number of nowcast stations to 1200 (till December, 2024) under 25 Nowcast Centers (RMC/RWFC/MC/CWC). Fig. 29(a) depicts the screen shot of Nowcast Warning Page on IMD website and Fig. 29(b) indicates the year-wise cumulative number of stations added on Nowcast Warning page for three hourly thunderstorm Nowcast. In addition to stationwise nowcasting, district level nowcast, which was started in July, 2019 was also issued for all the 735 districts of India [Fig. 29(c)]. Considering the importance and reliability of DWR and satellite based information for nowcast of severe weather, all district headquarters/major towns/tourist places and specific locations within capital cities (under Urban Meteorology and Climate project) in India are to be included for nowcasting of severe weather.

The Stationwise and district wise nowcast is issued for about nineteen categories [Fig. 29(d)] of different kinds based on severity of weather for lightning, thunderstorms, dust storms, hail storms, squalls, rain and snow etc. This nowcast warning

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

Fig. 29(d). Different categories of Nowcast Warnings

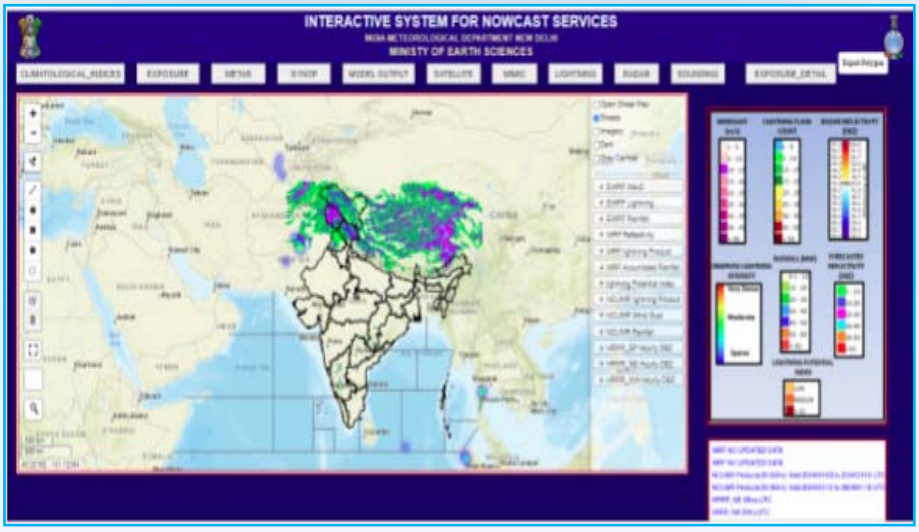


Fig. 29(e). New Portal-Interactive System for Nowcast Services
Link:http://103.215.208.18/dwr_img/GIS/nowcast.html

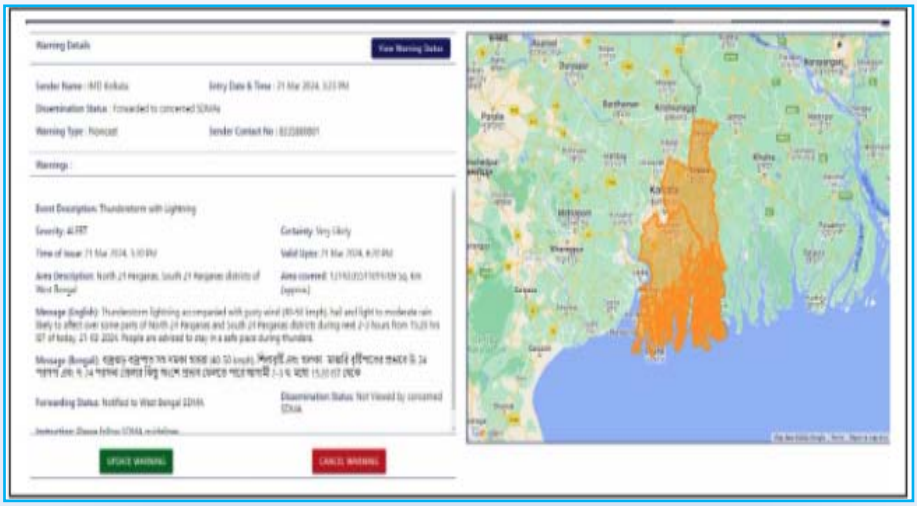


Fig. 29(f). Common Alert Protocol based warning issued through SACHET portal

Fig. 29(g). Automatic Nowcast Bulletin generated and issued through TDSS portal

page is available on new as well as old IMD websites.

A new web based Thunderstorm Decision Support System (TDSS) portal has been developed by IMD in 2024 - **'Interactive System for Nowcast Services'** [Fig. 29(e)]. All (i) observational data products including lightning data from IITM & ILDN networks, satellite & radar tools, (ii) mesoscale/ nowcast model products developed by IMD including newly developed nowcast models EWRF & HRRR, NCMRWF and (iii) climatological thermodynamic indices are integrated on this portal for monitoring of thunderstorms and associated phenomena. This integrated system guides a forecaster/nowcaster in generating impact based colour coded nowcast warnings in an effective way as well as their dissemination to various users and updating on IMD's Nowcast web Page.

There has simultaneously been a conscious thrust from all Meteorological centres to provide impact based dissemination of warnings of thunderstorms over the Indian region in line with the forecast Circular No. 1/2019 using Common Alert Protocol through SACHET portal [Fig. 29(f)]. Simultaneously, Automated generation of Nowcast Bulletin through the TDSS portal has allowed the penetration of IMD forecasts up to Tehsil level and more [Fig. 29(g)].

(i) FDP Bulletins

The thunderstorm forecasts issued for 24 hours during FDP STORM-2024 were verified with realised thunderstorm data. The monthwise evolution of forecast skill during 2024 as indicated by the verification results for thunderstorm forecast are shown in Table 2 and graphically by Fig. 29(h). Fig. 29(i) indicates the evolution of 24 hr

Thunderstorm forecast IOP skill during FDP season of 2016 to 2024 which shows a significant improvement in all the scores.

TABLE 2

Skill sores for Thunderstorm verification for FDP STORM - 2024 (March to June)

Month	Ratio Score	POD	FAR	CSI	ETS	BIAS
March	0.81	0.88	0.32	0.62	0.44	0.81
April	0.80	0.86	0.28	0.64	0.43	0.80
May	0.76	0.89	0.30	0.65	0.34	0.76
June	0.63	0.80	0.35	0.56	0.12	0.63
FDP-2024	0.75	0.86	0.32	0.61	0.34	0.75

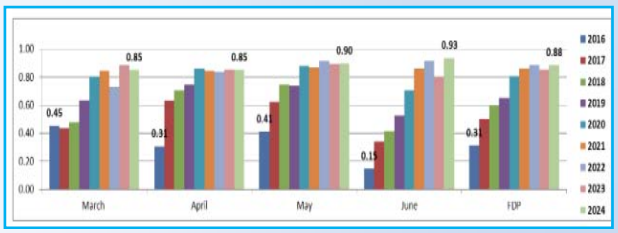


Fig. 29(h). Month wise evolution of the all India POD scores from March to June during the period of 2016 to 2024

Fig. 29(i). 24 hour thunderstorm forecast verification result for the entire FDP season of 2016 to 2024

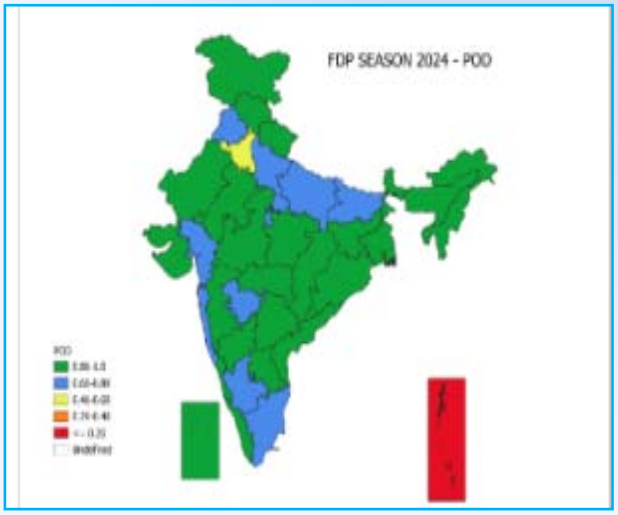


Fig. 29(j). 24 hour thunderstorm forecast verificationresult for the entire FDP season of 2024 – POD score

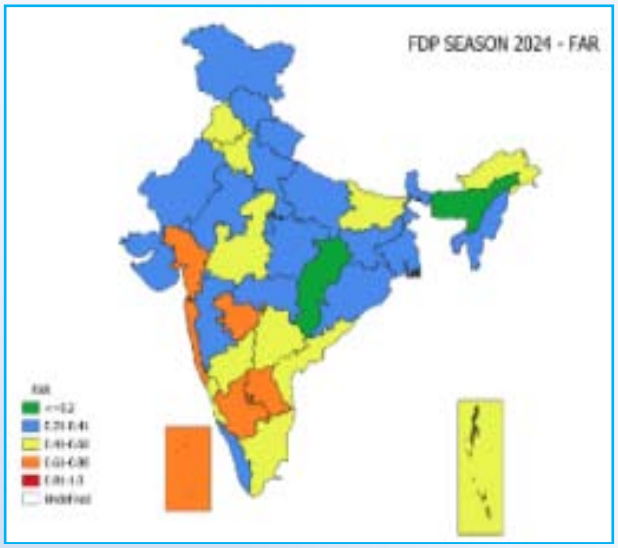


Fig. 29(k). 24 hour thunderstorm forecast verification result for the entire FDP season of 2024 – FAR score

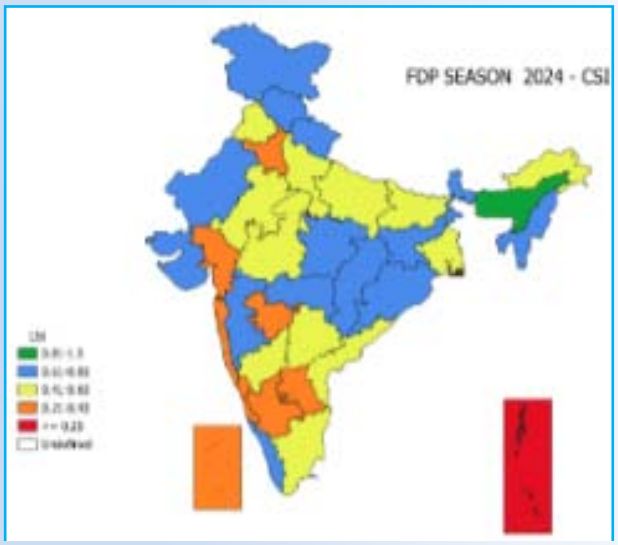


Fig. 29(l). 24 hour thunderstorm forecast verification result for the entire FDP season of 2024 – CSI score

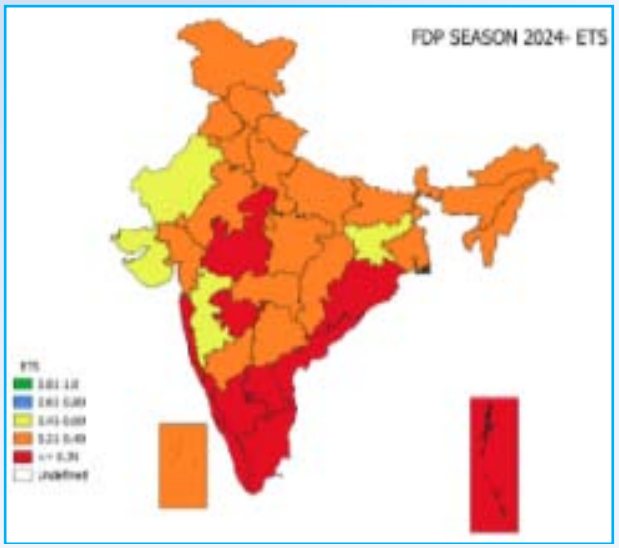


Fig. 29(m). 24 hour thunderstorm forecast verification result for the entire FDP season of 2024 – ETS score

Fig. 29(i) indicate that this year the thunderstorms were detected more accurately in all the months of the season as compared to similar result for all previous STORM seasons.

Figs. 29(j-m) display statewise POD, FAR, CSI and ETS scores of 24 hour IOP of Thunderstorm forecasts. As may be noted, forecastskills are poorer for the west peninsular India.

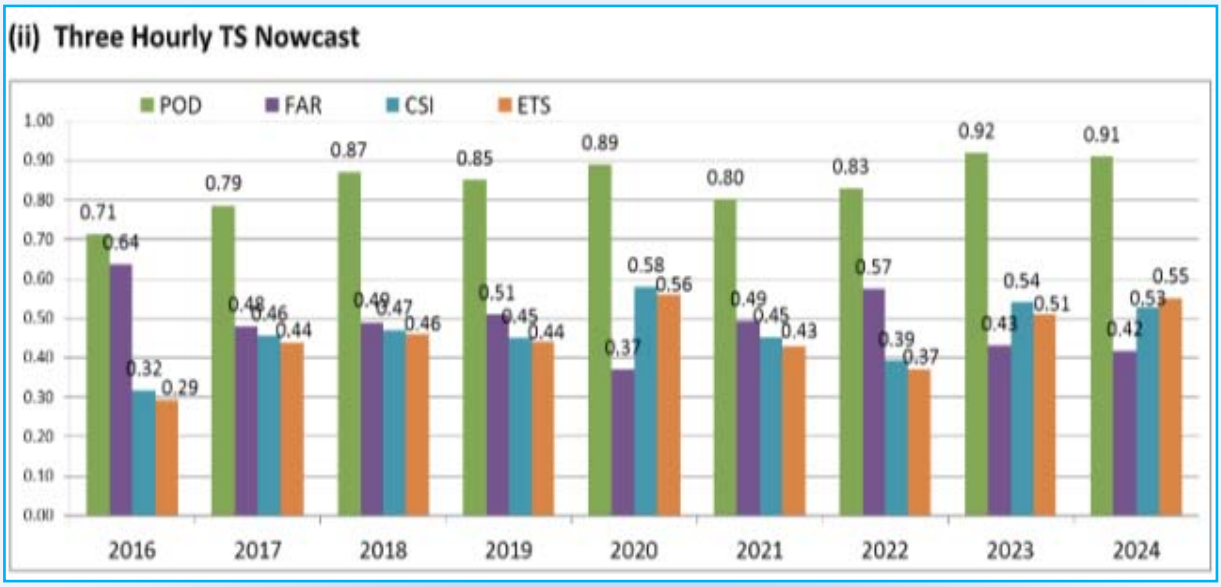


Fig. 29(n). Three hourly thunderstorm nowcast verification result for thr entire FDP season of 2016-2024

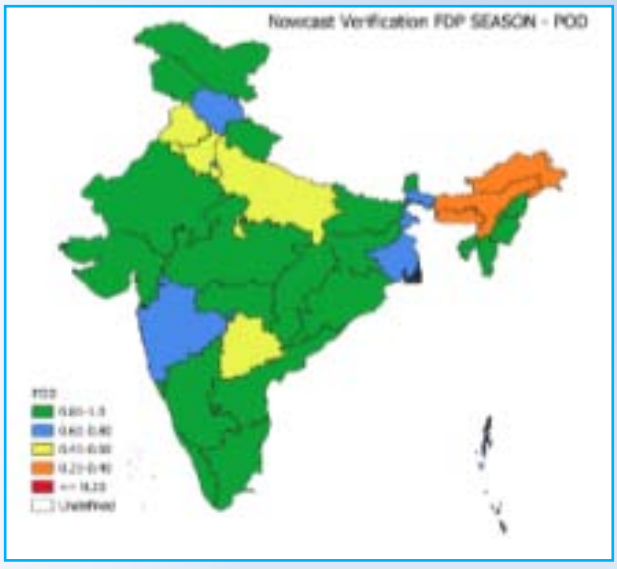


Fig. 29(o). 3 hour thunderstorm forecast verification result for the entire FDP season of 2024 – POD score

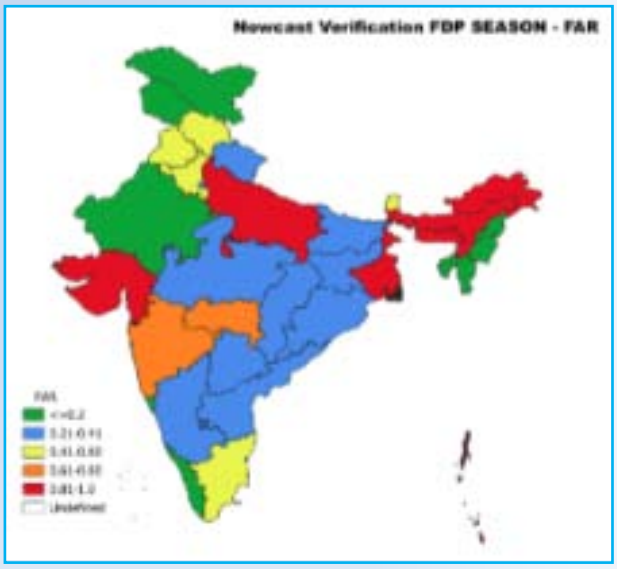


Fig. 29(p). 3 hour thunderstorm forecast verification result for the entire FDP season of 2024 – FAR score

Fig. 29 (n) indicates the all India POD, FAR, CSI and ETS scores of three hourly TS Nowcasts issued by various RMCs/MCs during FDP STORM (March to June) for the year-2016 to 2024. Figs. 29(o to r) display the statewise POD, FAR, CSI and ETS scores of 3 hour Thunderstorm nowcasts.

4.6.3. FDP STORM Report - 2024

A detailed STORM Report document, based on thunderstorm activities observed over India during March to June-2024, was prepared by Nowcast Division, NWFC. It contains information on daily

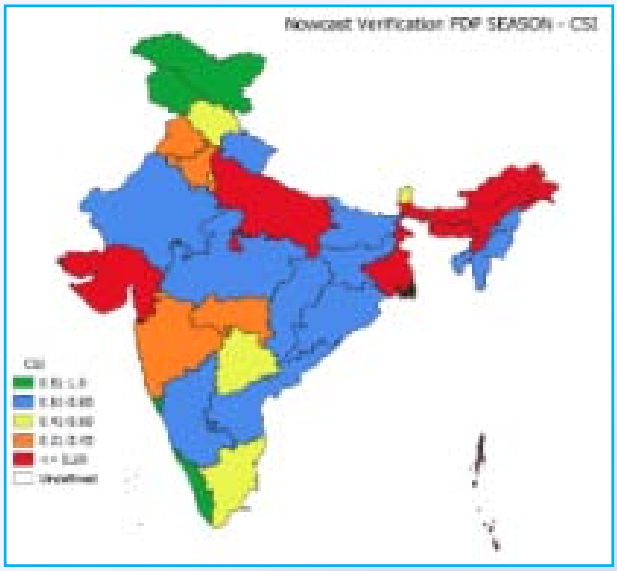


Fig. 29(q). 3 hour thunderstorm nowcast verification result for the entire FDP season of 2024 – CSI score

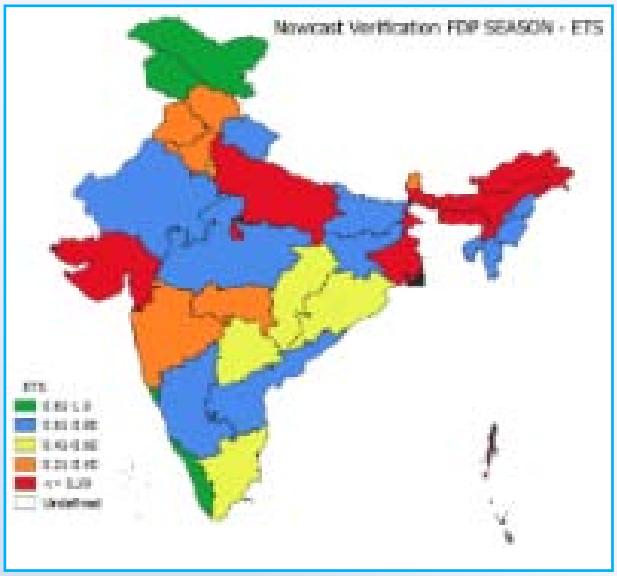


Fig. 29(r). 3 hour thunderstorm nowcast verification result for the entire FDP season of 2024 – ETS score

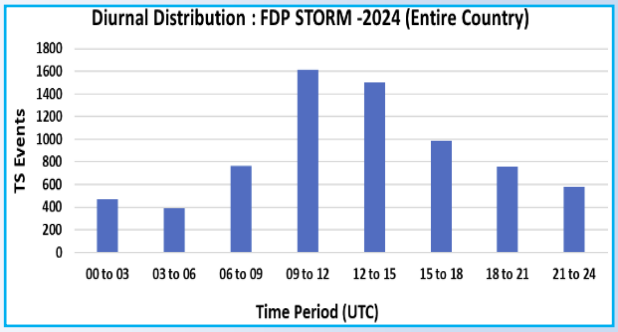


Fig. 29(s). Diurnal distribution of TS events over the country during FDP STORM-2024

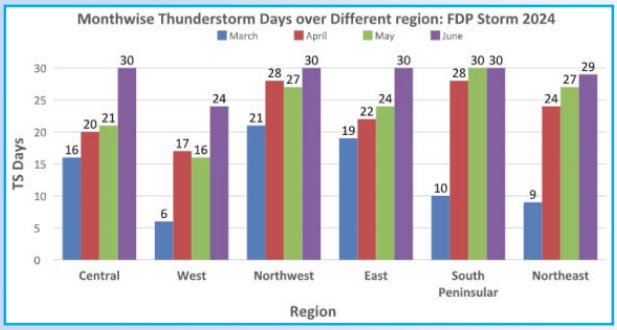


Fig. 29(t). Monthwise distribution of TS days over different regions of India during FDP STORM-2024

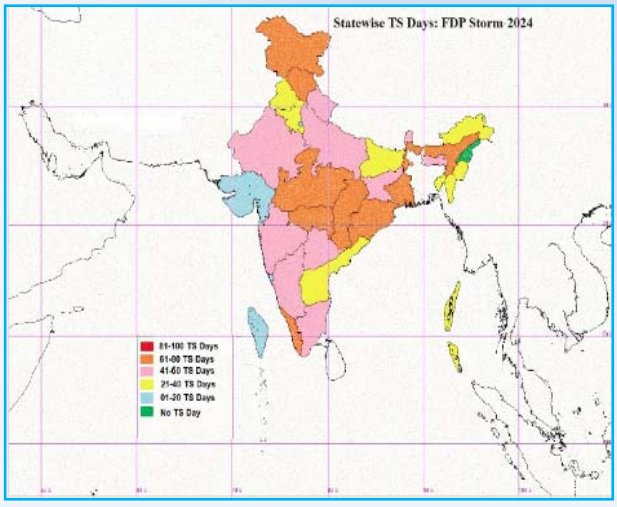


Fig. 29(u). Distribution of TS days over different states during FDP STORM-2024

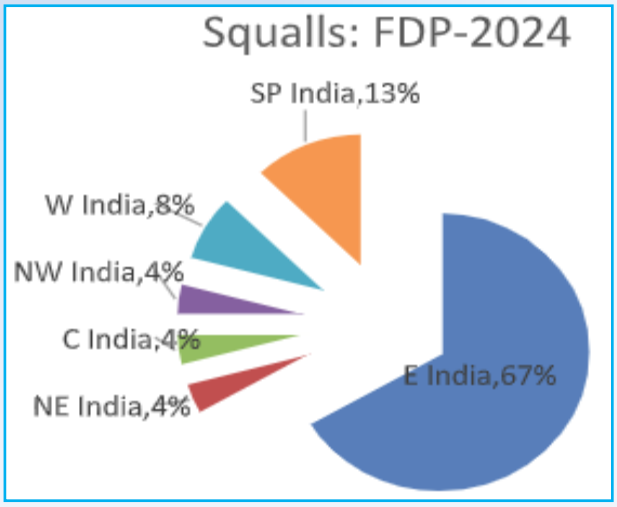


Fig. 29(u). Regionwise Distribution of squall events over the country during entire FDP STORM-2024

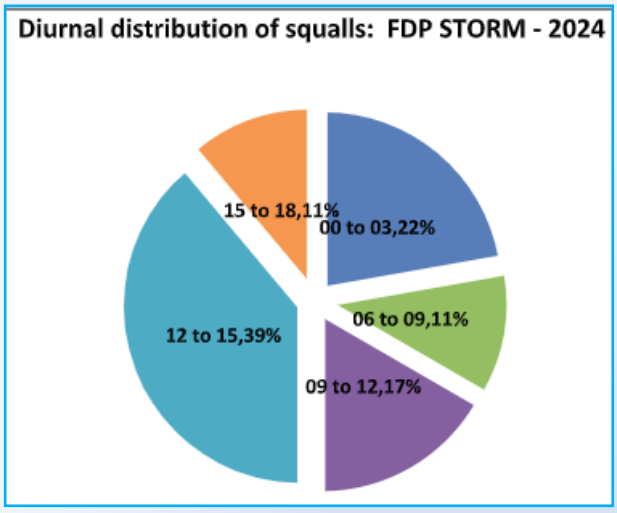


Fig. 29(v). Diurnal (time in UTC) distribution of thundersqualls during FDP STORM-2024

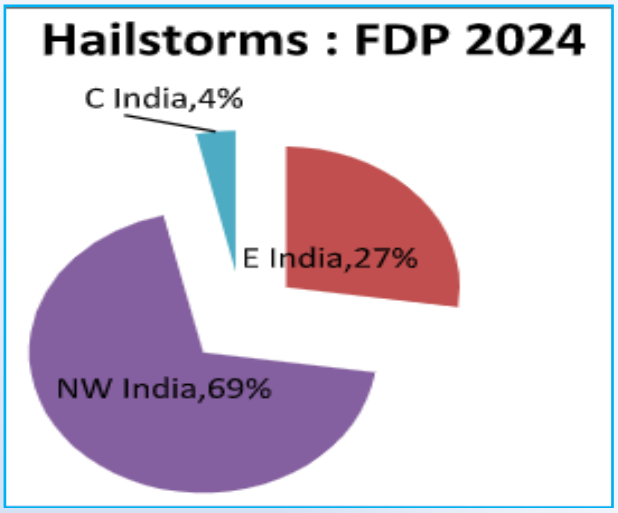


Fig. 29(w). Regionwise distribution of hailstorm events during FDP STORM-2024

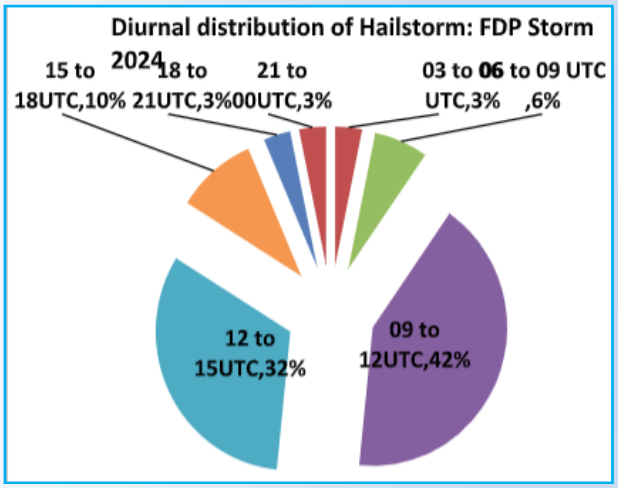


Fig. 29(x). Diurnal distribution of hailstorm events over the country during entire FDP STORM-2024

weather situation, important weather charts, severe weather events all through the campaign period, case studies and the bulletins issued during the period. The report has been published during IMD foundation Day on 15th January, 2024. Figs. 29(s-w) represent some of the salient features of the FDP STORM Report-2024.

4.6.4. New Initiatives undertaken by Nowcast Unit

(i) Automation of district nowcast verification

IMD operationally issues district level nowcasts for severe weather for all districts of India round theclock at three hourly intervals since 2018. The phenomena for which nowcasts are issued include: (a) Thunderstorms and associated weather and (b) rainfall. All these nowcasts are updated every threehours on the IMD website (https://mausam.imd.gov.in/imd_latest/contents/districtwisewarnings.php). The data from the groundbased lightning array network of the Indian Institute of Tropical Meteorology and Indian Air Forcehas been used for verification of the District level Nowcasts. This network currently has 83 sensorsand provides spatial accuracy of about 500 m. The point data for lightning with lat-long coordinatesis provided from the network in near realtime mode to IMD at 15 minute intervals for operationaluse. The point data is geolocated up to the district level using open source “Nominatim Server” software. For verification purposes, a yes-no criterion (2x2 configuration table) is applied foroccurrence-non-occurrence of thunderstorms in each district. All the eleven categories of nowcasts for thunderstorms and associated weather are considered for verification. A minimum of 2 (two) incidences of lightning occurrence in a district within the validity period of a nowcast is considered occurrence of thunderstorm over that district. The two flashes may occur concurrently or subsequently in time in any part of the district within a period of three hours, i.e., during the validitytime of the nowcast for the district. Based on both observation and nowcast for thunderstorms (anyone of the eleven categories), the forecast skill scores have been calculated. Figs. 30(y-z, aa-ab) represent the district wise POD, FAR, CST and ETS scores of 3 hourly district nowcast verification forthe month of June 2024.

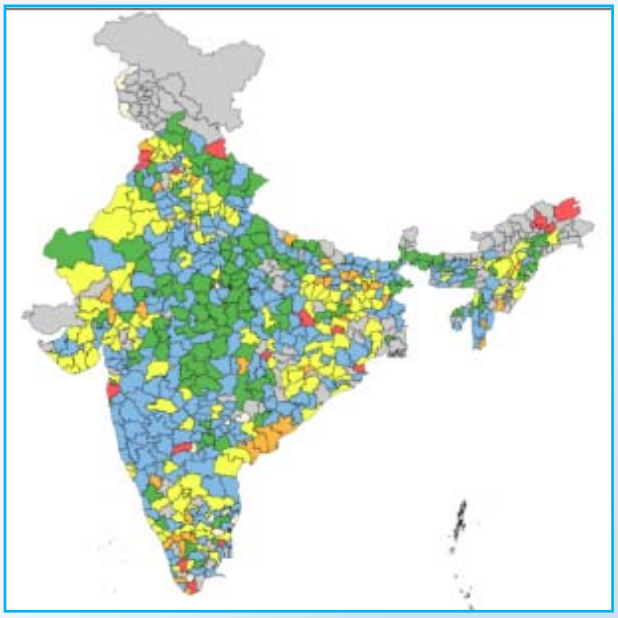


Fig. 30(y). Districtwise POD of 3 hourly district nowcast automatic verification for June 2024

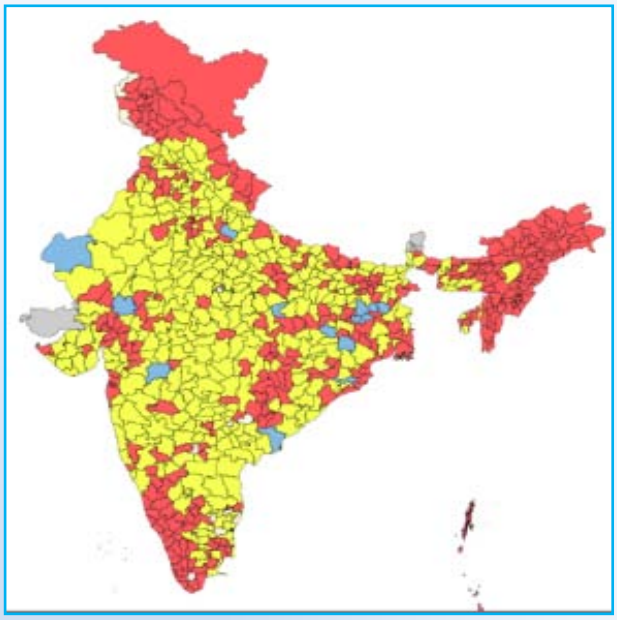


Fig. 30(z). Districtwise FAR of 3 hourly district nowcast automatic verification for June 2024

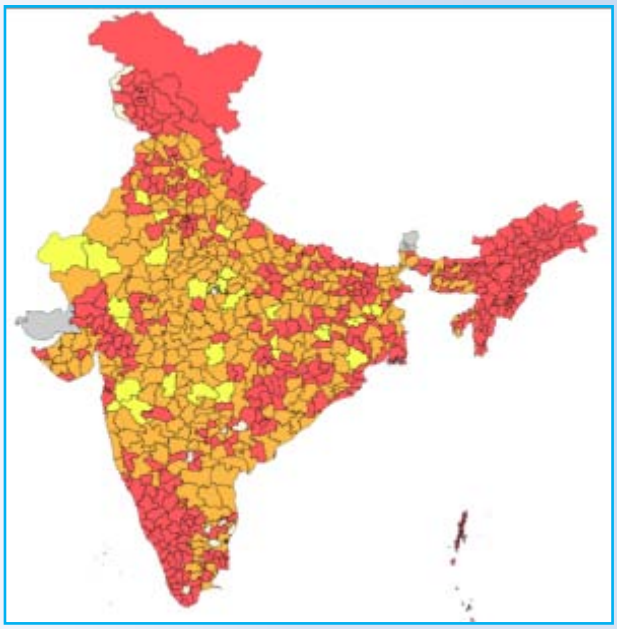


Fig. 30(aa). Districtwise CSI of 3 hourly district nowcast automatic verification for June 2024

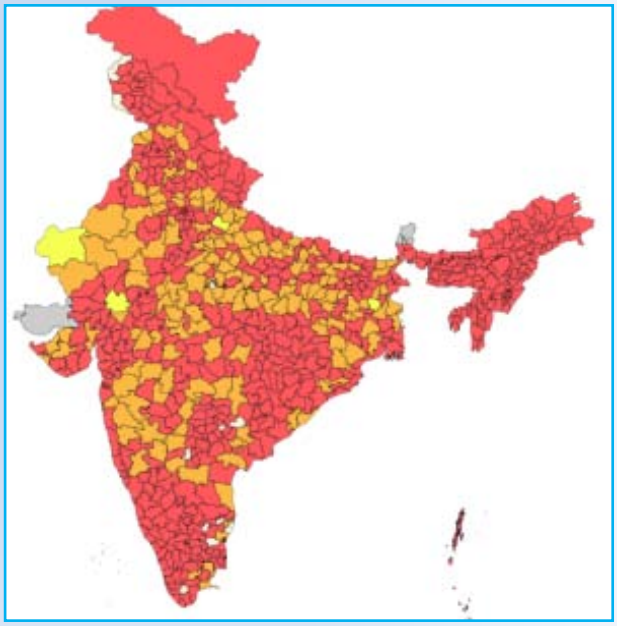


Fig. 30(ab). Districtwise ETS of 3 hourly district nowcast automatic verification for June 2024

(ii) Crowdsourcing

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

In recent years, with the improved understanding of the mesoscale nature of weather systems overIndian region, the constraints of the existing observatory network are sought to be supplemented by other sources of observations. This requirement has been partly met by remote sensed observationsof weather by radar and satellite based instruments and the lightning detection network. However, in the absence of

validation with ground data, the limitations of each instrument hamper the process of forming a clear picture of the weather occurred and its intensity and impact. The lack ofclarity in observations causes uncertainty in forecasts of subsequent weather and its associated impact. With the widespread availability of smart phones, information regarding the state of the atmosphere can now be obtained from many non-traditional sources in text, audio and video form from sources such as citizen scientists, amateur weather stations and sensors, smart devices andsocial-media/web 2.0.

Since 2021, IMD has started an online interface [Figs. 30(ac)] to collect the information of the weather that has occurred as well as the associated impact information for six weather events initially, viz., Rain. Hail, Duststorm, Wind Speed, Thunderstorm/Lightning & Fog. The target weather reportersare (a) Class II, Class III observatories (any observatory not covered under MMR) (b) AMFU, KVK observatories (c) Railways Station Masters (d) Power discom maintenance staff & (e) General Public.

Further, the interface has following features: (i) The reporting interface is without login requirement. (ii) The time of submission will be automatically recorded. (iii) The user machine address and time isautomatically recorded. (iv) The user has the facility to record the Location, State, District of observation. There is also the facility to add photo or video proof of the event.

Fig. 30(ac). Crowd sourcing weather reporting Interface Link: https://city.imd.gov.in/citywx/crowd/enter_th_datag.php

CHAPTER 5

WEATHER AND CLIMATE SERVICES OF IMD

5.1. Hydromet Services

5.1.1. Mandate of Hydromet Division

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

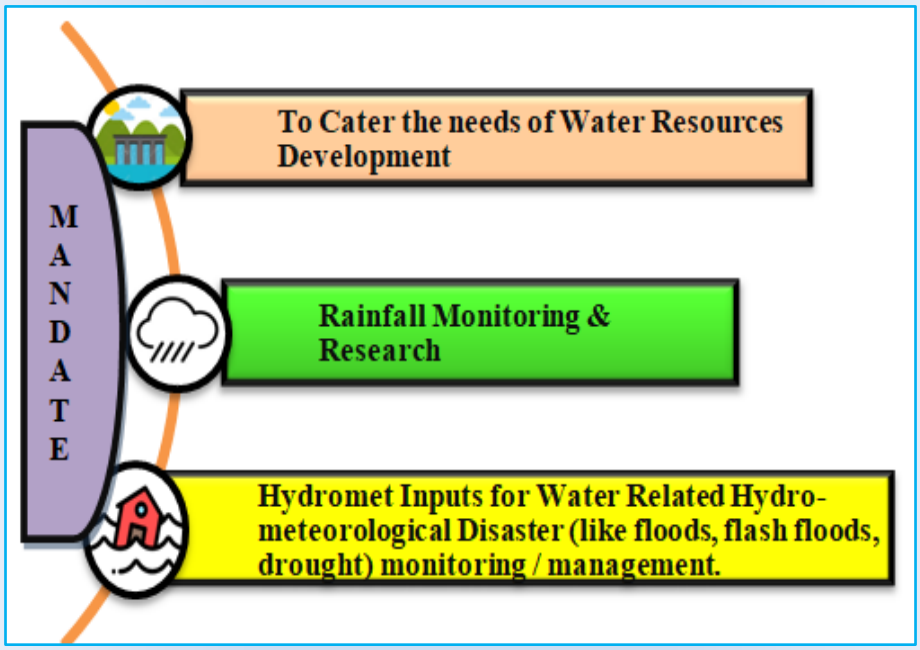


Fig. 1. Mandate of Hydromet Division

5.1.2. Overview of Hydro-meteorological Services of IMD

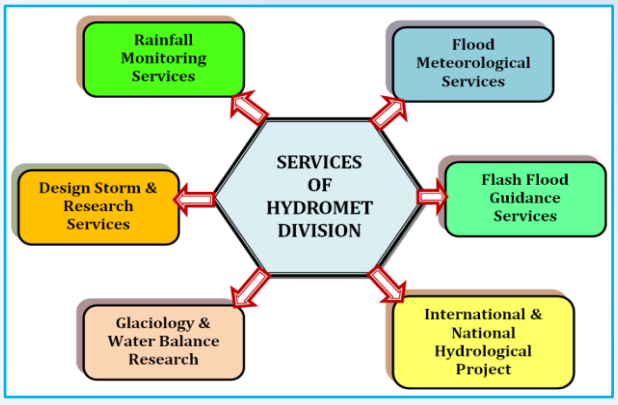


Fig. 2. Services of Hydromet Division

5.1.3. Hydro-meteorological Services of IMD

5.1.3.1. Flood Meteorological Services

The sub-basin wise Quantitative Precipitation Forecasts (QPFs) were issued (daily on operational basis) by 15 FMOs Agra, New Delhi, Asansol, Ahmedabad, Bhubaneswar, Guwahati, Jalpaiguri, Hyderabad, Lucknow, Patna, DVC Met Unit Kolkata, MC Srinagar, Chennai, Thiruvananthapuram and Bengaluru issued QPFs during the monsoon season 2024 for their area of jurisdiction from 1st June to 31st October, 2024. However, the FMOs Srinagar, Guwahati and Jalpaiguri for their area of jurisdiction also provide

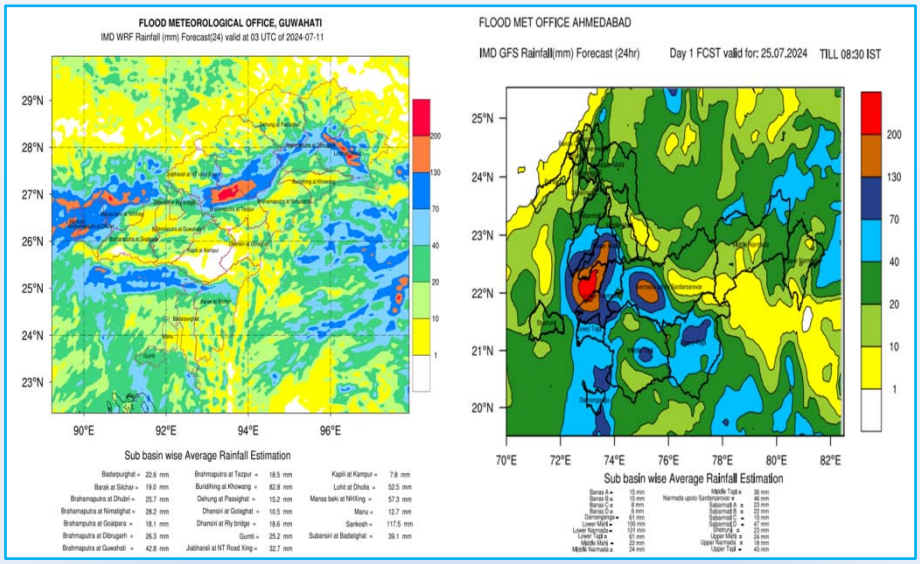


Fig. 3. Spatial distribution of rainfall along with QPF over catchments from different numerical models (WRF and GFS only shown)

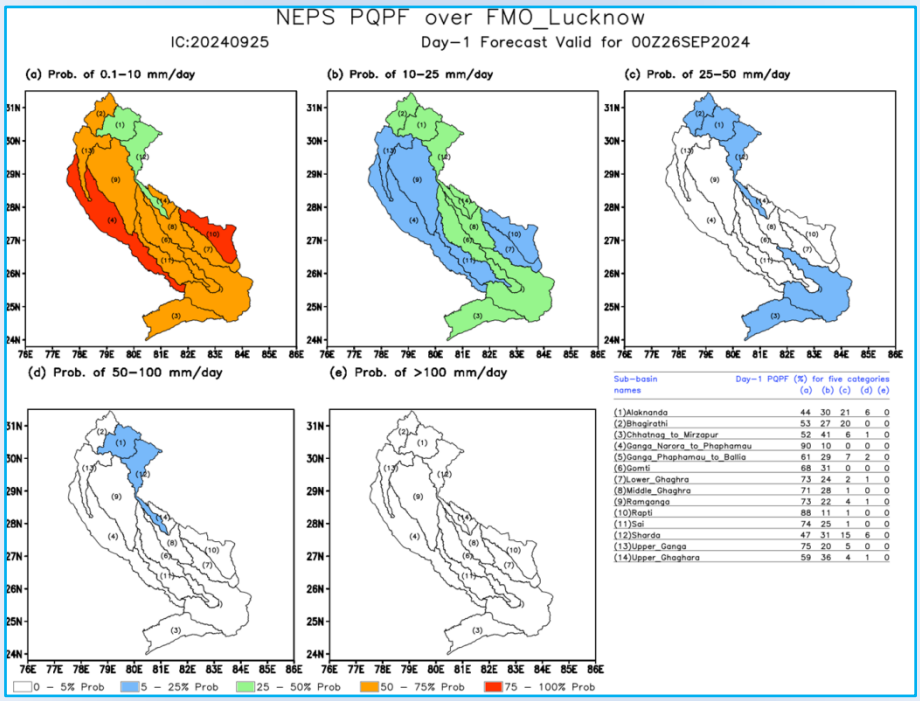


Fig. 4. Probabilistic forecast for QPF from NEPS

QPF guidance from 1st May to 31st October, 2024. FMOs Chennai, Thiruvananthapuram and Bengaluru issue QPFs up to 31st December, 2024. These operational QPF are provided to the field offices of Central Water Commission for the use in their Flood Forecast Model.

During this year, number of Sub-basins increased from 156 to 157 all over India by inclusion of "Shetrunji Basin" under FMO Ahmedabad.

