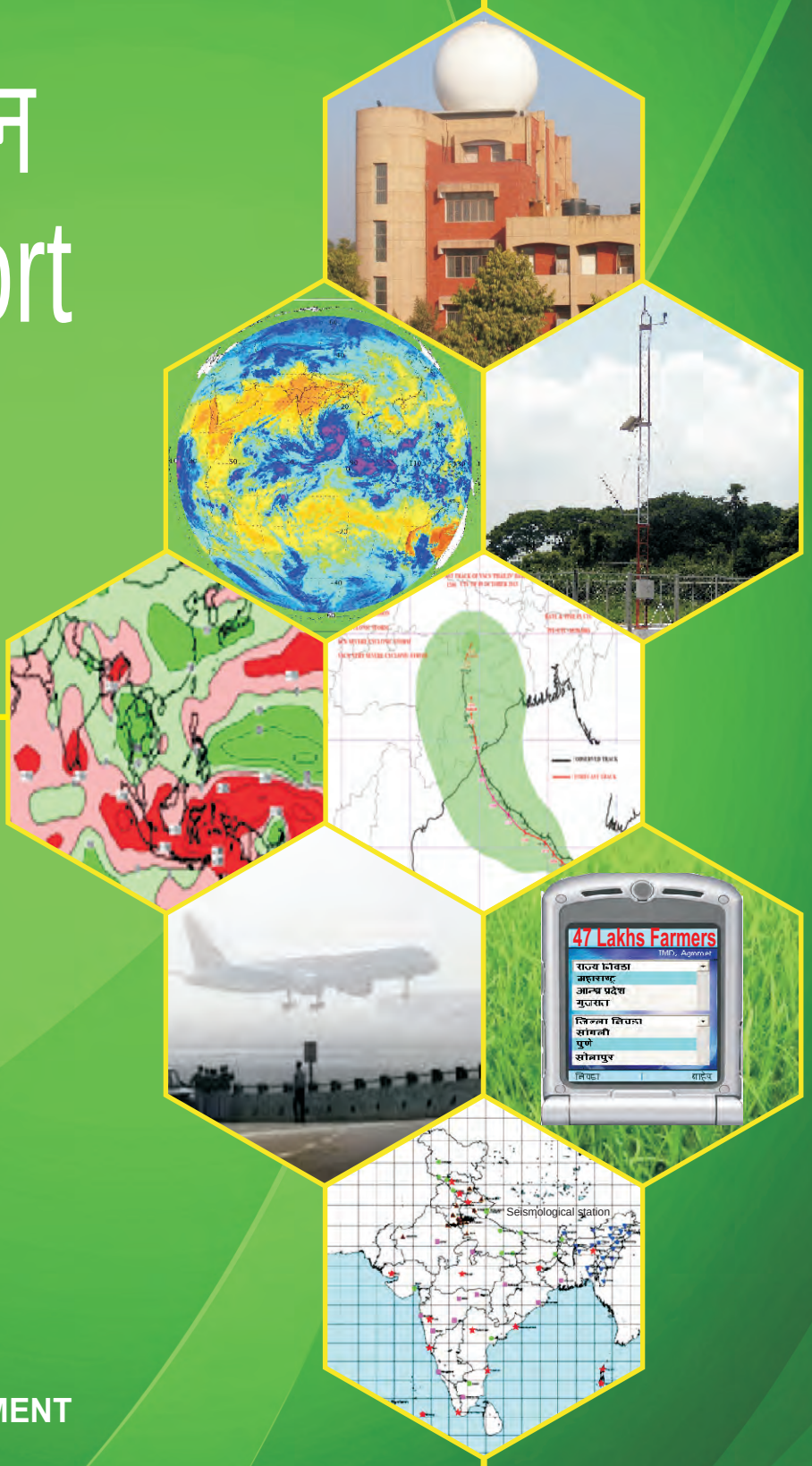
वार्षिक प्रतिवेदन
Annual Report
2013



भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

पृथ्वी प्रणाली विज्ञान संगठन
Earth System Science Organisation

पृथ्वी विज्ञान मंत्रालय, भारत सरकार
Ministry of Earth Sciences, Govt. of India

वार्षिक प्रतिवेदन

ANNUAL REPORT

2013

INDIA METEOROLOGICAL DEPARTMENT

(MINISTRY OF EARTH SCIENCES, GOVT. OF INDIA)

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FOREWORD

The year 2013 was very eventful in terms of severe weather and associated predictions. That said events, such as the extreme rainfall events of Uttarakhand and above normal cyclonic storms in Bay of Bengal, remind us of the critical role meteorology plays in managing crisis. India Meteorological Department (IMD) has played crucial role, supporting those responsible for disaster management. Accurate prediction & its timely dissemination for very severe cyclonic storm Phailin that crossed Odisha coast also underlined how indispensable our early warning system is.