River Sub basin-wise Quantitative Precipitation Estimate (Fig. 3) for Day-1, Day-2 & Day-3 using WRF ARW (3km x 3km) & NCUM-R (4km x 4km), for Day-1 to Day-7 using GFS (12km x 12km), GFS-BC (12km x 12km) & NCUM-G (12km x 12km), River sub basin wise 7 days Probabilistic QPF (Fig. 4) based on dynamical model GEFS & NEPS were uploaded in IMD website operationally for 157 river sub-basins.

During the SW Monsoon season 2024, the accuracy within same category of river sub-basin-wise QPF is 68% in Day-1, 63% in Day-2, 62% in Day-3, 60% in Day-4, 59% in Day-5, 59% in Day-6 and 59 % in Day-7 (Fig. 5).

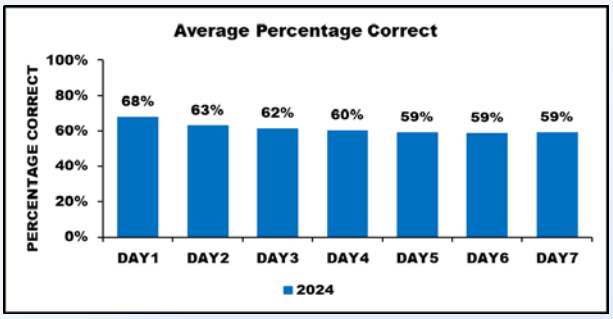


Fig. 5. Average Percentage correct during JJAS 2024 from Day-1 to Day-7

Investigation of QPF guidance for heavy rainfall episodes (Fig. 6) in association with variety of weather systems (Low pressures, Monsoon depression) in monsoon 2024 suggested that the probability of detection (Day 1) over higher categories (26-50 mm), (51-100 mm), (>100 mm) are about 47%, 68%, 40% and was reasonably good in providing the QPF guidance (high category flood situation).

Case study of heavy rainfall occurred in North East-region (FMO Jalpaiguri Fig. 7) has showed the consistency between the district rainfall warning with the QPF guidance issued which can be useful to enhance the operational QPF guidance services.

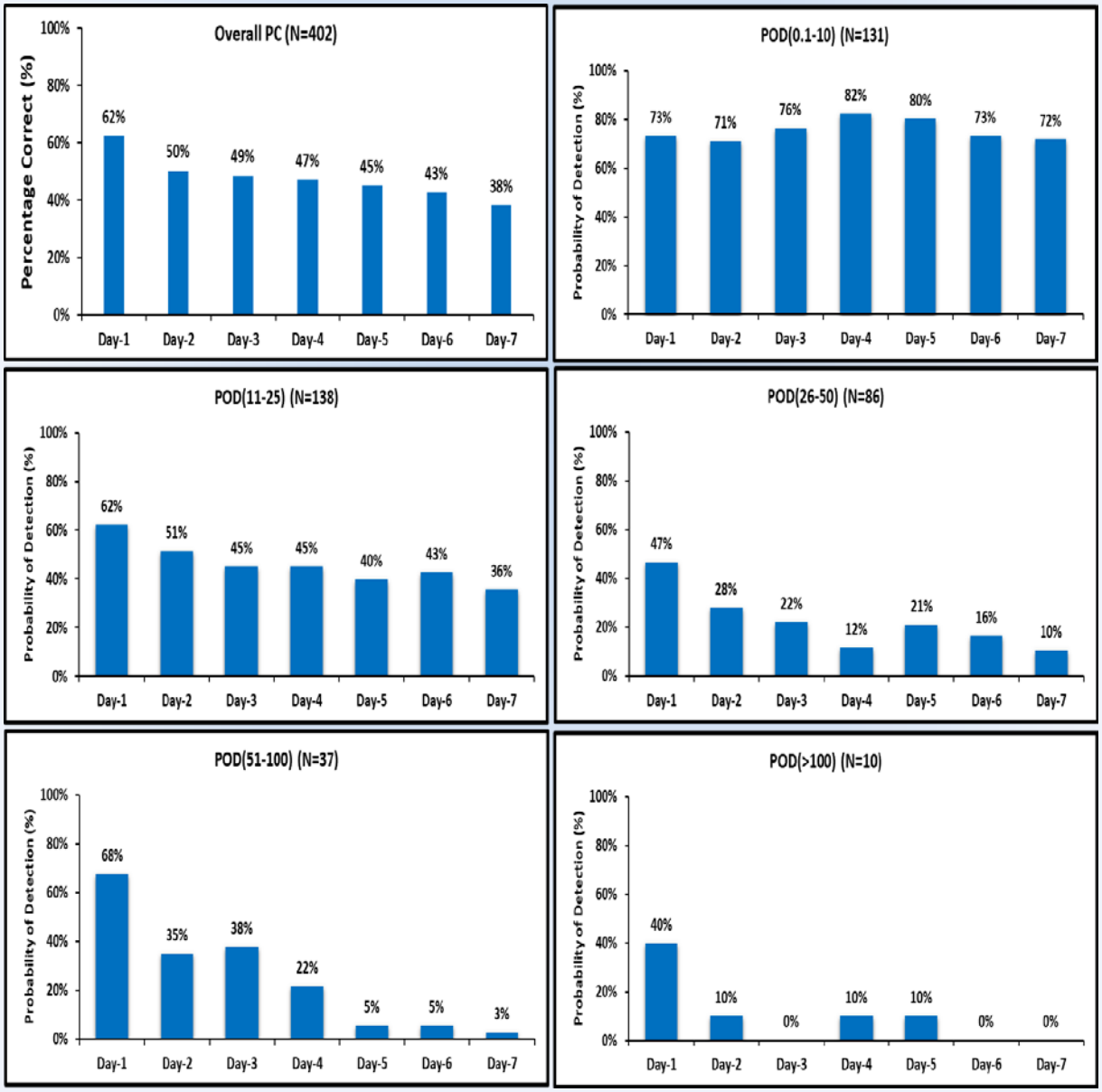


Fig. 6. Skill Scores for Heavy rainfall events happened during JJAS 2024 (a) PC for total QPF, (b) POD of Categorial QPF (0.1-10 mm), (c) POD of Categorial QPF (11-25 mm), (d) POD of Categorial QPF (26-50 mm), (e) POD of Categorial QPF (51-100 mm), (f) POD of Categorial QPF (>100 mm)

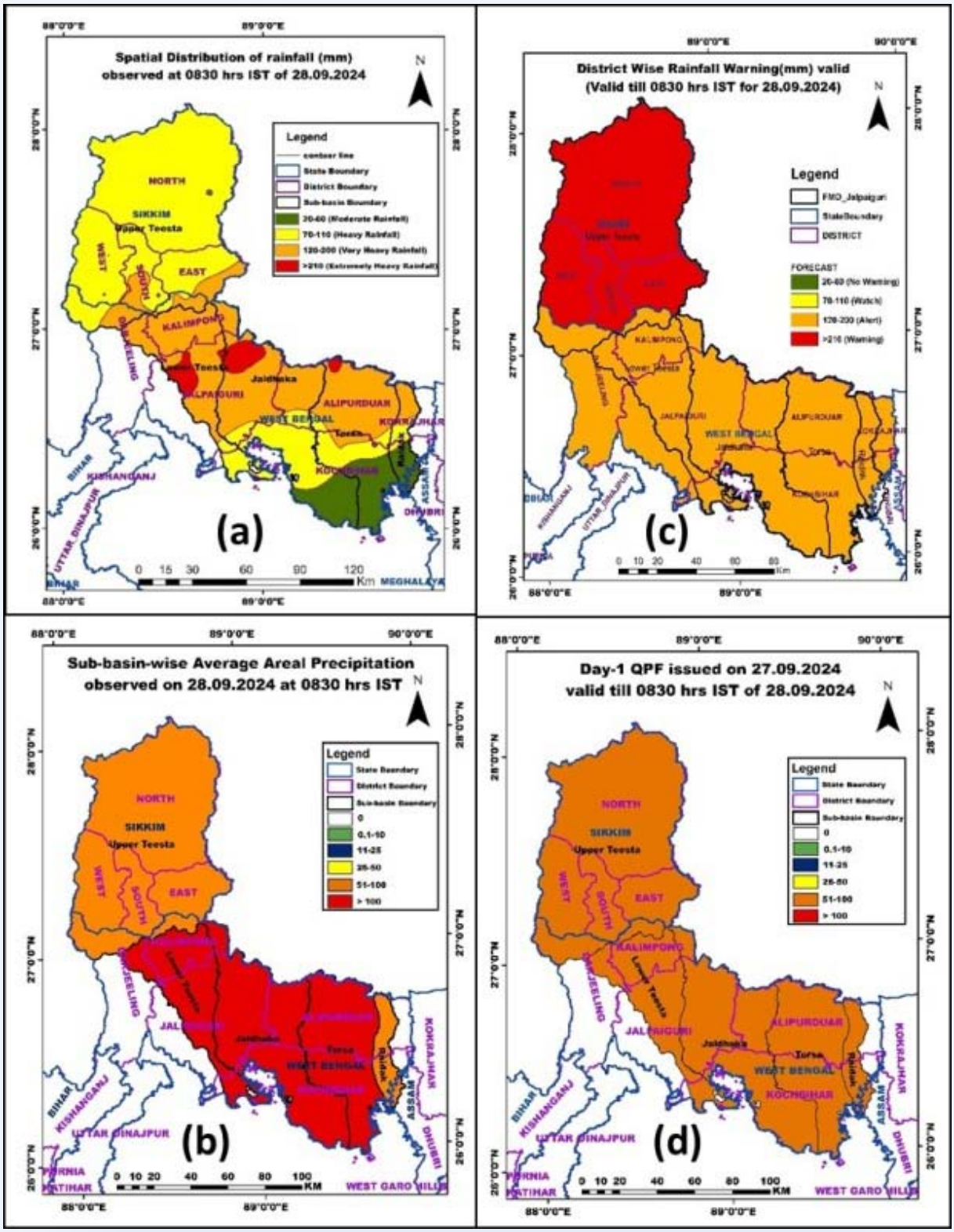


Fig. 7. Spatial distribution of (a) observed rainfall and (b) Quantitative distribution and forecasted (c) district rainfall and (d) QPF issued for 28thSep, 2024 under FMO Jalpaiguri

Issuing joint advisories (Fig. 8) on Flood Status of the country by IMD, CWC and NDRF as suggested by MHA.

Ministry of Home Affairs
Flood Situation in sub-basins

Date: 30.09.2024

Highest Flood Level — EXTREME
Danger Line — SEVERE
Warning Line — Above NORMAL

QPF categories (mm): 0 | 0.1-10 | 10-25 | 26-37 | 38-50 | 51-75 | 76-100 | >100

Sl.No.	River/Sub-Basin/Basin	State	Site/District	Rainfall Situation Day 1	Day 2	Day 3	Day 4	Day 5	Remarks/Advisories
1.	Baqmati/Kosi/ Ganga Basin	Bihar	Belsand/ Sitamarhi						• **Bihar: -** 19 teams of NDRF available i.e Patna-2, Supaul-1, Sahrasa-1, Bhagalpur-2, West Champaran-1, East Champaran-1, Gopalganj-2, Dharbanga-2, Kathiar-1, Muzaffarpur-1, Sheohar-1 & Sitamarhi- 4.
2.	Ichamati/Bhagirathi and Others/Ganga Basin	West Bengal	Bajitpur/North 24 Parganas						• **West Bengal: -** 13 teams of NDRF available i.e Murshidabad-2, Hooghly-1, Malda-4, Alipurduar-1, Jalpaiguri-1, RRC Kolkata-3 & RRC Siliguri- 1.
3.	Ichamati/Bhagirathi and Others/Ganga Basin	West Bengal	Kuthibari/North 24 Parganas						
4.	Ichamati/Bhagirathi and Others/Ganga Basin	West Bengal	Bangaon/North 24 Parganas						
5.	Ichamati/Bhagirathi and Others/Ganga Basin	West Bengal	Tarinipur/ North 24 Parganas						
6.	Ganga/ Gandak & Others/Ganga Basin	Bihar	Birpur/Supaul						• **Bihar: -** As mentioned above.
7.	Burhi Gandak/Gandak/ Ganga Basin	Bihar	Chanpatia /Pashchim Champaran						
8.	Gandak/Gandak/ Ganga Basin	Bihar	Dumariaghat/ Gopalganj						
9.	Gandak/Gandak/ Ganga Basin	Bihar	Lalganj /Vaishali						
10.	Burhi Gandak/Gandak/ Ganga Basin	Bihar	Khagaria/ Khagaria						

Fig. 8. Advisroy on flood situation

Daily monitoring of river sub basin wise (Fig. 9) Severe Flood Situation & high QPF (26-50 mm and above) is provided to Central Agencies.

भारत सरकार
भारतमौसमविज्ञानविभाग
पृथ्वी विज्ञान मँत्रालय
जल मौसम विज्ञान प्रभाग
नई दिल्ली
फोन- 011-24344559/4558

GOVERNMENT OF INDIA
INDIA METEOROLOGICAL
DEPARTMENT*(Ministry of Earth Sciences)*
Hydromet Division
New Delhi
Phone : 011-24344559/4558
Email :dgmfmu@gmail.com

Dated: 28/09/2024

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

Flood Monitoring Offices				Flood Level (CWC)		Quantitative Precipitation Forecast (QPF)																				
						Day-1 (28/09/24)*			Day-2 (29/09/24)*			Day-3 (30/09/24)*			Day-4 (01/10/24)*			Day-5 (02/10/24)*			Day-6 (03/10/24)*			Day-7 (04/10/24)*		
SNo	FMO	Basin	Sub-Basin	Severe Flood	Extreme Flood	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm	26-50mm	51-100mm	>100mm
1	FMO Ahmedabad	SHETRUNJI	SHETRUNJI -			✓																				
2	FMO Ahmedabad	Damanganga	Damanganga			✓																				
3	FMO Ahmedabad	Narmada	Lower Narmada			✓																				
4	FMO Ahmedabad	Tapi	Lower Tapi			✓																				
5	FMO Guwahati	Brahmaputra	Dehung at Passighat															✓			✓					
6	FMO Guwahati	Brahmaputra	Lohit at Dholla															✓			✓			✓		
7	FMO Guwahati	Brahmaputra	Brahmaputra at Dibrugarh															✓			✓			✓		
8	FMO Guwahati	Brahmaputra	Buridihing at Khowang															✓			✓			✓		
9	FMO Guwahati	Brahmaputra	Subansiri at Badatighat															✓			✓					
10	FMO Guwahati	Brahmaputra	B-putra at Neamatighat															✓			✓					
11	FMO Guwahati	Brahmaputra	Dhansiri (S) at Golaghat																					✓		
12	FMO Jalpaiguri	Brahmaputra	Upper Teesta	✓		✓																				
13	FMO Jalpaiguri	Brahmaputra	Lower Teesta	✓		✓																				
14	FMO Jalpaiguri	Brahmaputra	Jaldhaka			✓																				

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

Fig. 9. Subbasin wise real time monitoring of flood situation and QPF issued

River basin Rainfall Map (Fig. 10) of all sub-basins depicting realised actual rainfall, normal rainfall and corresponding percentage departure from normal, is prepared on daily basis, weekly and cumulative and is uploaded on IMD website on daily basis during JJAS 2024.

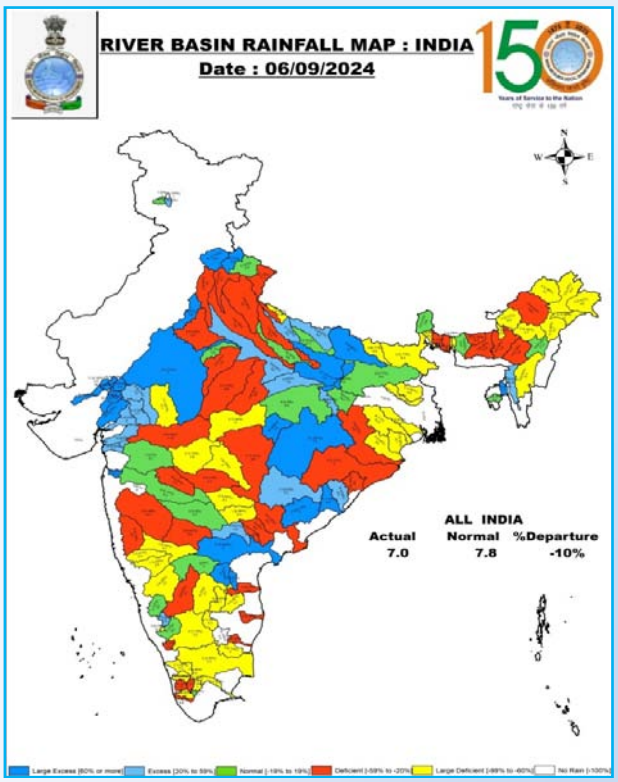


Fig.10. River basin rainfall map for various river subbasins (6 September 2024)

(iv) Enhanced capabilities of Flash Flood Guidance Services

Mr. Rahul Saxena, Scientist-G & Head of Hydrology, and Ms. Hemlata Bharwani, Scientist D, participated in an online meeting on December 11, 2024, organized by the World Meteorological Organization and the Hydraulic Research Centre, USA. The discussion centred around the new satellite precipitation product (SCaMPR) and its application within the South Asia Flash Flood Guidance System. The meeting included representatives from several countries, including Afghanistan, Bhutan, Bangladesh, Nepal, Pakistan, and Kazakhstan, fostering a collaborative exchange of insights and ideas.

Mr. Rahul Saxena, Scientist G and Head of Hydrometeorology, participated as the PMC Chair in the Second Flash Flood Guidance System (FFGS) Programme Management Committee (PMC) meeting, the Joint PMC-Expert Group (EG) meeting, and the EG meeting held from 16th to 18th December, 2024 in Istanbul, Türkiye. The event was organized by the World Meteorological Organization (WMO).

(v) Rainfall Monitoring Services

Major Services include Real-time rainfall monitoring and preparation of All India Rainfall statistics on Daily, Weekly, Monthly and Seasonal Basis. An annual Report on All India Rainfall Statistics is published.

The real time rainfall statistics was prepared for Annual (Jan to Dec)-2024. The rainfall for the country as a whole, for Annual (Jan to Dec)-2024 has been recorded as 1206.6 mm which is 104% of its Long Period Average (LPA) of 1160.0 mm. In all, category wise, 01 Met sub-divisions in LARGE EXCESS, 10 Met sub-divisions in EXCESS, 20 Met sub-divisions in NORMAL, 05 in DEFICIENT and none of any Met. Sub-divisions in LARGE DEFICIENT and NO RAIN category of rainfall (Fig. 11).

Fig. 11. SUBDIVISION-WISE RAINFALL (MM) DISTRIBUTION

SUBDIVISION-WISE RAINFALL (MM) DISTRIBUTION

S. NO.	METEOROLOGICAL SUBDIVISIONS	PERIOD: ACTUAL	ANNUAL (JAN-DEC) -2024 NORMAL	% DEP.	CAT.
EAST & NORTH EAST INDIA		1710.2	1946.5	-12%	
1	ARUNACHAL PRADESH	2192.8	2807.0	-22%	D
2	ASSAM & MEGHALAYA	2227.9	2577.0	-14%	N
3	N M M T	1739.8	2009.7	-13%	N
4	SHWB & SIKKIM	2568.5	2539.8	1%	N
5	GANGETIC WEST BENGAL	1668.2	1559.0	7%	N
6	JHARKHAND	1183.0	1220.7	-3%	N
7	BIHAR	916.7	1164.4	-21%	D
NORTH WEST INDIA		792.1	833.3	-5%	
1	EAST U.P.	791.0	900.3	-12%	N
2	WEST U.P.	798.4	765.3	4%	N
3	UTTARAKHAND	1486.2	1477.6	1%	N
4	HAR. CHD & DELHI	484.9	527.1	-8%	N
5	PUNJAB	391.5	565.5	-31%	D
6	HIMACHAL PRADESH	979.0	1245.1	-21%	D
7	J & K AND LADAKH	873.1	1232.3	-29%	D
8	WEST RAJASTHAN	511.1	328.9	55%	E
9	EAST RAJASTHAN	959.7	684.6	40%	E
CENTRAL INDIA		1296.5	1105.0	17%	
1	ODISHA	1372.9	1444.7	-5%	N
2	WEST MADHYA PRADESH	1168.3	951.3	23%	E
3	EAST MADHYA PRADESH	1297.4	1156.2	12%	N
4	GUJARAT REGION	1244.2	967.3	29%	E
5	SAURASHTRA & KUTCH	1006.8	572.4	76%	LE
6	KONKAN & GOA	3993.8	3041.5	31%	E
7	MADHYA MAHARASHTRA	1172.4	880.1	33%	E
8	MARATHWADA	876.6	771.5	14%	N
9	VIDARBHA	1153.2	1057.4	9%	N
10	CHHATTISGARH	1364.1	1266.6	8%	N
SOUTH PENINSULA		1292.6	1127.2	15%	
1	A & N ISLAND	2794.2	2838.2	-2%	N
2	COASTAL A. P.& YANAM	1168.6	1042.7	12%	N
3	TELANGANA	1113.5	938.7	19%	N
4	RAYALASEEMA	920.2	733.3	25%	E
5	TAMIL., PUDU. & KARAIKAL	1174.7	921.4	27%	E
6	COASTAL KARNATAKA	4337.1	3516.1	23%	E
7	N. I. KARNATAKA	730.5	696.3	5%	N
8	S. I. KARNATAKA	1187.4	1025.9	16%	N
9	KERALA & MAHE	2795.6	2890.7	-3%	N
10	LAKSHADWEEP	2144.1	1584.3	35%	E
COUNTRY AS A WHOLE		1206.6	1160.0	4%	

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

CATEGORY		PERIOD: ANNUAL (JAN-DEC) -2024 NO. OF SUBDIVISIONS	SUBDIVISIONAL % AREA OF COUNTRY
LARGE EXCESS		1	3%
EXCESS		10	29%
NORMAL		20	52%
DEFICIENT		5	16%
LARGE DEFICIENT		0	0%
NO RAIN		0	0%

(vi) Design Storm Analysis Activities

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

(vii) Central Hydromet Observatory (CHO) Activities

Awareness of Weather Observations by Central Hydromet Observatory: About 1565 visitors including Officers from Indian Navy, Research Scholars and Professors from IISER Bhopal and ICAR PUSA Institute Delhi including students and Professors from Banaras Hindu University Varanasi, Swami Shradhananda College Delhi University, Miranda House College Delhi University, ARSD College Delhi University, Athul Kumar Garg Engineering College (AKGEC), Ghaziabad, UP, Department of Environmental Science Delhi University, Salwan Public School New Delhi, DPS Dwaraka, Cambridge School New Delhi, Tagore International School New Delhi, Amity Institute Noida, National Bal Bhawan New Delhi, Queen's Valley School New Delhi, Vivekananda School New Delhi, DPMI Institute Delhi, DPSI Institute Gurugram, GNIOT Greater Noida, IMD FTC Training Batch, IMD IMTC Training Batch, Training Batch of Scientists of IMD.

5.2. Agrometeorological Advisories Services

5.2.1. Agrometeorological Observatories & Data Management

Under the network of observatories related to agrometeorology, at present there are 223 Agromet observatories across the country where observations are recorded at 0700 hrs and 1400 hrs LMT. These data are being used for preparation of district as well as block level agromet advisories. A web-based system has already been developed in collaboration with National Informatics Centre (NIC), Pune for receipt, scrutiny and archival of weather data from agromet observatories of IMD using internet.Additionally, 200 Agro-AWS have been established for improving the observation network for agrometeorological parametrers including, soil moisture and soil temperature installed at 4 soil depths (15cm, 30cm, 70 cm and 100cm). These Agro-AWS are installed in the premises of Krishi Vigyan Kendras (KVKs) under the network of the Indian Council of Agriculture Research (ICAR).

5.2.2. Weather Services under Gramin Krishi Mausam Sewa (GKMS)

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

- 671 bi-weekly District AAS bulletins and 2969 Block AAS Bulletins [1365 Block level Agromet Advisories by Agromet Field Units (AMFUs) and 1604 Block level Agromet Advisories by District Agromet Units (DAMUs)] have been prepared and uploaded in the website of Agrimet Division, Pune.

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

Heavy rainfall warning was issued by India Meteorological Department due to Cyclonic Storm "REMAL" over Bay of Bengal during May 2024. During the period **1,44,86,563** SMSs have been sent to the farmers in the States of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Tripura and West Bengal. Special Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division.

- Heavy rainfall with strong surface wind warning were issued by India Meteorological

Department due to Severe Cyclonic storm "DANA" over Bay of Bengal during October 2024. During this period **48,27,793** SMSs have been sent to farmers in the states of Odisha and West Bengal. Special Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division.

5.2.3. Launch of Panchayat Mausam Seva

India Meteorological Department celebrated the 150th year of its establishment and service to the nation onJanuary 15, 2024, at Vigyan Bhawan, New Delhi. Hon'ble Vice President of India graced the occasion as Chief Guest, and HMoES was the Guest of Honour. During the occasion, IMD launched the Panchayat Mausam Seva.

IMD under the Ministry of Earth Sciences (MoES), in collaboration with the Ministry of Panchayati Raj (MoPR), launched Mausamgram on 24th October, 2024 at Vigyan Bhawan, New Delhi. This initiative delivers Gram Panchayat-level weather forecasts to empower farmers and local communities for informed decisions on agriculture, disaster preparedness and resource management, enhancing resilience to changing weather patterns.

This is the first time that localized weather forecasts will be available at the Gram Panchayat level, supported by IMD's expanded sensor coverage. The forecasts will be disseminated through the Ministry's digital platforms: e-Gram Swaraj, which enables efficient governance, project tracking, and resource management; the Meri Panchayat app, which fosters community engagement by allowing citizens to interact with local representatives and report issues; and Gram Manchitra, a spatial planning tool that provides geospatial insights for development projects.

The launch was graced by the presence of Shri Rajiv Ranjan Singh alias Lalan Singh, Minister of Panchayati Raj, Shri (Dr.) Jitendra Singh, Minister of State (Independent Charge) for Science and Technology & Earth Sciences (Figs. 12 & 13) and Shri Prof. S. P. Singh Baghel, Minister of State for Panchayati Raj along with ShriVivekBharadwaj, Secretary, Ministry of Panchayati Raj, Shri Devesh Chaturvedi, Secretary, Ministry of Agriculture & Farmers Welfare, Dr. M. Ravichandran, Secretary, Ministry of Earth Sciences, Dr. Mrutyunjay Mohapatra, DG, India Meteorological Department, ShriAlokPrem Nagar, Joint Secretary, Ministry of Panchayati Raj and other senior officials from the Ministries of Panchayati Raj, Agriculture, Rural Development, National Disaster Management Authority (NDMA), Department of Science and Technology (DST) and other key stakeholders.

Fig. 12. Director General of Meteorology, IMD addressing the gathering regarding the Panchayat Mausam Seva portal

Fig. 13. Shri (Dr.) Jitendra Singh, Honorable Minister of State (Independent Charge) for Science and Technology & Earth Sciences addressing the gathering

As IMD celebrates 150 years of service, it continues to expand its reach and impact across all sectors, contributing significantly to India's socio-economic development. With advancements in forecasting, IMD has extended its lead time for weather predictions from three days to a full week, aiding better planning for stakeholders. Agrometeorological Advisory Services (AAS) already benefit 28 million farmers through various platforms, including state IT systems, mobile apps, and WhatsApp groups.

A standout initiative, "Har Har Mausam, Har Ghar Mausam" ensures that weather forecasts are accessible to people anywhere and anytime in the country. Through the Mausamgram platform, users can access forecasts by entering a location name, Postal Index Number (pin) code, or Panchayat / Block / Tehsils / District / City / Town name. Starting from 24th October 2024, daily gram panchayat-level forecasts are available for nearly all 2.6 lakh panchayats across India, covering parameters like temperature, rainfall, humidity, wind, and cloud cover. Forecasts include hourly updates for up to 36 hours, 3-hourly forecasts for five days, and 6-hourly forecasts for up to 10 days, helping farmers optimize crop management and enhance productivity. The Panchayat level forecast is also available on Panchayat Mausam Sewa portal https://mausam.imd.gov.in/greenalerts of IMD. The Panchayat level forecast is also disseminated to Panchayat Secretary and sarpanch.

IMD, MoES and Ministry of Rural Development (MoRD) are working together to disseminate the weather and climate information, as well as agrometeorological advisories through the village-level network of '*Krishi Sakhi*' and '*Pashu Sakhi*' under the *Deendayal Antyodaya Yojana-National Rural Livelihoods Mission* (Day-NRLM) of MoRD. This partnership seeks to equip farmers with actionable weather data, crop planning, water management, and risk mitigation. IMD data will support developing action plan for the Self Help Group (SHG) network, where trained members will act as weather information disseminators in their villages. SHG members will get timely alerts on floods, cyclones, and other hazards.

To strengthen the dissemination with the advancement of the technology a dedicated Mobile app called Meghdoot was designed to support agriculture and livestock sectors by providing weather forecast, observed weather data and crop advisory to help in decision making. The app is a joint initiative of India Meteorological Department (IMD), Indian Institute of Tropical Meteorology (IITM) and Indian Council for Agriculture Research (ICAR) developed by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) under Monsoon Mission. The app aggregates location specific weather forecast, Nowcast warnings, past weather data and crop specific advisories which are generated twice a week by muti-disciplinary units called Agro-Meteorological Units (AMFUs) and District Agromet Units (DAMUs) on every Tuesday and Friday in 13 languages for 717 districts of the country.

This localized approach ensures even remote communities have access to crucial weather data, making forecasts more relevant for local decision-making. IMD and MoES continue to improve its surface and upper-air instrumentation and satellite data collection and numerical weather prediction models to enhance forecast accuracy tailored to regional needs. The Mission Mausam initiative aims to significantly boost IMD's capabilities over the next five years.

IMD is also conducting workshops and training to help local communities interpret and utilize weather forecasts effectively. Collaboration with the Ministry of Panchayati Raj and Ministry of Rural Development ensures maximum outreach, with a focus on engaging panchayat members, farmers and local leaders.

5.3. Positional Astronomy Services

At the time of Independence, India had a large number of different calendars with divergent methods of reckoning the time. These calendars reflected the rich and varied political, cultural and historical traditions of India. Each calendar system had its advantages and disadvantages. Therefore, there was a need to adopt a scientific approach and evolve a uniform calendar for the entire country.

It was felt desirable by the Government of India to have uniformity in the calendar throughout the country for civic, social and other purposes. The Government appointed a Calendar Reform Committee in November, 1952, under CSIR with

Prof. Meghnad Saha as Chairman with a view to develop a unified National Calendar on the basis of most accurate modern astronomical data for the interest of national integrity. The committee recommended preparation of the Indian Ephemeris and Nautical Almanac calculated with most modern astronomical formulae, the National Calendar of India with timings of tithis, nakshatras, yoga etc, and also festival dates. The era chosen for this calendar was the Saka Era. The work of the Committee was taken up by the India Meteorological Department from 1st December, 1955. The work was entrusted to a unit named Positional Astronomy Centre at Kolkata. The unit undertook the preparation of 'The Indian Astronomical Ephemeris' for 1958, the first issue was published in 1957. Simultaneously the first issue of Rashtriya Panchang (containing data of National calendar along with usual panchang parameters to serve as a standard panchang for whole of the country) was started from 1879 Saka Era (1957-58 AD).

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

5.3.1. Present Activities

- Publication of Indian Astronomical Ephemeris
- Tables of Sunrise- Sunset, Moonrise-Moonset
- Preparation of Indian National calendar
- Publication of Rashtriya Panchang in 14 languages namely, Hindi, English, Sanskrit, Urdu, Assamese, Bengali, Gujarati, Marathi, Punjabi, Tamil, Telugu, Kannada, Malayalam and Odia.
- Supply data to meets up data requirements of a large number of users including Government organizations, non-Government organizations, astronomers, various panchang makers, general public etc.
- Taking observation on special astronomical events from time to time with the help of its portable telescopes.

5.3.2. Activities during the Year 2024

The Indian Astronomical Ephemeris for the year 2025, an annual publication of Positional Astronomy Centre, has been published both in hard copy and soft copy format. The publication contains mainly the positional data of the Sun, Moon and planets in different astronomical co-ordinate system; rising and setting time of the Sun and Moon; mean and apparent places of bright stars; diary of celestial events; eclipses and occultation data; calendric data; explanatory text and other useful information on astronomy.

Rashtriya Panchang of 1946 Saka Era (2024-25 AD) in 14 languages have been published both in hard copy and soft copy format.These are important regular publications of the centre catering to daily need of users of almanac, Panchang makers and other users. This publication contains Tithi, Nakshatra, Yoga and Karana in IST calculated for central point (82°30 E, 23°11' N); Lunar months commences from the ending moment of New Moon- traditional luni-solar arrangement; Tables of longitudes, beginning of lagnas, transits of the Sun, Moon and planets in different rasis and nakshatras; All India fairs and festivals for all communities; Tables of Sunrise-Sunset and Moonrise-Moonset.

Tables of Sunrise - Sunset, Moonrise-Moonset for 2025 have been published during the year 2024.

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

The monthly star charts and astronomical bulletins for all 12 months of 2024 has been prepared by the centre with the aim to provide helpful guidance on observing celestial objects in the night

sky. The bulletins comprise concise explanations of object positions in the sky, along with celestial diagrams, which can be used for practical demonstrations.

All India festivals for all communities have been fixed for the year 2025 in advance for declaration of holidays by the Government of India and other State Governments. Calendar data of Indian National Calendar along with Gregorian calendar data for the year 2025-26 has been prepared in advance for various stakeholders.

Advance panchang data has been prepared and supplied to different stakeholders.

Observations has been taken of special events throughout the year (Fig. 14).

Fig. 14. Observation at PAC Kolkata

5.4. Climate Research & Services

5.4.1. CLIMS

Development of Climate Information Management System (CLIMS) for Data collection, Data monitoring, Data quality Control, Metadata Management, Database Management, Data Archival / Retrieval, Data generation (Basic data, derived products generation), Data Visualization, Bulletin & report generation through one platform. The process of surface data scrutiny, verification and submission of data by all RMCs and MCs is now done on a single platform – CLIMS (Fig. 14). This facilitates online updating of historical database (Fig. 15).

Fig. 15. CLIMS at CRS Pune

5.4.2. Operational Long Range Forecast and its Verification

Operational LRF System

IMD has implemented a new strategy for issuing monthly and seasonal operational forecasts for the rainfall and temperature over the country by modifying the existing two state forecasting strategy in 2021. The new strategy uses the existing statistical forecasting system to generate these forecasts along with a newly developed Multi-Model Ensemble (MME) forecasting system based on coupled global climate models (CGCMs) from different global climate prediction and research centers including IMD's Monsoon Mission CFS (MMCFS) model. The Performance operational forecast (1988-2024) is shown in Fig. 16. Table 3 shows various long-range forecasts issued during the year. Details of the various long-range forecasts issued by IMD and their verification are discussed in this report.

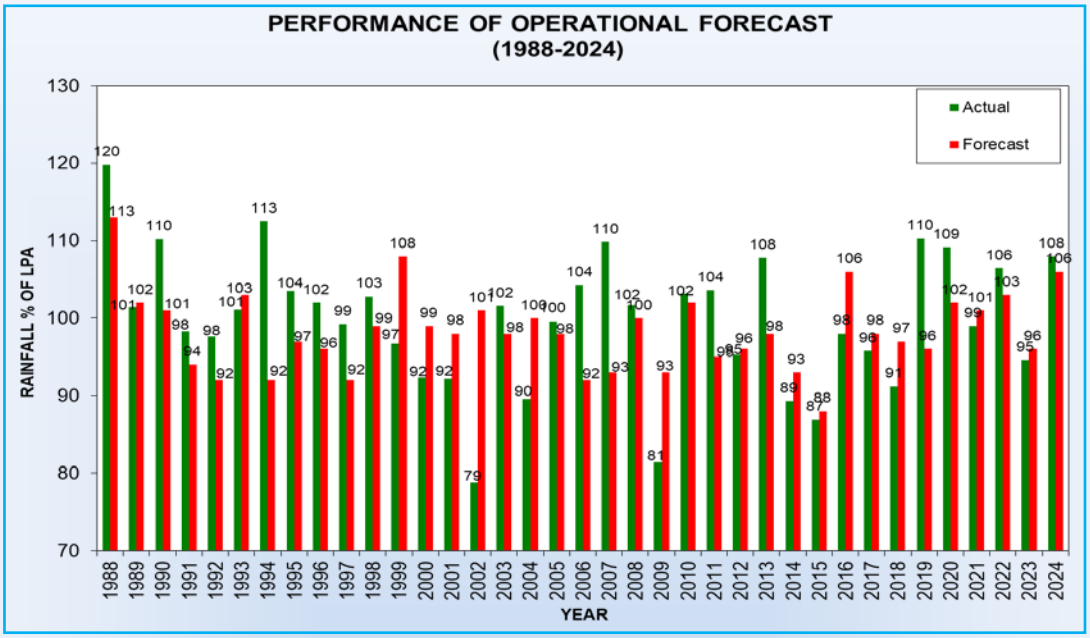


Fig. 16. Performance operational forecast (1988-2024)

TABLE 3

Details of the various long range forecasts issued by IMD

S. No.	Forecast for	Region for which forecast issued	Method/ Model
1 .	Monthly outlook for rainfall and temperatures during January 2024	North India	MME
2 .	Monthly outlook for rainfall and temperatures during February 2024	North India	MME
3 .	Seasonal (March-May) and Monthly (March) 2024 Outlook for the Rainfall and Temperatures	Country as a Whole	MME
4 .	Long Range Forecast for the 2024 Southwest Monsoon Season Rainfall	Country as a Whole	Statistical & MME
5 .	Monthly Outlook for the Temperature and Rainfall during May 2024	Country as a Whole	MME
6 .	Forecast of the Onset Date of Southwest Monsoon - 2024 over Kerala	Over Kerala	Statistical
7 .	Updated Long Range Forecast of Rainfall during Southwest Monsoon Season (June - September), 2024 and Monthly Outlook for Rainfall and Temperature during June 2024	Country as a Whole,	Statistical & MME
8 .	Forecast outlook for rainfall and temperatures during the month of July and July to September 2024 of Southwest monsoon season	Country as a Whole	MME
9 .	Forecast outlook for rainfall and temperatures during the month of August and August-September 2024 of Southwest monsoon season.	Country as a Whole	MME
10.	Forecast outlook for rainfall and temperatures for the Month of September 2024	Country as a Whole	MME
11 .	Forecast outlook for rainfall and temperatures for Post-monsoon Season (Oct-Dec) and October 2024	South Peninsular India	MME
12 .	Long Range Forecast for rainfall and temperature for November 2024	Country as a Whole	MME
13 .	Seasonal Outlook for Winter Temperatures and Rainfall and Temperature Forecast for December 2024	Country as a Whole	MME

5.4.3. Verification of Operational Long-Range Forecasts

Southwest Monsoon Season (June to September, 2024) Rainfall

The long range forecast for the 2024 southwest monsoon rainfall was issued in 2 stages. The first stage long range forecast issued on 15th April consisted of only forecast for season (June-September) rainfall over the country as a whole. In the second stage (27th May), along with the update for the April forecast, forecast for season rainfall over the four broad geographical regions (Northwest India, Central India, South Peninsula and Northeast India) and that for monthly rainfall over the country as a whole for the months of July, August and September were issued. In the 1st August, the forecast for the rainfall during the second half of the monsoon season over the country as a whole was issued.

The first stage forecast for the season (June-September) rainfall over the country as a whole issued in April was 106% of LPA with a model error of ± 5% of LPA. The update issued on 27th May for this forecast was (106% of LPA) with a model error of ± 4% of LPA. The actual season rainfall for the country as a whole was 108% of LPA. Thus, the both the forecasts were within forecast limits and therefore the forecast was correct.

Considering the four broad geographical regions of India, the forecasts issued in 27th May, the southwest monsoon seasonal rainfall was most likely to be above normal over central India and South Peninsular (>106 % of LPA), normal over Northwest India (92-108% of LPA) and below normal over North East India (<94 of LPA). The southwest monsoon seasonal rainfall over the monsoon core zone consisting of most of the rainfed agriculture areas in the country was most likely to be above normal (>106% of LPA. The actual rainfall departure over Northwest India, Central India, Northeast India, South Peninsula and Monsoon Core Zone were 7%, 19%, -14%, 14% and 22% of the LPA respectively. Thus, the forecasts for the four broad geographical regions of India were within the predicted limits, indicating that the forecast was accurate.

The forecasts for monthly rainfall over the country as a whole for the months of June, July, August, and September were: Normal (92-108% of LPA), Above Normal (>106% of LPA), Normal (94-106% of LPA), and Above Normal (>109% of LPA), respectively. The observed rainfall for these months was 89%, 109%, 115% and 112%, respectively. The realized spatial rainfall pattern matched well for all the individual months except July. The rainfall in the second half of the monsoon season (August–September) was expected to be above normal (>106% of LPA), and the actual rainfall also exceeded normal levels, confirming the accuracy of the forecast. Therefore, the trend of rainfall during the second half of the monsoon season was well predicted.

Table 4(a&b) below gives the summary of the verification of the long-range forecasts issued for the 2024 Southwest monsoon. Verification of Operational Long-Range Forecasts

TABLE 4(a)

Performance of Long-Range Forecast of Southwest Monsoon 2024

Seasonal Forecast		Observed
15 April, 2024-1st Stage For Season as a whole	**27th May, 2024-2nd stage**	
El Niño condition is likely to weaken further to neutral El Nino Southern Oscillation (ENSO) conditions during early part of the monsoon season and La Niña conditions are likely to develop during second half of monsoon season Positive IOD conditions are likely to develop during the later part of the southwest monsoon season	➢ Same ENSO forecast ➢ Same IOD forecast ➢ Same forecast was reiterated in 2nd Stage LRF issued on 27th May 2024, above normal with 106% with ± 4%.	◆ Neutral El Nino Southern Oscillation (ENSO) conditions developed in July and continued till Sept ◆ IOD remained neutral till end of Aug ◆ Rainfall is (107.8 % of LPA).

Stated that Eurasia snow cover has been less during December to February 2023-2024, Which will favour Monsoon over India. With Weakening of El-Nino, it was predicted that Quantitatively, ISMR likely to be above normal with 106% of LPA with a model error of ± 5%.		
1 Aug -3rd Stage (For 2nd half of Monsoon 2024 (Aug- Sep)		
➢ Currently, Neutral El Nino-Southern Oscillation (ENSO) conditions are prevailing in the equatorial Pacific region. La Nina is likely to develop in the second half of the monsoon season towards end of August ➢ Neutral IOD conditions are prevailing and likely to continue remaining part of the monsoon season. ➢ Rainfall is most likely to be above normal (>106% of LPA)		◆ Neutral El Nino-Southern Oscillation (ENSO) conditions prevailed. ◆ IOD remained neutral. ◆ 1st half of the monsoon season 2024 got less rainfall (2%, normal). It was above normal during 2nd half the season(15% above normal).

TABLE 4(b)

Performance of monthly Rainfall Forecast during Monsoon 2024

Month	Forecast	Realized
June 2024	Normal rainfall (92-108% of LPA) is most likely over the country as a whole during June, 2024.	-
July 2024	Above Normal (>106 % of LPA) is most likely over the country as a whole during July, 2024	109% of LPA
August 2024	Normal ((94 to 106 % of LPA) is most likely over the country as a whole during August, 2024	115% of LPA
September 2024	Above Normal (>109 % of LPA) is most likely over the country as a whole during September, 2024	112% of LPA

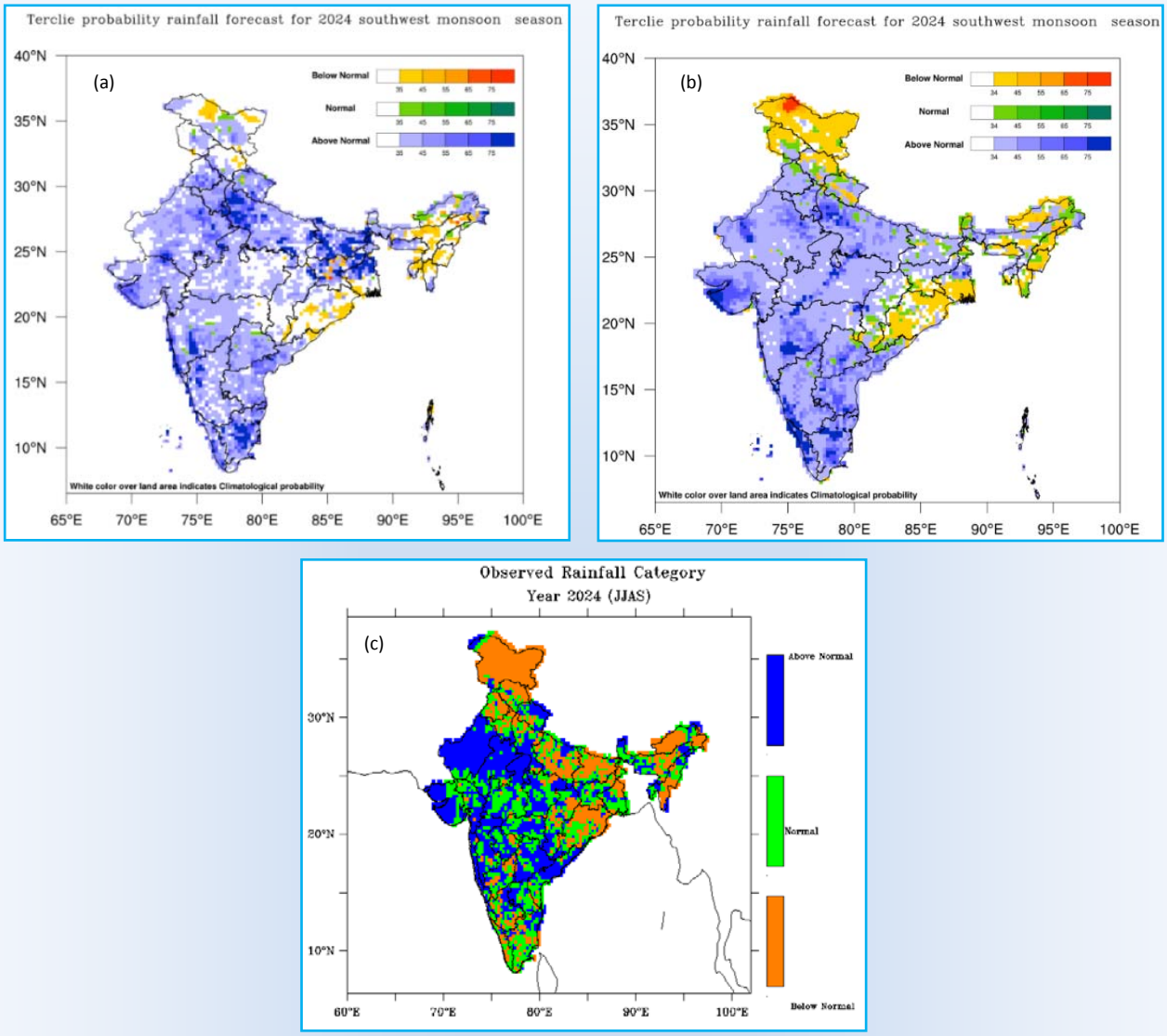
5.4.4. Spatial probability rainfall forecast Verification of Monsoon forecast 2024

The verification of the spatial probability rainfall forecast that was issued by IMD during the 2024 Southwest monsoon season is presented in Figs. 17(a-c). It indicates that the forecast was able to accurately capture and predict the spatial pattern.

5.4.5. 2024 Northeast Monsoon Forecast and Verification

Forecast

The Northeast Monsoon Season (October to December (OND)) 2024 rainfall over the south Peninsular India consisting of five meteorological subdivisions (Tamil Nadu, Puducherry & Karaikkal, Coastal Andhra Pradesh & Yanam, Rayalaseema, Kerala & Mahe and South Interior Karnataka) is most likely to be above normal [>112% of Long Period Average (LPA)]. The LPA of rainfall over south Peninsular India during the October to December season based on data from 1971 to 2020 is about 334.13 mm. The forecast indicates a probability of normal to above-normal rainfall is likely over many areas of central India, south peninsular India, and some parts of northeast India during the same period. However, most parts of northwest India and some parts of northeast India and southernmost parts of India are likely to receive below-normal rainfall.



Figs. 17(a-c). (a and b) Spatial forecast for the seasonal rainfall from June to September 2024, corresponding to the first stage (issued in April) and second stage (issued in May), respectively, (c) observed rainfall category

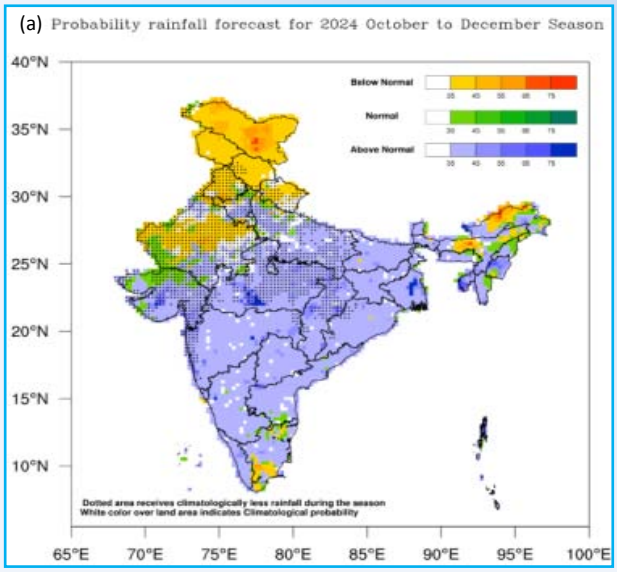


Fig. 18(a). Probability forecast of tercile categories* (below normal, normal, and above normal) for the 2024 Oct-Dec season rainfall over India

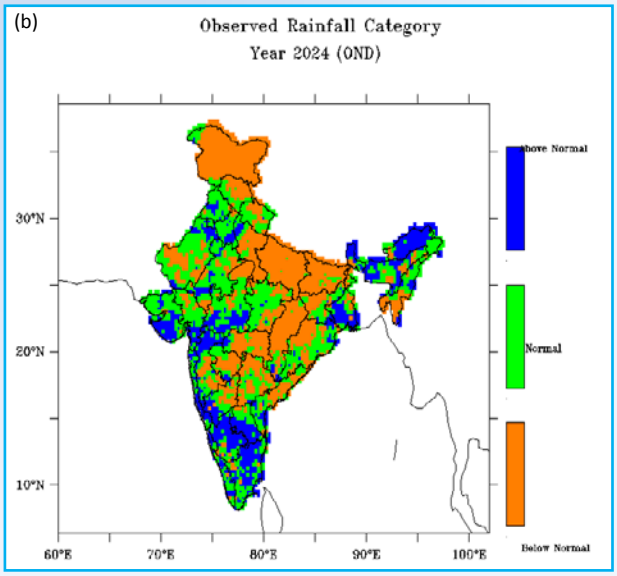


Fig. 18(b). Observed Rainfall Category of tercile categories* (below normal, normal, and above normal) for the 2024 Oct-Dec season rainfall over

Verification

Northeast Monsoon (October to December (OND)) season rainfall over the south Peninsular India was observed to be above normal [> 112% of Long Period Average (LPA)]. Comparison with observed indicates that rainfall outlook matched very well over many regions over Northwest, central and peninsular India. The spatial distribution of the corresponding observed rainfall category map is given in Figs. 18(a&b).

Figs. 18(a&b). Probability forecast of tercile categories* (below normal, normal, and above normal) and the corresponding observed rainfall category map for the Northeast Monsoon [October to December (OND)] season rainfall over the south Peninsular India.

5.4.6. Regional Climate Centre (RCC) Activities

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

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

(B) Prepare Seasonal Climate Outlook for rainfall and temperatures over south Asia for the next 2 moving 3-month seasons (total 4 months) with monthly update. The Seasonal probability (%) forecasts of precipitation for (a) NDJ 2024-25 (left) and (b) DJF 2024-25 (right) based on initial conditions of October 2024 is shown in the Fig. 19.

Similarly, the Seasonal probability (%) forecasts of temperature for (a) NDJ 2024-25 (left) and (b) DJF 2024-25 (right) based on initial conditions of October 2024 is shown in the Fig. 20.

(C) Prepare ENSO and IOD bulletin every month providing statement on the global SST anomalies and probabilities forecast with emphasis on the ENSO and IOD conditions for the next 9 months prepared based with monthly update. Fig. 21 gives the Global sea surface temperature anomaly and probability forecast for the month of November 2024 using the October initial conditions.

(D) Take lead role in preparing consensus forecast outlook for the monsoon season rainfall, northeast monsoon rainfall and winter rainfall over south Asia. All the products mentioned can be viewed and downloaded at www.imdpune.gov.in

(E) Acting as Lead Centre in conducting South Asia Climate Forum Activities for RA II Region and Conducting SASCOF for generating consensus outlook for South Asian region for Summer Monsoon, Northeast Monsoon and December to February (DJF) Season. This year the following workshops were conducted.

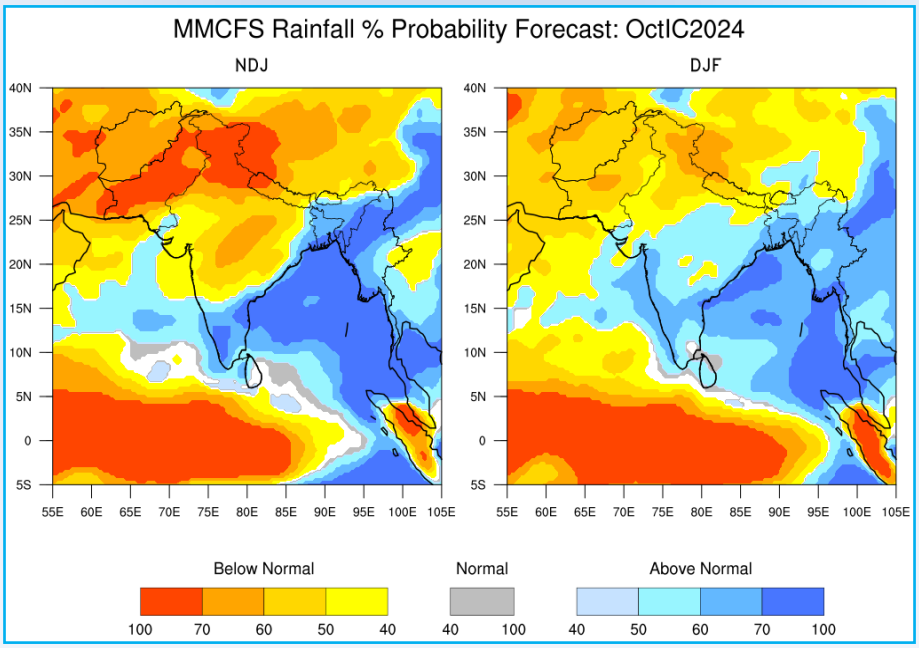


Fig. 19. Seasonal probability (%) forecasts of precipitation for (a) NDJ 2024-25 (left) and (b) DJF 2024-25 (right) based on initial conditions of October 2024

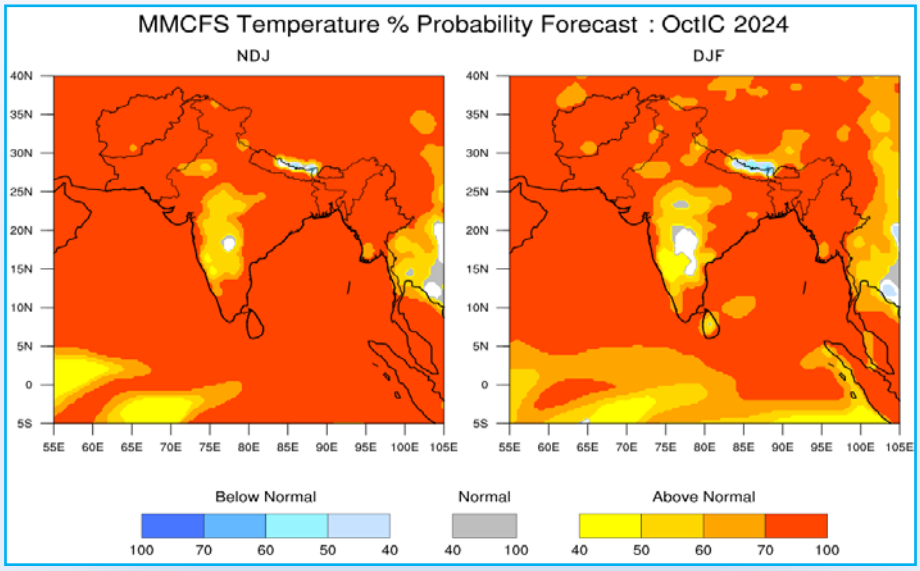


Fig. 20. Seasonal probability (%) forecasts of temperature for (a) NDJ 2024-25 (left) and (b) DJF 2024-25 (right) based on initial conditions of October 2024

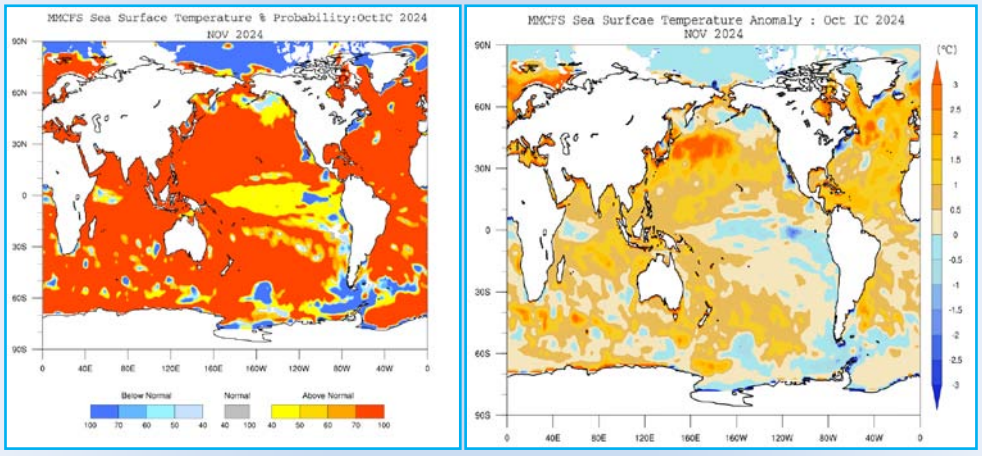


Fig. 21. gives the Global sea surface temperature anomaly and probability forecast for the month of November 2024 using the October initial conditions

(a) Twenty-eighth Session of South Asian Climate Outlook Forum (SASCOF-28) and Climate Services User Forum (CSUF) 29 – 30th April and 1 May, 2024. The aim of the workshop was to Prepare the Consensus Outlook for JJAS 2024 Season. The Climate Services User Forum (CSUF) which was conducted on the 1st May was aimed to focus on interface with users from the Water, Agriculture, Disaster Risk Reduction and Health sector to interpret seasonal climate information and understand their specific needs with a view to further customizes climate information.

(b) Twenty-ninth Session of South Asian Climate Outlook Forum (SASCOF-29) and Climate Services User Forum (CSUF) 25 – 26th and 3 October 2024. The aim of the workshop was to prepare the Consensus Outlook for OND 2024 Season. The Climate Services User Forum (CSUF) which was conducted on the 3rd October was aimed to focus on User-oriented sessions on sharing, understanding and interpreting the seasonal climate outlook .

5.4.7. SASCOF related activities

Statement on the Seasonal Climate Outlook over South Asia for the 2024 Southwest Monsoon Season (June – September)

Above normal rainfall is most likely during the 2024 southwest monsoon season (June – September) over most parts of the South Asia except some areas over northern, eastern and

north-eastern parts of the region, where below normal rainfall is most likely. The seasonal rainfall is most likely to be normal or of climatological probabilities over the remaining areas of the region.

During the season, above normal minimum temperatures are most likely over most parts of South Asia except a few areas over the south-eastern part of the region where normal temperatures are most likely. The seasonal maximum temperatures are most likely to be above normal over most parts of the region except some isolated areas over northern, north-western, southern and eastern parts of the South Asia, where normal to below normal maximum temperatures are most likely.

This regional climate outlook for the 2024 southwest monsoon season over South Asia has been collaboratively developed by all nine National Meteorological and Hydrological Services (NMHSs) of South Asia with the support from international experts at the 28th session of the South Asian Climate Outlook Forum (SASCOF-28) conducted online (Fig. 22). The process involved an expert assessment of the prevailing global climate conditions, national level forecasts and forecasts from different climate forecasting agencies around the world.

Currently moderate El Niño conditions are prevailing over the tropical Pacific Ocean. Based on the global climate model forecasts, there is strong consensus among experts that the prevailing the El Niño condition is likely to weaken further to neutral El Nino Southern Oscillation (ENSO) conditions during early part of the monsoon season and La Niña conditions are likely to develop during second half of monsoon season. However, there is uncertainty in its strength and the time of its onset. It is recognized that the global climate model predictions prior to and during the spring season generally have noticeable uncertainty due to spring barrier in the seasonal predictability. It is also recognized that other regional and global factors as well as the intra-seasonal features of the region can also affect the seasonal climate patterns over the region.

Fig. 22. Twenty-eighth Session of South Asian Climate Outlook Forum (SASCOF-28) and Climate Services User Forum (CSUF) 29 – 30th April and 1 May 2024

SASCOF-28 Update

The SASCOF28_Update session for the June – September (JJAS) 2024 for updating the SASCOF-28 outlook (released on 30th April, 2024) was held online via video conferencing on 25th June, 2024. World Meteorological Organization Regional Climate Centre (WMO-RCC) of Climate Research and Services, India Meteorological Department (IMD), Pune office has conducted the meeting in collaboration with UK Met Office as well as Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), Bangkok. National Meteorological and Hydrological Services (NMHSs) participants from different South Asian countries participated in the meeting. All participants discussed their views on current climate factors and the regional climate outlook over South Asia for the ongoing season JJAS 2024.

SASCOF-29

Twenty Ninth Session of South Asian Climate Outlook Forum and Climate Services User Forum (SASCOF-29 and CSUF) for ensuing Winter Season (October to December 2024) took place online

through video conferencing during 25-26 September and 3rd October 2024. The SASCOF-29 session was hosted by Regional Climate Centre (RCC), India Meteorological Department (IMD), Pune and the session organized by IMD, Pune in collaboration with World Meteorological Organization (WMO), UK Met. Office (UKMO) and Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), Bangkok. Experts from National Meteorological and Hydrological Service (NMHS) from nine south Asian countries, Japan Meteorological Agency (JMA), WMO Lead centre of Multi Model Ensemble, Korea Meteorological administration, South Korea, National Atmospheric and Oceanic Administration (NOAA), USA, UK Met office, UK and other experts from various research institutes participated in the Forum discussed outlook for rainfall and temperature during upcoming Winter season 2024 and summarized that the rainfall during coming winter season is likely to be normal to above normal. All the participants discussed their views on the current climate factors as well as regional climate outlook over South Asia for the upcoming winter season 2024 (October to December).

Statement on the Seasonal Climate Outlook over South Asia for the OND Season 2024 (October-December) for Rainfall and Temperature

Normal to above-normal rainfall is likely over most parts of South Asia during 2024 October to December (OND) season, particularly covering the south and eastern parts as well as a few isolated areas over northwestern parts. Below-normal rainfall is likely over the northwestern and northern parts of South Asia as well as over the small islands in the southwestern parts of South Asia.

During the season, normal to above-normal maximum and minimum temperatures are likely over most parts of South Asia. However, normal to below-normal maximum temperatures are likely over some central and south eastern parts of South Asia.

This consensus climate outlook for the 2024 OND season over South Asia has been prepared through an expert assessment of the prevailing global climate conditions influencing the South Asian climate and seasonal forecasts from different climate models around the world. Currently, neutral El Nino Southern Oscillation (ENSO) and neutral Indian Ocean Dipole (IOD) conditions are observed over the equatorial Pacific and Indian Ocean. These parameters are known to influence climate variability in South Asia. Latest forecasts from many global climate models indicate an enhanced probability of development of the La Niña conditions and a likelihood of neutral IOD conditions for the next OND season. Careful consideration is also given to other regional and global factors, as well as the intra-seasonal variability of the region that can affect the rainfall and temperature patterns over the region.

SASCOF-30

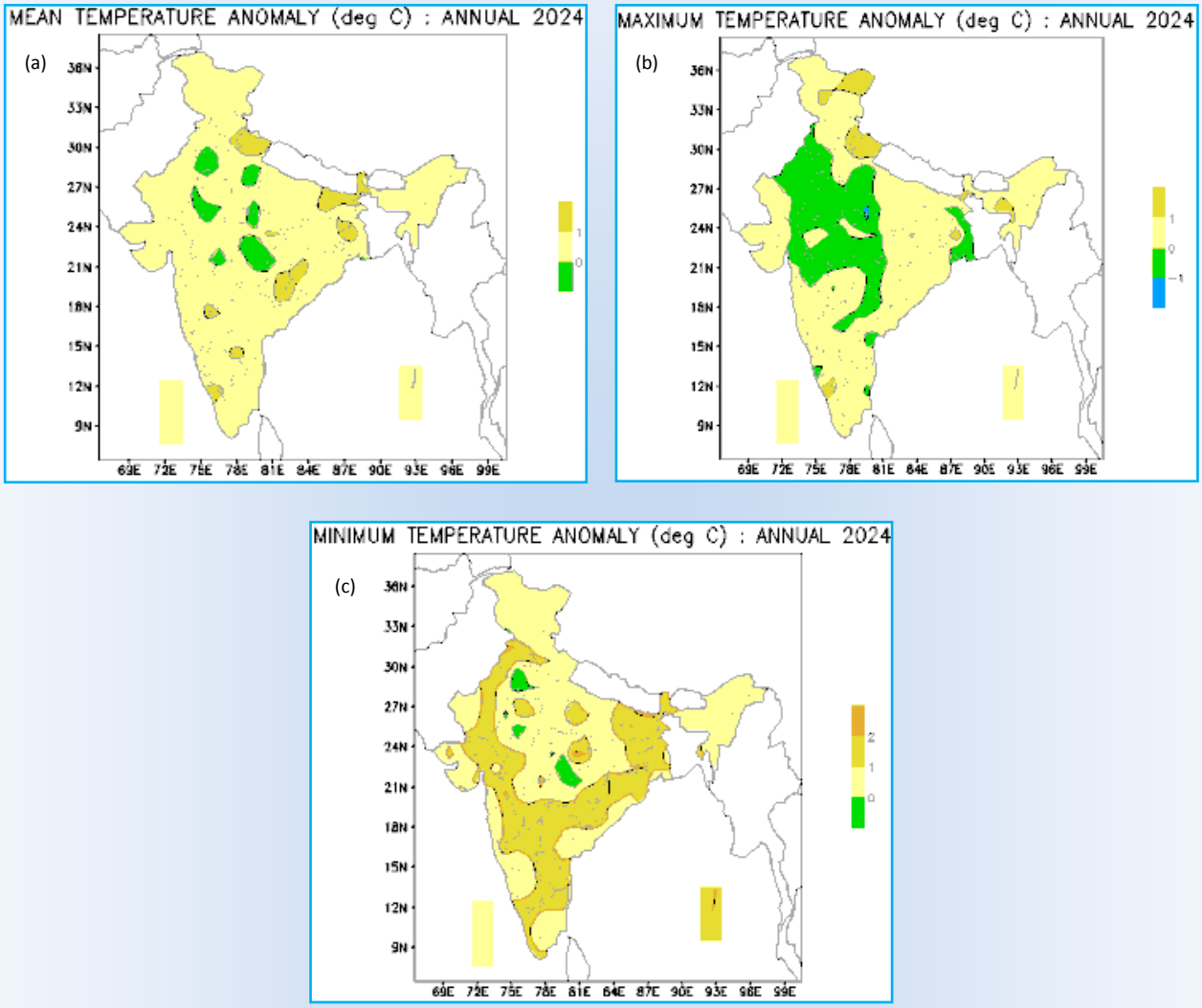
Thirtieth Session of South Asian Climate Outlook Forum (SASCOF-30) for ensuing Winter Season (December to January 2024/25) was held online through video conferencing on 5th December 2024. World Meteorological Organization Regional Climate Centre (WMO-RCC) of Climate Research and Services, India Meteorological Department (IMD), Pune office conducted the meeting in collaboration with UK Met Office as well as Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), Bangkok. Experts from National Meteorological and Hydrological Service (NMHS) from nine south Asian countries, Japan Meteorological Agency (JMA), WMO Lead centre of Multi Model Ensemble, Korea Meteorological administration, South Korea, National Atmospheric and Oceanic Administration (NOAA), USA, UK Met office, UK and other experts from various research institutes participated in the Forum to discuss outlook for rainfall and temperature during upcoming Winter season i.e. DJF 2024/25.

5.4.8. Climate Monitoring

(A) Annual Temperature 2024 (till 28 Nov2024)

Spatial pattern of annual mean, maximum and minimum temperature anomalies for 2024 areshown in (Fig. 23). During 2024, mean, minimum and maximum temperature anomalies over many parts of the country were generally above normal or near normal. Mean temperature over parts of Himachal Pradesh, Uttarakhand, East Madhya Pradesh, West Bengal state, Sikkim state,

Jharkhand, Chattisgarh, South Interior Karnataka, North Interior Karnataka, Madhya Maharashtra, Odisha, Bihar, Rayalaseema and Kerala & Mahe was above normal by about 1°C. Maximum temperature over parts of Jammu, Kashmir & Ladakh, Himachal Pradesh, Uttarakhand, West Bengal state, Assam & Meghalaya, South Interior Karnataka and Kerala & Mahe was above normal by about 1°C. However, maximum temperature over parts of East Uttar Pradesh and East Madhya Pradesh was below normal by about 1°C. Minimum temperature over parts of Punjab, Bihar, and East Madhya Pradesh was above normal by about 2°C.



Figs. 23(a-c). Annual temperature anomalies (°C) for 2024 (a) Mean temperature (b) Maximum temperature and (c) Minimum temperature. (Based on 1991-2020 Average)

The annual mean land surface air temperature for the country during the year 2024 was +0.65°C above the 1991-2020 average. Thus, making the year 2024 was the warmest year on record since 1901 (Fig. 24). The five warmest years on record, in descending order are 2024 (+0.65°C), 2016 (+0.54°C), 2009 (+0.40°C), 2010 (+0.39°C) and 2017 (+0.38°C). Observed 10 out of the 15 warmest years were pertaining to the recent fifteen years (2010-2024). The past decade (2015-2024) was also the warmest decade on record with the decadal averaged annual mean temperature anomaly (Actual-LPA) of 0.31°C. The country averaged annual mean temperature during 1901-2024 showed a significant increasing trend of 0.68°C / 100 years (Fig. 24). During the same period, significant increasing trends were observed in maximum (0.89°C /100 years) and minimum (0.46°C /100 years) temperatures.

The all India averaged seasonal mean temperature was above normal for all the seasons during the

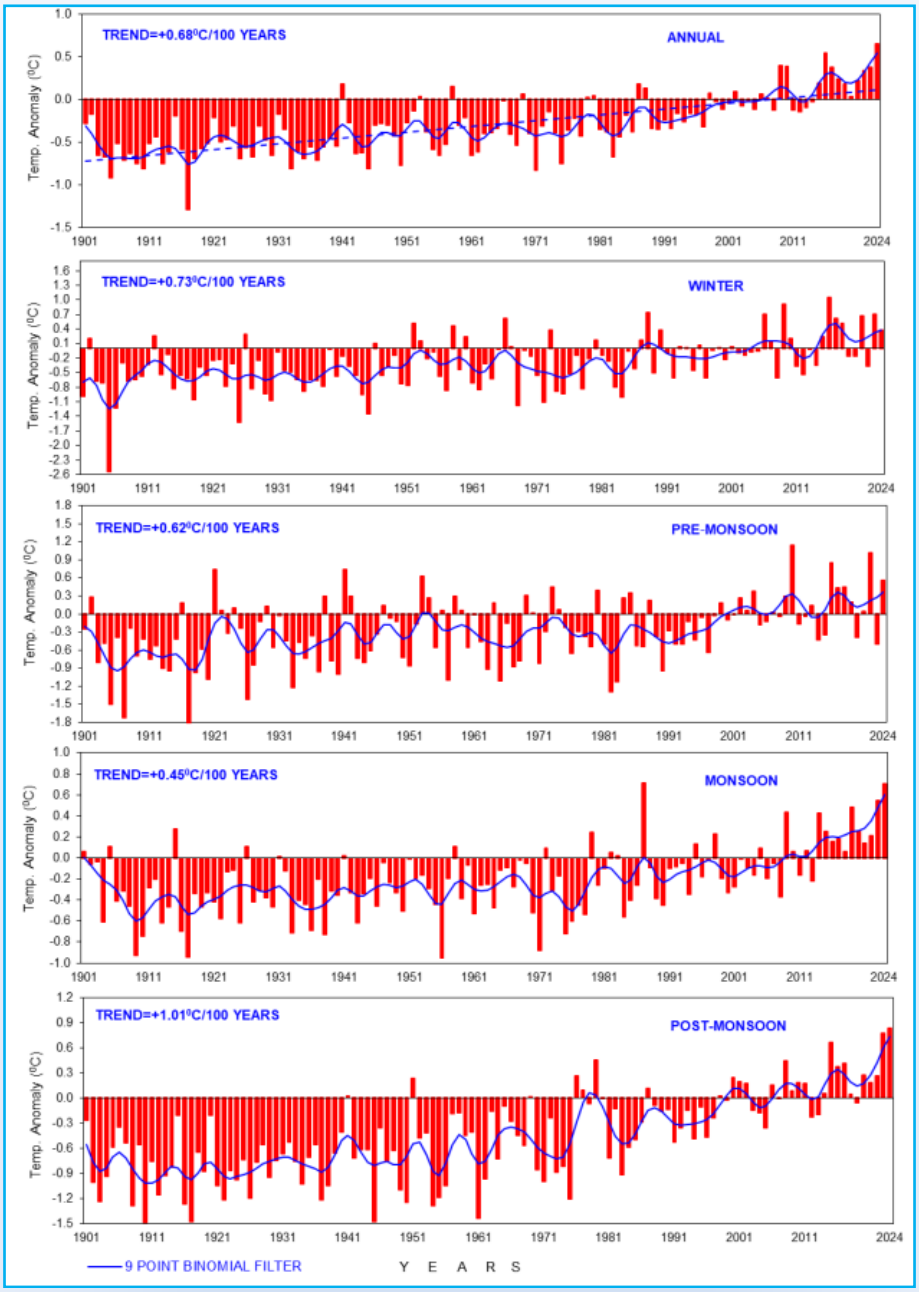


Fig. 24. All India mean temperature anomalies (a) Annual (b) Winter (c) Pre-monsoon (d) SW-monsoon(e) Post-monsoon for the period 1901 - 2024 shown as vertical bars. The solid blue curve exhibits sub-decadal time scale variations that have been smoothed with a Binomial Filter (Departures from the 1991 - 2020 average)

year 2024, the winter season (January - February, with an anomaly of +0.37°C), pre-monsoon season (March - May, with an anomaly of +0.56°C), southwest monsoon (June - September, +0.71°C) season and post-monsoon season (October-December, with an anomaly of +0.83°C).

The monthly mean temperatures averaged over the country during 2024 were above normal for all the months of the year except March (close to normal with an anomaly of +0.22°C). The mean monthly temperatures averaged over the country during the month October was the highest recorded (with an anomaly of +1.23°C), the 2nd highest during the months July & September (with an anomalies of +0.70°C, +0.76°C respectively) since 1901. In addition, the mean temperature during November was the 3rd highest (with an anomaly of +0.84°C), May & August were the 4th highest (with an anomalies of +0.69°C, +0.45°C respectively) since 1901.

In 2024, the monthly maximum temperature averaged over the country was the 2nd highest

(with an anomaly of +0.62°C) since 1901 for the month of November.

In 2024, the monthly minimum temperatures averaged over the country were the highest during the months of July, August, September and October with an anomalies of +0.89°C, +0.59°C, +0.99°C and +1.78°C respectively since 1901 and the 2nd highest ever recorded (with an anomaly of +0.79°C) for the month of February since 1901.

5.5. Cyclone Monitoring & Prediction

Annual Report on Cyclonic Disturbances during 2024 over the North Indian Ocean Regional Specialised Meteorological Centre, New Delhi

5.5.1. Annual Report on Cyclonic Disturbances during 2024

Year 2024 witnessed the formation of 12 cyclonic disturbances (CDs) against normal of 11.2 per year based on the data during the period 1965-2023. It included 8 depressions / deep depressions (maximum sustained wind speed (MSW): 32 – 61 kmph), 2 cyclonic storms (MSW: 62-91 kmph) and 2 severe cyclonic storms (92-117 kmph). All the 4 cyclones had recurving tracks. Out of 4 cyclones, 3 were landfalling cyclones (Remal, Dana and Fengal) and the depression over northwest Madhya Pradesh moved westwards, emerged into northeast Arabian Sea, intensified into cyclonic storm Asna over northeast Arabian Sea.

Following Cyclonic Disturbances (CDs) developed over the North Indian Ocean (NIO) during 2024:

- Severe Cyclonic Storm "REMAL" over the Bay of Bengal: 24 – 28 May
- Depression over the Bay of Bengal: 19 – 20 July
- Deep Depression over North Jharkhand and Neighbourhood: 02 – 06 August
- Cyclonic Storm "ASNA" over the land: 25 August – 02 September
- Depression over Westcentral Bay of Bengal: 31 August – 02 September
- Deep Depression over Westcentral and Adjoining Northwest Bay of Bengal: 08 – 10 September
- Depression over Northeast Madhya Pradesh: 11 – 13 September
- Deep Depression over Northeast Bay of Bengal and Adjoining Bangladesh: 13 – 17 September
- Depression over Central Arabian Sea: 13 – 15 October
- Depression over Southwest Bay of Bengal: 15 – 16 October
- Severe Cyclonic Storm "DANA" over Eastcentral Bay of Bengal: 22 – 26 October
- Cyclonic Storm "FENGAL" over Southwest Bay of Bengal: 29 November – 01 December

Basin wise, out of the 4 cyclones, 3 developed over the Bay of Bengal (BoB) and 1 over the Arabian Sea (AS) against normal of 3.5 over the BoB and 1 over the AS based on the data during the period 1965-2023. Season wise, 1 CD developed over the BoB, against normal of 0.9 per year (1965-2023) during pre-monsoon season. Similarly, over the Arabian Sea there was no CD against the normal of 0.5 per year based on the data during 1965-2023.

5.5.2. The salient features of 4 cyclones are given below

5.5.2.1. Severe Cyclonic Storm "REMAL" over the Bay of Bengal (24th - 28th May, 2024)

A low-pressure area formed over southwest and adjoining westcentral Bay of Bengal (BoB) on 23rd May. It concentrated into a depression over central BoB in the early morning (0000 UTC) of the 24th May. It intensified into a deep depression over eastcentral & adjoining BoB in the morning (0000 UTC) of 25th and into the cyclonic storm (CS) "REMAL" {pronounced as RE-MAL} over the north and adjoining eastcentral BoB in the same evening (1200 UTC) of 25th May. Continuing to move nearly northwards it intensified further into a severe cyclonic storm (SCS) over the North BoB in the early morning (0000 UTC) of 26th May. It crossed Bangladesh and adjoining West Bengal coasts between Sagar Islands and Khepupara close to southwest of Mongla between 1700 UTC of 26th May and 1830 UTC of 27th May, 2024 as an SCS with wind speed of 110 to 120 kmph gusting to 135 kmph (60 gusting to 70 knots). Continuing to move northwards, it weakened into a CS over coastal

Bangladesh and adjoining coastal West Bengal in the early morning (0000 UTC) of 27th May. It continued to move nearly northwards till the afternoon 1430 hours IST (0900 UTC) of 27th May and thereafter gradually recurved northeastwards. It weakened into a DD during the night (1500 UTC) of 27th May over central Bangladesh. Continuing to move further northeastwards, it weakened into a Depression over northeast Bangladesh in the early morning (0000 UTC) and into a well-marked low pressure area (WML) over south Assam and neighbourhood in the evening (1200 UTC) of 28th May, 2024. The observed track of the system is presented in Fig. 25.

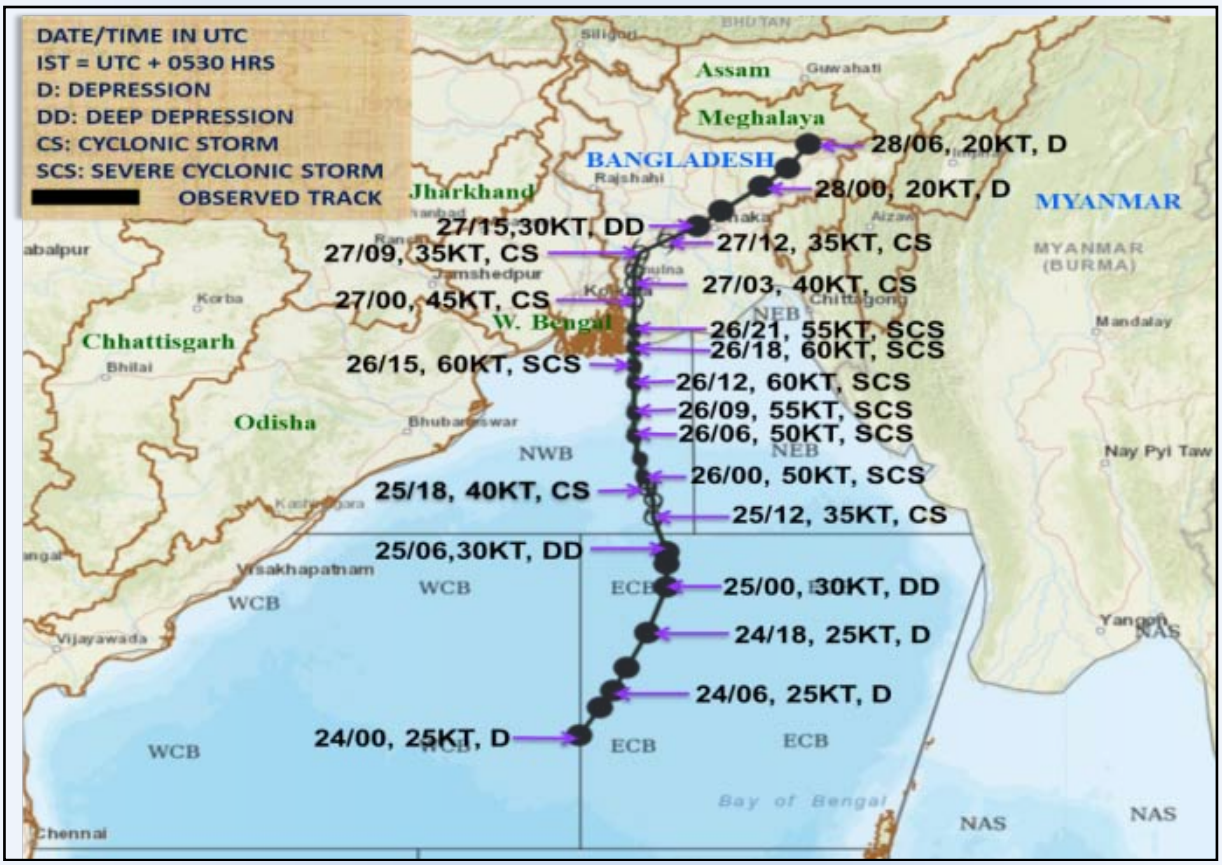


Fig. 25. Observed track of severe cyclonic storm "REMAL" over the Bay of Bengal during 24th - 28th May, 2024

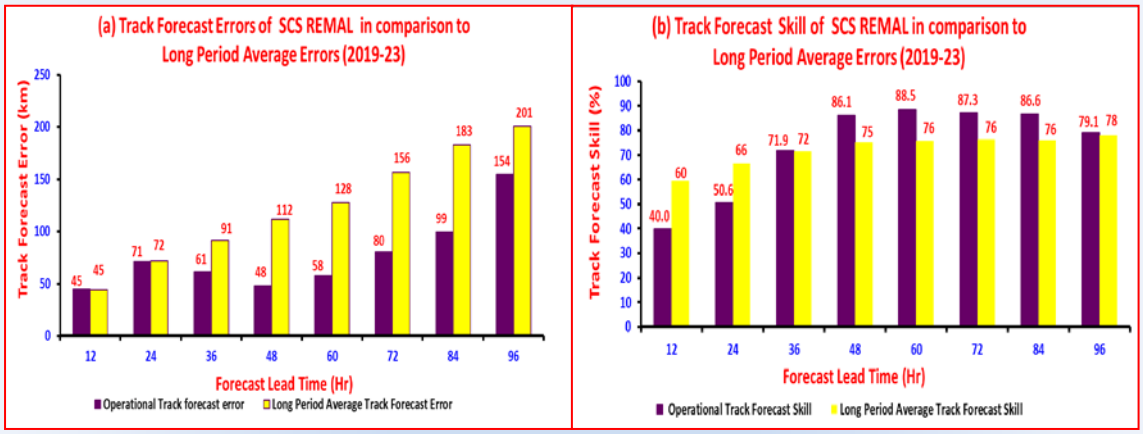
Forecast Performance

RSMC New Delhi issued first information about likely cyclogenesis (formation of depression) over BoB towards the end of the week (17th-23rd May) in the extended range outlook dated the 9th May (about 15 days ahead of formation of depression on 24th May). On 16th May, the same was reiterated with moderate confidence with likely cyclogenesis over central BoB on 16th May about 8 days before formation of depression and 11 days before landfall. Daily tropical weather outlooks from 19th May predicted moderate probability of formation during 24th - 25th May and graphical outlooks during 19th - 22nd May highlighted the genesis area 5 days ahead. On 23rd May, pre-genesis track and intensity forecast was issued with genesis (formation of depression) on 24th May, with northwards movement towards the Bangladesh-West Bengal coasts.

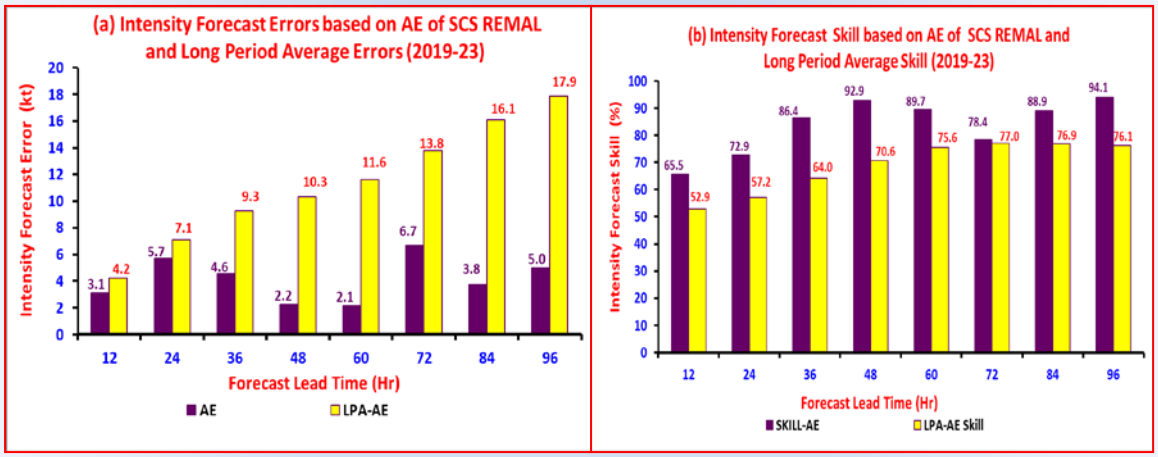
Operational track, intensity and landfall forecast performance

- The track forecast errors for 24, 48 and 72 hrs lead period were 71, 48 and 80 km respectively against the long period average (LPA) errors of 72, 112 and 156 km respectively based on data of

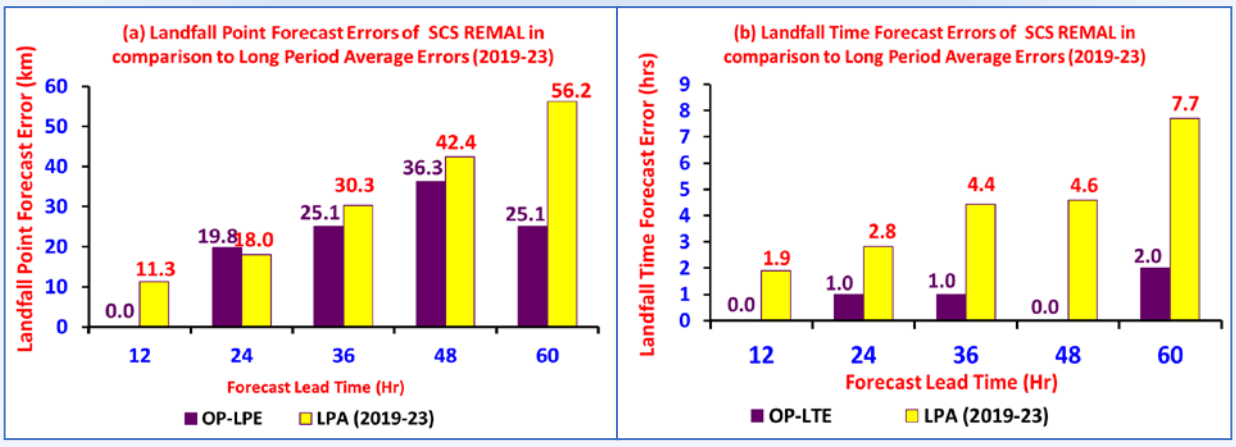
2019-23 [Fig. 26(a)]. The track forecast skills calculated against Climatology & Persistence (CLIPER) forecast for 24, 48 and 72 hrs lead period were 51, 86 and 87 km respectively against the long period average (LPA) skill of 66, 75 and 76% respectively based on data of 2019-23 [Fig. 26(b)]. The operational track forecast errors were less than the LPA errors for all lead periods.