The year 2013 has been both a year for consolidation and a year for preparing the future. Years of consolidation because the developments initiated in XI five year plan for creating the state-of-the-art meteorological infrastructure of Doppler Weather Radars (DWRs), Automatic Weather Stations (AWSs), Automatic Rain Gauges (ARGs), GPS upper air systems, telecommunication systems and High Performance computing systems (HPCS) to implement global data processing, assimilation and numerical weather prediction (NWP) for weather forecasting services have borne fruit. Augmentation in observing system including surface, upper air, ocean, Radar and satellites and assimilation of observations generated by them into global and regional Numerical Weather Prediction models (~20 GB per day) facilitated through High Power Computing Systems (HPCS) in conjunction with improved understanding of physical processes & constant improvement in NWP models has led to significant improvement in the forecasting capabilities of the department and public perception. Integration of scientific programs related to atmosphere, ocean, cryosphere and geosphere has further added to its performance.

A year for preparing the future by tracking down the XII five year plan schemes and foundations of our future activity were laid. After some intense internal reflections and discussions with authorities at Ministry of Earth Sciences, new schemes and initiatives, setting the framework for improving the services are laid out. It confirms the priorities given to safety, but also in particular stresses the

importance of research, observations, modeling, forecasting and services. This outlines an ambitious endeavour for IMD, aimed at placing itself, in the future as in the past, at the forefront of meteorological and climate service provision. The new schemes of the department have begun to be implemented. Understanding needs for augmentation of very specialized services of Earth Science System Organization (ESSO) and IMD in particular constant efforts are made and will be further augmented. This will strengthen our early-warning capacities in the face of events, further enriching our range of tools designed to protect people and property.

Agromet Advisory services program of the Department has a direct impact on livelihood & farming community. 47 Lakhs farmers are provided weather information based advisories through mobile phones. Beside this, farmers are getting this information through all possible modes of information dissemination including Radio, television, internet, print media etc. This programme would be continued to have larger coverage with improved advisories, and having closer coordination with State government authorities to improve the existing district level Agromet Advisory Services (AAS) to block level. To further improve weather forecasting and services and upgrade the meteorological systems to strengthen its observing system in data gap areas, particularly in mountainous region Integrated Himalayan Meteorology Program has been planned.

Here, I take the opportunity to draw attention to the commitment of the staff at IMD, working in the public interest, and to thank them for all of the results obtained over the years, while the unexpected, which is of course the rule in weather and climate matters, continually presented itself and required still more effort from us all.

Despite a difficult year, the achievements give us confidence that the IMD has the capacity to meet the challenges and thus commit itself to serving all users, mobilizing its staff and technical resources, combining high level research, operational control and expertise.

Dr. Laxman Singh Rathore
Director General of Meteorology

1. IMD: A SCIENTIFIC AND TECHNICAL ORGANIZATION

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.

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.