Figs. 26(a&b). (a) Track forecast errors and (b) skills against Climatology & Persistence (CLIPER) compared to LPA errors & skills respectively



Figs. 27(a&b). (a) Intensity forecast errors (AE) and (b) skills against Persistence compared to long period average (LPA of 2019-23) errors & skills respectively based on absolute error (AE)



Figs. 28(a&b). (a) Landfall point and (b) time errors against the long period average (LPA: 2019-2023) errors

- The absolute errors (AE) in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 5.7, 2.2 and 6.7 knots against the LPA errors of 7.1, 10.3 and 13.8 knots based on data of 2019-23 respectively [Fig. 27(a)]. The skills in intensity forecast based on AE calculated against persistence-based forecast for 24, 48 and 72 hrs lead period were 73, 93 and 78% against the LPA skills of 57, 71 and 77% based on data of 2019-23 respectively [Fig. 27(b)]. For all lead periods, the operational intensity forecast errors were less and skills were more than the LPA.

- The landfall point forecast errors for 12, 24, 48 and 60 hrs lead periods were Zero, 20, 36 and 25 km respectively against the LPA errors of 11, 18, 42 and 56 km based on data of 2019-23 respectively [Fig. 28(a)]. Considering the average eye diameter as 50 km, there was almost zero landfall point forecast errors for all lead periods. The landfall time forecast errors for 12, 24, 48 and 60 hrs lead period were Zero, 1.0, Zero and 2.0 hours respectively against the LPA errors (2018-22) of 2, 2.8, 4.6 and 7.7 hours based on data of 2019-23 respectively [Fig. 28(b)]. For all lead periods, the landfall time errors were appreciably less than LPA errors.

- The absolute errors (AE) in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 5.7, 2.2 and 6.7 knots against the LPA errors of 7.1, 10.3 and 13.8 knots based on data of 2019-23 respectively [Fig. 27(a)]. The skills in intensity forecast based on AE calculated against persistence-based forecast for 24, 48 and 72 hrs lead period were 73, 93 and 78% against the LPA skills of 57, 71 and 77% based on data of 2019-23 respectively [Fig. 27(b)]. For all lead periods, the operational intensity forecast errors were less and skills were more than the LPA.

- The landfall point forecast errors for 12, 24, 48 and 60 hrs lead periods were Zero, 20, 36 and 25 km respectively against the LPA errors of 11, 18, 42 and 56 km based on data of 2019-23 respectively [Fig. 28(a)]. Considering the average eye diameter as 50 km, there was almost zero landfall point forecast errors for all lead periods. The landfall time forecast errors for 12, 24, 48 and 60 hrs lead period were Zero, 1.0, Zero and 2.0 hours respectively against the LPA errors (2018-22) of 2, 2.8, 4.6 and 7.7 hours based on data of 2019-23 respectively [Fig. 28(b)]. For all lead periods, the landfall time errors were appreciably less than LPA errors.

5.5.2.2. Cyclonic Storm "ASNA" over the Arabian Sea (25th August - 2nd September, 2024)

A low-pressure area formed over northwest BoB and adjoining areas of West Bengal and Bangladesh on the morning (0000 UTC) of 16th August 2024. It moved across South Bangladesh during 17th - 19th August, Central Bangladesh on 20th August and North Bangladesh during 21st - 22nd August. It then moved westwards towards West Bengal and adjoining Northeast Jharkhand on 23rd August. While moving westwards, it intensified into a well-marked low-pressure area over Southeast Uttar Pradesh and adjoining northeast Madhya Pradesh on 24th August. It further intensified into a depression over Northwest Madhya Pradesh on 25th August and into a deep depression over East Rajasthan and adjoining West Madhya Pradesh later that day. The deep depression moved west-southwestwards, reaching North Gujarat by 26th August, then crossed Gujarat during 27th - 29th August, and emerged into the Northeast Arabian Sea off Kachchh and adjoining Pakistan on 30th August. It intensified into Cyclonic Storm "ASNA." Over northeast Arabian Sea. Thereafter, it moved westwards and intensified slightly on 31st August. Thereafter, it moved south-southwestwards and weakened into a deep depression on 1st September and into a depression on 2nd September over northwest Arabian Sea. It further weakened into a well-marked low-pressure area in the afternoon (0600 UTC) of 2nd September and a low-pressure area over the westcentral and adjoining northwest Arabian Sea in the morning (0000 UTC) 3rd September, 2024. Observed track of the system is given in Fig. 29.

Forecast performance

First information about likely of cyclogenesis (formation of Depression) with moderate confidence (34-67%) was issued in the extended range outlook issued on 15th August (about 10 days ahead of formation of depression on 25th August). The extended range outlook was further updated on 24th August. It indicated likely formation of depression over Northwest Madhya Pradesh with high confidence (68-100%) (about 1 day ahead of formation of depression) and probable emergence of system into the northeast Arabian Sea. Daily

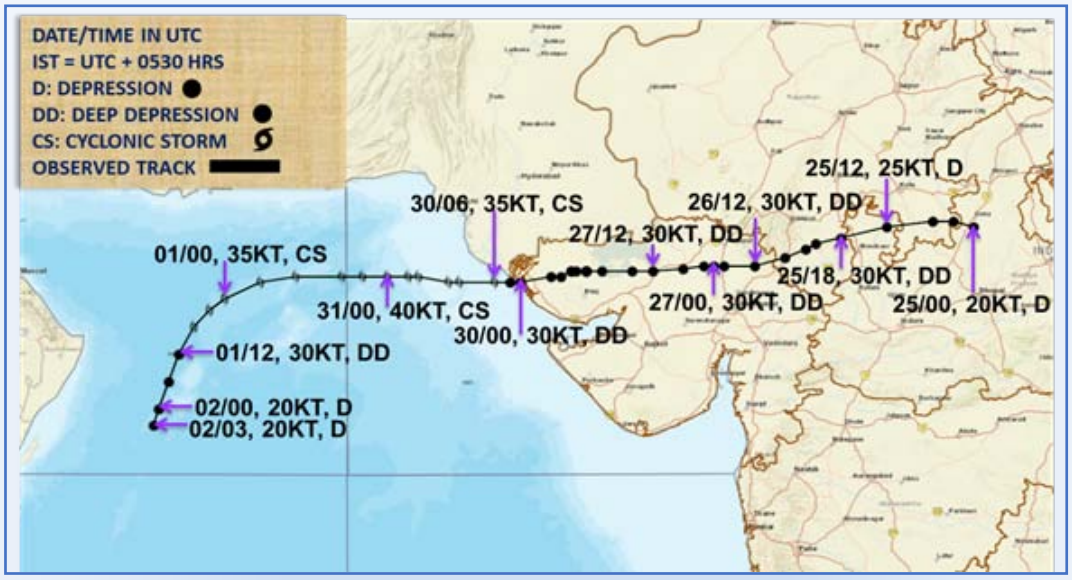


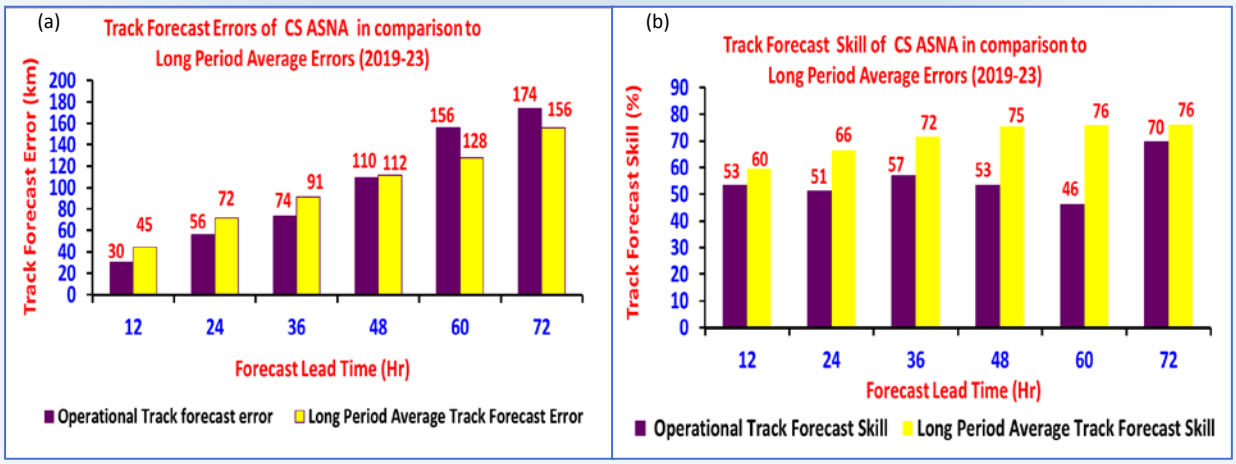
Fig. 29. Observed track of cyclonic storm "ASNA" over the Arabian Sea during 25th August - 2nd September, 2024

tropical weather outlook issued since 24th August indicated probability of formation of depression over land around 26th August.

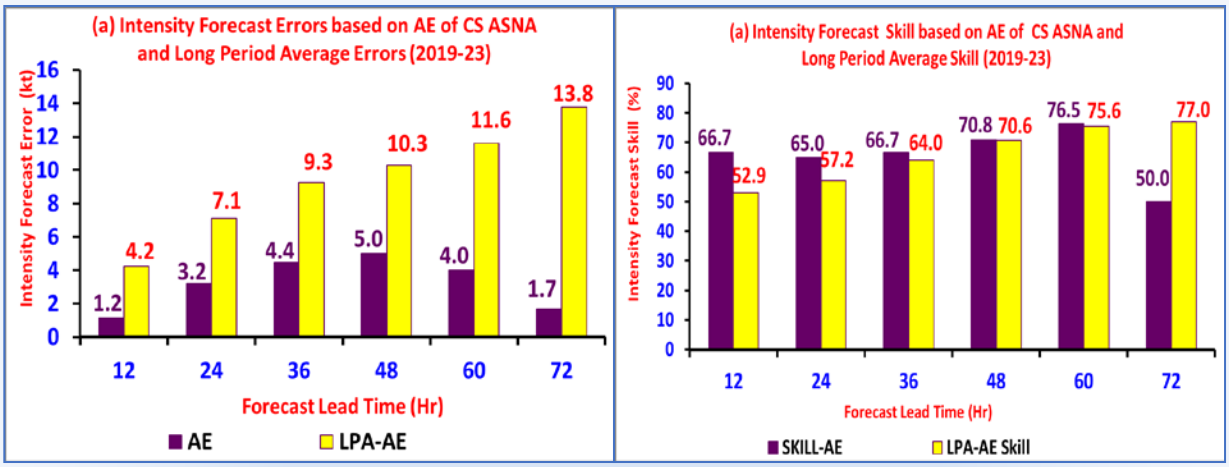
Operational track, intensity and landfall forecast performance

The track forecast errors for 24, 48 and 72 hrs lead period were 56, 110 and 174 km respectively against the long period average (LPA) errors of 72, 112 and 156 km respectively based on data of 2019-23 [Fig. 30(a)]. The track forecast skills calculated against Climatology & Persistence (CLIPER) forecast for 24, 48 and 72 hrs lead period were 51, 53 and 70 km respectively against the long period average (LPA) skill of 66, 75 and 76% respectively based on data of 2019-23 [Fig. 30(b)]. The operational track forecast errors were less than the LPA errors for all lead periods upto 48 hours.

The absolute errors (AE) of intensity (wind) forecast for 24, 48 and 72 hrs lead period were 3.2, 5.0 and 1.7 knots against the LPA errors of 7.1, 10.3 and 13.8 knots based on data of 2019-23 respectively [Fig. 31(a)]. The skills in intensity forecast based on AE calculated against persistence-based forecast for 24, 48 and 72 hrs lead period were 71, 71 and 50% against the LPA skills of 57, 71 and 77% based on data of 2019-23 respectively [Fig. 31(b)]. For all lead periods, the operational intensity forecast errors were less than the LPA.



Figs. 30(a&b). (a) Track forecast error and (b) skill against Climatology & Persistence (CLIPER) forecast compared to long period average (LPA of 2019-2023) errors & skills respectively



Figs. 31(a&b). (a) Absolute Error (AE) intensity forecast and (b) skill against Persistence forecast compared to long period average (LPA of 2019-23) error & skill respectively based on absolute error (AE)

5.5.2.3. Severe Cyclonic Storm "DANA" over the Bay of Bengal (22nd - 26th October, 2024)

A cyclonic circulation formed over the central Andaman Sea on 19th October. It lay over North Andaman Sea on 20th October, 2024. Under its influence, a low-pressure area formed over the eastcentral Bay of Bengal and adjoining north Andaman Sea in the evening (1200 UTC) of 20th October. Moving west-northwestwards, it became a well-marked low-pressure area on 21st October, a depression by the early morning of 22nd October, and a deep depression later that evening. It intensified into Cyclonic Storm "DANA" on the early morning of 23rd October, further strengthening into a severe cyclonic storm by midnight. It made landfall near Habalikhati Nature Camp (Bhitarkanika) and Dhamara, Odisha, between 2000 and 2200 UTC on 25th October, with wind speed of 100-110 kmph gusting to 120 kmph. The landfall process began late on 24th October and lasted until the morning of 25th October. The system weakened to a cyclonic storm, then a deep depression, and eventually into a depression by the night of 25th October. It further weakened into a well-marked low-pressure area over North Odisha on the morning of 26th October 2024. Observed track of the system is given in Fig. 32.

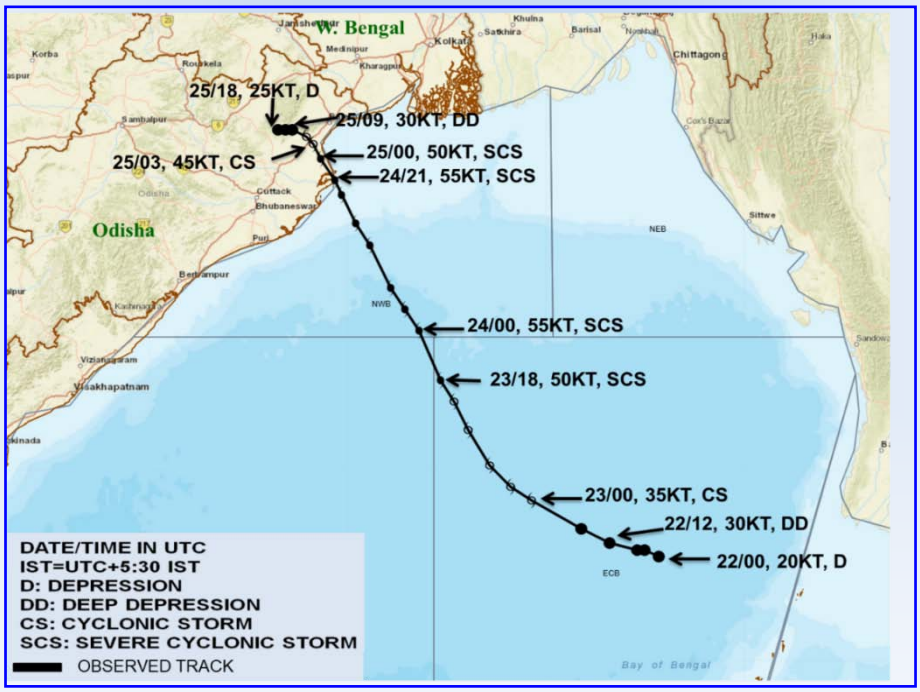


Fig. 32. Observed track of severe cyclonic storm "DANA" over eastcentral Bay of Bengal during 22-26 October, 2024

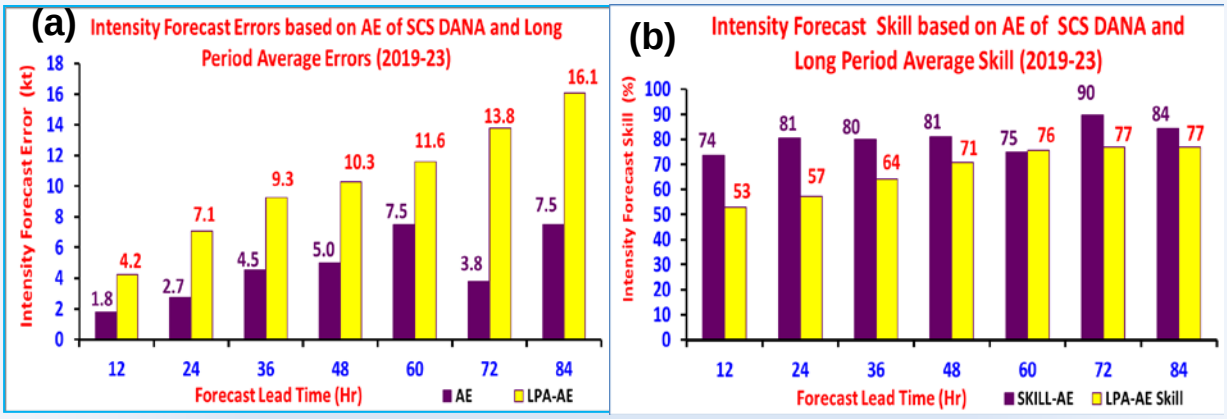


Fig. 33. (a) Track forecast errors and (b) skills against Climatology & Persistence (CLIPER) compared to long period average (LPA) errors & skills respectively based on 2019-2023

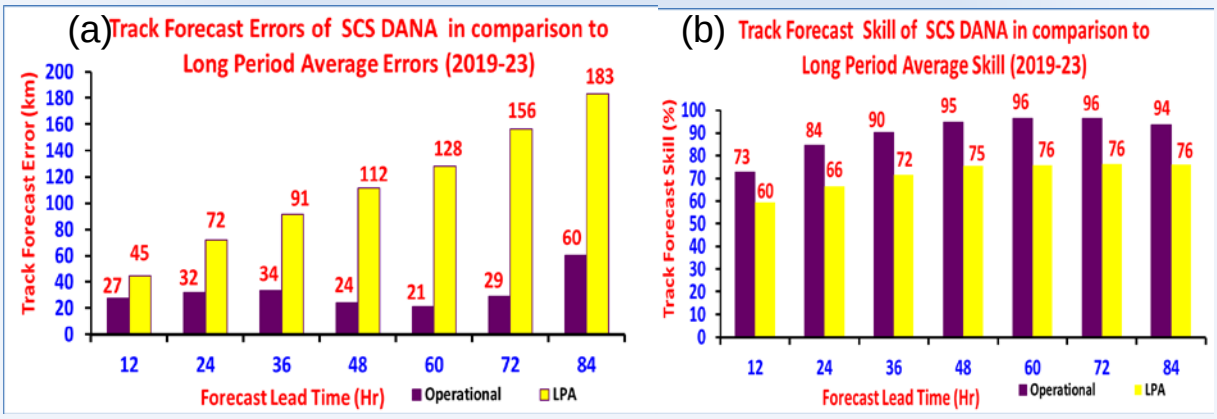
Forecast performance

First information about likely formation of an upper air cyclonic circulation over Andaman Sea around 21st October was issued in the daily report on 16th October under Tropical Cyclone Forecasting Programme carried out by IMD since 2008 during October to December as an initiative to improve forecast through enhanced observations & model guidance (about 3 days ahead of the formation of upper air cyclonic circulation over central Andaman Sea on 19th October). First information about likelihood of cyclogenesis (formation of Depression) with High confidence (67-100%) was issued in the extended range outlook issued on 17th October (about 5 days ahead of formation of depression on 22nd October).

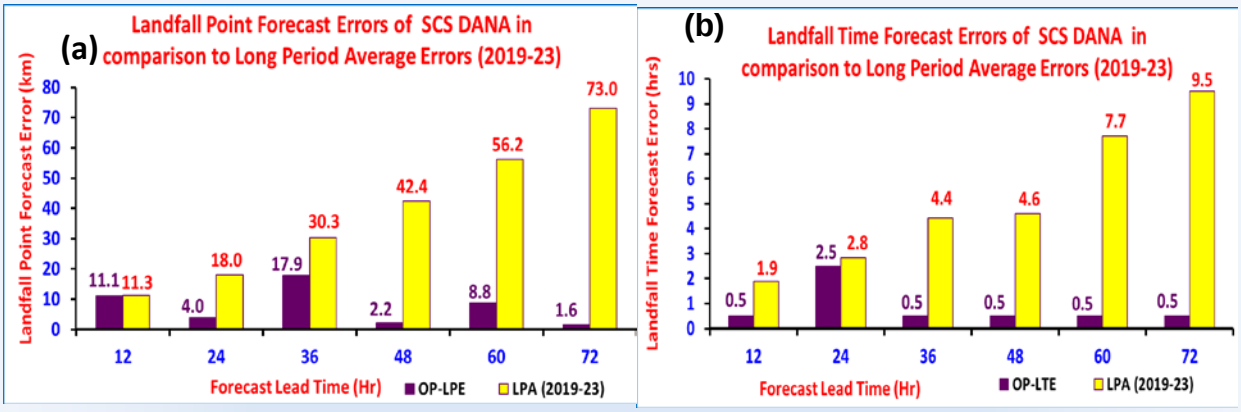
Track, intensity and landfall forecast performance

The track forecast errors for 24, 48 and 72 hrs lead period were 32, 24 and 29 km against the long period average errors of 72, 112 and 156 km respectively based on the data of 2019-23 [Fig. 33(a)]. The track forecast skills calculated against Climatology & Persistence (CLIPER) forecast for 24, 48 and 72 hrs lead period were 84, 95 and 96 % respectively against the long period average skills of 66, 75 and 76% respectively based on the data of 2019-23 [Fig. 33(b)]. For all lead periods, the operational track forecast errors were markedly below the long period average errors.

The absolute errors (AE) in intensity (wind) forecast for 24, 48 and 72 hrs lead period were 2.7, 5.0 and 3.8 knots against the long period average errors of 7.1, 10.3 and 13.8 knots based on the data of 2019-23 respectively [Fig. 34(a)]. The skills in intensity forecast based on AE calculated against the persistence-based forecasts for 24, 48 and 72 hours lead period were 81, 81 and 90 % against the long period average skills of 57, 71 and 77% based on data of 2019-23 respectively [Fig. 34(b)]. For all lead periods, the operational intensity forecast errors were less and the skills were more than the long period average.



Figs. 34(a&b). (a) Intensity forecast errors (AE) and (b) skills against Persistence compared to long period average (LPA) errors & skills respectively based on absolute error (AE)



Figs. 35(a&b). (a) Landfall point and (b) time errors against the long period average (LPA) errors based on 2019-2023

The landfall points forecast errors for 24, 48 and 72 hrs lead period were 4, 2 and 2 km respectively against the long period average errors of 18, 42 and 73 km based on data of 2019 - 23 [Fig. 35(a)]. The landfall time forecast errors for 24, 48 and 72 hrs lead period were 2.5, 0.5 and 0.5 hours respectively against the long period average error of 2.8, 4.6 and 9.5 hours respectively based on the data of 2019-23 [Fig. 35(b)]. The operational landfall point & time forecast errors were markedly less than the LPA errors for all lead periods. There was almost zero error in landfall point prediction for all lead periods upto 90 hours. The landfall intensity forecast errors were also almost zero even upto 90 hrs lead period.

5.5.2.4. Cyclonic Storm FENGAL over Bay of Bengal (25-31 November)

Cyclonic storm Fengal developed from a low pressure area that formed over East Equatorial Indian Ocean (EEIO) and adjoining Southeast BoB in the morning (0300 UTC) of 23rd November. It moved west-northwestwards, and became a well-marked low pressure area over southeast BoB and adjoining EEIO in the morning (0300 UTC), of 24th November. Further moving west-northwestwards, it intensified into a depression over central parts of south BoB and adjoining EEIO in the morning (0300 UTC) of 25th November, into a deep depression over Southwest BoB in the morning (0300 UTC) of

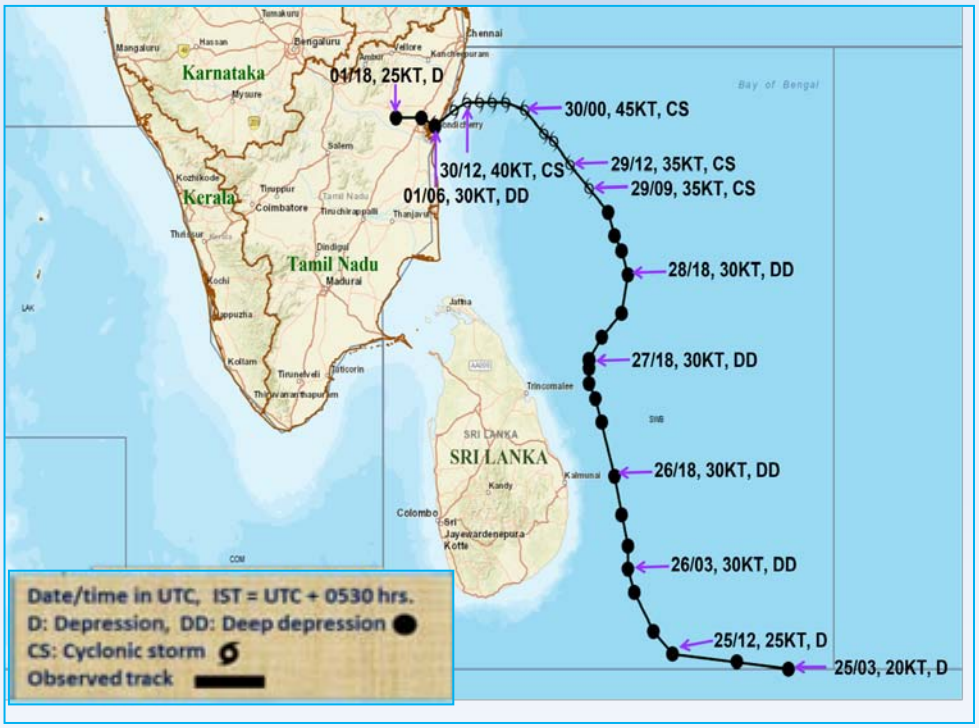
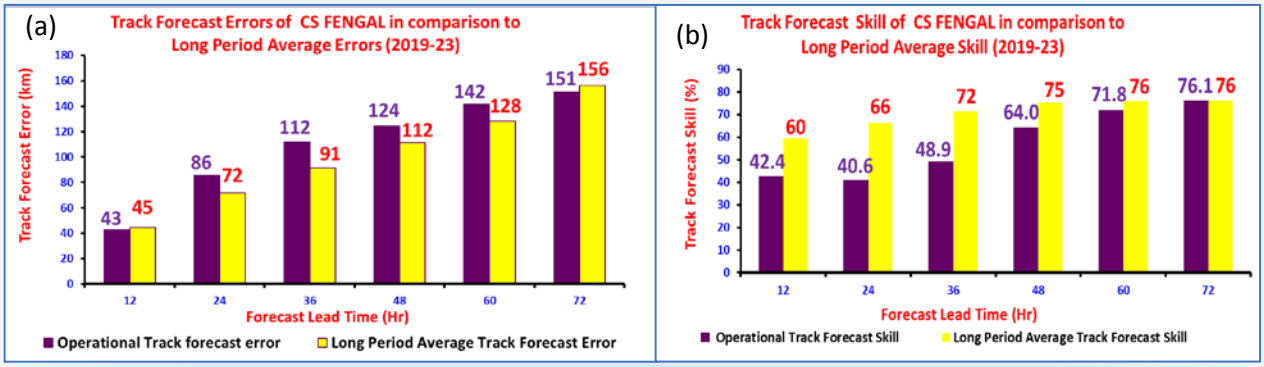


Fig. 36. Observed track of severe cyclonic storm "Fengal" over Bay of Bengal during 25-31 August, 2024



Figs. 37(a&b). Track forecast errors compared to long period average (LPA) errors & skills respectively based on 2019

26th November and into the cyclonic storm "FENGAL" [pronounced as FEINJAL] over Southwest BoB in the afternoon (0900 UTC) of 29th November. Thereafter, it moved initially westwards, then west-southwestwards and crossed North Tamil Nadu & Puducherry coasts close to Puducherry, between 1700 and 1800 UTC of 30th November as a cyclonic storm with a wind speed of 70-80 kmph gusting to 90 kmph. Thereafter, it remained practically stationary over the same region and weakened into a deep depression in the forenoon (0600 UTC) and into a depression over the same region in the evening (1200 UTC) of 1st December. It then moved nearly westwards and weakened into a Well-Marked Low Pressure Area over North Interior Tamil Nadu in the early morning (0000 UTC) of 2nd December. Observed track of the system is presented in Fig. 36.

Forecast performance

The genesis of cyclone Fengal was first predicted in the extended range outlook issued on 14th November 2024. It was again reiterated on 21st November with high probability. Genesis occurred on 25th Nov, 2024. It was predicted to cross coast close to Puducherry since evening of 27th November (78 hrs in advance of landfall).

Track, intensity and landfall forecast performance

The track forecast errors for 24, 48 and 72 hrs lead period were 86, 124 and 151 km against the long period average errors of 72, 112 and 156 km respectively based on the data of 2019-23 [Fig. 37(a)]. The track forecast skills calculated against Climatology & Persistence (CLIPER) forecast for 24, 48 and 72 hrs lead period were 0.6, 64 and 6.1 % respectively against the long period average skills of 66, 75 and 76% respectively based on the data of 2019-23 [Fig. 37(b)]. The operational track forecast errors consistently outperformed the LPA benchmarks, underscoring the improved track prediction capabilities overall lead periods.

The absolute errors in intensity forecast for 24, 48, and 72 hours lead periods were 4.2, 7.3, and 5.5 knots, respectively, against the LPA errors of 7.1, 10.3 and 13.8 knots [Fig. 38(a)]. The skills in

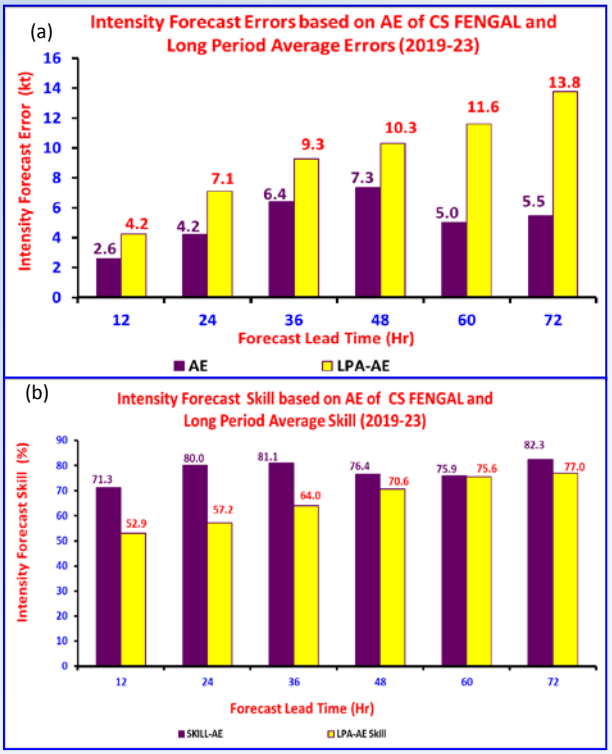
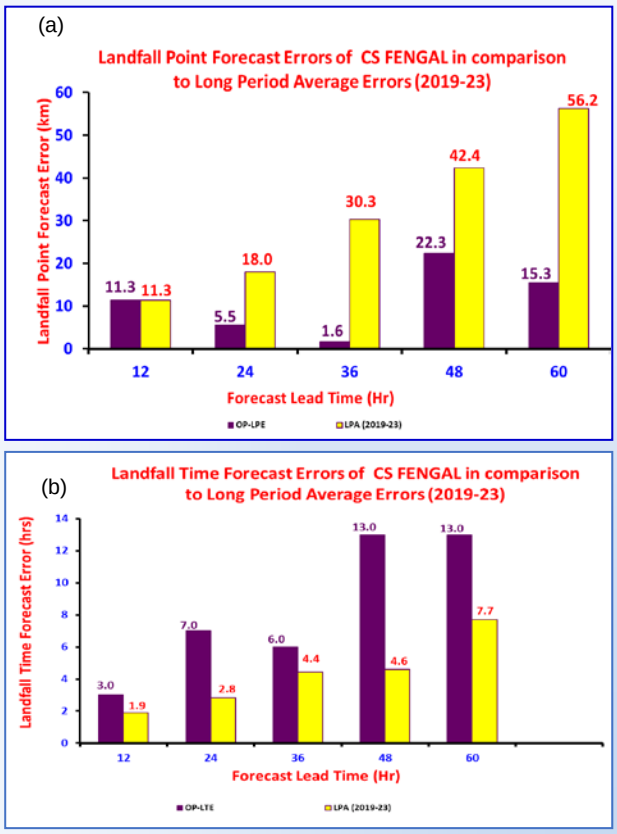
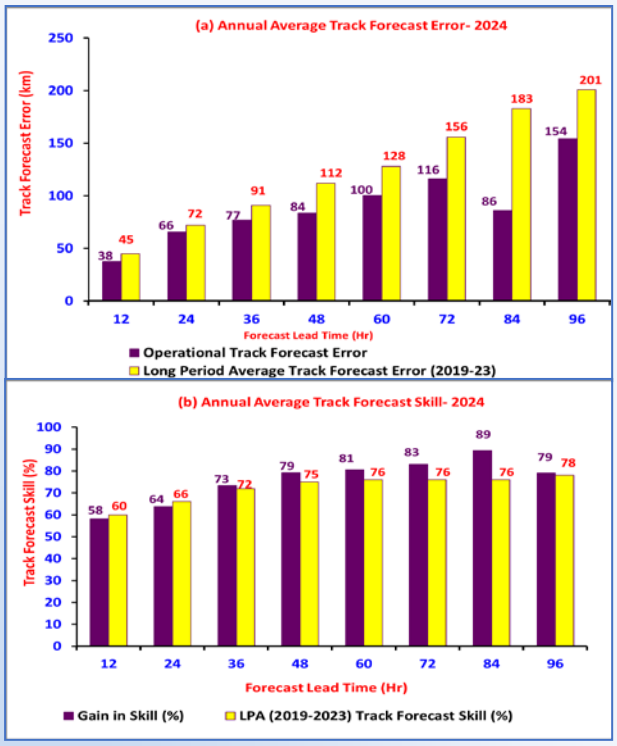


Fig. 38. Intensity forecast errors (AE) compared to long period average (LPA) errors & skills respectively based on absolute error (AE)



Figs. 39(a&b). (a) Landfall point and (b) time errors against the long period average (LPA) errors based on 2019-2023



Figs. 40(a&b). Annual average track forecast (a) error (km) (b) skills (%) during 2024 as compared to LPA of that during 2019-2023

intensity forecast based on AE calculated against the persistence-based forecasts for 24, 48 and 72 hours lead period were 80, 76 and 82 % against the long period average skills of 57.2, 70.6 and 77% based on data of 2019-23 respectively [Fig. 38(b)]. The operational intensity forecast errors were less than the long-period average errors for all lead periods.

The landfall point forecast errors for 24, 36, and 48 hours lead periods were 5.5, 22.3, and 15.3 km, respectively, against the long-period average (LPA) errors of 18.0, 30.3 and 42.4 km [Fig. 39(a)]. The operational landfall point forecast errors were significantly below the LPA errors for all lead periods, showcasing an improved accuracy in predicting the landfall location.

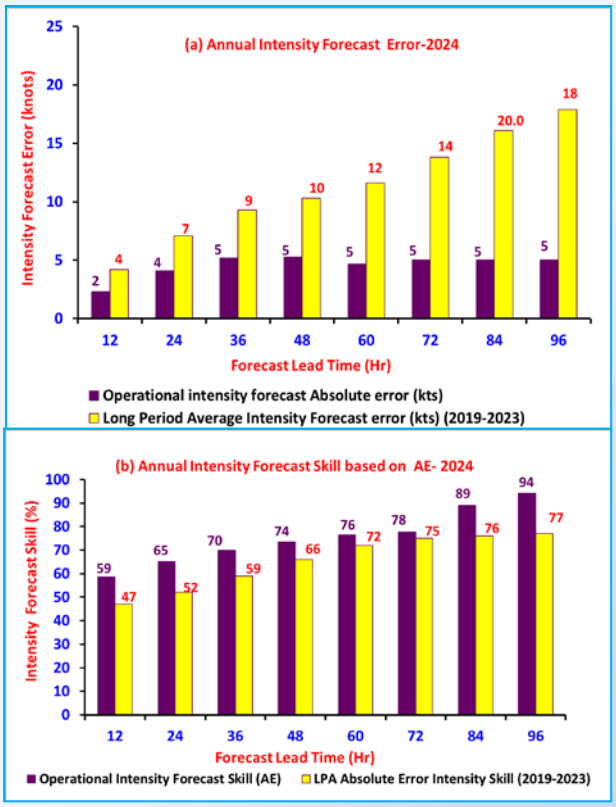
The landfall time forecast errors for 24, 48, and 60 hours lead periods were 7.0, 6.0 and 13.0 hours, respectively, compared to LPA errors of 2.8, 4.4 and 4.6 hours [Fig. 39(b)]. The operational errors were more than LPA errors for all lead periods because the system had a recurving track and thus the landfall time could not be predicted accurately.

5.5.3.1. Annual Performance of cyclone landfall, track and intensity forecast

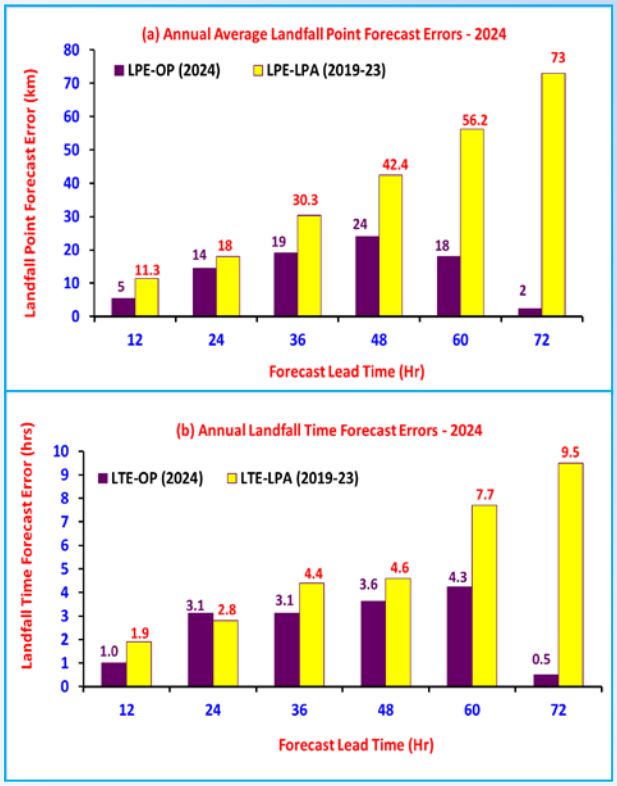
The annual average track forecast errors in 2024 have been 66 km, 84 km and 116 km, for 24, 48 and 72 hrs respectively against the past five-years average error of 72, 112 and 156 km based on data of 2019-2023. For all lead periods, the errors have been lesser during this year as compared to long period average (LPA) (2019-23). The track forecast skills compared to climatology and persistence forecast have been 64%, 79% and 83% respectively for the 24, 48 and 72 hrs lead period which was also less than long period average of 2019-2023 (66%, 75% & 73% respectively). The annual average track forecast errors and skill during 2024 are presented in Figs. 40(a&b).

Compared to LPA of that during 2019-2023

The annual average absolute error (AE) in intensity forecast error [Fig. 41(a)] has been 4, 5 and 5 knots respectively for 24, 48 and 72 hrs lead period of forecast against the past five-year average of 7, 10 and 14 knots. The skill in terms of AE compared to



Figs. 41(a&b). Annual average intensity forecast error (km) (a) based on AE (b) based on RSME during 2024 as compared to LPA of that during 2019-2023



Figs. 42(a&b). Annual average (a) landfall points forecast error (km) and (b) landfall time forecast errors as compared to long period average errors during 2019-2023

persistence forecast was 65%, 74% and 78% as compared to long period average (2019-23) of 52%, 66% and 75% for 24-, 48- and 72-hours period [Fig. 41(b)].

The annual average landfall point forecast errors for the year 2024 have been 14 km, 24 km and 2 km for 24, 48 and 72 hrs lead period against the past five years average errors of 18 km, 42 km and 73 km during 2019-2023. The landfall time forecast errors have been 3.1, 3.6 and 0.5 hrs for 24, 48 and 72 hrs lead period during 2024 against the average of past five years of 2.8, 4.6 and 9.5 hrs during 2019-2023. Annual average landfall forecast errors for the year 2024 and the landfall time forecast errors during 2024 against the average of past five years during 2019-2023 are presented in Figs. 42(a&b).

5.5.3.2. Comparative analysis of forecast accuracy in recent five years (2020-24) as compared to previous five years (2019-23)

The comparative analysis of average track forecast error and skill during 2020-24 and 2015-19 is presented in Fig. 43. The average track forecast errors during 2020-24 were 72 km, 111 km & 154 km against 81 km, 126 km & 171 km during 2015-19 for 24, 48 and 72 hrs lead period respectively.

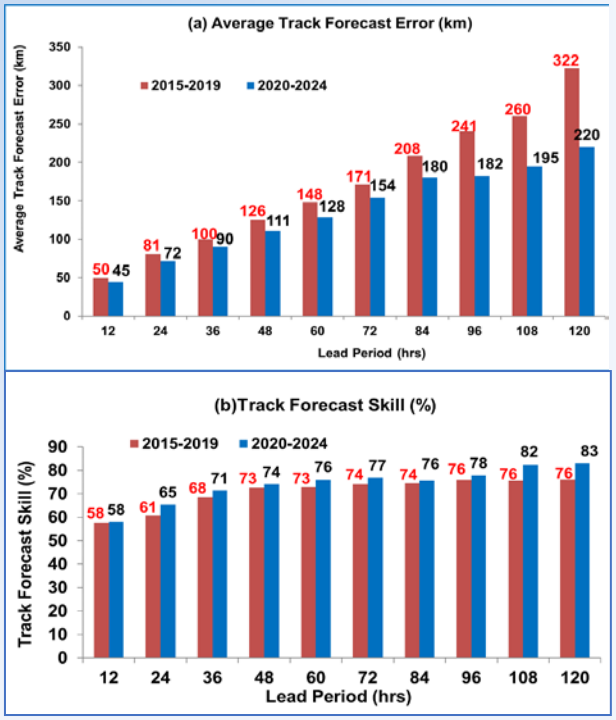


Fig. 43. Comparative Average track forecast (a) error (km) (b) skill (%) during 2020-2024 vis-à-vis 2015-19

The 24, 48 and 72 hr average track forecast skills during 2020-24 were 65%, 74% and 77% against 61%, 73% and 74% respectively during 2015-19.

The comparative analysis of average intensity forecast error and skill based on AE and RMSE during 2020-24 and 2015-19 are presented in Figs. 44 (a&b). The average intensity forecast error based on AE for 24hrs, 48hrs and 72hrs are 5.9 knots, 8.3 knots and 9.8 knots during 2020-24 against 8.9 knots, 13.0 knots and 15.4 knots during 2015-19. Based on RMSE the intensity forecast errors were 7.9 knots, 11.0 knots and 19.2 knots during 2020-24 against 11.5 knots, 16.7 knots, and 19.2 knots during 2015-19. It can be seen that there has been marginal improvement in intensity forecast during recent five years (2020-24) as compared to previous five years (2015-19).

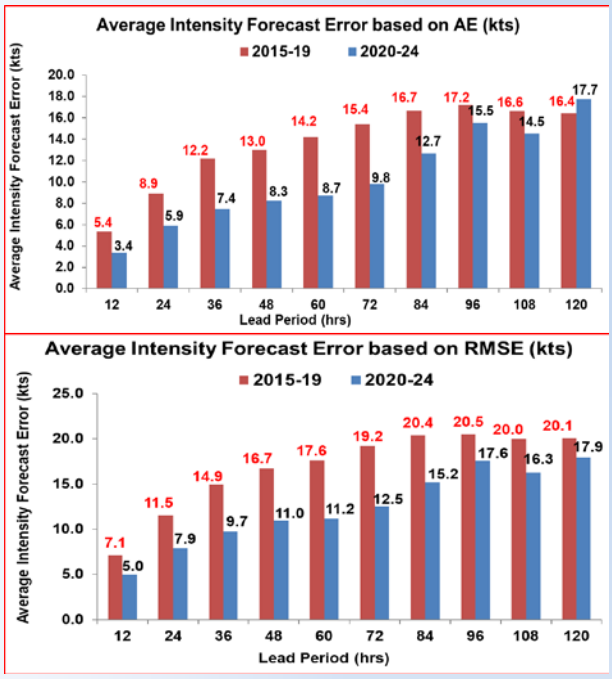


Fig. 44. Comparative Average Intensity forecast errors (kts) based on (a) absolute error and (b) root mean square errors during 2020-2024 vis-à-vis 2015-19

Comparative analysis of landfall point error (LPE) and landfall time error (LTE) during 2020-24 vis-à-vis 2015-19 is presented in Figs. 45 (a&b). The LPE for 24, 48 and 72 hrs lead period during 2020-24 were 16.2 km, 39.3 km and 69.5 km against 44.7 km, 69.4 km and 109.3 km respectively during 2015-19. The LTEs for 24, 48 and 72 hrs lead period during 2020-24 were 2.9hrs, 4.2hrs & 7.5hrs against 3.0 hrs, 5.4hrs & 8.6hrs respectively during 2015-19.

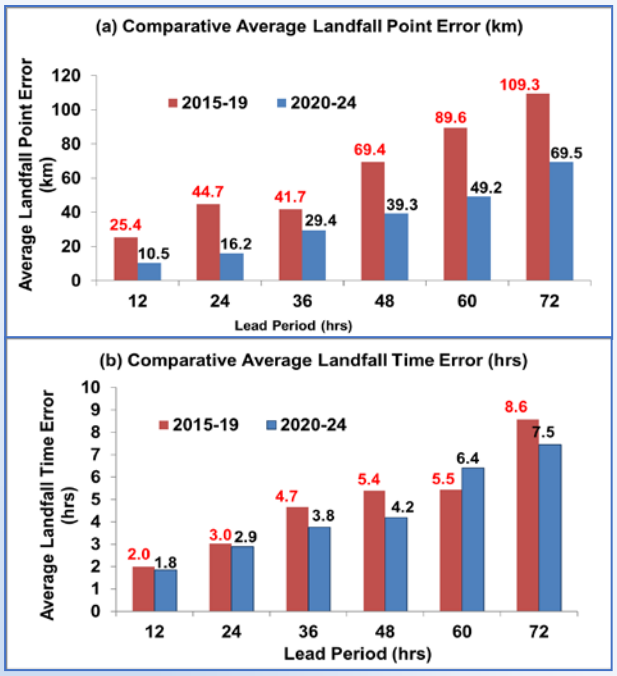
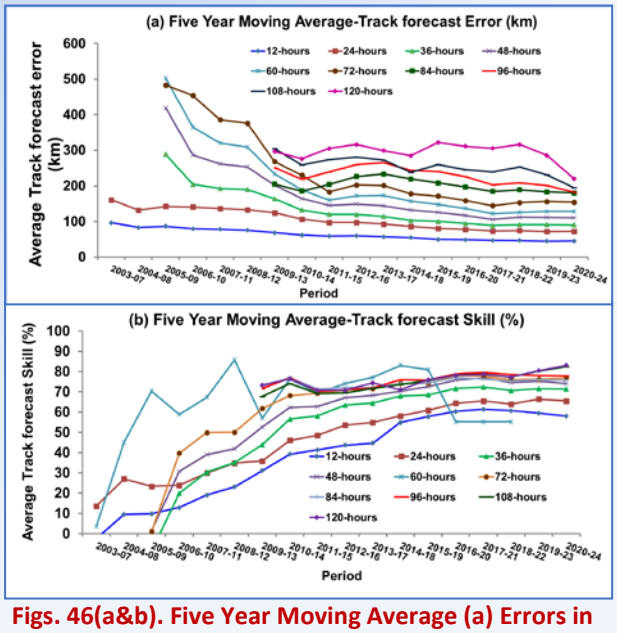


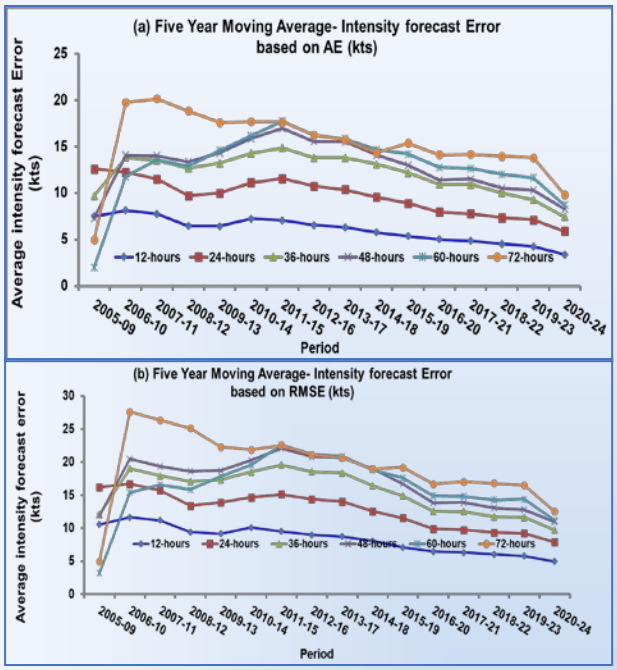
Fig. 45. Comparative average landfall (a) points and (b) time forecast errors during 2020-2024 vis-à-vis 2015-19

5.5.3.3. Five Year Moving Average errors and skill over north Indian Ocean

Five year moving average track forecast errors and corresponding skills for different lead periods upto 120 hours are presented in Fig. 46, indicating consistent decrease in track forecast errors over the years since 2003. Five years mean average has been calculated and presented here, as the annual frequency of cyclones is very less over the NIO.

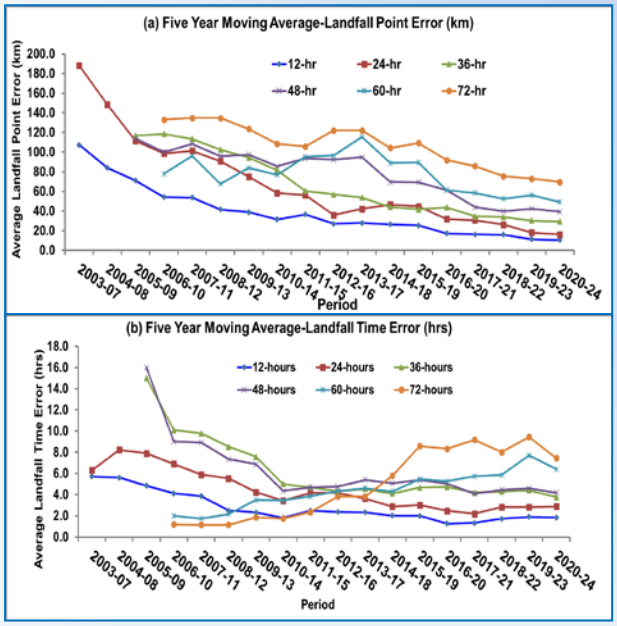


Figs. 46(a&b). Five Year Moving Average (a) Errors in Track Forecast (km) and (b) skill of RSMC, New Delhi over north Indian Ocean



Figs. 47(a&b). Five Year Moving Average Intensity Forecast skill based on (a) AE and (b) RMSE of RSMC, New Delhi over North Indian Ocean

Five year moving average intensity forecast errors and corresponding skills for different lead periods upto 120 hours are presented in Fig. 47 indicating consistent decrease in intensity forecast errors since 2003.



Figs. 48(a&b). Five Year Moving Average Errors in (a) Landfall Point (km) and (b) Landfall Time (hrs) of RSMC, New Delhi over north Indian Ocean

Five year moving average landfall point and time forecast errors for different lead periods upto 120 hours are presented in Fig. 48 indicating consistent decrease in intensity forecast errors since 2003. Probabilistic Storm Surge during SCS REMAL (Fig. 49).

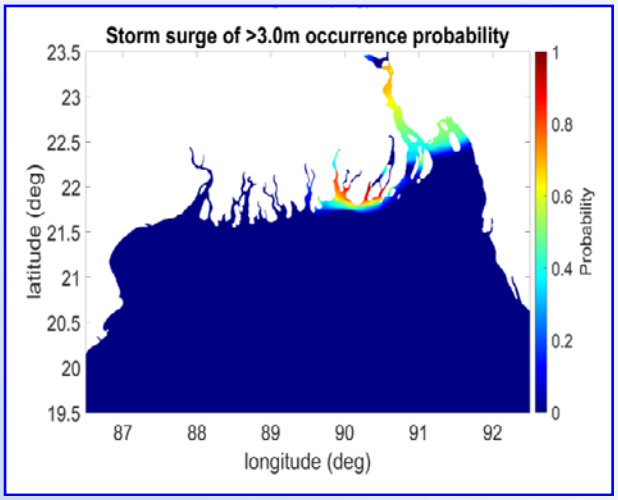


Fig. 49. Probabilistic Storm Surge during SCS REMAL

5.5.4. Major Initiatives In Various Components Of Early Warning System For Tropical Cyclones During 2024

(a) Forecasting and Warning Services:

- ❖ Introduction of probabilistic storm surge forecast experimentally during cyclone Remal
- ❖ Extension of customized location specific forecast to Ports, Nuclear Power Corporation, Indian Air Force, Indian Coast Guard locations
- ❖ Dissemination of Severe Weather Guidance to 9 member countries under Severe Weather Forecasting Programme by email.

Fig. 50. Dissemination of Severe Weather Guidance to 9 member countries

TABLE 4: CYCLONIC DISTURBANCE FORECAST FOR PORTS BASED ON 2330 hrs IST of 25th May,2024														
SI	DESCRIPTION OF PORT NAME(LAT°N /LON°E)	LOCATION		CURRENT LOCATION FROM CENTRE OF CYCLONIC DISTURABANCE		FORECAST PARAMETERS WHEN THE CYCLONIC DISTURBANCE WOULD BE NEAREST TO THE PORT								
		LAT (°N)	LON (°E)	DISTANCE (KM)	DIRECTION	DATE/ TIME(IST) OF OCCURRENCE	DISTANCE OF CD FROM PORT	DIRECTION OF CD FROM PORT	MSW OVER PORT(KTS)	UNCERTAINTY IN		STORM SURGE	SIGNIFICANT WAVE HEIGHT (M)	STATE OF SEA
										DISTANCE (KM)	MSW (KTS)			
ACWC Kolkata														
12.	Port Blair (11.67,92.5)	19.3	89.4	912	NNW	25.05.24/2330	912	SSE	<27	5	5		<4	Rough
13.	Sagar Island (21.72,88.1)	19.3	89.4	302	SSE	26.05.24/2030	124	W	49	20	10		6-10	High
14.	Haldia (22.02,88.06)	19.3	89.4	333	SSE	26.05.24/2330	128	W	49	25	10		6-10	High
15.	Kolkata Port (22.32,88.18)	19.3	89.4	359	SSE	26.05.24/2330	121	WNW	49	25	10		6-10	High
CWC Bhubaneswar														
16.	Checked out Gopalpur (19.27,84.92)	19.3	89.4	471	E	25.05.24/2330	471	W	<27	5	5		<4	Rough
17.	Puri (19.81,85.83)	19.3	89.4	379	E	26.05.24/0830	373	W	<27	10	5		<4	Rough
18.	Paradip (20.27,86.67)	19.3	89.4	306	ESE	26.05.24/1130	278	W	33	15	5		4-6	Very Rough
19.	Dhamra (20.78,86.97)	19.3	89.4	303	ESE	26.05.24/1130	243	W	33	15	5		4-6	Very Rough

Fig. 51. Customized Location specific bulletin for Ports

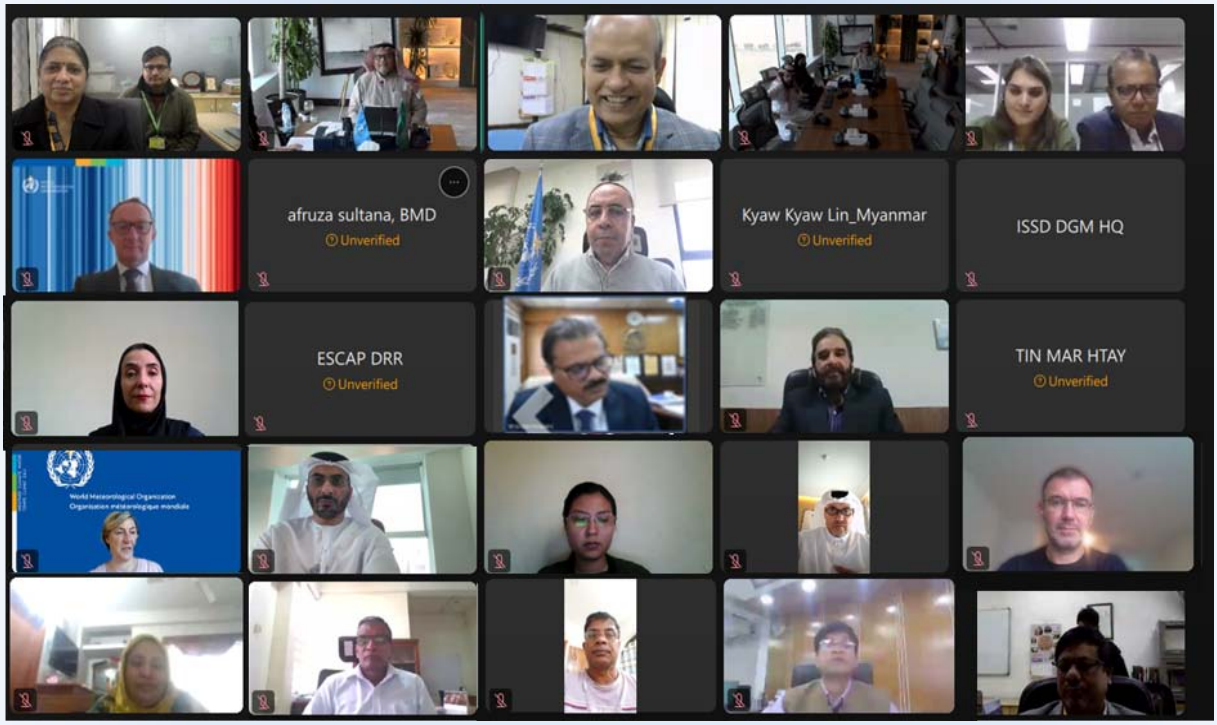


Fig. 52. 51st Session of WMO/ESCAP Panel on Tropical Cyclones (online) during 16th - 20th December, 2024

- Customized Location specific bulletin for Ports (Fig. 51)
- 51st Session of WMO/ESCAP Panel on Tropical Cyclones (online) during 16th - 20th Dec, 2024 (Fig. 52).

(b) Major achievements

- WMO appreciated RSMC New Delhi for organizing 20th Annual Attachment Training for cyclone forecasters in August.

- WMO/ESCAP Panel on Tropical Cyclones appreciated the role of PTC Secretariat for preparation of Vision 2030 of PTC, PTC News Letter, updation of Tropical Cyclone Operation Plan (TCP-21) and for organizing 51st session

5.6. Drought Monitoring & Prediction

Drought Monitoring and Prediction is being done using different indices like SPI (Standardized Precipitation Index), AAI (Aridity Anomaly Index) and SPEI Drought monitoring using Aridity Anomaly Index (AAI). The SPI maps are being generated every week as well as every month to identify the regions with prevailing or beginning/ ending of the extremely/severely/moderately dry/ wet conditions. The detailed statistics of the SPI computed for the entire SW monsoon period helps the various state government agencies for initiating drought management. Weekly SPI maps and values is being sent to all the state authorities as demanded by them according to new Drought manual of Ministry of Agriculture.

Weekly Drought monitoring using Standardized Precipitation Evaporation Index (SPEI) has been done in the year 2020. Prediction of one-week advance SPI and AAI maps is being done during SW monsoon and NE monsoon using IMD GFS district rainfall forecast. SPI Forecast maps for one week to four weeks are also being generated using ERFS data.

CHAPTER 6

CAPACITY BUILDING, PUBLIC AWARENESS & OUTREACH PROGRAMME

6.1. Important Events

IMD CELEBRATED 150TH YEAR OF ITS SERVICE TO THE NATION

IMD celebrated 150th year of its establishment and service to the nation on 15th Jan, 2024 at Vigyan Bhawan, New Delhi. **Hon'ble Vice President of India Shri Jagdeep Dhankar Ji** graced the occasion as Chief Guest. **Shri Kiren Rijiju Ji**, Honorable Union Cabinet Minister, Ministry of Earth Sciences (MoES) graced the occasion as Guest of Honour. **Dr. M. Ravichandran,** Secretary MoES presided over the function. Former Secretaries of Ministry of Earth Sciences, former Director Generals of India Meteorological Department (IMD), Heads of various sister organisations in MoES, Secretaries of various Ministries, Chief Secretaries & Resident Commissioners of various States and Union Territories, Heads of various disaster management agencies, Heads of various Universities and linstitutions, employees of IMD, researchers & academicians and press & electronic media participated in the ceremony. **Hon'ble Vice President in his address appreciated IMD for its service to nation, in particular the accurate prediction of cyclones Amphan, Biparjoy and Mocha.**

Hon'ble Vice President of India Shri Jagdeep Dhankar Ji, Shri Kiren Rijiju Ji, Honorable Union Cabinet Minister, MoES, Dr. M. Ravichandran, Secretary MoES, Dr. M. Mohapatra, DG IMD, Mrs. Ranju Madan, DDG(A) IMD, during ceremonial lighting of lamp & release of "Souvenir on Evolution of IMD" by the dignitaries

THE MAIN ACTIVITIES OF THE PROGRAMME

Appreciation by Hon'ble Prime Minister Shri Narendra Modi : Hon'ble Prime Minister in his tweet appreciated the services of IMD for the nation since last 150 years. In his tweet, he also acknowledged that IMD has played a pivotal role in weather forecasting and research & development in the field of climate & weather services. IMD has played a significant role in improving our understanding towards disaster risk reduction and environment. He also shared the video released by IMD on this occasion on the evolution of IMD since 1875. The same is available at: https://x.com/narendramodi/status/1746862479836348455?s=20.

During the inaugural ceremony following releases were made: Souvenir on Evolution of IMD, Documentary Film on Evolution of IMD, Indigenously developed Decision Support System (DSS), Panchayat Mausam Seva (PMS), IMD's Mobile App and National Framework for Climate Services.

Dr. Jitendra Singh assuming the charge of Minister of State (Independent Charge) of the Ministry of Earth Sciences

Hon'ble Minister Dr. Jitendra Singh assumed the charge of Ministry of Earth Sciences (MoES)

Dr. Jitendra Singh assumed the charge of Minister of State (Independent Charge) of the Ministry of Earth Sciences (MoES) on 11th June, 2024 at the Prithvi Bhavan HQ in New Delhi. He was welcomed by **Dr. M Ravichandran**, Secretary of MoES, along with senior scientists, officials, and MoES staff. Dr. Jitendra Singh has held this portfolio nearly for two consecutive terms except for a brief period since 2014. He is a member of Parliament from the Udhampur Lok Sabha constituency. He is also the Minister of State (Independent Charge) of the Ministry of Science and Technology; Minister of State in the Prime Minister's Office; Minister of State in the Ministry of Personnel, Public Grievances and Pensions; Minister of State in the Department of Atomic Energy; and Minister of State in the Department of Space. Addressing the media after assuming charge **Dr. Jitendra Singh** thanked the **Honorable Prime Minister Shri Narendra Modi**, for his continued trust, support, and encouragement. "The challenges facing our planet demand bold action and scientific innovation. We must remain committed to harnessing the immense potential of Earth sciences to foster sustainable development, mitigate climate risks, advance data-driven policy and decision making, safeguard our people from risks, and enhance environmental stewardship for future generations." **Dr. Singh**. **Twenty-eighth (28th) Session of South Asian Climate Outlook Forum (SASCOF-28).**

Twenty-eighth (28th) Sessionof South Asian Climate Outlook Forum (SASCOF-28)

Twenty-eighth (28th) Sessionof South Asian Climate Outlook Forum (SASCOF-28) for the Summer Season and Climate Services User Forum (CSUF), Pune, India was held in April 29-30 & 1 May, 2024. The aim of the workshop was to prepare a climate outlook for the 2024 summer monsoon season covering the months from June to September. **National Meteorological and Hydrological Services (NMHSs) from SASCOF member countries Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka, as well as several regional and global experts will jointly prepare this consensus outlook.** The CSUF special session focused on interface with users from the Water, Agriculture, Disaster Risk Reduction and Health sector to interpret seasonal climate information and understand their specific needs with a view to further customizes climate information.

20th WMO Attachment Training for Tropical cyclone Forecasters during 19-30 August

Release of Souvenir by Secretary Ministry of Earth Sciences by Secretary Ministry of Earth Sciences

India Meteorological Department organised 20th Annual Attachment Training for Tropical Cyclone Forecasters in 13 WMO/ESCAP Panel member countries (19-30 August). IMD is conducting this training regularly every year since 2005. There were a total of 43 international participants with 9 joining in -person and remaining 34 joining online apart from the participants from India. The training aimed at building capacity of the cyclone forecasters in the region by understanding the latest developments in observations, monitoring, modelling, prediction and early warning services of cyclones over the Bay of Bengal and the Arabian Sea region. The training covered all aspects of early warning system of cyclones through theoretical deliberations as well as detailed hands on sessions. It has enhanced the competency of the forecasters in the region leading to improved early warning service delivery by the member countries. It has resulted in significant reduction in death toll due to cyclones over the region and establishes the leadership of India Meteorological Department, Ministry of Earth Sciences in the region.

Group photograph of participants and delegates during the Inaugural ceremony

The Inaugural ceremony of the training was held at Ministry of Earth Sciences (MoES) on 19th August. Dr. M Ravichandran, Secretary Ministry of Earth Science inaugurated the training programme. While appreciating RSMC New Delhi for organising such training programmes, he highlighted the success in early warning of cyclones in the region. He urged upon the trainees to learn to utilise the latest tools & technology and the standard operation procedure. As the human intelligence is crucial inspite of all technological developments including even the Artificial Intelligence, the capacity building through training programs is very much essential.

On this occasion, RSMC New Delhi released a Souvenir highlighting its international responsibilities, role in capacity building, monitoring and forecasting of tropical cyclones and its achievements.

The training covered all aspects of detecting, monitoring, forecasting and products generation and dissemination of warning products in association with tropical cyclones with six special practical sessions by DG IMD.

10th Meeting of World Meteorological Organization (WMO) Regional Steering Group (RSG) Asia Node on Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) and Workshop on Dust and Aerosol in New Delhi, India on 23-24 September 2024

India Meteorological Department organized 10th meeting of World Meteorological Organization

Dr. M. Mohapatra warmly welcomed Dr. Takashi Maki in the august presence of Dr. M. Ravichandran, Secretary, MoES and Shri Rajendra Singh, Member and Head, NDMA

(WMO) Regional Steering Group (RSG) Asia Node on Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) and Workshop on Dust and Aerosol in Hybrid Mode in New Delhi on 23-24 September 2024. There were about 50 participants from different countries and organizations Including WMO, Japan Meteorological Agency (JMA), Korea Meteorological Administration (KMA), Information and Research Institute of Meteorology, Hydrology and Environment Mongolia, China Meteorological Administration (CMA), National Center for Meteorology Saudi Arabia, Caribbean Institute for Meteorology and Hydrology, IIT Delhi, IIT Bhubaneswar, Aryabhatta Research Institute of Observational Sciences (AIRES), Central Pollution Control Board (CPCB), Commission for Air Quality Management (CAQM), Ministry of Environment, Forest and Climate Change of India, National Disaster Management Authority (NDMA), National Center For Medium Range Weather Forecasting (NCMRWF), IITM Pune, University of Delhi, Delhi Technical University, Jawaharlal Nehru University, National Physical Laboratory of India.

14th Asia-Oceania Meteorological Satellite Users' Conference during 04-06 December

The 14th Asia-Oceania Meteorological Satellite Users' Conference (AOMSUC-14) was held during 4-6 December, 2024 at New Delhi, India and was inaugurated by **Hon'ble Minister of Earth Science in the presence Secretary, MoES and DGM, IMD Director, Space application Centre, ISRO was the Guest of Honour in the inaugural function**. The conference aimed to: (*i*) Promote the importance of satellite observations (*ii*) Advance satellite remote sensing science (*iii*) Provide a platform for dialogue and collaboration between satellite operators and users (*iv*) Inform the community about the current status and future plans of international space programs (*v*) Encourage the development of new technologies for weather satellite sensing (*vi*) Engage young scientists in the field.

Asia-Oceania Meteorological Satellite Users' Conference

IMD and WMO jointly organized the 1st Regional Training workshop on Multi-Hazard Early Warning System Interoperability Implementation at New Delhi during 9-13 Dec 2024. **Dr. M. Ravichandran**, Secretary, MoES inaugurated the training programme. The forecasters from nine countries participated in this training workshop along with national participants. The objective of training is to train the National Meteorological and Hydrological Services in South Asia on the interoperability and integration of early warning initiatives, programmes, and activities as feasible into a coordinated and sustainable, multi-hazard interoperable environment, to enhance the capacities of NMHSs. The programme aimed at developing a coordinated and sustainable, multi-hazard interoperable environment through (*i*) sharing good practices (*ii*) improve regional collaboration (*iii*) maximizing available resources

(*iv*) developing synergized standard operating procedures (*v*) strengthen national institutional coordination and arrangements for MHEWS (vi) sharing of data and products compatible to various systems to contribute to MHEWS interoperability (*vii*) integrate various services into one package (*viii*) minimization of number of warning bulletins and development of consolidated bulletin as per user's requirements. **Dr. M. Mohapatra**, in his address highlighted the role of interoperability, co-operation and collaboration among various agencies.

Regional Training workshop on Multi-Hazard Early Warning System Interoperability

Memorandum of Understanding

Dr. M. Mohapatra, DG IMD signed a Memorandum of Understanding with the Government of Uttar Pradesh on 8th March, 2024 for enhancement of observational network in Uttar Pradesh.

Dr. Mrutyunjay Mohapatra, DG IMD made a Courtesy Call on RBI Governor Shri Shaktikanta Das during the signing in ceremony of the Memorandum of Understanding between IMD and RBI to share weather and climate information with RBI to enhance cooperation between the two agencies w.r.t. to planning of various economic activities in the country. An MoU between RBI and IMD was signed on 14th March, 2024.

An MoU between RBI and IMD was signed on 14th March, 2024

Vikram University, Ujjain celebrated its 28th Convocation ceremony on 9thApril, 2024. Hon'ble Governor of Madhya Pradesh and Chancellor of Vikram University, **Shri Mangu Bhai Patel Ji** presided over the function. Chief Guest, **Dr. Mrutyunjay Mohapatra**, Director General of Meteorology delivered the convocation address during the ceremony. Padmashri **Dr. Bhagwati lal Rajpurohit,** Hon'ble Senior Educationist & Litterateur graced the ceremony as Guest of Honour. On this occasion, **India Meteorological Department and Vikram University signed an MOU** for collaboration in research and development on weather and climate science & services.

Convocation Ceremony Photograph (L to R): PadmashriDr.BhagwatilalRajpurohit, Hon'ble Senior Educationist and Literateur, Prof. Akhilesh Kumar Pandey, VC Vikram University, Hon'ble Governor of MP Shri Mangu Bhai Dr. M Mohapatra, DG IMD and Prof. Anil Kumar Sharma, Registrar Vikram University

Dr. M. Mohapatra, DG IMD and Prof. Akhilesh Kumar Pandey, VC Vikram University

Dr. M. Mohapatra, DG, IMD and **Mr. Biraj Patnaik,** Executive Director, National Foundation of India signed an MoU on 6th May, 2024 to enhance collaboration between the two organisations aimed at raising awareness on extreme weather events.

Dr. M. Mohapatra, DGM IMD and Mr. Biraj Patnaik, Executive Director, National Foundation of India signing an MoU

IMD signed an MoU with Motilal Nehru National Institute of Technology (MNNIT), Allahabad on 9th May, 2024 to enhance collaborative research and development activities between the two institutes.

MoU between IMD and MNNIT

MoU between IMD and BITS Mesra

IMD signed an MoU with BITS, Mesra, Ranchi on 10th May to enhance collaborative research and development activities between the two institutes with a focus on thunderstorms.

A Memorandum of Understanding signed between **India Meteorological Department and Renew Pvt. Ltd.** on 19th June, 2024 at IMD, HQ for Technical Collaboration to improve optimization in electricity distribution and generation sector and to support further integration of Renewable Energy in Indian Grid.

A Memorandum of Understanding (MoU) has been signed between India Meteorological Department (IMD) and ITC, Limited, Agribusiness Div., Guntur on 16th October, 2024. **Dr. M. Mohapatra**, DG, IMD and **Shri Rahul Gouraha** (Vice President-ITCMAARS, Agribusiness Division), signed the MoU on behalf of the two organizations in the presence of senior officials from both the organizations. The MoU aims to collaborate on disseminating weather and climate information, as well as agromet advisories, to 2 million farmers registered with ITCMAARS' digital platform.

IMD signed a Memorandum of Understanding with ITC Ltd. For dissemination of agro Meteorological advisory services bulletin to farmers.

A memorandum of understanding was signed between IMD and Ministry of Rural Development on 28th October for dissemination of **weather forecast to Krishi Sakhi and Pashu Sakhi** under National Rural Livelihood Mission. The event was attended by **Secretary MoES, Secretary, MoRD and DG IMD** among others.

Memorandum of Understanding between IMD and Synoptic Data Public Benefit Corporation (PBC) was signed on 6 November, 2024 virtually agreement aims to improve the accuracy, visualization and dissemination of weather information, **Dr. M. Mohapatra**, DG IMD and**Mr. Ashish Raval**, President and **CEO of Synoptic data PCB** Signed the MoU.

Dr. M. Mohapatra, DG IMD participated in the signing in ceremony of Memorandum of Understanding (MoU) between Department of Physics, Tripura University and IMD at Meghdoot Hall, MoES on 24thDecember, 2024 in presence of Secretary MoES.

MoU between Department of Physics, Tripura University and IMD

6.2. MEETINGS

Dr. Mrutyunjay Mohapatra, DG IMD and **Dr. R. K. Jenamani**, Sc. 'G' participated in the meeting at Election Commission of India on 5th January, 2024 regarding weather updates during forthcoming elections.

Shri Raja Acharya, Met-B, participated virtually in the webinar "**Advances in propulsion system for launch vehicle, satellite and landing missions**" held on 20th January, 2024 organized by the Astronautical Society of India, Department of Space Govt of India.

Dr. Ashok Kumar Das, Sc. 'F' attended a 6th Project Monitoring Committee meeting of Early warning system for Flood prediction in the river basins of India organized by C-DAC Pune on date: 21st January, 2024.

Shri K. C. Saikrishnan, Sc. 'G' and Dr. A. K. Mitra, Sc. 'F' attended the Pre-Shipment Review of INSAT-3DS on 22nd January, 2024 at Bengaluru.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Eighty Second Session of the WMO Bureau {BUR-82} regarding familiarization on the terms of reference and associated tasks on 24th and 25th January, 2024.

Officers from NRSC, ISRO, DoS, NIDM and NDMA visited IMD for a familiarisation meeting on WEB-DCRA & DSS tool for cyclone risk mitigation and response planning on 29th January, 2024. DG IMD, Dr. Mrutyunjay Mohapatra chaired the meeting. Dr. Ananda Kumar Das, Sc. 'F' made the presentation on Cyclone Warning Services and Web DCRA tool.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the meeting of Joint Collaborative Board (JCB) of World Meteorological Organisation (WMO) and Intergovernmental Oceanographic Commission (IOC) Co-Chairs on 30th January, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the 15th Session of the Consultative Meeting on High level Policy on Satellite Matters at Geneva during 6-7 February, 2024 and made a presentation on India's role in satellite applications for weather monitoring and forecasting during the meeting. WMO Secretary General had sent congratulatory video message to Dr. M. Mohapatra, DG IMD which was screened during the 150th Year of Foundation of IMD.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the15th Session of the Consultative Meeting

Dr. A. K. Mitra, Sc. 'F' attended INSAT-3D, 3DR Task Team meeting to discuss ground segment interface between MCF and SAC on 12th February, 2024.

Dr. Kripan Ghosh, Head, Agrimet Division and Dr. Ashutosh Kumar Misra, Sc. 'D' attended the online meeting "**to determine the technical and economic parameters of various measures for soil and water conservation**" organised by Agriculture Commissioner Office, Govt. of Maharashtra on 15th February, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated along with Mr. K. S. Hosalikar, Sc. 'G' in the webinar on GBON National Contribution Plan in the context of Systematic Observations Forecasting (SOFF) on 16th February, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the launch of GSLV-F14/INSAT-3DS spacecraft from Satish Dhawan Space Centre, Sriharikota on 17th February, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD delivered special address on "**IMD Works towards national development using Geospatial technologies**" during the India Geospatial Leadership Summit 2024 on the theme "Geospatial Technologies Accelerating National Development organized by Association of Geospatial Industries (AGI India) on 20th February, 2024.

The 16th review meeting of the **Project Monitoring & Advisory Committee (PMAC)** was held through VC on 20th February, 2024 to monitor the progress of activities under ACROSS-IMD for the quarter October-December, 2023 and to suggest suitable remedial measures for successful implementation of the activities.

Dr. Satyaban B. Ratna, Sc. 'E' as a member of the CLIVAR/GEWEX Monsoon Panel, attended an online meeting with the members of WG-AMM (Working Group on American Monsoons) on 20th February, 2024.

Dr. Kuldeep Srivastava, Sc. 'F' attended fifth meeting of the Expert Team on Radio Frequency Coordination (ET-RFC) held in Port of Spain, Trinidad and Tobago, Caribbean Telecommunications Union (CTU), from 20-22 February, 2024 in virtual mode.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Panel discussion/interactive session with members of SPSTI, Chandigarh, Chapters of NASI, INSA, INYAS on the theme "**Global Warming**" through online mode on 24th February, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Opening Meeting of the International Maritime Organization (IMO) Members State Audit of India in the office of Director General of Shipping Mumbai on 26th February, 2024. The meeting was chaired by Secretary, Shipping.

Dr. A. K. Mitra, Sc. 'F', attended Meeting to discuss the weather modules incorporation on Continuously Operating Reference Stations (CORS) under the Chairmanship of the Joint Secretary, Ministry of Panchayati Raj and provided the input regarding GNSS system of IMD on 27th February, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD Co-Chaired with Dr. T Srinivas, Director INCOIS the Joint Collaborative Board (JCB) of Intergovernmental Oceanographic Commission (IOC) & World Meteorological Organisation (WMO) the Meeting of JCB (online) during 27th - 29th February, 2024.

Dr. Madhulatha Akkisetti, Sc. 'D', attended the 2nd Meeting of the Committee for joint flood management study in wake of the extensive floods in the state of Himachal Pradesh, Punjab and Uttarakhand in 2023 on 29th February, 2024 at Committee Room, CWC, 2nd Floor, Sewa Bhawan, R. K. Puram, New Delhi.

Dr. M. Mohapatra, DG IMD alongwith Dr. D. R. Pattanaik, Sc. 'F' and Mrs. Monica Sharma, Sc. 'D' participated in the First Meeting of High-Level Committee (HLC) Committee to implement recommendations made by HLC in the aftermath of cyclone 'Tauktae' on 4th March, 2024.

Dr. A. K. Mitra, Sc. 'F', attended the follow-up meeting on 6th March, 2024 regarding ICAO's proposal for cost recovery mechanism for Space Weather Information Services and contributed for suggestions in the field of Civil Aviation.

Dr. Ashutosh Misra, Sc. 'D', **Dr. Jaya Dhami Parihar**, Sc. 'D' and **Dr. Asha Latwal**, Sc. 'C' attended online meeting to discuss the plan of the start-up project focusing on "**Solar and AIoT powered precision farming by combining meteorology and data science to develop customized weather services for farmers and**

agronomists" under the chairmanship of Head, AASD, IMD, New Delhi with MrSisir Chandra, CEO, Navariti Innovation Pvt. Ltd. and Scientists from AASD, New Delhi on 8th March, 2024.

Dr. A. K. Mitra, Sc. 'F', attended the GSICS EP Annual meeting online. Global Space-based Inter-Calibration System (GSICS) annual meeting took place during 11-15 March, 2024 at EUMETSAT HQ in Darmstadt, Germany. He represented IMD's agency report on CALVAL. The GSICS meeting serves as a platform for coordinating the development of inter-calibration algorithms and exploring other pertinent calibration-related topics.

Dr. Kripan Ghosh, Sc. 'F' and**Dr. Ashutosh Kumar Misra**, Sc. 'D' attended online meeting regarding "**Integration of IMD Weather Forecast and Agromet Advisories with state portal and AI Chatbot**" with the officials from Stat Agriculture Department, Govt. of Uttar Pradesh, MC Lucknow and AASD, New Delhi on 12th March, 2024.

Dr. Kripan Ghosh, Sc. 'F', attended "**Annual Monsoon Review (AMR)-Annual Cyclone Review (ACR)-2024**" meeting at RMC Guwahati from 12-13 March, 2024 and presented on "**Meteorological Services to Farmers and related sectors : IBF, outreach and way forward**" on 12 March, 2024.

Dr. O. P. Sreejith, Sc. 'F', **Dr. Satyaban B. Ratna**, Sc. 'E', **Smt. Arti Bandgar**, Sc. 'D', **Dr. Sabeerali**, Sc. 'C' and **Dr. Rohini P**., Sc. 'C', attended the SASCOF-28 planning meeting (online) with UKMO and RIMES on 12th March, 2024.

Shri K. S. Hosalikar, Sc. 'G', **Dr. O. P. Sreejith**, Sc. 'F', **Dr. Satyaban B. Ratna**, Sc. 'E', attended the "**WMO and Met Office Workshop for learning and sharing between RCOFs: Decision-maker engagement**" meeting (Online) on 13th March, 2024.

Dr. M. Mohapatra, DG IMD Chaired the Annual Cyclone Review and Annual Monsoon Review Meeting 2024 organised by IMD during 12-13 March, 2024 at Guwahati. Shri S. C. Bhan, Sc. 'G', Shri S. K. Manik, Sc. 'D' and Dr. Madhulatha Akkisetti, Sc. 'D' attended ACR & AMR Meeting on 12-13 March, 2024 and given presentation on Hydromet Services during 2023 and recent advancement & planning for the year 2024.

Dr. M. Mohapatra, DG IMD made a presentation on "**Update of India Meteorological Department functions and Weather Forecasting**" at PM Office on 15th March, 2024.

Dr. M. Mohapatra, DG IMD participated in the Second Meeting of the BIMSTEC Expert Group on Disaster Management Cooperation (EG-DMCF) under the Chairmanship of Shri Kamal Kishore, Member & HoD NDMA, to discuss upon the inputs received from participating organizations and finalise the DRR Plan of Action and other related issues on 18th March, 2024.

Dr. M. Mohapatra, DG IMD had a meeting with Mr. Ellie Chang, Asstt. Director of Taiwan Economic and Cultural Center (TECC) in INDIA, to discuss the possible partnership between Central Weather Administration (CWA) of Taiwan and IMD on 19th March, 2024.

Dr. A. K. Mitra, Sc. 'F', attended WMO-DBNet coordination group meeting during 19-22 March, 2024 at Melbourne, Australia and presented IMDs overall activities regarding Polar Microwave, Data Reception and current data flow from NRSC Hyderabad and other centers.

Dr. M. Mohapatra, DG IMD had a meeting with Ms. Alexandra Llovaiskaya, Head of International Cooperation, Talent and Success educational Foundation, 'Sirius' Science & Technology University, Russia through VC on 20th March, 2024.

Shri K. S. Hosalikar, Sc. 'G', Dr. O. P. Sreejith, Sc. 'F', Dr. Satyaban B. Ratna, Sc. 'E', attended the WHO/WMO project on health impacts of ENSO - Introductory meeting with RCC Pune (online), 21st March, 2024.

Dr. M. Mohapatra, DG IMD and **Dr. D. R. Pattanaik**, Sc. 'F' participated in the Financial Sector Assessment Program (FSAP) Exercise - Meeting on Climate Modelling and data at Ministry of Finance on 22nd March, 2024.

Dr. R. K. Giri, Sc. 'F' participated in the 4th TCC Virtual Update Meeting through VC on 22nd March, 2024.

Dr. Sankar Nath, Sc. 'F' participated in the Thematic Information Session - WISeastern hemisphere through zoom on 26-27 March, 2024.

Dr. M. Mohapatra, DG IMD participated in the meeting under Chairmanship of Principal Secretary to PM on preparedness on Glacial Lake Outburst Flood (GLOF) hazard in the Himalayas at PM Office on 26th March, 2024.

Dr. R. K. Giri, Sc. 'F', IMD participated in the meeting of the EC Task Force on the Comprehensive Review of the WMO Regional Mechanisms and approaches through VC on 26th March, 2024.

Dr. Satyaban B. Ratna, Sc. 'E', attended the CLIVAR Climate Dynamic Panel (CDP) 1st Meeting of 2024 on 26th March, 2024.

Dr. Sankar Nath, Sc. 'F', IMD participated in the Thematic Information Session - WIGOS - network - eastern hemisphere through zoom on 27th March, 2024.

Dr. M. Mohapatra, DG IMD, Mr. S. C. Bhan, Sc. 'G' and Dr. Shesha Kumar, Sc. 'E' participated in the meeting under the Chairmanship of Secretary, DA&FW to discuss about the improvement in outreach to farmers for Agro Advisories on 27th March, 2024.

Dr. M. Mohapatra, Director General, India Meteorological Department (DG, IMD) had a meeting with Mr. Vincent Josee AMELIE, PR of Seychelles on 1stApril, 2024. The delegation led by PR of Seychelles visited IMD for familiarisation of best practices followed by IMD for weather services.

Dr. M. Mohapatra, DG, IMD participated in an online meeting with Ministry of Rural Development regarding dissemination of Agromet Advisories using Ministry of Rural Development (MoRD) network was held on 2nd April, 2024. Dr. R Balasubramaniam, Sc.'F', MC Bhopal also participated in the meeting.

Dr. Kripan Ghosh, Sc.'F' attended an online meeting regarding "collaboration between IMD and Ministry of Rural Development (MoRD), Govt. of India, for dissemination of agromet advisories using MoRD network" under the chairmanship DG, IMD, New Delhi with officials from MoRD, IMD, New Delhi and MC, Bhopal on 2nd April, 2024.

Dr. M. Mohapatra, DG, IMD and Dr. T. Srinivas, Director INCOIS Chairs WMO & IMO Joint Collaborative Board (JCB), the President of the Commission for Observation, Infrastructure and Information Systems (INFCOM) and the Advisory Groups (AG) Ocean Chairs participated in the WMO Advisory Group meeting on 3rd April, 2024 to discuss leveraging mechanism among various governing bodies on Ocean Information Services.

Dr. Ashutosh Misra,Sc.'D', **Dr. Jaya DhamiParihar**, Sc.'D' and **Dr. Asha Latwal,**Sc.'C' attended the following webinars organised by WMO Climate and Energy Team:Online technical webinar on "WMO Energy demonstration products in Costa Rica and Chile" on 4th April, 2024.

Dr. M. Mohapatra, DG, IMD participated in the meeting under the Chairmanship of **Dr. V. K. Paul**, Hon'ble Member (Health) to review preparedness measures to mitigate the risk of Heat related illness during the summer season on 8th Apr, 2024.

Dr. Ashok Kumar Das, Sc. 'F' M.C. Ahmedabad attended 6th online meeting of the committee on **Disaster Risk Reduction** on 8th April, 2024 organised by NDMA.