Alipore Observatory, Kolkata founded in 1877

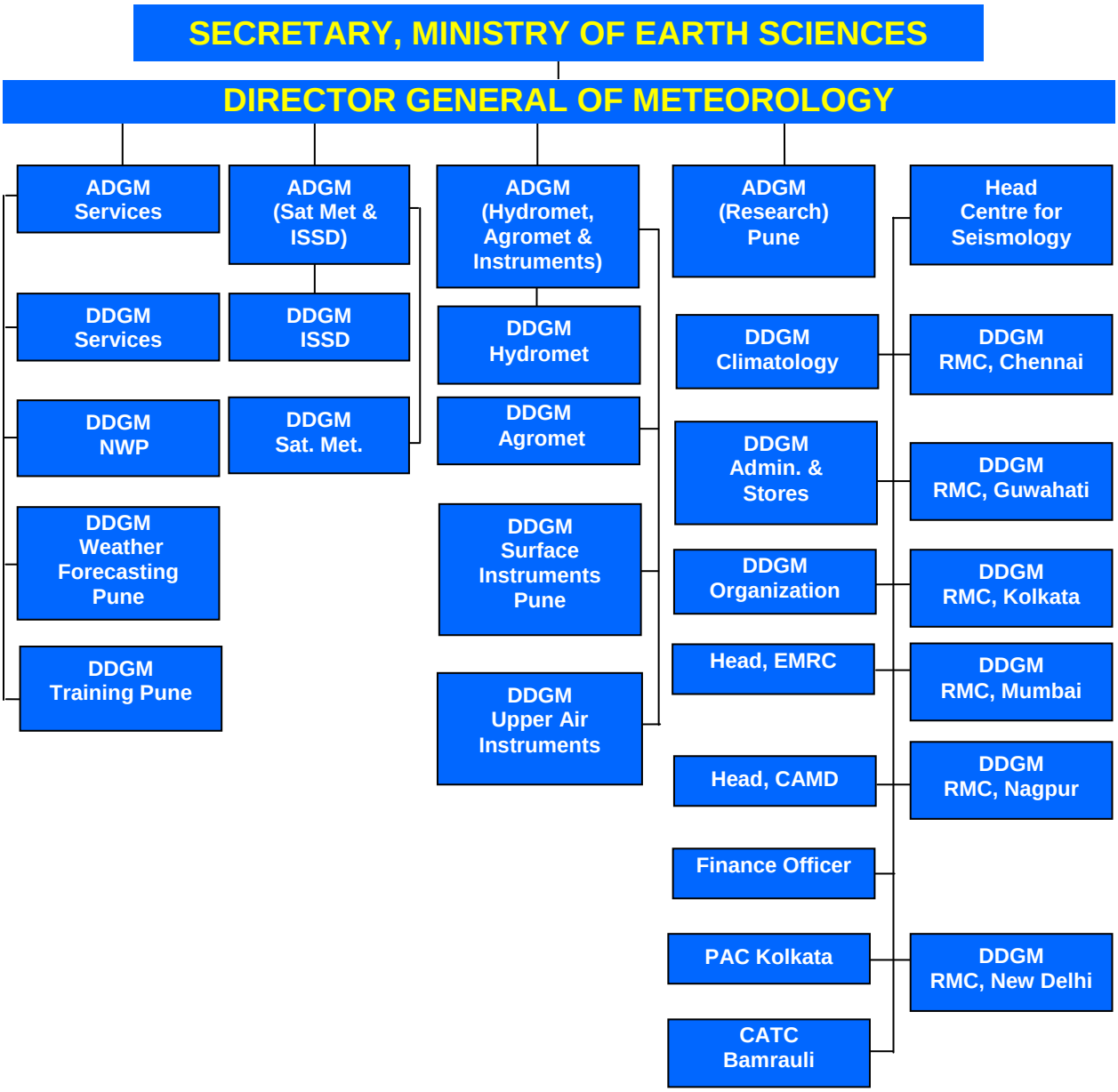
The Headquarters of IMD were later shifted to Shimla, then to Poona (now Pune) and finally to New Delhi.

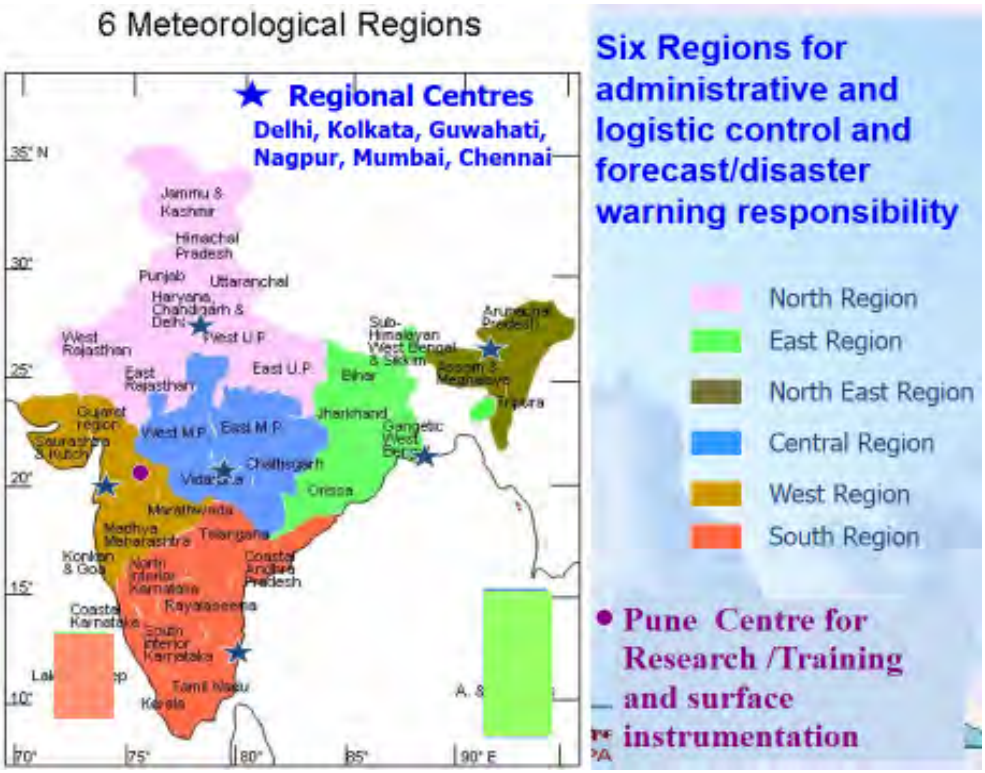
From a modest beginning in 1875, IMD has progressively expanded its infrastructure for meteorological observations, communications, forecasting and weather services and it has achieved a parallel scientific growth. IMD has always used contemporary technology. In the telegraph age, it made extensive use 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 138 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.