Dr. D. S. Pai, Sc. 'G', attended meeting of National Executive Committee (NEC) to review the preparedness measure reg ensuing hot weather conditions chaired by Home Secretary on 9th April, 2024 at North Block, New Delhi.

IMD team led by **Dr. M. Mohapatra**, DG, IMD participated in the meeting with a delegation led by Additional Secretary, National Centre for Disease Control (NCDC), Ministry of Health on 10thApril, 2024 at IMD, New Delhi for collaborative research on heat wave and human health.

Hon'ble Prime Minister reviewed the preparedness measures for heat wave conditions in the country on 11th April, 2024. DGM, IMD participated in the meeting.

Dr. M. Mohapatra, DG IMD, **Dr. D. S. Pai**, Sc.'G', **Dr. K. S. Hosalikar**, Sc.'G' and **Dr. Seshakumar Goroshi**, Sc.'E' participated in the meeting with JS & CEO, Pradhan Mantri FasalBimaYojna (PMFBY)

and **Shri Chandrajit Chatterjee**, Director (Crop Insurance), Department of Agriculture & Farmers Welfare and **Dr. C. S. Murty**, Indian Council for Agriculture Research (ICAR) on 10th April, 2024.

IMD officials of MC Shillong attended the two **days "One Health Surveillance Conclave"** organized by NHM Meghalaya on 12 & 13 April, 2024. Shri ThangjalalLhouvum, Head MC Shillong presented the IMD surveillance system in Meghalaya. And the follow up meeting was held again on 29th May, 2024.

Shri Thangjalal Lhouvum, presenting the IMD surveillance system

Shri K. N. Mohan, Sc. 'G' Guwahati represented India as leader of Delegation in the third session of the Commission for Observation Infrastructure and Information System (INFCOM-3) held in, Geneva, Switzerland from 15-19 April, 2024.

Dr. D. S. Pai, Sc. 'G', attended ESSO Review Meeting at IITM, Pune during 22-23 April, 2024.

A follow up meeting among the experts **from India Meteorological (IMD) and Reserve Bank of India (RBI)** was held at IMD, New Delhi on 19th April, 2024 after the signing of Memorandum of Understanding (MOU) on 21st March 2024. The meeting aimed at familiarising IMD and RBI experts with the data available with each of the organisation and it's optimal utilisation for further improvement in warning services by IMD and planning various economic reforms by RBI for the socio-economic improvement of the nation.

Dr. Praveen Kumar, Sc.'C', delivered a talk as Invited Expert Speaker over the topic "**Extreme Weather events and Meteorological Services**" at Department of Civil Engineering, G. H. Raisoni College of Engineering, Nagpur on the occasion of Short Term Training Program on Disaster Management, Nagpur on 22nd April, 2024.

Dr. Praveen Kumar, Sc. 'C' during the event

Dr. Madhu Latha Akkisetti, Sc. 'D' and **Shri S K Manik,** Sc.'D' attended the 32nd Plenary meeting of ISO/TC 113 Hydrometry and its subcommittees, scheduled to take place from April 22-25th April, 2024, at the India Habitat Centre in New Delhi.

Dr. O. P. Sreejith, Sc.'F', attended (online) on 23 April, 2024 release of WMO state of Climate in Asia 2023 report.

Dr. M. Mohapatra, DG, IMD participated in the meeting convened by the Election Commission of India to discuss issues related to heat wave and mitigate the risk during the period of elections on 22nd April, 2024.

Dr. Ashok Kumar Das, Sc. 'F' attended online meeting to discuss the various activities of IMD for Marine Services with Port Officials under the Chairmanship of DGM on , 2024.

Dr. M. Mohapatra, DG, IMD addressed the inaugural session of the 28th South Asian Climate Outlook Forum (SASCOF-28) through VC on 29th April, 2024.

Dr. Kuldeep Srivastava, Sc. 'F' and **Dr. Sankar Nath,** Sc. 'F' and **Dr. Kripan Ghosh**, Sc. 'F' participated in seventeenth meeting of the project monitoring & Advisory Committee (PMAC) to monitor the periodic progress of the projects under ACROSS-IMD and to suggest suitable

remedial measures for successful implementation of the activitieson 3rd May, 2024 through online mode.

Shri Abhimanyu Chauhan, Sc. 'C' attended **ASL meeting** at Airport regarding PM visit on 6- 7 May, 2024.

Dr. Partha Roy, Sc. 'C' and **Shri Aditya Raj** Verma, Sc.'C' conducted with NDRF DY. Commander and officials regarding MC Agartala facilities and information exchange at MC Agartala office on 7th May, 2024.

Shri Thangjalal Lhouvum, Sc-D, MC Shillong attended Monsoon Preparedness meeting with Commissioner & Secretary, Revenue and Disaster Management Department in presence of Executive Director, Meghalaya SDMAs, DDMAs along with other departments at main Secretariat on 10th May, 2024 and **Shri Thangjalal Lhouvum**, Sc. 'D' presented the summary of Monsoon 2023 and 1st LRF for Monsoon 2024.

Shri S. K. Manik, Sc.'D' and **Dr. R. K. Jenamani**, Sc.'G' attended 3rd meeting of the Committee for Joint Flood management of Himachal Pradesh, Uttarakhand and Punjab on 14th May, 2024 at CWC.

Dr. D. S. Pai, Sc. 'G', **Dr. Shravan Kumar Muppa**, Sc. 'E', **Dr. Madhu Latha Akkisetti,** Sc. 'D', **Shri S. K. Manik**, Sc. 'D' attended Virtual Meeting on "Flood preparedness for the ensuing monsoon season 2024" held on 20th May 2024 under the chairmanship of DGM.

National Crisis Management Committee (NCMC) meeting was held under the chairmanship of Cabinet Secretary on 24th May based on the cyclone warnings issued by IMD to review the preparedness and follow up actions. **Dr. M. Mohapatra,** DG, IMD made the presentation on current status and forecast/Warnings issued as well as damage expected and suggested actions for West Bengal, Odisha and Northeastern states.

Hon'ble Prime Minister **Shri Narendra Modi** reviewed the response and preparedness on 26th May, 2024. DG IMD presented the current status and forecast/Warnings issued as well as damage expected and suggested actions for West Bengal, Odisha and Northeastern states.

Dr. M. Mohapatra, DG, IMD presenting the status before Hon'ble Prime Minister Shri Narendra Modi

Dr. Partha Roy, Sc. 'C' and **Mr. Aditya Raj Verma,** Sc. 'C' participated in State Executive Committee meeting (SEC) at Tripura Secretariat under Chief Secretary Chairmanship on26thMay, 2024.

Shri Thangjalal Lhouvum, Sc. 'D' MC Shillong attended online meeting with Chief Minister, Dy. Chief Minister and SDMA, Meghalaya on 27th May, 2024 for pre-cyclone landfall meeting and preparations (**for Cyclone Remal**).

Shri Raja Acharya, Met. 'B' participated virtually in theWMO Hybrid Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction and Earth System Prediction held during 27-30 May, 2024.

Shri H. S. Sawhney, Sc. 'E' attended a meeting of Standing Committee of Experts to investigate the failure of various transmission line towers failed during the period from January 2024 to April 2024. This meeting was convened by Central Electricity Authority under the chairmanship of Chief Engineer (PSE&TD) on 30th May, 2024 at Sewa Bhawan, New Delhi.

Dr. M. Mohapatra, DG IMD participated in the selection committee meeting for the 69th International Meteorological Organisation (IMO) Prize under Chairmanship of Professor D. Karnawati, Chair on 4th June, 2024.

Dr. M. Mohapatra, DG IMD participated on line in the Third Pole Climate Forum Meeting in Lijiang, China on 4th June, 2024 and addressed the delegates.

Shri S. K. Manik Sc. 'D' attended the 'Webinar on 'Alternate Drinking Water Supply

Provision during Crisis - Requirements'on 4th June, 2024.

Dr. Kripan Ghosh, attended an online meeting regarding "collaboration between IMD and National Commodity and Derivatives Exchange Limited (NCDEX)" under the chairmanship of **Dr. M. Mohapatra**, DG IMD, New Delhi with officials from IMD, New Delhi, IMD, Pune and NCDEX on 7th June, 2024.

Shri T. Lhouvum, Sc. 'D' attended online METEO IRS 2024, 2nd International Symposium on Remote Sensing in Meteorology conducted by Istanbul Technical University during 11-13thJune,2024.

Dr. Kuldeep Srivastava, Sc.'F' attended Session for National Focal Points on Radio Frequency Matters for Asia-Pacific countries on 20th June, 2024 via online mode.

Shri Rohit Thapliyal, Sc. 'D' attended First Half-Yearly meeting of NARAKAS, Dehradun organized by NARAKAS (Office-2), ONGC, Dehradun at Auditorium, ONGC, Dehradun on 20th June, 2024.

Dr. M. Mohapatra, DG IMD participated in the meeting of National Executive Committee (NEC) under the Chairmanship of Union Home Secretary to review flood preparedness measures of Govt. of NCT of Delhi on 29th June, 2024.

IMD is organizing a series of lecture on during the year 2024-25 as part of **"150 years of IMD"** celebrations. In the series, IMD organized a lecture on "Advancing Atmospheric Composition Analysis and Predictions and Related Services to Meet the Growing Societal Needs" by Prof. Gregory Carmichael from University of Lowa, USA at Avani Hall, MoES, New Delhi on 31st May, 2024.

Dr. V. K. Soni, Sc.'F' attended a meeting convened by Central Electricity Authority regarding key weather parameters required for the development of the Electricity Demand Forecasting and Load Survey Tool under the chairmanship of Member (Planning), CEA on 26th June, 2024 at Sewa Bhawan, New Delhi.

WMO Briefing team led by **Mr. Johan** briefed **Dr. M. Mohapatra**, DG IMD & 3rd Vice President of WMO on the Session to be chaired by him during the EC-78 meeting at Geneva in June 2024.

Dr. D. S. Pai, Sc. 'G', Dr. **Shravan Kumar Muppa**, Sc. 'E', **Dr. MadhuLathaAkkisetti,** Sc. 'D', **Shri S.K. Manik**, Sc. 'D' attended meeting of Committee on retrieval of Weather Parameters on 28th June, 2024 at Krishi Bhawan, New Delhi.

Dr. M. Mohanty, Sc. 'F' attended the 4thweekly meeting of the **Crop Weather Watch Group Committee (CWWG) for Kharif-2024** at the Conference Hall of Krushi Bhawan on 1st July, 2024, 15th July, 2024 and 22nd July, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the meeting under the Chairmanship of Union Home Secretary to discuss about the network spread of IMD across the country at districts and block level on 2ndJuly, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the meeting with team from Civil Aviation Department, Govt. of Haryana headed by **Shri V. P. Agrawal**, Senior Member, (Ex. Chairman, AAI), regarding installation of equipment & operations at Hisar Airport on 2ndJuly, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD and **Dr. V.K. Soni**, Sc. 'F' participated in the meeting to discuss issues related to **renewable energy forecasting** at Ministry of earth Sciences (MoES) in the presence of the Secretary (Power) and the Secretary (MoES) on 3rd July, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD delivering the lecture

Shri Sunil Narayan Thool, Sc. 'E'attended a meeting on 3rd July, 2024 focused on "**Prevention of Lightning & Heat**" at the Bihar State Disaster Management Authority, Patel Bhawan, Patna.

Dr. O. P. Sreejith, Sc. 'F' attended the **first Monsoon Forum Meeting** for Assam state jointly organized by the United Nations World Food

Program (WFP), Assam State Agriculture Department and IMD on 5th July, 2024 at Assam Administrative Staff College, Guwahati and delivered a lecture on "**Review of 2023 climate and 2024 southwest monsoon Seasonal forecast for Assam** "

Shri Thangjalal Lhouvum, Sc. 'D' attended online meeting with DGM (CAMD) regarding pending DGCA Audit points for AMS Barapani on 7th July, 2024. Latest ATR on HAWOS & DCWIS installation and commissioning was already sent to CAMD.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the 5th Session of WMO's Task Force on Elections and Appointments through on 8th July, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD during the session

Dr. Satyaban B. Ratna, Sc. 'E' attended (Online) the **Sixth Session of the CLIVAR/GEWEX Monsoons Panel** and **the Joint Meeting between MP& WG-AAM**, held in Japan on 11thJuly, 2024.

Shri Rahul Saxena, Sc. 'G' attended the meeting with Lt. Governor on 11th July, 2024 to discuss on "**Flood Preparedness for Delhi**".

Dr. M. Mohanty, Sc. 'F' attended a meeting under the Chairmanship of the Hon'ble Minister, Revenue & DM Deptt on the progress of work "**Construction of Doppler Weather Radar (DWR) Building at Balasore and Sambalpur**" in the office chamber of Hon'ble Minister, Revenue & DM Deptt. (Secretariate first floor conference hall) on 15thJuly, 2024.

Dr. M. Mohapatra, DG IMD participated in the Joint Collaborative Board (JCB) Co-Chairs meeting to discuss the Agenda for the forthcoming Mariners Workshop at Paris in the month of September on 20th July, 2024.

Dr. M. Mohapatra, DG IMD participated in the Annual Children's Meet organized by Odisha Welfare Association "**Bal Vikas Dhara**" as a Guest of Honour on 20thJuly, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD at the Annual Children's Meet

Dr. M. Mohapatra, DG IMD participated in the meeting under the Chairmanship of Union Home Secretary to discuss Proposal for Mitigation Project for Lightning Safety in on 22ndJuly, 2024.

Dr. M. Mohapatra, DG IMD participated as Guest of Honour in the Workshop on High Altitude Platform for Near Space Applications at Ashoka Auditorium, Delhi Cantt. on 26th July, 2024.

Dr. M. Mohapatra, DG IMD participated in the meeting with **Dr. Isao Kanda**, MD, **Mr.Takenori Suzuki**, General Manager and **Mr. Sridhara Nayak**, Japan Meteorological Corporation regarding collaboration of weather services between the two organisations on 27th July, 2024.

Dr. M. Mohapatra, DG IMD participated in the**Second Meeting of the RA II Task Team** on review of the regional partnership and sub-regional cooperation (TT-RP) of WMO through VC on 29th July, 2024.

On 29th July, 2024, **Shri Umasankar Das**, Sc. 'D' attended the weekly meeting of **crop weather watch group committee (CWWG) for Kharif, 2024** under the chairmanship of Director of Agriculture & Food Production, Odisha in the 3rd floor conference hall, krushibhawan, Bhubaneswar.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Meeting of WMO and IOC Joint Collaborative Board to discuss about the major topics to be considered for discussion during the Paris Meeting on 30th July, 2024.

Dr. Kripan Ghosh, and **Dr. Ashutosh Misra**, Sc.'D', attended an online meeting with RBI officials to discuss "V**arious scientific and technical aspects**" under the chairmanship of Head, CR&S, IMD, Pune on 2nd August, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the meeting under the Chairmanship of Secretary, Ministry of Panchayati Raj at Secretary's Chamber to review the progress of the IMD Weather Forecast at Gram Panchayats level on 5th August, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the meeting of **Task Force of WMO on Elections and Appointments Preparation** on 5th August, 2024.

Dr. Kripan Ghosh, Sc. 'F' attended the "**18th meeting of the Project Monitoring and Advisory Committee (PMAC) IMD**" to monitor the periodic progress of the projects under ACROSS-IMD and to suggest suitable remedial measures for successful implementation of the activities through virtual mode on 6th August, 2024.

Shri Satyendra Kumar, Met. 'A' and **Shri Donald M. Dkhar**, S. A. attended the meeting conducted by The Commissioner & Secretary, Revenue & Disaster Management Department to discuss matters relating to Impact Based Forecast Bulletins on the 6thAugust, 2024 at Main Secretariat Building, Meghalaya.

Sh. S. K. Manik, Sc.'D' attended the meeting for final submission of the Committee report headed by Chairman, CWC related to joint flood management study of river Yamuna for its reach between Hatnikund to Okhla barrage on 14 Aug., 2024 at CWC, R K Puram, New Delhi.

One-day Stakeholders Consultation Meeting on "**Implementation of Emergency Action Plan (EAP)**" for Tilaiyadam of Damodar Valley Corporation (DVC) at Tilaiya dam, Dist. Koderma Jharkhand attended by Dr. Somenath Dutta Scientist-G (Head, Regional Meteorological Centre, Kolkata) and Shri Abhishek Anand Scientist C (Head, Meteorological Centre, Ranchi) on 23rdAugust, 2024 on behalf of Hydromet Division.

Dr. Kuldeep Srivastava, Sc.'F' participated in fifteenth meeting of Geospatial Information Sectional Committee, LITD 22 with its Panels on 29-08-2024 in online mode.

Dr. Kuldeep Srivastava, Sc. 'F'and **Dr. Sankar Nath**, Sc. 'F', has participated **in** Meeting with Ministry of Civil Aviation, Indian Meteorological Department, and BISAG-N to discuss data requirement for Airport Planning by MoCA on 7thAugust, 2024 in virtual mode. Themeeting aimed to discuss the data requirements for airport planning, focusing on the need for specific data from IMD, such as the wind data, temperature data, climatic trends, and other relevant data points.

Shri Anand Shankar, Sc. 'D' attended a joint meeting with Farmers regarding impact of deficient rain on Kharif Crops on 12th August, 2024 at Doordarshan, Patna.

Shri Abhishek Anand, Sc. 'C' and **Shri Jeevan Baske,** SO-I attended the Meeting of Airport Advisory Committee 2024, under the chairmanship of **Shri Sanjay Seth**, Hon'ble MP and Minister of State for Defence cum Chairman, Airport Advisory Committee, on 24th August, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Inaugural ceremony of IMD-WMO Group Fellowship Training on "**Development of Competency in Weather Forecasting**" at MTI, Pune on 25th August, 2024. India Meteorological Department signed a Memorandum of Understanding (MoU) with Integrated Research and Action for Development on 30th August Secretary MoES inaugurated the programme. **Dr. M. Ravichandran**, Secretary MoES released a Souvenir on WMO Regional Training Centres in India.

Dr. M. Mohapatra, DG IMD and others during program

Dr. Kripan Ghosh, **Dr. Ashutosh Misra**, Sc. 'D' and **Dr. Jaya Dhami Parihar**, Sc. 'D' attended the inaugural program of the Joint WMO-IMD International Fellowship Training on "**Development of Competency in Weather**

forecasting", hosted by Meteorological Training Institute (MTI), IMD Pune at IITM, Pune on 26th August, 2024.

Shri Bikram Singh, Sc. 'F' attended a meeting under the Chairmanship of Additonal Chief Secretary, Govt. of Uttarakhand regarding "**Hon'ble Vice President visit to Uttarakhand**" at Secretariat, Dehradun on 30th August, 2024 and briefed about the likely weather conditions.

Dr. Kuldeep Srivastava, Sc. 'F' and **Ms. Suman Gurjar**, Sc. 'D' have participated in **National Spatial Data Infrastructure (NSDI) Executive Committee (EC)** on 6th September, 2024 at Technology Bhavan, Department of Science and Technology, New Delhi. This meeting happened in physical mode.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Stakeholders Meeting organized by Regional Weather Forecating Centre, Mumbai on 15th September.

Dr. Mrutyunjay Mohapatra, DG IMD during the meeting

Dr. Mrutyunjay Mohapatra, DG IMD participated as Guest of Honour at the Inaugural Function of the International Conference on "**Building Small holder Climate Resilience for Achieving Sustainable Food Systems**" at Odisha University of Agriculture and Technology, Bhubaneswar on 17th September.

Dr. Mrutyunjay Mohapatra, DG IMD at the conference

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Stakeholders Meeting commemorating 150 Years of the India Meteorological Department and 50 Years of Cyclone Warning Centre, Visakhapatnam and Hindi Sangoshti on completion of 50 years of Cyclone Warning Centre, Visakhapatnam on 24th September. During the ceremonies a Souvenir on "**Golden Jubilee**" celebrations of CWC Visakhapatnam was released by the Guests of Honour.

Dr. Mrutyunjay Mohapatra, DG IMD at CWC Visakhapatnam

Dr. G. N. Raha, Scientist 'E', MC Gangtok, participated in the meeting organized by Sikkim State Disaster Management Authority for observing State Disaster Risk Reduction Day at Chintan Bhawan, Gangtok on 04.10.2024. Hon'ble Chief Minister, Sikkim, Dignitaries from NDMA and Experts on GLOF from Nepal also participated in the meeting.

Dr. M. Mohapatra, DG IMD held a meeting with **Dr. Upendra Baitha**, Additional Professor, Department of Medicine, AIIMS, New Delhi to discuss about the initiatives by IMD for the Health Sector.

Dr. M. Mohapatra, DG IMD participated in the 19th Session of Regional Association VI (Europe) of the World Meteorological Organization (WMO) through zoom during 15th & 16th October.

Dr. M. Mohapatra, DG IMD participated in the 1st Meeting of the Department-related Parliamentary Standing Committee meeting on Science & Technology, Environment, Forests & Climate Change regarding functioning and activities of Ministry of Earth Sciences on 21st October.

Dr. Kripan Ghosh, Scientist 'F', Agrimet Division and **Dr. Asha Latwal**, Scientist 'C' attended online meeting regarding "**Utilization of RISAT-1A in Ministry of Agriculture**" under the chairmanship of Additional Secretary (DA) with officials from SAC, Ahmedabad, NRSC, Bangalore, MNCFC, New Delhi and IMD on 25th November, 2024.

Dr. Kripan Ghosh, Scientist 'F', Agrimet Division, attended "**XXXIII Board of Studies meeting in Agricultural Meteorology discipline**" at Department of Agricultural Meteorology, College of Agriculture, Pune on 27th November, 2024.

Dr. M. Mohanty, Scientist 'F', MC Bhubaneswar, attended review meetings on the preparedness for cyclone '**DANA**' under the chairmanship of the Chief Minister, Odisha on 21.10.2024, 22.10.2024, 23.10.2024 and 24.10.2024.

Dr. M. Mohapatra, DG IMD participated in the Inaugural Session of the 40th Session of the Data Buoy Cooperation Panel (DBCP) Annual Meeting at INCOIS, Hyderabad on 22nd October.

Shri Umasankar Das, Scientist 'D' and **Shri L. K. Giri**, SO-I, M.C Bhubaneswar attended a preparatory meeting due to cyclone 'DANA' at 2nd floor conference room of APD office, on 22.10.2024 and 23.10.2024.

Dr. M. Mohanty, Scientist 'F', attended the state level programme for observance of "**Odisha Disaster Preparedness Day & National Day for Disaster Reduction**", at Rabindra Mandap, Bhubaneswar on 29.10.2024.

Dr. G. K. Das, Scientist 'E', MWO Kolkata, **Shri Sunny Chug**, Sc-D and **Shri D. Bhattacharya**, Met-B attended the meeting on 29.10.2024 at AAI Conference Hall regarding findings & Obs. of DGCA inspection for Kolkata Airport, with High Officials of AAI.

Dr. M. Mohapatra, DG IMD participated in the discussion with CWC on Integration of IMD Rainfall Data for RSMS Portal Enhancement on 28th November.

Stakeholders' Meet at Kolkata

Dr. Somenath Dutta, Scientist 'G', with other officers and staff of RMC Kolkata attended the one-day Stakeholders' Workshop commemorating 150 years of IMD on "**Weather Services Rendered by IMD for High-Impact Weather Phenomena in the West Bengal State**", at the B. R. Ambedkar Auditorium, Geological survey of India, Kolkata on 29.11.2024.

Shri Anirban Biswas, Met 'A' attended General Body Meeting of the Central Government Employees Welfare Coordination Committee (CGEWCC), Sikkim on 29.11.2024 for finalization of the list of holidays, AMA etc. for all Central Government Offices in the state of Sikkim for the year 2025.

The Stakeholders Workshop on "**Severe Weather and Meteorological Services in Bihar**" was organized by MC Patna to commemorate its 150th anniversary, held on 18.12.2024 at Hotel Patliputra Continental, Patna. **Chief Guest Shri Samrat Choudhary, Hon'ble Deputy Chief Minister, Government of Bihar, Guest of Honour Smt. Sahila, IAS, Joint Secretary (Disaster Management), Government of Bihar, Dr. M. Mohapatra**, DG IMD along with 200 participants were also present in the event.

Stakeholders' Meet at Patna

Shri Sunny Chug, Scientist 'D' and **Abhishek Mandal**, S.A., MWO Kolkata, attended the Safety Assessment Meeting for "Parallel ATC operations of all units of ADC from New ATS Tower was conducted Conference Hall, ATS Complex, NSCBI Airport, Kolkata between IMD and AAI Officials, on 18.12.2024.

Dr. M. Mohapatra, DG IMD attended Stakeholders Meeting at M. C. Bhubaneswar on 23rd December, 2024.

Stakeholders meeting at Bhubaneswar

Dr. Rizwan Ahmed, Scientist 'D' also participated in the National Symposium on Recent Advances and Challenges in Understanding and Predicting High-Impact Weather and Climate Extremes over the Indian Subcontinent in the Climate Change Context (TROPMET-2024). He presented a paper titled "**A Teleconnection between TCs and Fog : A Case Study over the IGB, India**".

6.3. CONFERENCE/PRESENTATIONS

Dr. Satyaban B. Ratna, Sc. 'E', attended IITM CCCR server TEC meeting by video Conference on 8th January, 2024.

Dr. Satyaban B. Ratna, Sc. 'E' attended a video Conference with the Government of Arunachal Pradesh on 9th January, 2024 for a proposal to organize a stakeholder consultation workshop for northeast India.

Dr. O. P. Sreejith, Sc. 'F' attended "**Indian Ocean Regional Decade Conference 2024**" from 1st to 3rd February, 2024 at INCOIS, Hyderabad.

B. Sudarsan Patro, Sc. 'D', gave a presentation on, "**Daily Rainfall Prediction Using Long Short-Term Memory Algorithm**", in International Conference on Climate Change and Agroecosystem : Threats, Opportunities and Solutions (INAGMET-2024) from 8-10 February 2024, Jointly organized by Association of Agrometeorologists Banaras Hindu University and India Meteorological Department South Asian Forum on Agricultural Meteorology.

Dr. Satyaban B. Ratna, Sc. 'E', attended the webinar "**Forecasting Monsoon Onset and Withdrawal under Climate Change: Indian Perspective**" on 14th February, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Conference on Disaster Resilience - 2024 - Uniting Disaster Mitigation Stakeholders at Tamarind Hall, India Habitat Centre, Lodi Road, New Delhi on 15th February, 2024.

B. Sudarsan Patro, Sc. 'D', gave a presentation on "**Daily Rainfall Prediction Using Recurrent Neural Network**", in International Conference On Industrial Engineering & Analytics Theme : "**Data to Decisions**" (ICONIEA-2024) from 16-18 February, 2024, organised by IIT Kharagpur.

Dr. Kuldeep Srivastava, Sc. 'F' attended India Geospatial Leadership Summit 2024 (IGLS 2024) on 20th February, 2024 in virtual mode at India International Centre, New Delhi on the theme Geospatial Technologies Accelerating National Development.

Shri S. K. Manik, Sc. 'D' participated in the conference"**Recent Advances in Public Procurement**" on 4th March, 2024 at Scope Convention Centre, SCOPE Complex, Lodi Road, New Delhi.

Dr. Satyaban B. Ratna, Sc. 'E', attended the Joint WCRP/WWRP Webinar Series : African Monsoon on 6th March, 2024.

Dr. A. Sandeep, Sc. 'D' attendedthe online press conference on "**Long Range Forecast of Monsoon"** 2024 on 15th April, 2024.

Shri Rohit Thapliyal, Sc. 'D' participated in 'Orientation & Coordination Conference' on 23rdApril, 2024 & 'Table Top Exercise' on 30th April, 2024 as a part of State Level Mock Exercise conducted at Secretariat, Dehradun by SDMA, Govt. of Uttarakhand & NDMA, Govt. of India prior to start of Char DhamYatra.

Dr. M. Mohapatra, DG IMD participated in the **"National Conference on Agriculture for Kharif Campaign, 2024"** on 30th April, 2024 at National Agriculture Science Centre (NASC), ICAR, New Delhi organized by Department of Agriculture and Farmers Welfare on 30th April, 2024.

Shri Raja Acharya, Met. 'B' participated virtually in the UN Conference on Sustainable Lunar Activities organised by the UN Office of the Outer Space Affairs (UNOOSA) held on 18thJune, 2024.

Dr. Gargi Rakshit, Sc. 'C' was on deputation to participate in 4th URSI Atlantic Radio Science Conference (URSI AT-RASC 2024), ExpoMeloneras Convention Centre, Gran Canaria, Canary Islands, Spain during 19-24 May, 2024.

Shri Raja Acharya, Met. 'B' participated virtually in the "WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-2024)" held during 23-26 September, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the **Global Energy and Water Exchanges Project (GEWEX) Conference** during 7 – 12 July, 2024 at Tokyo, Japan. He delivered a special lecture on "**Evolution of Monsoon Research and Prediction in India**".

Shri Rahul Saxena, Sc. 'G' and **Ms. HemlataBharwani**, Sc. 'D', **Shri Asok Raja S. K.,** Sc. 'D', **Shri S. K. Manik**, Sc. 'D', **Ms. Yashika Garg**, Met. 'A', **Shri Chandan Kumar**, S. A.and**Sourabh Singha**, S. A. attended the ESRI USER India Conference on 6th September, 2024. **Shri Saxena**, Sc. 'G' was invited panelist in the '**Leveraging GIS Technology to Mitigate Climate Risks**' session.

Shri Anand Shankar, Scientist 'D', MC Patna participated in the AeroMetSci-2024 Conference held in Geneva, Switzerland, from 21-25 October 2024. He presented a poster titled "**Improving Aeronautical Visibility and Marginal Visibility (Runway Visual Range) Reporting : A Hybrid Deep Learning Approach**" and delivered an oral presentation on "**Optimizing Flight Safety andEconomy with Deep Learning-Based Take-off Data Predictions**" and participated in a panel discussion.

Shri Sudarsan Patro, Scientist 'D', was invited as an esteemed speaker for the online Climate Conference : Monsoon Session, organized by Delhi Public School branches in Patna, Pune, Ludhiana and Coimbatore on 25th December, 2024.

6.4. TRAINING

On job training (OJT) in Sat. Met. Division was provided during 17-19 January, 2023 to 22 trainees of Advance Training Course in MI & IS, Batch No. 13 and Direct Recruited Scientist Course (Instrumentation), Batch No. 2.

Dr. Kuldeep Srivastava, Sc. 'F' attended 42nd Chief Information Security Officers (CISO) deep-dive training. This training was under Cyber Surkashit Bharat and held in physical mode from 5th to 9th February, 2024 at the Indian Institute of Public Administration, New Delhi.

Dr. Kuldeep Srivastava, Sc. 'F' attended training Workshop on Radio Frequency Matters on 19 & 23 February, 2024 in virtual mode which was held in Port of Spain.

ISSD organized training for Unified mobile app from 13 December, 2023 - 12 January, 2024 in which representative of Ms RV solutions along with nominated persons from divisions like NWP, UAID, CWC, CAMD are attending Unified Mobile App meeting for module learning.

Shri Sunny Chug, Sc. 'D' delivered lectures during month of December, January & February, 2024 to Direct Scientist Batch at ICITC and AMTC batch at ICITC related to Communication systems, Networking, WMO GTS procedures, security systems, etc.

Shri Sunny Chug, Sc. 'D' delivered lectures of FTC batch running at MTI during February, 2024 related to WMO RTH System.

Dr. Ashutosh Misra, Sc. 'D', **Dr. Jaya Dhami-Parihar**, Sc. 'D', **Dr. Asha Latwal**, Sc.'C', **Ms. Indu Kumbria**, Met. 'A', **Ms. Twinkle Grover,** S.A. and **Mr. Amit Kumar, S. A.** attended Online meeting regarding "Ithenticate Subscription for MoES Institutes through National Knowledge Resource Consortium (NKRC)" organised by IMD, New Delhi on 15th May, 2024.

Mrs. Suman Gurjar, Sc. 'D' delivered NWP refresher course lecture on "Use of Mausamgram" during 20-24 May, 2024 and coordinated a training program on"Fundamentals of Artificial Intelligence and Machine learning" course held during 27-31 May, 2024.

Shri Sunny Chug, Sc. 'D' **and Shri Prashant Bansal,** Sc. 'D' and other officers from RMC's and Mc's have attended training in System administrator for maintenance of XML BASED AMSS installed at Delhi, Chennai, Mumbai and Kolkata for four weeks through offline mode during 13 May-7 June, 2024.

Ms. Anu Bhargava, Met. 'A' and **Ms. Twinkle Grover**, S. A. attended Claruvate's "Awareness and Engagement Program 2024 - New Delhi edition" on 12th June, 2024**.**

Dr. Kuldeep Srivastava, Sc. 'F' attended a virtual training on **Cyber Security Basics** by Microsoft organised by DoPT (Mission Karmayogi Bharat) on 22ndJuly, 2024.

Shri Atul Kumar Singh, Sc.'D' attended a joint IMD-WMO Fellowship Training Program on "**Development of Competency in Weather Forecasting**" from 26th August-27th September, 2024 at Meteorological Training Institute Pune (Recognised as WMO Regional Meteorological Training Centre for RA-II) along with 16 participants from 11 countries of RA-II.

Shri Atul Kumar Singh Scientist D participated in joint IMD-WMO as resource person

Dr. M. Mohanty, Sc. 'F' attended Training Programme for Veterinary Officers arranged by OSDMA in collaboration with State Fishery and Animal Husbandry Department on Disaster management at Veterinary Officers Training Institute and delivered Lectures on "**Weather Forecasting and Early Warning**", on 07.08.2024, 21.08.2024 and 28.08.2024.

20th RSMC New Delhi Attachment Training for Forecasters of 13 member countries of WMO/ESCAP Panel during 19-30 August.

RSMC New Delhi organized 20th Annual Training for Cyclone Forecasters during 19-30 August, 2024 in hybrid mode

Mr. Ajay Kumar Rai, S. A. successfully completed the training for the 44th Indian Scientific Expedition to Antarctica (ISEA). The training spanned from August 14, 2024, to September 20, 2024, and took place at several locations in India.

44th Pre-Antarctic Snow Ice Acclimatization Course Batch-II

Dr. G. N. Raha, Sc-E, Head M.C. Gangtok has attended the "Stakeholder's meeting to explore the modalities of weather-based Crop insurance scheme for plantation crops" at the Conference Hall of Krishi Bhawan on 02.09.2024.

Dr. Kuldeep Srivastava, Sc. 'F' has toattend Joint IMD - WMO Training Course on Techniques and technology commonly used in forecast offices on 26th September, 2024 at IMD Pune.

A Customized Basic Observation and Weather Forecasting training course was conducted from 2nd to 30th December, 2024 with 13 participants from NHMS Bhutan.

Weather Forecasting training

Training on **Airport Meteorological Instruments, Surface Ozone Instrument and High Wind Speed recorder** was imparted to Met officials from Bhutan.

Training on Airport Meteorological Instruments

1st Severe Weather Forecasting Programme (SWFP) Regional Training Workshop on Multi-Hazard Early Warning System (MHEWS) Interoperability Implementation during 9th to 13th December, 2024. **Dr. Kuldeep Srivastava**, Scientist 'F', **Dr. Sankar Nath**, Scientist 'F' and **Ms. Suman Gurjar**, Scientist 'D' have participated as resource person .

1st Training on Multi-hazard Interoperability Implementation was held at New Delhi during 09-13 December under WMO's Severe Weather Forecasting Programme

6.5. LECTURE

Shri Ramashray Yadav, Sc. 'D' delivered online lecture to GIDM trainees on 1st January, 2024 regarding "**Early Warning System: Services of IMD in India**".

Dr. Ashok Kumar Das, Sc. 'F', delivered an online lecture on topic "**Quantitative Precipitation forecast and Quantitative Precipitation Forecast**" to the FTC trainees batch no. FTC-197 on 17th January, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated as Guest of Honour in the Agri Vision 2024 during 19th - 20th January, 2023 and delivered a Plenary lecture during the event.

Dr. Mrutyunjay Mohapatra, DG IMD, during Agri Vision 2024

Dr. A. K. Mitra, Sc. 'F', delivered the Online lecture on 22nd January, 2024 on the topic of IMD data product - Significant & Utilization by IMD.

Dr. Ashok Kumar Das, Sc. 'F', delivered an online lecture on 22nd January, 2024 to the officers & Staff of CWC (HQ) and field officers regarding "**Data Products given in IMD Website (Central & Regional Met Centers) those are relevant/ connected to Rainfall Prediction**".

Dr. Ashok Kumar Das, Sc. 'F', delivered an online lecture on 24th January, 2024 to the GIDM (Gujarat Institute of Disaster Management) trainees regarding "**Hydro Meteorological services of IMD in India/Gujarat**".

Dr. O. P. Sreejith, Sc. 'F' has conducted an online lecture on "El Nino Oscillation (ENSO) and Indian Ocean Dipole (IOD) and its connection with Monsoon during "**online lecture for two days on the topic of IMD data product - Significant & Utilization**" on 23rd January, 2024.

Dr. Ashutosh Kumar Misra, Sc. 'D' delivered lectures on "**IMD services for the farming community**" to the undergraduate students and faculty members of University of Agriculture Sciences, Raichur, Karnataka on 24th January, 2024 and College of Agriculture, Bhimarayangudi, Karnataka on 30th Jan, 2024.

Dr. Satyaban B. Ratna, Sc. 'E', delivered lectures for ICAR-Winter School on "**Application of Weather Information for Climate Resilient Farming**" at CRIDA, Hyderabad, on 1st February, 2024.

Dr. Kripan Ghosh, Sc. 'F', Dr. Ashutosh Kumar Misra, Sc. 'D', Dr. Jaya Dhami Parihar, Sc. 'D' and Dr. Asha Latwal, Sc. 'C', attended online lecture on "**Bracing for the Climate Change: Recent Methodologies for Climate Response**" by Dr. D. S. Pai, Sc. 'G', IMD, New Delhi on 28th February, 2024.

Dr. Ashutosh Kumar Misra, Sc. 'D' and Dr. Jaya Dhami Parihar Sc. 'D' delivered lectures on "**IMD services for the farming community**" to the undergraduate students and faculty members of University of Agricultural Sciences, Dharwad on 12-13, 19-20 and 26-27 March, 2024.

Dr. Kripan Ghosh, Sc. 'F', delivered a lecture on "**Agromet Advisory Services**" through virtual mode in the training programme on "Effective utilization of various APIs and websites of IMD" organised by Reliance Foundation, Mumbai on 21st March, 2024.

Dr. O. P. Sreejith, Sc. 'F', delivered a talk on "Large Scale Features of Monsoon and its relationship with Rainfall over India (ENSO & IOD)" at the 2nd Southwest Monsoon Training Workshop on 6th May, 2024.

An online Training Programme on **2nd SW Monsoon Training Workshop** attended by Sh. Ramashray Yadav, Sci-D, Sh. Pradeep Sharma, Sci-D, Shri Abhimanyu Chauhan, Sci-C, Ms. Madhu Sarkar, Met-B and Sh. NS Darji, Met-A during 6- 11 May, 2024.

Dr. Satyaban B. Ratna,Sc.'E', delivered a talk on "MJO in conjunction with Large Scale Features (IOD, ENSO etc.) and its impact on rainfall over India" at the 2nd Southwest Monsoon Training Workshop on 7th May, 2024.

Dr. O. P. Sreejith, Sc. 'F', attended (online) the 20thSession of the Forum on Regional Climate Monitoring, Assessment and Prediction for Asia (FOCRAII), and delivered talk on "Climate Services

Progress in India" during 9-11 May, 2024, Qingdao, China.

Sh. Ramashray Yadav, Sc. 'D' delivered a lecture under the capacity building of various officials of state departments and organizations organized by the Gujarat Institute of Disaster Management (GIDM), Gandhinagar on 24th May, 2024 through a Virtual Classroom based training program on **"Warning and Early Warning System: Services by IMD in India/Gujarat"**.

Dr. Kuldeep Srivastava, Sc.'F' and **Dr. Sankar Nath,** Sc. 'F' participated in Online webinar on moving towards SOFF implementation-Engagement with SOFF peer advisors on WIS 2.0 on 28thMay, 2024.

Dr. Ashutosh Misra, Sc. 'D' participated in Joint Agresco-2024 and delivered a lecture on "Southwest monsoon 2023 and activities under GKMS in Maharashtra" at PDKV, Akola on 7th June, 2024.

Dr. Kripan Ghosh, Sc. 'F', **Dr. Ashutosh Misra**, Sc. 'D', **Dr. Jaya Dhami Parihar**, Sc. 'D' and **Dr. Asha Latwal**, Sc. 'C' attended the WCSSP India Annual Meeting 2024 Webinars on following themes:

(i) Developing seamless ensemble coupled systems across scales (work package one) on 2nd July, 2024.

(ii) Risk based forecasting of high-impact weather events (work package four) on 3rd July, 2024.

(iii) Evaluation and understanding of monsoon processes and hazards (work package two) on 4th July, 2024.

(iv) Observing the environment to improve predictions (work package three) on 5th July, 2024.

Shri Rohit Thapliyal, Sc. 'D' participated as a Speaker for State-Level Workshop on "Climate Change and Human Health" organized by Directorate of Medical Health & Family Welfare, Govt. Of Uttarakhand in Chander Nagar, Dehradun on 02.07.2024. Shri Rohit Thapliyal, Scientist-D delivered a talk on "**Climate Change, Extreme Events, and Uttarakhand: Present Vulnerability and Projected Changes**" in the said workshop.

Dr. Kripan Ghosh, Scientist 'F' delivered an online talk on "**Impact Based Forecast (IBF) for Agriculture**" in the Work Package 4th session (Risk based forecasting of high-impact weather events) of WCSSP India Annual Meeting on 3rd July, 2024.

Dr. Somenath Dutta, Sc. 'G' had delivered a talk in the National Seminar on "**Challenges in Climate Change and Sustainable Development – Indian Perspective**" at BC Roy Engineering College, Durgapur, WB organised by Durgapur Viswagandha Science Society on 24th July, 2024.

Dr. O. P. Sreejith, Sc-F attended the Meeting with the Reserve Bank of India (RBI) on 26thJuly, 2024 at RBI, New Delhi and delivered a lecture "**Status of Monsoon 2024 & Seasonal Outlook issued by IMD for the 2024 Southwest Monsoon Season (June - September)** ".

Dr. Kripan Ghosh, Head Agrimet Division delivered a guest lecture on "Agromet Advisory Services in India for Risk Management in Agriculture" in an online training programme on "**ECHO Disaster Management and Mitigation Strategies in Agriculture and Allied Sectors**" on 31st July, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD delivered an Invited Talk on **Space Applications for Operational Meteorology** at the National Space Day 2024 celebrated by INCOIS, Hyderabad.

Dr. Mrutyunjay Mohapatra, DG IMD participated and delivered Opening Remarks during the meeting regarding Navigating Climate Challenges, Insights and Strategies for the Global South on 9th August.

Dr. Ashok Kumar Das, Sc. 'F' delivered a lecture on "**Hydromet support for Flood Forecast**", on 10th August 2024 during the Inauguration of c Narmada and stake holders meet at Gandhinagar.

Dr. Mrutyunjay Mohapatra, DG IMD delivered the valedictory speech at the closing session of the One Day Workshop on Monsoon Variability and Climate Change on 12th August organised by National Disaster Management Authority (NDMA).

Shri Ramashray Yadav, Sc. 'D' delivered a lecture on Meteorology & Forecasting", online mode to IIPH Gandhinagar trainees on 12th August, 2024.

Shri Debabrata Bandyopadhyay, S.O.-I participated in National Space Day celebration on

20th August, 2024 at CWC Asansol and give a presentation on Meteorological satellites and Payloads. He explained the importance of meteorological satellites in weather forecasting, predicting weather patterns, including storm systems and cloud patterns.

Dr. Kuldeep Srivastava, Sc. 'F', **Dr. Sankar Nath**, Sc. 'F' and **Mr. Sunny Chug,** Sc. 'D' delivered lecture on Met Data communication and processing for Decision Support System(DSS), WIS, Networking, communication and video Conference data communication in IMD in "**A Short-term Refresher Course**" in Met Telecommunication on 22nd August 2024 in online mode.

Ms. Suman Gurjar, Sc. 'D' has participated as facilitator in Joint IMD - WMO Training Course on Forecast Competency program from 27-29 August 2024 at IMD Pune. She also gave presentation on communication/dissemination during Western Disturbances (text, audio, video, graphics, sector specific and user specific bulletins, GIS & Web-GIS products) & Forecast and warning generation to press and electronic media through press conference and press briefing.

Dr. Sankar Nath, Sc. 'F' attended Joint IMD-WMO Training Course on Forecast Competency program during 28-29 August, 2024 at IMD Pune. He has given lecture to participants to prepare warning using Common Alert Protocol.

Dr. Praveen Kumar, Sc. 'C', delivered a talk as **Invited Speaker** over the topic "**Weather Forecast and Weather Warning to Stakeholders: Impact and Preparedness**" organised during DAKSH by Disaster Management Relief and Rehabilitation Department, Nagpur Commissionaire on 30th August, 2024.

Dr. Praveen Kumar during the talk

Mrs. Shanta Unnikrishnan (Assistant Director of Official Language) and Shri P. S. Chinchole, Met. 'B'participated and presented a talk during All India Inter-Ministerial/Inter-Departmental Hindi Sangosthi organized at the Meteorological Center, Visakhapatnam.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the meeting of Joint Collaborative Board (JCB) as the Chairman at Paris, France during 4 - 6 September, 2024. The meeting aimed to identify the priority areas of work where the JCB can provide strategic advice on joint work between World Meteorological Organisation (WMO) and Inter-governmental Oceanographic Commission (IOC) of UN, including proposing new actions and technical and scientific recommendations for WMO and IOC subsidiary bodies.

Dr. H. R. Biswas, Sc-F, RMC Kolkata attended "**Joint IMD - WMO Training Course on Forecast Competency**" programme as resource person during 4-6 September, 2024 at Pune.

Dr. O. P. Sreejith, Sc. 'F' and **Dr. SatyabanRatna**, Sc. 'E' attended the webinar on "**Enhancing Health Actions in the Climate Crisis: Tackling the Health Impacts of El Niño and La Niña in the WHO South-East Asia Region**"on 10th September, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD delivered a Public Lecture on "**Rising Phenomenon of Urban Flooding: Causes, Consequences & Sustainable Solutions**" organized by Toxics Link, New Delhi on 11th September, 2024.

Dr. Somenath Dutta delivering the talk

Dr. Somenath Dutta, Sc. 'G' delivered a talk as a speaker on "**Services of MoES in the field of Ocean and Atmospheric Science**" on behalf of Secretary, MoES at the inaugural ceremony of 27th National Science Exhibition on the theme of "**India Developed Nation by 2047**" at Science City,

Kolkata on 11.09.2024. **Dr. Anwesa Bhattacharya**, Sc. 'C', **Smt. Manika Kar**, Met. 'A', **Shri Milan Kanti Das**, Met. 'A', **Shri Soumitra Ghosh**, Met. 'A', participated in the Exhibition in MoES pavilion during 11-14 September, 2024.

Dr. Shravan Kumar Muppa, Sc. 'E' attended the National Seminar on Current Trends in Atmospheric and Oceanic Processes related to Climate Change Studies (CURTAIN RAISE-2024), held at Andhra University, Visakhapatnam during 18th-20th September, 2024 and presented an oral talk entitled "**Development of a new forecasting tool for the thunderstorm detection over the east and north-eastern Indian region**".

Shri Sudarsan Patro, Scientist 'D', was invited on 8th November, 2024 as an expert lecturer for third-year E&TC Engineering students at Cusrow Wadia Institute of Technology, one of the pioneer diploma institutes in Maharashtra State.

Shri Sunny Chug, Scientist 'D', MWO Kolkata delivered a invited talk to the 43rd Indian Expedition to Antarctica team members about the "**Safety Measures – Do's and Don't**" and "**Scientific activities in Antarctica**" on 12.11.2024.

Shri Abhishek Anand, Scientist 'C', MC Ranchi, delivered Speech at One day International Conclave on Atmospheric Sciences at BIT Mesra, on 20.11.2024.

Dr. O. P. Sreejith, Scientist 'F' attended the one day brainstorming session on Soil Moisture Measurements to Modeling and Scaling (SoM2Ms) on 26th November, 2024.

Dr. O. P. Sreejith, Scientist 'F', **Dr. V. K. Soni**, Scientist 'F', **Dr. C. T. Sabeerali**, Scientist 'C' and **Dr. Anikendra Kumar**, Scientist 'C' attended the second session of the Third Pole Climate Forum (TPCF-2), which was held online on November 28th and 29th 2024.

Dr. H. R. Biswas, Scientist 'F', RWFC Kolkata, delivered a Keynote Lecture at the 2nd International Seminar on Innovative Approaches in Geographical Research (IAGR) on 30.11.2024 at Rampurhat College, Birbhum, West Bengal and presented on "**Extreme weather events and sustained development**".

A meeting between CRS, Pune, MSLDC (Maharashtra State Load Dispatch Centre) and **Dr. Radhika** from Somaiya University was held on 20.12.2024 to discuss an action plan and data requirements for Demand and Renewable energy forecasting at the NDC conference hall, Pune. The meeting concluded with a commitment to work together towards developing a reliable and efficient demand and renewable energy forecasting model. **Dr. Satyaban Bishoyi Ratna**, Scientist 'E', **Dr. Soumi Chakravorty**, Sc. 'D', **Dr. Ananya Karmakar**, Sc. 'C', **Ms. Neha Rani**, S.A., **Ms. Tanu Sharma**, S.R.F. and **Dr. Ravi Ranjan Kumar**, Project Scientist II participated in the meeting.

Dr. Kripan Ghosh, Agrimet Division, acted as a convener to organise "**The Anna Mani Memorial Lecture**" to commemorate 150 years of IMD's dedicated service to the nation at Meghdoot Hall, IITM, Pune on 31st December, 2024.

Scientists of the division delivered lectures on following topics during the Customized Intermediate to Advance training on "**Basic Observation and Weather forecasting**" for the officials of National Centre for Hydrology and Meteorology (NCHM), Bhutan, organized by MTI, CR&S, Pune:

Dr. Rizwan Ahmed, Scientist 'D', delivered a lecture to Air Force officers on December 19, 2024, at the IAF Sonegaon Conference Hall, Nagpur. The session was titled "**Interpretation of Winter Weather Systems Using Satellite Data over the Indian Region**".

6.6. Workshop

Shri K. C. Saikrishnan, Sc. 'G' and **Dr. A. K. Mitra**, Sc. 'F' (Project Director Cal/Val) participated in the Joint Cal/Val campaign of IMD in association with SAC Ahmedabad conducted at Bhuj during the period 17- 22 January, 2024.

Dr. S. I. Laskar, Sc. 'E' attended the WMO Regional Workshop Manama, Bahrain

Dr. S. I. Laskar, Sc. 'E' attended the WMO Regional Workshop on '**Implementation of Competencies in Climate Services**' in Manama, Bahrain during 21-25 January, 2024.

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Ocean Decadal Workshop organised by Indian National Centre for Ocean Information Services (INCOIS) at Hyderabad during 2nd -3rd February, 2024. He also participated in the 25th Foundation Day Ceremony of INCOIS at Hyderabad on 3rd February, 2024. **Dr. O. P. Sreejit,** Sc. 'F'**, Dr. P. L. N. Murty**, Sc. 'E' and **Mrs. Monica Sharma,** Sc. 'D' also participated in the above event from IMD.

Dr. Mrutyunjay Mohapatra, DG IMD participated and presented "**Weather Services and Effectiveness of Heat Wave Warnings**" during the National Workshop on Heat Wave 2024 at Vigyan Bhavan, New Delhi on 13th February, 2024 organised by NDMA.

Smt. Arti B Bandgar, Sc. 'D', attended the workshop on vector borne diseases for field workers arranged by **Pune Knowledge Cluster** at Purandar Panchayat Samiti on 15th February, 2023 and delivered a talk on Importance of Disease Data Analysis and use of disease data in understanding disease spread and prediction (special focus on Dengue and Chikungunya).

Shri Raja Acharya, Met-B, participated in the WMO Virtual Workshop on, "**Standardization of First-mile Data Collection from Automatic Observing stations and platforms**" held on 19-20th February, 2024 and Virtual Workshop on "**Resilience to Natural Hazards through AI Solutions**" held on 13 March, 2024, in Maryland, United States organised by ITU/WMO/UNEP and NASA.

Dr. Kripan Ghosh, Sc. 'F', participated in two-days Bilateral International Workshop, on invitation, on "**Climate Smart Farming Resilient Technologies and Practices in Japan and Opportunities for Indian Farmers and Agri-Tech Start-up Entrepreneurs**" at IIT, Kharagpur jointly organised by IIT, Kharagpur, ICRISAT, Hyderabad and University of Toyama, Japan from 6-7 March, 2024. During the workshop, he also delivered a lecture on "**Agromet advisory services in India for management of risks in Agriculture**" on 6th March, 2024. He also acted as the Chairman of Evaluation Committee for the scientific research papers presented in the Workshop as well as one of the panellists in concluding session.

Dr. (Ms.) Madhulatha Akkisetti, Sc. 'D', participated in virtual workshop on "**Thunderstorm Monitoring and Forecasting workshop**" on dated 06-09 March, 2024 and presented on "**Hydrometeorological Hazards-Effect of Land surface processes Diagnostic products to further improve Tx forecast**".

The officer and staff of MC Shillong **Shri Thangjalal Lhouvum**, Sc. 'D', **Shri T. T. Haokip,** SA, **Shri T. Ngaihte**, SA, **Shri N. Warbah**, SA and **Smt. Rosie L**, SA, attended the training workshop on "Thunderstorm Monitoring and Forecasting" organized from 06-09 March 2024, through online mode by Nowcast Division, NWFC.

Dr. Kripan Ghosh, Sc. 'F', delivered a Key note address on "**Agricultural Services during monsoon 2023**" at IITM, Pune during Annual Monsoon Workshop (AMW-2023) organized by Indian Meteorological Society, Pune Chapter (IMSP) in association with IITM and IMD, Pune on 18th March, 2024.

B. Sudarsan Patro, Sc. 'D', gave online presentation on "**Different Methods for Imputing Missing Rainfall Data Utilizing Automatic Weather Station Data**", in Two Day National Seminar On Data-Driven Predictive Analytics & Modelling-2024 (DDPAM-2024) from 19-20 March, 2024, organised by Sambalpur University.

Regional Meteorological Centre, Chennai organized stakeholders workshop at National Institute of Ocean Technology, Chennai on 25th April, 2024. **Dr. M Ravichandran**, Secretary, MoES and **Dr. M. Mohapatra**, DG IMD participated in the event and delivered address. **The Additional Chief Secretary and CRA of Tamil Nad**u addressed the workshop as Chief Guest.

Dr. M. Mohapatra, DG IMD, **Dr. D. S. Pai**, Sc. 'G' and **Dr. R. K. Jenamani,** Sc. 'G' participated in the Brainstorming Workshop on decentralizing and enhancing Early Warning Systems (EWS) in the Context of Climate Change at Tapovan, NDMA Bhawan, New Delhi on 2nd May, 2024. DGM, IMD presented the current status and future plans of IMD for improvement in early warning system. Member & Head NDMA appreciated the EWS by IMD.

Dr. M. Mohapatra, DG IMD participated in the meeting on Digital Agriculture Strategy for India under the Chairmanship of **Dr. V. K. Saraswat,** Hon'ble Member, Science & Technology, Niti Aayog on 2nd May. **Dr. M. Mohapatra**, DG, IMD made a presentation on **"Strengthening Agricultural Decision Making: Collaborative models between Agritech sector and IMD for institutional linkage"** during the meeting.

Shri Thangjalal Lhouvum, Sc. 'D', MC Shillong along with Smt. Evakordor K Jyrwa, Project Scientist (GKMS) and **Shri N Warbah**, SA visited Myrkhan Village on 3rd May, 2024 for Farmer's Awareness Programme and Briefing the villagers on IMD weather forecast and warnings. And also delivered Agromet and AWS related information and awareness to farmers.

Shri ThangjalalLhouvum during Farmer's Awareness Programme

Dr. M. Mohapatra, DG IMD participated in the WMO's Bureau meeting to discuss the preparations for Executive Council (EC) -78 virtually on 16th May.

Dr. M. Mohapatra, DG IMD and other scientists from IMD including **Shri K. C. Sai Krishnan**, Sc.'G', **Shri Gajendra Kumar**, Sc.'F' and **Dr. Sankar Nath**, Sc.'F' participated in the meeting with **Air Vice Marshal, J. S. Sihmar**, Assistant Chief of the Air Staff Operations (Meteorology), Indian Air Force, Vayu Bhavan, New Delhi on 21st May, 2024.

Shri H. S. Sawhney, Sc. 'E' attended a Workshop on RE Modelling and RE generation forecasting organised by GRID-INDIA on 21-22 May, 2024 at SCOPE Complex New Delhi.

RMC New Delhi organized a half day program on awareness of weather and climate services in agriculture for Delhi–NCR region on 12th June, 2024 at RMO Ayanagar, New Delhi under the chairmanship of DGM, India Meteorological Department. Scientists from RMC New Delhi, AASD Division and AMFU Pusa were the resource persons. 26 Farmers from various parts of Delhi and NCR, In- charges of various section under RMC New Delhi, Scientists from MOES, MWO Palam, MO Safdurjung, officials from RMO Ayanagar and Organizing committee of IMD participated in this program.

Officers during Awareness Programme

The main objective of this program was to aware the farmers of Delhi-NCR about the dissemination and source for daily seven day forecasts, bi-weekly agro advisories, impact based forecasts for agriculture as well as Meghdoot app. through which they can easily access day to day weather information and take the better decision for agronomic practices for their farms and crops in timely manner.

Various queries of farmers related to weather and climate, agronomy aspects and utilization of agro advisories were explained during the interactive session.

Farmers of Delhi-NCR during the interactive session

Dr. Shravan Kumar Muppa, Sc. 'E', Hydromet Division, Attended the International workshop on "Stratosphere-Troposphere Interactions and Prediction of Monsoon Weather Extremes" (STIPMEX)at IITM, Pune during 2 - 7 June 2024 and presented work titled "An Investigation on thePrediction of Extreme Rainfall events over Indian Peninsular region during North-East Monsoon 2023".B.SudarsanPatro, Sc-D, Presented a poster in the workshop.

Shri Raja Acharya, Met. 'B' participated virtually in the the 18th WCRP/BSRN (Base Surface Radiation Network) Scientific Review and Workshop (HYBRID MODE) during the period (1-5 July 2024).

Dr. Rajib Chattopadhyay, Sc. 'E' attended the **5th WCSSP-India Annual Science Workshop**from 2 - 5 July, 2024.Also, Lekshmi S, Senior Research Fellow participated and presented a talk on "**Skill Analysis of Heatwaves Using IITM EPS and Other S2S Models**".

Shri Ramashray Yadav, Sc. 'D', **Shri Pradeep Sharma**, Sc. 'D', **Shri Abhimanyu Chauhan**, Sc. 'C' and **Shri N. V. Patel**, Met. 'A' attended workshop on 11th July 2024 at CWC Gandhinagar to sensitize the CWC stake holders about IMD products and technical terms used by IMD.

On 24th July, 2024, **Dr. M. Mohanty**, Sc. 'F' and **Shri R. K. Mohapatra**, Met. 'B' attended Technical Workshop on UN-Habitat's Quality of life initiative in collaboration with Bhubaneswar Municipal Corporation meeting.

Participants of summer school of WMO and Integrated Carbon Observations System (ICOS) on Greenhouse Gases, which was held in Wageningen, the Netherlands, 19-24 August, 2024

Dr. Chinmay Kumar Jena, Sc. 'C', India Meteorological Department participated in the WMO and Integrated Carbon Observations System (ICOS) summer school on Greenhouse Gases, which was held in Wageningen, the Netherlands, 19-24 August 2024.

Dr. Ashutosh Misra, Sc. 'D', participated in the training cum workshop on '**FramingAgriculture-Climate Connections**' at the Anil Agarwal Environment Training Institute (AAETI) Nimli, Rajasthan, organised by Centre for Science and Environment (CSE), New Delhi from 21-23 August, 2024 and delivered a talk on "**Weather-based Agro-advisories: Challenges and Possibilities**" on 22nd August, 2024.

Dr. V. K. Soni, Scientist 'F' participated in WMO Infrastructure Commission (INFCOM) Management Group Meeting held during 01-04 October, 2024 at Versoix, Geneva, Switzerland.

MC Shillong officers and staff attended the online one-day International Workshop on "**Dust and Aerosol"** organised by ESSO-IMD in collaboration with WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Asia Node in New Delhi on 24th September, 2024.

Dr. O. P. Sreejith, Scientist-F attended Cold Wave Preparedness Workshop, organized by Sphere India Academy in collaboration with Integrated Centre for Adaptation, Disaster Risk Reduction & Sustainability (ICARS), on 7th October, 2024 and give presentation on "**Role of IMD on Cold wave Preparedness**".

Dr. Ashutosh Kumar Misra, Scientist 'D' delivered an invited talk on '**Agricultural Aspects of SW Monsoon 2024**' at the Annual Monsoon Workshop 2024, organized by the Indian Meteorological Society Pune (IMSP) at Savitribai Phule Pune University on 18th October, 2024.

Dr. Satyaban B. Ratna, Scientist 'E', as a member of the CLIVAR/GEWEX Monsoon Panel, attended the Asian-Australian-African (3A) Monsoons Programme International workshop (Online) held in Chiba on 19th November, 2024.

Dr. V. K. Soni, Scientist 'F' participated in Global Cryosphere Watch (GCW) – WMO Integerated

Processing and Prediction System (WIPPS) meeting from 3-5 December 2024 in Geneva, Switzerland.

Dr. H. R. Biswas, Scientist 'F', RWFC Kolkata, attended an online workshop in regional training workshop on Multi Hazard Early Warning interoperability implementation system in New Delhi, India during 09.12.2024 - 13.12.2024 and delivered a lecture on "**Integrated Impact-based forecast and warning services (IBFWS) for heavy rainfall at district level**" on 10.12.2024.

6.7. FOREIGN DEPUTATION

Dr. S. I. Laskar, Sc. 'E', was on deputation 21-25 January, 2024 forWMO Course on Implementation of Competencies in Climate Services, in Manama, Bahrain.

Ms. Ranju Madan, Sc. 'G', Shri Anshul Chauhan, Sc. 'C', Shri Kapil Dev Meena, CAFAT were on deputation during 02-09 Feburary, 2024 to Japan, conduct FAT (Factory Acceptance Test) iro procurement of GPS Radiosondes along with compatible ground receiving systems for operation of GUAN stations of IMD.

Dr. M. Mohapatra, DG IMD was on deputation during 06-07 February, 2024 to participate 15th session of the Consultative Meeting on High-level Policy on Satellite Matters (CM-15) in Geneva.

Dr. S. N. Dutta, Sc. 'G', Dr. B. Geetha, Sc. 'D', Dr. Bushair MT, Sc. 'C', was on deputation during 06-09 February, 2024 to participate 4th South Asia Hydromet Forum (SAHF-IV) in Colombo, Sri Lanka.

Shri S. P. Singh, Sc. 'D' was on deputation during 27 February to 01 March, 2024 to participate 56th ESCAP/WMO Typhoon Committee Session, Kuala Lumpur, Malaysia.

Dr. D. S. Pai, Sc. 'G', Dr. Soma Sen Roy, Sc. 'F' and Shri A. D. Tathe, Sc. 'E' were on deputation to participate 3rd (SERCOM-3) and the Gender Conference, Bali, Indonesia during 4-9 March, 2024.

Shri Gajendra Kumar, Sc. 'F' was on deputation to participate ICAO Asia and Pacific (APAC), 22nd Meeting of the Meteorological Information Exchange Working Group (MET/IE WG/22) during 18-21 March, 2024.

Dr. Ashim Kumar Mitra, Sc. 'F' was on deputation to participate 7th meeting of (DBNet) to be hosted in Melbourne, Australia during 19-21 March, 2024.

Mr. Sunit Das, Sc. 'F' was on deputation 25-29 March, 2024 for conducting tanning on Meteorological satellite Data Analysis and Dr. H. R. Biswas, Sc. 'F' was on deputation 22-26 March, 2024 for conducting training on Short-range weather forecasting (intermediate to advanced operational meteorology) at NCHM, Bhutan.

Shri K. N. Mohan, Sc. 'G'**, Dr. V. K. Soni,** Sc. 'F' and **Dr. Sankar Nath,** Sc. 'F' were on deputation to participate in third session of the Commission for Observation, Infrastructure and Information System (INFCOM-3) at WMO HQrs, Geneva during 15-19 April, 2024.

Dr. Habibur Biswas, Sc. 'F' was on deputation to NCHM Bhutan for imparting Training during 22-26 April, 2024.

Dr. Neeti Singh, Sc. 'C' was on deputation to Bangkok, Thailand for ICAO Asia and Pacific (APAC), 13th Meeting of the (MET/R WG/13), including (MET/ATM Seminar) during 22-26 April, 2024.

Dr. Somenath Dutta, Sc. 'G' was on deputation to Geneva, Switzerland to participate Ninth meeting of the WMO Executive Council Capacity Development Panel (EC-CDP-9) during 22-23 April, 2024.

Shri Ramashray Yadav, Sc. 'D' and **Sh. Shibin Balakrishnan**, Sc. 'D' were on deputation to participate inCGMS working Group meeting at EUMETSAT, Darmstadt, Germany during 22-26 April, 2024.

Dr. Siddhartha Singh, Sc. 'F' was on deputation to participate in 12th meeting of the Ozone Research Managers of the parties to the Vienna Convention for the Protection of the Ozone Layer during 22-26 April, 2024.

Dr. Gargi Rakshit, Sc. 'C' was on deputation to participate in 4th URSI Atlantic Radio Science Conference (URSI AT-RASC 2024), ExpoMeloneras Convention Centre, Gran Canaria, Canary Islands, Spain during 19-24 May, 2024.

Dr. Habibur Biswas, Sc. 'F' was on deputation to participate in 9th International verification methods

workshop at Cape Town, South Africa during 20-22 May, 2024.

Dr. K. S. Hosalikar, Sc. 'G' was on deputation to participate in RA II Working Group on Infrastructure (WG-I) plans to be held in Changsha, China, on 21-23 May 2024.

Ms. Arpita Rastogi, Sc. 'D'was on deputation to participate in 8th WMO Workshop on the Impact of Various Observing Systems on NWP and Earth System Prediction in Norrköping, Sweden during 28-30 May, 2024.

Dr. V. K. Soni, Sc. 'F' and **Dr. O. P.Sreejith,** Sc. 'F' were on deputation to participate in Inaugural Session of the Third Pole Climate Forum (TPCF 1) and Third Pole Regional Climate Centre Network (TPRCC-Network) Task Team to be held in Lijiang, China during 4-6 June, 2024.

Dr. M. Mohapatra, DGM and **Shri Anikender**, Sc. 'C' were on deputation to participate in WMO Executive Council Meeting (EC-78) during 10-14 June, 2024.

Dr. M. Mohapatra, DGM was on deputation to participate in Invite for DGM for Keynote address at UR24 Hydromet/EWS and Inclusive DRM Focus Day session at Himeji, Japan on 21st June, 2024.

Dr Ashok Kumar Das was on deputation to participate in KICT Korea during 1-2 July, 2024.

Dr. R. K. Jenamani and **Mr. Shobhit Katiyar** were on deputation to participate in WCSSP Annual Science Meeting during 1-5 July, 2024.

Dr. M. Mohanty delivering the talk on Cyclone 'Tauktae'

Dr. M. Mohapatra, DG, IMD and **Dr. D. R. Pattanaik**, Sc.'F' were on deputation to participate in (GEWEX) Open Science Conference at Keio Plaza Hotel, Sapporo, Japan during 9-10 July, 2024 and 7-12 July, 2024 respectively.

Dr. M. Mohanty, Sc. F and **Dr. S. K. Goroshi**, Sc. 'E' were on deputation to attend RIMES Regional Training Workshop for the SAHF Forum Expanded Service Support and IBF WG Meeting, 29-31 July 2024, Thailand.

6.8. VISITORS

On 15th January, 2024, INSAT AWS & Central Radiation Lab organized a science outreach program at St. Joseph High School, Pashan. Approximately 700 students and faculty members attended the event, where **Shri B. Sudarsan Patro**, Sc. 'D', and **Dr. Somnath Mohoto**, Project Scientist, elucidated IMD's 150-year legacy of weather services to the nation. They explained the instruments used, including surface, AWS, radiation, aviation, radar, satellite, and state-of-the-art techniques and models for forecasting services.

The Students from NID (National Institute of Design) visited the M.C. Ahmedabad on date : 21st January, 2024 to discuss regarding Heat Wave readiness & mitigation.

Shri Manoj Kumar, Deputy Commandant at BSF Shillong visited MC Shillong on 5th February, 2024 for AWS cooperation and data sharing request.

Shri Pynshainam Mylliem, Consultant NPCCHH Mehghalaya visited on 6th February, 2024.

Shri Hubert Syngkon, Sr. Lecturer at Shillong Polytechnic visited MC Shillong with his family on 8th February, 2024 for weather discussion.

Trainees of FTC Batch at New Delhi

About 408 visitors including students of Amity Institute Noida, FTC Batch, IMT Trainees, Delhi University, PM Shri K. V. Tagore Gardern School, DPS International School Gurugram, Indian Institute of Science Education and Research (IISER) visited the Central Hydromet Observatory from 1st January, 2024 to 31st March, 2024.

Students of Delhi University

American India Foundation Trust organized a Advance Weather Balloon Launch Event on 29-30 January, 2024 with the help of M.C. Ahmedabad for 100 students of various Govt. Schools of Ahmedabad.

American India Foundation Trust organized a Advance Weather Balloon Launch Event

60 Students from PDEU visited M.C. Ahmedabad on 2nd February, 2024 organized by Centre for Environment Education.

The 140 Students from LD College of Engineering visited M.C. Ahmedabad on 13-14 March, 2024 for acquiring knowledge on functioning of Meteorology.

On March 14, 2024, a group of fifteen **Indian Air Force trainees** visited the INSAT AWS & Radiation Lab at CR&S Pune, where the lab team conducted science outreach training activities. The program included comprehensive theoretical and practical sessions covering AWS, radiation, wind tunnel, and calibration facilities.

Indian Air Force trainees visited the INSAT AWS & Radiation Lab at CR&S, Pune

On 23rd March, 2024, CR&S Pune celebrated World Meteorological Day by arranging a Meteorological exhibition. The exhibition on the theme '**At the Frontline Climate Action**' showcasing the weather and climate services activities of CR&S Pune was inaugurated by the Dr. Anupam Kashyapi, LACD Head, CR&S. Live demonstration of meteorological and seismological instruments, 'Be a weather observer' segment for students to take their own weather observation, Mausam quiz corner and a short documentary film on 'Expedition to Antarctica' were shown in the exhibition. About **450** visitors including students, scientists, scholars, journalists visited the exhibition. All visitors marked their comments with great enthusiasm. A few photos of the event are given below.

About 450 visitors including students, scientists, scholars, journalists visited the exhibition at CR&S Pune

22 students and 02 teachers from JawaharLal Nehru Degree College, Etah, Uttar Pradesh were allowed to visit Meteorological Centre Dehradun premises on 10.04.2024. **Shri Rohit Thapliyal**, Sc. 'D' delivered a lecture on "**Different Weather Forecasting Products and Climate Services**" being provided by MC Dehradun. Shri BhaumikIndrawal, Met-A showed the students the activities of weather forecasting section and Shri Akash Chandra, Met-A briefed them about RS/RW observation & surface met. observatory.

Students of JawaharLal Nehru Degree College, Etah, Uttar Pradesh

35 trainees from GIDM visited M.C. Ahmedabad on 12th June 2024 A/N.

Trainees from GIDM visited M.C. Ahmedabad

Jumda Padu and Vikram Singh from Centre of Earth Sciences and Himalayan Studies visited MC Shillong on 14th June, 2024.

Visitors at MC Shillong

About **307** visitors including students of Swami Shraddhanand College Delhi University, B.H.U. Varanasi, Somerville School Delhi, National Bal Bhawan, New Delhi visited the Central Hydromet Observatory from 1st April to 30th June 2024.

Students of Swami Shraddhanand College at Central Hydromet Observatory

31 resident Doctors (M.D. Medicine) group from B.J. Medical College visited M.C. Ahmedabad on 9th July 2024 for familiarization with Met Services.

Doctors (M.D. Medicine) group from B.J. Medical College visited M.C. Ahmedabad

Students from Himalayan Institute of Medical Sciences, Dehradun were allowed to visit Meteorological Centre Dehradun premises on 26.07.2024, 20.08.2024 & 20.09.2024. **Shri Bhaumik Indrawal**, Met. 'A', **Shri Ashutosh Kala**, Met. 'A' and Shri **Ankit Sharma**, Met. 'A' showed the students the activities of weather forecasting section and Shri Akash Chandra, Met-A briefed them about RS/RW observation & surface met. Observatory.

Students from Himalayan Institute of Medical Sciences, Dehradun visiting MC Dehradun

Dr. Divesh Choudhury, Sc. 'D' gave brief lecture on Agriculture and **Sri Sukumar Roy**, Met. 'B' gave a lecture on Agromet Instruments and activities of GKMS, to students of ATC SAMETI WB, Ramkrishna Mission Ashram, Narendrapur on 31st July, 2024.

Students of ATC SAMETI WB, Ramakrishna Mission Ashram, Briefed about Agro-meteorology by Dr. Divesh Choudhury

Around 50 students with 5 faculty members from St. Edmund's College Shillong, Department of Geography visited MC Shillong for their field study on 13th August, 2024.

Students from St. Edmund's College Shillong, Department of Geography visited MC Shillong

Director, Space Applications Centre, visited IMD and had a familiarization of various operational centres of IMD on 16thAugust on 16th August, 2024.

Visit of Students and Faculty from various Institutes for the familiarization with different activities related to weather observation and forecast at RMC Nagpur.

Students from KISS-DU at IMD Bhubaneswar

About183 visitors, including students ofTagore International School, ITL Public School, ICAR Pusa Institute, ARSD College Delhi University, Miranda House College Delhi University, and OJT Traineesvisited the Central Hydromet Observatory from July 2024 to September 2024.

ARSD College, Delhi University

ICAR (IARI) PUSA INSTITUTE

ITL PUBLIC SCHOOL, NEW DELHI

On October 14, 2024, the INSAT AWS & Central Radiation Laboratory, Pashan, conducted a science outreach program, including practical demonstrations of the Automatic Weather Station and sensors, calibration techniques, and radiation instruments. The program was attended by 50 third-year Computer Science Engineering students and 5 professors from Pimpri Chinchwad College of Engineering, Pune.

INSAT AWS & CRL, Pashanconducted a science outreach program

The Director of National Centre for Hydrology and Meteorology, Royal Govt. of Bhutan visited RMC Kolkata office and Alipore Observatory on 16.11.2024.

The INSAT AWS & Central Radiation Laboratory, Pashan on 18th November, 2024, conducted science outreach program and practical demonstration of Automatic Weather station and Sensors, Calibration, Radiation Instruments, for 12 Bhutan Meteorological Trainees.

Royal Govt. of Bhutan visited RMC Kolkata office and Alipore Observatory

Prof. Berrien Morre, Prof. Pierre Kirsrtellerand **Prof. T. Venkatesan** of University of Oklahoma, US visited IMD and had an interaction with DGM & senior officials of IMD on 19th November.

The INSAT AWS & Central Radiation Laboratory, Pashan on 22nd November, 2024, conducted science outreach program and practical demonstration of instruments, for 15 Naval Officers, School of Naval Oceanology and Meteorology, Kochi.

INSAT AWS & CRL, Pashanonducted science outreach program

On 16 November, 2024, science outreach activities were conducted at the INSAT AWS & Central Radiation Laboratory, Pashan, with 50 students

and faculty members from the Civil Engineering Department of Dr. D. Y. Patil Institute of Engineering, Management and Research, Akurdi.

Science outreach activities were conducted at the INSAT AWS & Central Radiation Laboratory, Pashan

Around Nine Hundred (900) students of VI to X, accompanied with 18 Teachers of Kendriya Vidyalya, Ajni, Nagpur visited RMC Nagpur during 11 -13 December and 16 - 18 December, 2024.

6.9. Infrastructure Development and Installation

Third Generation Meteorological Satellite INSAT-3DS for meteorological observations and monitoring of land and ocean surfaces for weather forecasting and disaster warning successfully launched on 17th February, 2024. This significant achievement marks a substantial advancement in India's meteorological observation capabilities. The deployment of INSAT-3DS heralds a new era in meteorological data acquisition and analysis. Various departments under the Ministry of Earth Sciences, including the India Meteorological Department (IMD) and the National Centre for Medium-Range Weather Forecasting (NCMRWF), will harness the satellite's data to provide enhanced weather forecasts and vital meteorological services.

IMD has installed and commissioned H-AWOS at 11 heliports, which were inaugurated by **Shri Kiren Rijiju**, Hon'ble Union Minister of Earth Sciences on 25th February, 2024 at Itanagar Arunachal Pradesh.

Shri Kiran Rijiju, Hon'ble Minister, MoES presided the Foundation Stone Laying and Bhumi Pujan Ceremony of Meteorological Observatory, Gangasagarat Sagar Island, Rudranagar, South 24, Parganas District, West Benagal on 28th February, 2024 .

X-Band Doppler Weather Radar (DWR) at Lansdowne inaugurated by **Shri Kiran Rijiju**, the Hon'ble Minister, MoES on February , 2024.

Dr. Mrutyunjay Mohapatra, DG IMD had a meeting with **Dr. Mrudula G.**, Senior Principal Scientist, Centre for electromagnetics, CSIR, NAL, Bangalore on 15th February, 2024 regarding joint R&D activities related to aviation weather forecasting. Mr. Gajendra Kumar, Head, Central Aviation Meteorology Division also participated in the meeting.

During the Quarter January-March, 2024, 21 new stations were added in Rainfall Network.

DCWIS and PWD Systems were installed at Keshodairport (RWY 23) in May 2024.

DCWIS & PWD at Keshod Airport

DCWIS & PWD at Keshod Airport

Drishti transmissometer, DCWIS and PWD Systems were installed at Raipur airport (RWY 24) in June 2024.

Drishti Transmissometer at Raipur Airport

DCWIS & PWD

DCWIS (at RWY 05) and PWD (RWY 23) Systems were installed at Rajahmundry airport in July, 2024.

DCWIS (at RWY 05) and PWD (RWY 23) Systems installed at Rajahmundry airport

DCWIS (at RWY 05) and PWD (RWY 23) Systems installed at Rajahmundry airport

An H-AWOS was installed at Kedarnath ji for providing aviation met services on 06.09.2024 by touring party from CRS, Pune in collaboration with Meteorological Center Dehradun and Uttarakhand Civil Aviation Development Authority, Govt. of Uttarakhand. The newly installed H-AWOS at Kedarnath ji was inaugurated by the Secretary, Ministry of Earth Sciences, Govt. of India on 29.09.2024. On this occasion Shri Bikram Singh, Head/Scientist-F, Meteorological Center, Dehradun, Officials from MoES & senior officials of the Govt. of Uttarakhand were also present.

H-AWOS installation at Kedarnath ji

H-AWOS installation at Kedarnath ji

H-AWOS installation at Kedarnath ji

The three new Automatic Weather Observing Systems (AWOS) have been installed at Runway-27, Runway-Mid and Runway-09 of CCSI Airport Lucknow during August' 2024 to enhance the quality of RVR observation and Meteorological data required for Aviation.

Mast of Automated Weather Observing System (AWOS) (Carrying Wind Sensor, ATRH Sensor and Pressure Sensor)

Development of Climate Information Management System (CLIMS) for Data collection, Data monitoring, Data quality Control, Metadata Management, Database Management, Data Archival / Retrieval, Data generation (Basic data, derived products generation), Data Visualization, Bulletin & report generation through one platform. The process of surface data scrutiny, verification and submission of data by all RMCs and MCs is now done on a single platform - CLIMS. This facilitates online updating of historical database.

Development of Climate Information Management System

R&D activity on drone-based sensor payloads

Surface Instrument Division, O/o CRS Pune has taken up R&D activity on drone-based sensor payloads as a part of the Thunder Storm Test Bed (TTB). A feasibility study of drone-based observations was proposed and directions were taken from the Drone committee. In this connection, SID is developing sensor payloads for drones. To test the developed sensors on a balloon (normally used with Radio Sonde) for a limited

height in a controlled manner, a test trial was conducted on 25/11/2024 at CAgMO observatory, Pune before the drone experiment. The outcome of this experiment will help further refine the system to attach to a drone.

6.10. NEW PROJECTS/SCHEMES INITIATED

Design storm Studies for the two projects Poshir Project and Shilar Medium Irrigating Project in Maharashtra have been completed and values sent to the concerned Project Authority.

Dr. G. N. Raha, Sc-E, Head M.C. Gangtok has attended the "Stakeholder's meeting to explore the modalities of weather-based Crop insurance scheme for plantation crops" at the Conference Hall of Krishi Bhawan on 02.09.2024.

6.11. Awareness and Outreach Programme

Dr. Mrutyunjay Mohapatra, DG IMD participated in the Meeting of Sub-Committee of National Executive Committee (SC-NEC) to consider the NDMA's proposal on "**National Lightning Safety Education and Awareness Programme (NLSEAP)**" on 18th January, 2024.

Impact based forecast (IBF) for Agriculture in the month of Feburary-2024, 652 district level AAS bulletins, 2635 Block level AAS bulletins issued and 368000 Meghdoot mobile apps for AAS downloaded. Agromet Advisories Disseminated through WhatsApp groups to 17,74,702 framers in 1,36,321 villages in 4023 blocks and Agromet advisories disseminated through State Govt. mobile Apps 15.6 million farmers. 23 Farmers' Awareness Programme (FAPs) conducted under GKMS.

All officers and staff of MC Shillong participated in a country-wide mass pledge against Drugs on 12th August, 2024 regarding the flagship mass awareness campaign "Nasha Mukti Bharat Abhiyan".

Plantation drive "**EK PED MAA KE NAAM**" as per the orders of Headquarters New Delhi, a tree plantation program was organized in the courtyard of Regional Meteorological Centre, Nagpur under the "**One Tree in the Name of Mother**" drive on 13th September, 2024.

Officials during Plantation Drive

Dr. O. P. Sreejith, Sc. 'F' attended the **first Monsoon Forum Meeting** for Assam state jointly organized by the United Nations World Food Program (WFP), Assam State Agriculture Department and IMD on 5thJuly, 2024 at Assam Administrative Staff College, Guwahati and delivered a lecture on "**Review of 2023 climate and 2024 southwest monsoon Seasonal forecast for Assam** "

Vigilance Awareness Week 2024 was observed 28.10.2024 to 02.11.2024. Integrity pledge is administered on 28.10.2024 at RMC Office Kolkata, AMO Kolkata, MC Patna, MC Gangtok and other sub offices.

FAP conducted by AMFU, Roorkee at Gadhaurona Village, Narsan Block, Haridwar District, Uttarakhand on 30th November, 2024

FAP conducted by DAMU, Jalore at Keshwana Village, Jalore Block, Jalore District, Rajasthan on 20th December, 2024

FAP conducted by AMFU, Targhadi at Jasdan Taluka, Rajkot District, Gujarat on 9th July, 2024

During the quarter 6 Farmers awareness programmes (FAPs) were organized across the country.

Dr. M. Mohapatra, DG IMD attended the state level meeting as a Guest of Honour along with Hon'ble Chief Minister of Odisha and other dignitaries on the occasion of Odisha Disaster preparedness and National day for Disaster Reduction held on 29th Oct, 2024 at Ravindra Mandap Bhubaneswar. **Hon'ble Chief Minister Shri Mohan Charan Majhi** appreciated IMD for the very accurate forecast of cyclonic storm DANA well in advance.

Odisha Disaster preparedness and National day for Disaster Reduction

CHAPTER 7

RESEARCH PUBLICATIONS

7.1. Research contributions

Twenty four (24) research articles have been published in *MAUSAM* (Vol. **75**, No. 1), January, 2024 issue.

Twenty three (23) research articles have been published in *MAUSAM* (Vol. **75**, No. 2), April, 2024 issue.

Twenty five (25) research papers got published in Quarterly Journal '*MAUSAM*', Vol.**75**, Issue No.3.

Seventeen (17) research papers got published in Quarterly Journal '*MAUSAM*', Vol.**75**, Issue No.4.

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7.4. Other Publications

Published the Technical Report entitled **"Design Storm Studies undertaken during 2023**" and uploaded in IMD website during June 2024.

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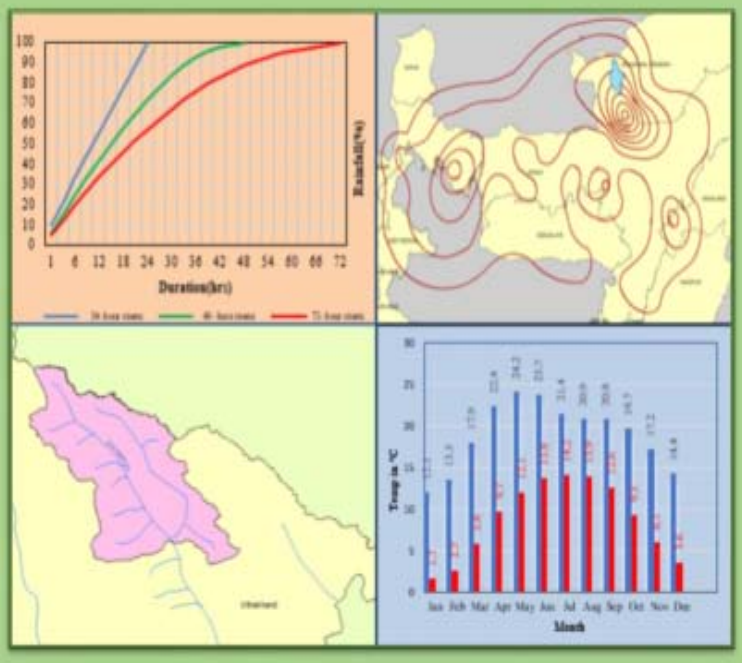
भारत मौसम विज्ञान विभाग (पृथ्वी विज्ञान मंत्रालय)
India Meteorological Department (Ministry of Earth Sciences)
Tech. Report No. ESSO/MoES/IMD/HS/Technical Report-DSS(2023)/01(2024)/63

TECHNICAL REPORT
ON
DESIGN STORM STUDIES UNDERTAKEN DURING 2023



Prepared by:

Dr. D.S Pai, S.K. Manik, Shashi Chauhan, Praveen Kumar Ghildiyal,
Chandan Kumar, Kanchan & Subhash Chandra Chaudhary

Hydromet Division, New Delhi
June 2024

CHAPTER 8

FINANCIAL RESOURCES AND MANAGEMENT PROCESS

8.1. Budget Outlay of approved schemes of IMD

IMD received its budget allocation under two categories namely, budget for implementation of Central Sector schemes and budget for Establishment related expenditure. Budget Estimates (B.E.) during Financial Year 2024-25 are as follows:

Budget Estimate 2024-25 (Rs. In Crores)		
Central Sector Schemes	Establishment	Total
180.11	537.08	717.19

8.2. Expenditure incurred during FY 2023-24

Budget Estimate 2023-24 (Rs. In Crores)		
Central Sector Schemes	Establishment	Total
210.18	530.57	740.75

8.3. Launch of the new scheme 'Mission Mausam'

The Union Cabinet approved the central sector scheme Mission Mausam on September 11, 2024, with a budget outlay of 2,000 crores over two years (2024-25 to 2025-26) with the goal of making Bharat a "Weather-ready and Climate-smart" nation. The mission seeks to exponentially enhance the country's weather and climate observations, understanding, modelling and forecasting, leading to better, more useful, accurate and timely services. The previously approved sub-scheme ACROSS under the PRITHVI scheme is merged with the current scheme.