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 06 Regional Meteorological Centres, each under a Deputy Director General with headquarters at Mumbai, Chennai, New Delhi, Kolkata, Nagpur and Guwahati. Under the administrative control of Deputy Director General, there are different types of operational units such as Meteorological Centres, Forecasting Offices, Agrimet. Advisory Centres, Flood Meteorological Offices and Cyclone Detection Radar Stations.

ORGANISATIONAL STRUCTURE





In addition, there are separate divisions to deal with specialized subjects, which are:

IMD ORGANIZATION CHART

INDIA METEOROLOGICAL DEPARTMENT
MINISTRY OF EARTH SCIENCES
GOVT. OF INDIA

Hon'ble Minister for Ministry of Science & Technology, Ministry of Earth Sciences.

Dr. Shailesh Nayak
Secretary, Ministry of Earth Sciences

Dr. L. S. Rathore,
Director General of Meteorology

Divisional Heads

Shri Rajeev Sharma, DDGM (Administration & Store)
Dr. L. R. Meena, Scientist 'F' / DDGM (Information System & Services Division)
Shri A. K. Sharma, Scientist 'F' / DDGM (Satellite Meteorology)
Dr. R. S. Dattatrayam, Scientist 'F' /Head (Centre for Seismology)
Shri M. K. Bhatnagar, Scientist 'F' / Head (Central Aviation Meteorology Division)
Dr. (Smt.) S. Kaur, Scientist 'F'/ DDGM (Hydrology)
Dr. S. K. Roy Bhowmik, Scientist 'F' /DDGM (Numerical Weather Prediction)
Shri R. P. Lal, Scientist 'D' (Finance Office)

Shri S. K. Kundu, Scientist 'F' / Head (Technical Aspects UAI & SI)
Shri B. K. Bandyopadhyay, Scientist 'F' / DDGM (Services)
Shri S. K. Peshin, Scientist 'F'/ Head (Environment Monitoring & Research Centre)
Shri Satish Bhatia, Scientist 'F' / DDGM (Upper Air Instruments)
Dr. K. K. Singh, Scientist 'F'/Head (Agrimet.)
Shri Surya Bali, 'F' / DDGM (Procurement)
Dr. S. D. Attri Scientist 'E'/DDGM (Organisation)

Regional Administrative & Technical Heads

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Shri M. K. Gupta, Scientist 'F' / DDGM (RMC, Guwahati)
Shri Devendra Pradhan Scientist 'E'/DDGM (RMC, Kolkata)

Shri K. S. Hosalikar, Scientist 'E'/DDGM, RMC, Mumbai)
Dr. P. K. Nandankar, Scientist 'E'/ DDGM (RMC, Nagpur)
Dr. O. P. Singh, Scientist 'F' / DDGM (RMC, New Delhi)

Pune office

Shri S. Krishniah, Scientist 'F' / ADGM(R) & Surface Instruments)
Dr. N. Chattopadhyay, Scientist 'E'/DDGM (Agrimeteorology)
Dr. Somenath Dutta, Scientist 'E' / DDGM (Training)

Shri B. Mukhopadhyay Scientist 'F'/DDGM (Climatology)
Dr. (Ms.) Medha Khole, Scientist 'E'/ DDGM (Weather Forecasting)

2. WEATHER SUMMARY 2013

Winter Season (January & February)

Salient Features

Cold wave/cold day conditions prevailed over the northern and central parts of the country during first 10 days of January and most of the days during second fortnight of January. Dense foggy conditions prevailed over northern/northeastern parts of the country almost throughout January. During February, these conditions prevailed at isolated places on a few occasions over central and northern parts of the country during the first three weeks of the month. The peninsular parts of the country were abnormally warmer during the first two weeks of January when both maximum and minimum temperature was above normal by over 5°C.