The objectives of the scheme "Mission Mausam" includes:

- Develop Cutting Edge Weather Surveillance Technologies & Systems
- Implement Higher resolution atmospheric observations with better temporal and spatial sampling/coverage
- Implement Next-generation radars and satellites with advanced instrument payloads
- Implement High-Performance Computers (HPC).
- Improve understanding of weather and climate processes and prediction capabilities
- Develop improved earth system models, and data-driven methods (use of AI/ML)
- Develop Technologies for weather management
- Develop state-of-art dissemination system for last mile connectivity
- Capacity building

The Mission Mausam will be implemented by IMD and other institutes of MoES. IMD will mainly focus on the observations, services, decision support system and dissemination. Major IMD activities under Mission Mausam include:

- Commissioning of 53 Doppler Weather Radars
- Establishment of 60 RS/RW stations
- Commissioning of 100 Disdrometers
- Commissioning of 10 Wind profilers
- Commissioning of 25 Microwave Radiometers

- Augmentation of Solar Radiation Monitoring Network- 55 Nos.
- Commissioning of 10 Aerosol / Raman LiDARs
- Procurement of 20 Skyradiometers
- Expansion of BC Aerosol Network (BC, EC/OC)- 25 stations
- Ozonesonde Network (3 India+ Maitri+ Bharati)
- Total Columnar Ozone (TCO3)- 5 Nos.
- Commissioning of Visualization and Decision Support System (mini HPCS)
- Collaboration with various agencies and startups for the indigenous development of met instruments / sensors and software and provide useful outputs for enhancing precipitation forecasting, validation of weather forecasting models, and dissemination of information and products
- Establishment of Radar data centre, R&D Labs for Tropical Cyclones, severe weather events, Aviation Meteorology, Mountain weather and Augmentation of Training centre.

8.4. REVENUE GENERATED DURING THE YEAR 2024

Sale of Meteorological Data

RCs/MCs	Total revenue received by sale of meteorological data during the month (Amount in Rupees)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DGM, New Delhi												
DGM SATMET	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
DGM HYDROLOGY	330330	299448	NIL	NIL	Nil	377080	44250	1617920	NIL	745452	1045786	NIL
DGM (Publication)	28675	30175	27900	1125	8225	22000	1125	NIL	4225	8675	NIL	12000
RMC, New Delhi												
New Delhi	7766	21981	5852	10178	26280	17204	15593	8914	12,099	0	8715	27714
Jaipur	32720	8443	12250	1463	30364	26320	27497	23677	62734	34286	68581	11689
Lucknow	11376	26923	57681	0	16720	10400	17074	36537	8142	90121	20042	72291
Srinagar	35327	15464	5546	6393	9904	20549	72422	4113	22184	11717	5685	2173
Chandigarh	2773	17213	10484	8726	5311	0	13521	1770	14743	0	0	1517
Shimla	12435	0	19559	7806	4316	15025	0	27295	0	22753	1422	2664
Dehradun	5900	11800	24435	7080	1253	5310	7395	26619	10634	0	5310	28504
RMC, Mumbai												
Mumbai	12655	20539	79854	20719	24834	27976	35325	16304	26122	10938	13281	13656
RMC, Nagpur												
Nagpur	4072	50468	10041	71173	16026	55803	51888	20116	12164	27807	9413	12662
Bhopal	4131	7421	00	00	00	2874	00	00	00	00	00	00
RMC, Kolkata												
RMC Kolkata	13825	45029	5312	23768	43891	9223	29635	6544	13813	44693	12840	145723
PAC Kolkata	Nil	10968	Nil	Nil	37312	Nil	Nil	7753	Nil	32002	Nil	Nil
Patna	Nil	53177	20748	Nil	3124	7080	Nil	5273	Nil	Nil	Nil	2950
Bhubaneswar	59665	Nil	9073	9885	118975	7080	71928	8324	8850	45835	14351	14070
Gangtok	Nil	Nil	Nil	Nil	Nil	Nil	7080	Nil	Nil	Nil	Nil	Nil
Ranchi	17767	Nil	3084	Nil	2885	1770	10620	9900	19168	Nil	17684	5839
RMC, Guwahati												
Guwahati	141399	35078	23945	52145	81042	104018	37370	48670	52332	37257	54719	12762
Agartala	Rs.68,177/-											
RMC, Chennai												
Chennai	63638	30484	103713	35072	30764	40838	40417	26188	6210	15650	19501	7949
Thiruvananthapuram	11919	10620	19440	6784	14536	10124	1770	6878	10620	11494	5310	1770
Hyderabad	15245	82600	37059	31150	38035	16258	31288	4756	10965	56054	34070	10180
Bangalore	66165	75109	76057	101935	60554	83409	76398	127064	91275	67004	162768	72933
CWC Visakhapatnam	3472	Nil	1689	Nil	Nil	1209	Nil	Nil	Nil	Nil	Nil	Nil
Pune	476389	593330	600398 225 US$	719234	902016 484 US$	374039	275261	556860	259899	747546	386112	1370371

CHAPTER 9

राजभाषा नीति का कार्यांवयन

संसदीय राजभाषा समिति द्वारा निरीक्षण

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा मौसम कार्यालय एवं पवन सूचक गुब्बारा वेधशाला–कोटा का दिनांक 16.01.2024 को जयपुर में निरीक्षण किया गया। निरीक्षण के दौरान पवन सूचक गुब्बारि वेधशाला–कोटा से श्री देवेन्द्र कुमार यादव, मौ. वि. 'ए' ने भाग लिया। निरीक्षण सफल एवं संतोषजनक रहा।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा प्रादेशिक मौसम केंद्र–नागपुर का दिनांक 18.01.2024 को मुंबई में निरीक्षण किया गया। निरीक्षण के दौरान मुख्यालय से श्री एस. सी. भान, वैज्ञानिक 'जी' और श्रीमती सरिता जोशी, उपनिदेशक (रा.भा.) तथा प्रादेशिक मौसम केंद्र–नागपुर से श्री एम. एल. साहू, वैज्ञानिक 'एफ' ने भाग लिया। निरीक्षण सफल एवं संतोषजनक रहा।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 23.10.2024 कोमौसम केंद्र भुवनेश्वार का भुवनेश्वंर में निरीक्षण किया गया। निरीक्षण के दौरान मुख्यांलय से श्री विवेक सिन्हाम, वैज्ञानिक 'जी' और श्रीमती सरिता जोशी, उपनिदेशक (रा.भा.), प्रादेशिक मौसम केंद्र–कोलकाता से डॉ. सोमनाथ दत्ता, वैज्ञानिक 'जी' तथा मौसम केंद्र–भुवनेश्वर से श्रीमती मनोरमा मोहंती, वैज्ञानिक 'एफ' ने भाग लिया। निरीक्षण सफल एवं संतोषजनक रहा।

संसदीय राजभाषा समिति द्वारा मौसम केंद्र–भुवनेश्वर का निरीक्षण

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा प्रादेशिक मौसम केंद्र, गुवाहाटी का दिनांक 20.11.2024 को गुवाहाटी में निरीक्षण किया गया। निरीक्षण के दौरान मुख्यांलय से श्रीमती रंजू मदान, वैज्ञानिक 'जी', और श्रीमती सरिता जोशी, उपनिदेशक (रा.भा.) तथा प्रादेशिक मौसम केंद्र, गुवाहाटी से श्री के. एन. मोहन, वैज्ञानिक 'जी' ने भाग लिया।

संसदीय राजभाषा समिति द्वारा प्रादेशिक मौसम केंद्र, गुवाहाटी का निरीक्षण

राजभाषायी ई–निरीक्षण

मुख्याालय की उपनिदेशक (रा.भा.) श्रीमती सरिता जोशी द्वारा दिनांक 19.03.2024 को 10 उपकार्यालयों प्रादेशिक मौसम केंद्र–नागपुर, प्रादेशिक मौसम केंद्र–गुवाहाटी, मौसम केंद्र–अगरतला, मौसम केंद्र–शिलांग, मौसम केंद्र–ईटानगर तथा प्रादेशिक मौसम केंद्र,–नई दिल्ली, मौसम केंद्र–जयपुर, मौसम केंद्र–देहरादून, मौसम केंद्र–लखनऊ और मौसम केंद्र–चंडीगढ़ का राजभाषायी ई–निरीक्षण किया गया।

मुख्योलय की उपनिदेशक (राजभाषा) श्रीमती सरिता जोशी द्वारा दिनांक 25.04.2025 को 04 उपकार्यालयों नामत:– मौसम केंद्र–बेंगलूरू, मौसम केंद्र–तिरूवनंतपुरम, मौसम केंद्र–हैदराबाद और मौसम केंद्र–अमरावती का राजभाषायी ई–निरीक्षण किया गया।

मुख्योलय की उपनिदेशक (रा.भा.) श्रीमती सरिता जोशी द्वारा दिनांक 22.05.2024 को 02 उपकार्यालयों प्रादेशिक मौसम केंद्र–चेन्नैक और खगोल विज्ञान केंद्र–कोलकाता का राजभाषायी ई–निरीक्षण किया गया।

दिनांक 28.05.2024 को प्रादेशिक मौसम केंद्र–नागपुर द्वारा 03 अधीनस्थम उपकार्यालयों मौसम केंद्र–भोपाल, मौसम केंद्र–रायपुर और मौसम कार्यालय–ग्वांलियर का राजभाषायी ई–निरीक्षण किया गया। निरीक्षण के दौरान मुख्यालय से उपनिदेशक (रा.भा.) श्रीमती सरिता जोशी उपस्थित रही और आवश्यक दिशा निर्देश दिए। मुख्यामलय की उपनिदेशक (रा.भा.) श्रीमती सरिता जोशी द्वारा दिनांक 20.06.2024 को 02 उपकार्यालयों मौसम केंद्र–लेह और मौसम केंद्र–शिमला का राजभाषायी ई–निरीक्षण किया।

मुख्यालय की उपनिदेशक (रा.भा.) श्रीमती सरिता जोशी द्वारा दिनांक 22.08.2024 को 03 उपकार्यालयों प्रादेशिक मौसम

केंद्र–कोलकाता, मौसम केंद्र–भुवनेश्वशर और जलवायु एवं अनुसंधान सेवाएँ–पुणे का राजभाषायी ई–निरीक्षण किया गया ।

दिनांक 22.11.2024 को प्रादेशिक मौसम केंद्र–नागपुर द्वारा 04 अधीनस्थं उपकार्यालयों मौसम कार्यालय–अकोला, मौसम कार्यालय–अम्बितकापुर, मौसम कार्यालय–बिलासपुर और मौसम कार्यालय–सागर का राजभाषायी ई–निरीक्षण किया गया। निरीक्षण के दौरान मुख्यापलय से उपनिदेशक (रा.भा.) श्रीमती सरिता जोशी उपस्थिात रही और आवश्यक दिशा निर्देश दिए।

दिनांक 12.11.2024 को प्रादेशिक मौसम केंद्र–नई दिल्ली द्वारा 03 अधीनस्थ उपकार्यालयों मौसम कार्यालय–हिसार, विमानन पत्तन मौसम कार्यालय–शिमला और मौसम कार्यालय–जोत का राजभाषायी ई–निरीक्षण किया गया। निरीक्षण के दौरान मुख्यौालय से उपनिदेशक (रा.भा.) श्रीमती सरिता जोशी उपस्थित रही और आवश्यकक दिशा निर्देश दिए।

हिंदी संगोष्ठी

भारत मौसम विज्ञान विभाग की 150वीं वर्षगाँठ के अवसर पर निदेशानुसार दिनांक 24–09–2024 से 26–09–2024 तक (तीन दिवसीय) विशाखापट्टनम में अखिल भारतीय अंतर मंत्रालय/अंतर विभागीय हिंदी संगोष्ठी – 2024 "सामाजिक आर्थिक उत्थान – मौसम सेवाओं का योगदान" आयोजित की गई। संगोष्ठी पाँच सत्रों में आयोजित की गई–

प्रथम सत्र – 'राजभाषा'
द्वितीय सत्र – 'आपदाएं और प्रबंधन'
तीसरा सत्र – 'जलवायु परिवर्तन'
चतुर्थ सत्र – 'मॉनसून'
पंचम सत्र – 'आपदाएं और पूर्व चेतावनी'

विशाखापट्टनम में अखिल भारतीय अंतर मंत्रालयध अंतर विभागीय हिंदी संगोष्ठी दृ 2024

उद्घाटन समारोह में संगोष्ठी की प्रस्तुतियों का "सार संकलन", विभागीय गृह पत्रिका "मौसम मंजूषा" के 39वें संस्करण और प्रादेशिक मौसम केंद्र, चेन्नै की गृह पत्रिका 'पवनदूत' का विमोचन किया गया।

संगोष्ठी की प्रस्तुतियों का "सार संकलन", विभागीय गृह पत्रिका "मौसम मंजूषा" और प्रादेशिक मौसम केंद्र, चेन्नै की गृह पत्रिका 'पवनदूत' का विमोचन

प्रकाशन

विभाग की गृह पत्रिका 'मौसम मंजूषा' के 38वें संस्करण का विमोचन विभाग के 149वें स्थापना दिवस के अवसर पर विज्ञान भवन में पूर्व महानिदेशक डॉ. लक्ष्मण सिंह राठौर, अन्य मंचासीन महानुभावों के साथ महानिदेशक महोदय द्वारा किया गया।

भारत मौसम विज्ञान विभाग की गृह पत्रिका 'मौसम मंजूषा' के 39वें संस्करण का विमोचन मुख्य अतिथि पूर्व महानिदेशक डॉ. अजित त्यागी, महानिदेशक महोदय डॉ. मृत्युंजय महापात्र सहित अन्य मंचासीन अधिकारीगणों द्वारा अखिल भारतीय अंतर विभागीय/अंतर मंत्रालय संगोष्ठी के दौरान विशाखापट्टनम में दिनांक 24.09.2024 को किया गया।

हिंदी दिवस समारोह

मुख्यालय में हिंदी माह/ हिंदी दिवस–2024 समारोह दिनांक 30.09.2024 को आयोजित किया गया। समारोह के मुख्य अतिथि कवि श्री गजेन्द्र सोलंकी रहे।

मुख्यालय द्वारा हिंदी माह/हिंदी दिवस–2024 के दौरान आयोजित की गई 06 प्रतियोगिताओं के 30 विजेताओं को कार्यकारी महानिदेशक डी. एस. पई एवं मुख्य अतिथि श्री गजेन्द्री सोलंकी जी तथा समिति अध्यंक्ष श्री के. सी. साईंकृष्णन, वैज्ञानिक 'जी' के करकमलों से प्रमाण पत्र प्रदान किए गए।

राजभाषा हिंदी में सर्वश्रेष्ठ कार्य करने हेतु वर्ष 2023–2024 के लिए राजभाषा चलशील्डक केंद्रीय विमानन मौसम प्रभाग को प्रदान की गई।

कार्यकारी महानिदेशक डी. एस. पई एवं मुख्यट अतिथि श्री गजेन्द्र सोलंकी जी द्वारा राजभाषा हिंदी में सर्वश्रेष्ठ कार्य करने हेतु वर्ष 2023–2024 के लिए राजभाषा चलशील्ड केंद्रीय विमानन मौसम प्रभाग को प्रदान की गई

मुख्यालय में हिंदी दिवस/हिंदी माह 2024 के समापन समारोह में सरकारी कामकाज मूलरूप से हिंदी में करने की प्रोत्साहन योजना 2023–2024 के मुख्यालय तथा प्रादेशिक मौसम केंद्र–नई दिल्ली के विजेताओं को कार्यकारी महानिदेशक महोदय, मुख्य अतिथि तथा समारोह समिति के अध्यक्ष द्वारा प्रमाण पत्र प्रदान किए गए।

कार्यशाला/व्याख्याकन/बैठकें

मुख्यालय, नई दिल्ली द्वारा दिनांक 22.03.2022 को पूर्ण दिवसीय ई–हिंदी कार्यशाला का आयोजन किया गया। इस कार्यशाला में मुख्यालय के कार्मिकों के साथ उपकार्यालयों के लगभग 150 कार्मिकों ने भाग लिया। श्रीमती सरिता जोशी, उपनिदेशक (रा.भा.) सुश्री रेवा शर्मा, सेवानिवृत्ते उपनिदेशक (रा.भा.) तथा श्री बीरेन्द्र कुमार, सेवानिवृत्त वरिष्ठ अनुवाद अधिकारी ने व्याकख्याान दिए।

भारत मौसम विज्ञान विभाग (मुख्यालय) नई दिल्ली की राजभाषा कार्यान्वयन समिति की 165$^{वीं}$ तिमाही बैठक कार्यभारी महानिदेशक श्री एस. सी. भान की अध्यलक्षता में दिनांक 11.03.2024 को, 166$^{वीं}$ तिमाही बैठक कार्यभारी महानिदेशक डॉ. डी. एस. पई वैज्ञानिक 'जी' की अध्येक्षता में दिनांक 13.06.2024 को और 167$^{वीं}$ तिमाही बैठक कार्यभारी महानिदेशक श्री विवेक सिन्हा, वैज्ञानिक 'जी' की अध्यगक्षता में दिनांक 29.10.2024 को आयोजित की गई।

राजभाषा नीति का कार्यान्वयिन

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 10.07.2023 को विमानन मौसम कार्यालय–राजकोट, दिनांक 15.07.2023 को मौसम वेधशाला–कोष्किोड, दिनांक 12.07.2023 को मौसम विज्ञान वेधशाला–मंगलुरू, दिनांक 15.07.2023 को मौसम विज्ञान केंद्र–लखनऊ,दिनांक 24.08.2023 कोचक्रवात चेतावनी केंद्र–विशाखापट्पम, दिनांक 26.05.2023 को मौसम केंद्र–देहरादून, दिनांक 27.12.2024 कोखगोल विज्ञान केंद्रदृ कोलकाता ,दिनांक 01.12.2024 को मौसम कार्यालयदृ वाराणसी औरदिनांक 16.01.2024 को पवन सूचक गुब्बा वेधशाला–कोटा के निरीक्षण के दौरान समिति को दिए गए 'आश्वोसन' और 'ध्यान देने योग्य बातें' पर की गई अनुवर्ती कार्रवाई की अनुपालनात्मक रिपोर्ट पृथ्वी विज्ञान मंत्रालय के माध्यम से समिति सचिवालय को भेजी गई।

अनुवाद

पृथ्वी विज्ञान मंत्रालय की वर्ष 2023–2024 की वार्षिक रिपोर्ट के लिए भारत मौसम विज्ञान विभाग की सामग्री, 'मौसम' पत्रिका के 80 सारों, वैज्ञानिक 'बी' के भर्ती नियमों, उपरितन वायु उपकरण प्रभागसे प्राप्तग समझौता ज्ञापन, अवर श्रेणी लिपिक के भर्ती नियम एवं अधिसूचना, प्रशासनिक प्रशिक्षण से संबंधित प्रमाण–पत्र, 'योगदानकर्ताओं के लिए निर्देश' की सामग्री और उपग्रह मौसम प्रभाग से प्राप्तर झांकी से संबंधित सामग्रीका हिंदी अनुवाद किया गया। पृथ्वीं विज्ञान मंत्रालय की वर्ष 2023–2024 की वार्षिक रिपोर्ट के हिंदी पाठ और 'विमानन उपकरणों की स्थापना रखरखाव और संचालन के लिए मानक परिचालन प्रक्रिया 2024' (100 पृष्ठट) के हिन्दी पाठ का पुनरीक्षण किया गया।

उपनिदेशक (राजभाषा) द्वारा मंत्रालय से प्राप्ति लोकसभा के 19 तथा राज्यसभा के 13 तारांकित/अतारांकित प्रश्नों के हिंदी पाठ का पुनरीक्षण कार्य किया गया।

CHAPTER 10

STATUS OF SC/ST/OBC AS ON 01.01.2024

(i) Status of SC/ST/OBC as on 01.01.2024 (Group wise)

	Representation of SCs / STs/ OBCs as on 1.1.2024				Appointments by Promotion during the calendar year		
Groups	No. of Employees	SCs	STs	OBCs	SCs	STs	Total
Group A	277	49	24	62	24	22	99
Group B (Gaz.)	1460	259	110	347	34	13	258
Group B (Non- Gaz.)	1663	244	154	590	13	0	13
Group C	996	271	100	207	26	9	35
TOTAL	4396	823	388	1206	97	44	405

(ii) Status of SC/ST/OBC as on 01.01.2024 (Pay Scale Wise)

	Representation of SCs / STs / OBCs as on 1.1.2024				Appointments by promotion during the calendar year		
Pay Scale in Rs.	No. of Employees	SCs	STs	OBCs	SCs	STs	Total
PB-3 + GP 5400	0	0	0	0	0	0	2
PB-3 + GP 6600	116	24	13	17	14	17	53
PB-3 + GP 7600	66	7	3	21	4	2	20
PB-4 + GP 8700	44	9	5	13	0	0	0
PB-4 + GP 8900	38	9	2	10	4	3	19
PB-4 + GP 10000	12	0	1	1	2	0	5
75500-80000	1	0	0	0	0	0	0
TOTAL	277	49	24	62	24	22	99

CHAPTER 11

MISCELLENEOUS

11.1. Honours and Awards

IMD Awards

Best Employees Awards on the occasion of WMO Day-2024

S. No.	Name of the officials & designation	Office/Division/Place of posting
1.	Sh. T. Arulalan, Sc -C	NWP, DGM Office, New Delhi
2.	Ms. Suman Gujar, Sc-D	ISSD, DGM, Office, New Delhi
3.	Sh. Anshul Chauhan, Sc- C	UAID, DGM, Office
4.	Sh. Krishna Mishra, Sc - C	NWFC, DGM Office, New Delhi
5.	Sh. M.T. Bushair, Sc - C	NWP, DGM Office, New Delhi
6.	Sh. Rama Naik D, Met-B	AMS Bajpe, Met. Office, Mangaluru
7.	Sh. V.P. Devesia, Met - A	AMS, Kozhikode
8.	Sh. R.K. Mohapatra, Met -B	M.C. Bhubneshwar
9.	Ms. RenuVerma, Met- B	DGM(AASD)
10.	Ms. Yashika Garg, Met- A	DGM(Hydrology)
11.	Ms. Rhythm Naswa, Met- A	DGM(UAID)
12.	Sh. A.P. Vijayan, AO-III	RMC Chennai
13.	Sh. H.W. Joshi, AO-II	DGM, New Delhi
14.	Sh Amit Kumar Gupta, SA	MC Raipur
15.	Sh. P. Kartik, SA	M.C. Thiruvanthapuram
16.	Ms. Kusum LATA, SA	DGM(NWFC)
17.	Ms. Neeru Barak, SA	DGM(CWD)
18.	Sh.RahulBhurwan,SA	DGM(ESTT.)
19.	Ms. Divya Kumari, SA	DGM(ISSD)
20.	Sh P Ali Sheik Kadar, Asstt.	RMC Chennai
21.	Sh. P.K. Verma, Asstt.	DGM(B&P)
22.	Ms. Rajni Sharma, Asstt.	DGM(Bills)
23.	ShBagesh Kumar, UDC	MC Patna
24.	Sh. Dhandhapani, MO-I	RMC Chennai
25.	Ms. Esha Chandra, UDC	DGM(Medical Bill)
26.	Ms Laxmi Dubey, UDC	DGM(Estt.)
27.	Sh Sharif Khan, MTS	MC Bhopal
28.	Sh. Kanak Chander Das, MTS	RMC, Guwahati
29.	Sh. Chandrashekar N, MTS	AMS Bajpe

Best RMC/MC/MO/ AMO/AMS/DWR Awardson the occasion of WMO Day-2024

1.	Best RMC/MC	M.C. Patna
2.	Best AMO/MWO/AMS	AMO Kolkata
3.	Best M.O	M.O. Nalliya and M.O. Baptala
4.	Best DWR	DWR Nagpur

RMC Nagpur got first prize from "Nagar Rajbhashakaryanwahan samiti" for Rajbhasha Karyanwahan. Additionally "Protsahan Prize" for Riturang Magazine.

IMD feels proud to announce that its employees participated in Inter Ministry Music, Dance and Short Play Competition 2024-25 organized by Central Civil Services Cultural & Sports Board (CCSCSB) (DoPT) and the following officials won medals:

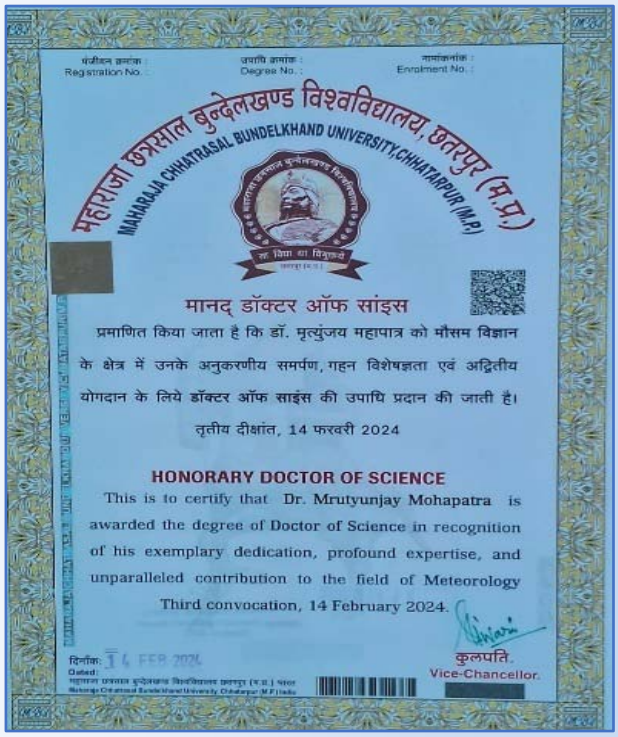
Name of event	Name of winners	Position/Medal acquired
Short Play	Ms. Banashri Bandyopadhyay	Gold (Best actress –Female)
Group Folk Dance	Ms. Monika Pernaul Ms. Deepti Koli Ms. Priyanka Jha Ms. Twinkle Grover Ms. Sonia Ms. Krishna	Bronze

Patent Granted to **Dr. Shirish Yograj Khedikar**. "**An improved portable electronic device**", Patent No. 507054, application No. 201621026922 dated 2nd September, 2016, Patent Granting date : 5th February, 2024.

Dr. S. Mahato, PS-III, attended and presented cyclone track work using Satarkabarta at the 14th Asia-Oceania Meteorological Satellite Users Conference (AOMSUC-l4) to be held at New Delhi from 4th to 6th December, 2024 and received 3rd poster presentation award.

Appreciation Received

Hon'ble Governor of Madhya Pradesh and Chancellor of Maharaja Chhatrasal Bundelkhand University conferred the Honorary Degree of Science (D.Sc.) upon **Dr. Mrutyunjay Mohapatra**, DG IMD during it's Convocation Ceremony at Chhatarpur, Madhya Pradesh on 14th February, 2024.


महाराजा छत्रसाल बुन्देलखण्ड विश्वविद्यालय, छतरपुर (म.प्र.)
MAHARAJA CHHATRASAL BUNDELKHAND UNIVERSITY, CHHATARPUR (M.P.)

मानद् डॉक्टर ऑफ साइंस

प्रमाणित किया जाता है कि डॉ. मृत्युंजय महापात्र को मौसम विज्ञान के क्षेत्र में उनके अनुकरणीय समर्पण, गहन विशेषज्ञता एवं अद्वितीय योगदान के लिये डॉक्टर ऑफ साइंस की उपाधि प्रदान की जाती है।

तृतीय दीक्षांत, 14 फरवरी 2024

HONORARY DOCTOR OF SCIENCE

This is to certify that Dr. Mrutyunjay Mohapatra is awarded the degree of Doctor of Science in recognition of his exemplary dedication, profound expertise, and unparalleled contribution to the field of Meteorology

Third convocation, 14 February 2024.

कुलपति
Vice-Chancellor

Dr. Mrutyunjay Mohapatra, DG IMD conferred the Honorary Degree of Science (D.Sc.)

Dr.Mrutyunjay Mohapatra, DG IMD conferred the Honorary Degree of Science (D.Sc.)

Chief Secretary, Sikkim Shri V. B. Pathak, IAS visited IMD HQ on 16th February, 2024 and presented an appreciation letter to **Dr. Mrutyunjay Mohapatra**, DG IMD and his team including the team at Meteorological Centre Gangtok for their exemplary services especially during Sikkim Floods recently in 2023.

Chief Secretary, Sikkim Sh. V B Pathak, IAS visited IMD HQ on 16th February, 2024 and presented an appreciation letter to Dr. Mrutyunjay Mohapatra, DG IMD

Hon'ble President of India Mrs. Draupadi Murmu conferred the Honorary Degree of Science upon **Dr. Mrutyunjay Mohapatra**, DG IMD for his exemplary dedication, profound expertise and unparalleled contribution to the field of Meteorology during 53rd Convocation Ceremony of Utkal University in the presence of Governor of Odisha, Hon'ble Minister of higher education, Odisha and Vice Chancellor, Utkal University on 29th February, 2024.

Hon'ble President of India Mrs. Draupadi Murmu conferred the Honorary Degree of Science upon Dr.Mrutyunjay Mohapatra, DG IMD during 53rd Convocation Ceremony of Utkal University

Appreciation letter has been received from Commanding Officer, INS Porbandar for invaluable

contribution by IMD Scientist Shri Abhimanyu Chauhan, Sc. 'C', during the HADR workshop held on 10-11th June at Naval Station Porbandar.

Appreciation letter dated-12-07-2024 is received from Chief Engineer, CWC for support & presentation in the knowledge sharing workshop held on 11thJuly, 2024.

11.2. Media Interaction

Unified Mobile App & Decision support system (DSS) was launched on 15th January, 2024 by Honourable Vice President of India, **Shri Jagdeep Dhankhar** in Inaugural function of IMD 150th foundation Day celebration.

Introductory Video for MAUSAM mobile app & theme song of IMD was released on 15th January, 2024 in Inaugural function of IMD 150th foundation Day celebration.

A facility for sending E-Mail on 1st and 15th date of every month to the pensioners and soon-to-be retiring employees under Anubhav Outreach Campaign, 2024 created on METNET.

Online Applications Forms made LIVE in METNET for all IMD employees w.e.f. 17th January, 2024 with initially three forms listed below: a. Permission of Higher Education b. Intimation of purchasing of Immovable property c. Intimation of purchasing of movable property.

IMD organized Press Conference on 1st January, 2024 regarding monthly outlook of temperature and rainfall for the month of January, 2024. **Dr. Mrutyunjay Mohapatra**, DG IMD briefed the Press. The detailed of Press Release issued in this regard is available at link: https://internal.imd.gov.in/ press_release/ 20240131_pr_2788.pdf.

Impact based forecast (IBF) for Agriculture in the month of January-2024, 671 district level AAS bulletins, 2969 Block level AAS bulletins issued and 0.367 million Meghdoot mobile apps for AAS downloaded. Agromet Advisories Disseminated through WhatsApp groups to 2,76,26, 903 framers and Agromet advisories disseminated through State Govt. mobile Apps 15.6 million farmers.

Impact based forecast (IBF) for Agriculture in the month of Feburary-2024, 652 district level AAS bulletins, 2635 Block level AAS bulletins issued and 368000 Meghdoot mobile apps for AAS downloaded. Agromet Advisories Disseminated through WhatsApp groups to 17,74,702 framers in 1,36,321 villages in 4023 blocks and Agromet advisories disseminated through State Govt. mobile Apps 15.6 million farmers. 23 Farmers' Awareness Programme (FAPs) conducted under GKMS.

Impact based forecast (IBF) for Agriculture in the month of March-2024, 649 district level AAS bulletins, and 371.8k Meghdoot mobile apps for AAS downloaded. Agromet Advisories Disseminated through WhatsApp groups to 1803795 farmers in 137904 villages in 4023 blocks and Agromet advisories disseminated through State Govt. mobile Apps 15.6 million farmers.

India Meteorological Department organized Press Conference on Monthly Outlook for Temperature and Rainfall on 1st March, 2024. **Dr. M Mohapatra**, DG IMD made a presentation during the Press Conference.

IMD organized Press Conference on release of 2nd stage of forecast of Southwest Monsoon 2024 on 27th May. Dr. M. Mohapatra, DG IMD addressed the Press Conference. The highlights of the Press Release are given below:

- Quantitatively, the southwest monsoon seasonal rainfall over the country as a whole is likely to be 106% of the long period average (LPA) with a model error of ± 4%. Thus Above Normal rainfall is most likely over the country as a whole during the monsoon season (June to September), 2024.

- The southwest monsoon seasonal (June to September, 2024) rainfall is most likely to be above normal over Central India and South Peninsular India (>106% of LPA), normal over Northwest India (92-108% of LPA) and below normal over Northeast India (106% of LPA).

Dr. M. Mohapatra, DG, IMD participated as Expert Speaker in the Idea Exchange Programme of The Indian Express with Mr. Amitabh Sinha, Editor on 10th June. The interview is available at https://indianexpress.com/article/idea-exchange/ heatwaves-will-now-become-more-frequent-durable-and-intense-9382334/

Dr. Ashutosh Kumar Misra, Sc.'D',**Dr. Jaya DhamiParihar**, Sc. 'D' and**Dr. Asha Latwal**, Sc.'C' gave bi-weekly TV Bytes for the Programme 'Mausam Khabar' of DD Kisan Channel during the quarter.

Heavy rainfall warning was issued by India Meteorological Department due to Cyclonic Storm "Remal" over Bay of Bengal during May 2024. During the period 14486563 SMSs have been sent to the farmers in the States of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Tripura and West Bengal. Special Agromet Bulletins have also been prepared and uploaded in the website of Agricultural Meteorology Division.

Krishi Darshan aaniAamchi Mati Amchi Mansa' Programme Telecasted on **'Doordarshan Sahyadri'** on 15-05-2024 6PM on the occasion of 'Climate Change Day'. Participation by Shri PS Chinchole Meteorologist-B RMC Nagpur.

Krishi Darshan aaniAamchi Mati Amchi Mansa' Programme being telecasted

IMD issued daily weather forecasting video of about 5 minutes duration in English & Hindi through YouTube, Facebook, Twitter and IMD website.

11.3. New Projects / Schemes / Programmes Approved / Initiated

Infrastructure Development & Installations

Third Generation Meteorological Satellite INSAT-3DS for meteorological observations and monitoring of land and ocean surfaces for weather forecasting and disaster warning successfully launched on 17th February, 2024. This significant achievement marks a substantial advancement in India's meteorological observation capabilities. The deployment of INSAT-3DS heralds a new era in meteorological data acquisition and analysis. Various departments under the Ministry of Earth Sciences, including the India Meteorological Department (IMD) and the National Centre for Medium-Range Weather Forecasting (NCMRWF), will harness the satellite's data to provide enhanced weather forecasts and vital meteorological services.

IMD has installed and commissioned H-AWOS at 11 heliports, which were inaugurated by **Shri Kiren Rijiju**, Hon'ble Union Minister of Earth Sciences on 25th February, 2024 at Itanagar Arunachal Pradesh.

Shri Kiran Rijiju, Hon'ble Minister, MoES presided the Foundation Stone Laying and Bhumi Pujan Ceremony of Meteorological Observatory, Gangasagarat Sagar Island, Rudranagar, South 24, Parganas District, West Benagal on 28th February, 2024 .

X-Band Doppler Weather Radar (DWR) at Lansdowne inaugurated by **Shri Kiran Rijiju**, the Hon'ble Minister, MoES on February , 2024.

Dr. Mrutyunjay Mohapatra, DG IMD had a meeting with **Dr. Mrudula G.**, Senior Principal Scientist, Centre for electromagnetics, CSIR, NAL, Bangalore on 15th February, 2024 regarding joint R&D activities related to aviation weather forecasting. Mr. Gajendra Kumar, Head, Central Aviation Meteorology Division also participated in the meeting.

During the Quarter January-March, 2024, 21 new stations were added in Rainfall Network.

SERVICES

Hon'ble Minister of Earth Sciences inaugurated the Doppler Weather Radar at Lansdowne, Uttarakhand on 23rd February, 2024 in the presence of **Dr. M. Mohapatra**, DG IMD, Hon' ble MP and former Chief Minister of Uttarakhand, **Shri Tirath Singh Rawat and Mr. Ranjit Sinha**, Secretary, Disaster Management, Uttarakhand.

IMD Visitor Management System (IMD VMS) started in DGM office with effect from 20th February, 2024 for issuing Gate Pass to the visitor at New Delhi office after capturing his/her photograph with other details.

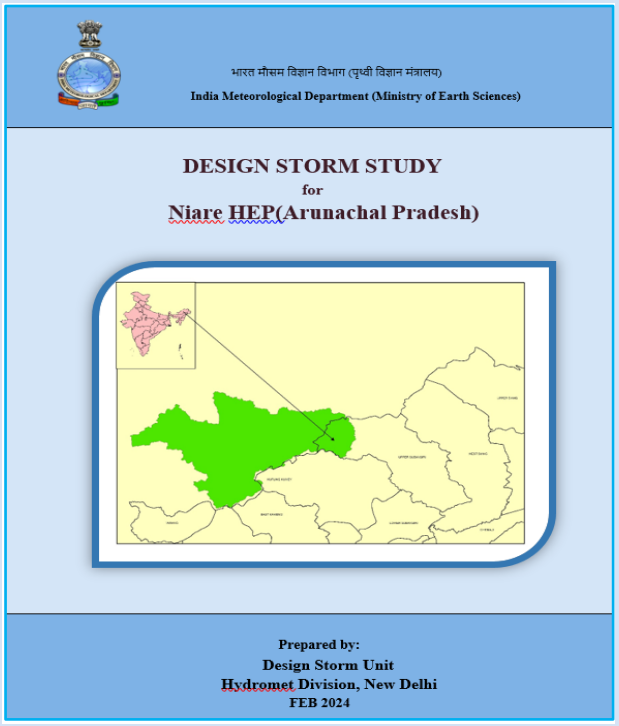
Online Applications Forms made LIVE in METNET for all IMD employees w.e.f. 17th January, 2024 with initially three forms listed below: a. Permission of Higher Education b. Intimation of purchasing of Immovable property c. Intimation of purchasing of movable property.

Two Modules created for Ex-IMD employees 1) Getting feedback and 2) Confirmation of participation in Inaugural function of IMD 150th foundation Day celebration.

Online Applications Forms made LIVE in METNET for all IMD employees are as follows:

- Application for Change of Home Town - w.e.f. 09.02.2024.
- Application for issue of NOC for obtaining passport to visit foreign countries - w.e.f. 09.02.2024.
- NPS Form 1 – Option to avail benefits in case of death or discharge on invalidation or disability of Govt. Servant / subscriber during service - w.e.f. 22.02.2024.
- NPS Form 2 – Form for Details of Family w.e.f. 22.02.2024

Detailed Project Report of Niare Hydro Electric Project, Arunachal Pradesh has been completed and values sent to the concerned Project Authority.



Design Storm Study for Niare Hydro Electric Project, Arunachal Pradesh

11.4. ADDRESSES OF VARIOUS REGIONAL METEOROLOGICAL CENTRES & METEOROLOGICAL CENTRES

RMC New Delhi
Head, Regional Meteorological Centre,
IMD, RMC Building,
Lodi Road, New Delhi – 110003
e-mail : rmc.delhi@imd.gov.in

RMC Chennai
Head, Regional Meteorological Centre,
IMD, RMC Chennai, New 6, Tamil Nadu – 600006
e-mail : rmc.chennai@imd.gov.in

RMC Mumbai
Head, Regional Meteorological Centre,
IMD, RMC Mumbai, Colabba,
Maharashtra – 400005
e-mail : rmc.mumbai@imd.gov.in

RMC Kolkata
Head, Regional Meteorological Centre,
RMC Kolkata, 4, Dual Avenue, Alipur
Kolkata – 700027
e-mail : rmc.kolkata@imd.gov.in

RMC Nagpur
Head, Regional Meteorological Centre,
IMD, DBAI Airport, Sonegaon, Nagpur – 440005
e-mail : rmc.nagpur@imd.gov.in

RMC Guwahati
Head, Regional Meteorological Centre,
IMD, RMC Guwahati, LGB I Airport,
Guwahati – 781015
e-mail : rmc.guwahati@imd.gov.in

Climate Research & Services, IMD Pune
The Head, Climate Research and
Services, IMD, Shivajinagar,
Pune - 411 005

Positional Astronomy Centre, Kolkata
Block AQ, Sector-V, Salt Lake, Mahish
Bathan, Kolkata 700 091, West Bengal

Delhi Region

Head
MeteorologicalCentre,
Sector 39 C, Chandigarh – 160036.
e-mail:chandimet@yahoo.com

Head
Meteorological Centre,Budhsinghpura,
Sanganer,Jaipur (Rajasthan) – 302029.
e-mail:mcjpr@imd.gov.in

Head
MeteorologicalCenterLucknow,
Chaudhary Charan Singh International Airport,Amausi,
Kanpur Road, Lucknow (Uttar Pradesh) – 226009.
e-mail:amo.lkn@imd.gov.in

Head
MeteorologicalCentre,
Ram Bagh Bridge, Airport Road,RamBagh,Srinagar,
(Jammu and Kashmir) – 190015.
e-mail:mc.srn@imd.gov.in

Head
Meteorological Centre,Mohkampur, Haridwar
Road,Dehradun(Uttarakhand)–248005.
e-mail:metcentre-dehradun@imd.gov.in

Head
MeteorologicalCentre,
BibraHouse,CliffendEstate,
Shimla (Himachal Pradesh) – 171001.
e-mail:mc.sml@imd.gov.in

Head
Meteorological Centre,LehLadakh Ecological
Hostel,Yurthung Leh, Ladakh – 194101.
e-mail:metcentreleh@gmail.com

Chennai Region

Head
Meteorological Centre,PalaceRoad,
Bengaluru (Karnataka) – 560001.
e-mail:mc.bng@imd.gov.in

Head
MeteorologicalCentre,
AirportColony,MotilalNehruNagar,Begumpet,Hyderabad(Telangana)–500016.
e-mail: mchyd@imd.gov.inamo.hyd@imd.gov.in

Head
Meteorological Centre,ObservatoryHills,
VikasBhavan,
Thiruvananthapuram (Kerala) – 695033.
e-mail:mc.trv@imd.gov.in

Head
Meteorological Centre,
AmaravatiSRM University Campus,
Neerukonda, Guntur District,
(AndhraPradesh) – 522503.
e-mail:mc.amaravati@gmail.com

Mumbai Region

Head
Meteorological Centre, AhmedabadRS/RW Building,
Airport Colony,
Ahmedabad(Gujarat) –382475.
e-mail:mc.ahm@imd.gov.in

Head
Meteorological Centre, GoaAltinho,
Panaji (Goa) – 403001.
e-mail:mc.goa@imd.gov.in

Kolkata Region

Head
MeteorologicalCentre,
Biju Patnaik International Airport,
Bhubaneshwar (Odisha) – 751020.
e-mail:mc.bwn@imd.gov.in

Head
MeteorologicalCentre,
Baluwakhan, Gangtok (Sikkim) – 737103.
e-mail:mc.gtk@imd.gov.in

Head
MeteorologicalCentre,
Jayprakash Narayan International Airport,
Patna (Bihar)– 800014.
e-mail:mc.patna@imd.gov.in

Head
MeteorologicalCentre,
Hinoo,NearBirsaMundaAirport,Ranchi(Jharkhand) – 834002.
e-mail: metranchi.admn@gmail.com
metranchi@gmail.com

Head
MeteorologicalCentre, Portblair
South Andaman(A&NIslands)–700027.
e-mail: imd.gspbl@gmail.com
URL: https://mausam.imd.gov.in/portblair/

Nagpur Region

Head
Meteorological Centre,
AreraHills, Jail Road,
Bhopal(MadhyaPradesh)–462011.
e-mail:mc.bhp@imd.gov.in

Head
Meteorological Centre, NearMMI Hospital,
Lalpur,Raipur(Chhattisgarh)–492015.
e-mail:mc.rpr@imd.gov.in

Guwahati Region

Head
Meteorological Centre, ItanagarOpp. SBI
Banderdewa,Banderdewa (POST),
PapumPare(Distt.),(Arunachal Pradesh) – 791123.
e-mail :mcitanagar@yahoo.com
mcitanagar@gmail.com

Head
Meteorological Centre, Agartala
AgartalaAirport,
WestTripura,
Agartala(Tripura)–799009.
e-mail:mc.agt@imd.gov.in

Head
Meteorological Centre, Shillong
3rd Mile Laimer, Upper Shillong
(Meghalaya) – 793005.
e-mail:metshillong@gmail.com
Website URL : https://mausam.imd.gov.in/shillong/

Head
MeteorologicalCentre, Kohima
AAI Residential Colony Dimapur
Airport Dimapur, Nagaland – 797115.
e-mail : nalnishchaudhary@gmail.com

Head
Meteorological Office,
PO- Lengpui, Distt.- Aizwal (Mizoram) – 796421.
e-mail: admin.rmcguwahati@imd.gov.in

Head
MeteorologicalCentre, Imphal
Airport, PO- Changangei,
Distt.- Imphal West (Manipur) – 795140.
e-mail: ambedkar444@gmail.com
Website URL : https://mausam.imd.gov.in/imphal/

भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

पृथ्वी विज्ञान मंत्रालय, भारत सरकार

Ministry of Earth Sciences, Govt. of India