Rainfall

Rainfall activity over the country during the season as a whole was above normal. It was below normal during January (60 % of LPA) and was substantially above normal during February (181 % of LPA). Many subdivisions of north India received about two to three times of their respective normal rainfall. Except for the eastern/northeastern region which received less rainfall, excess/normal rainfall was observed throughout the country. During the season, out of 36 meteorological subdivisions, 25 received excess rainfall, 4 received normal rainfall, 2 received deficient rainfall and 5 received scanty rainfall (Fig.1 & Fig. 2).

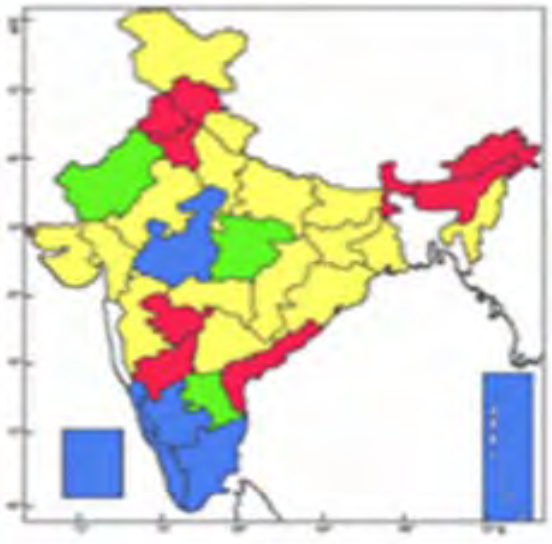


Fig. 1. Sub-division wise rainfall percentage departure for the winter season 2013

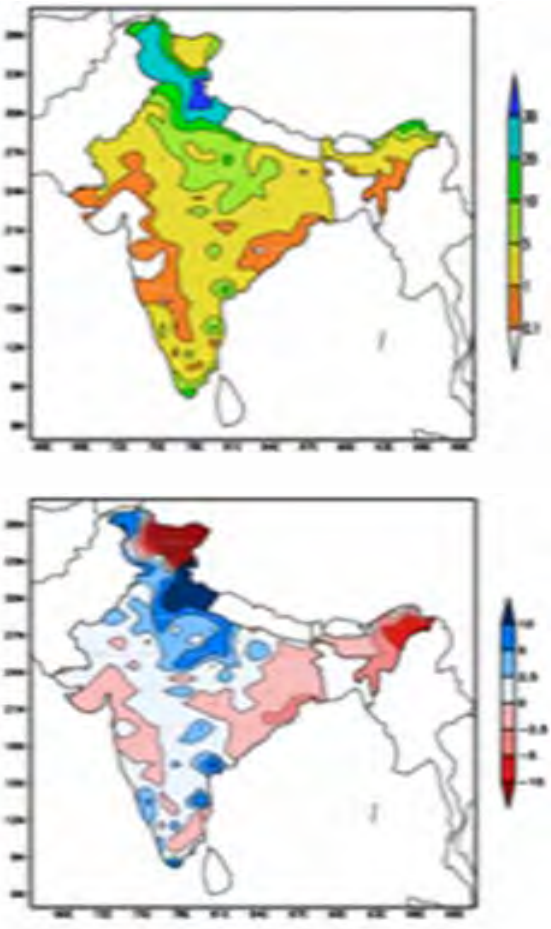


Fig. 2. Seasonal rainfall (cm) and Seasonal rainfall anomaly (cm) based on 1951-2000 Normals

Temperature

Mean seasonal maximum and minimum temperature anomalies are shown in Fig. 3a & 3b respectively. Maximum temperature was below normal over the plains of northern and eastern India and adjoining central parts of the country, and was above normal elsewhere. Over parts of Punjab, Haryana, Chandigarh & Delhi, West Rajasthan, West Madhya Pradesh, most parts of Uttar Pradesh it was below normal by about 1°C and over northern parts of Uttar Pradesh, it was below normal by about 2 to 3°C. Maximum temperature was above normal by about 1 to 2°C over parts of south peninsula and extreme northern parts of the country and by about 2 to 3°C over extreme northeastern parts of the country.

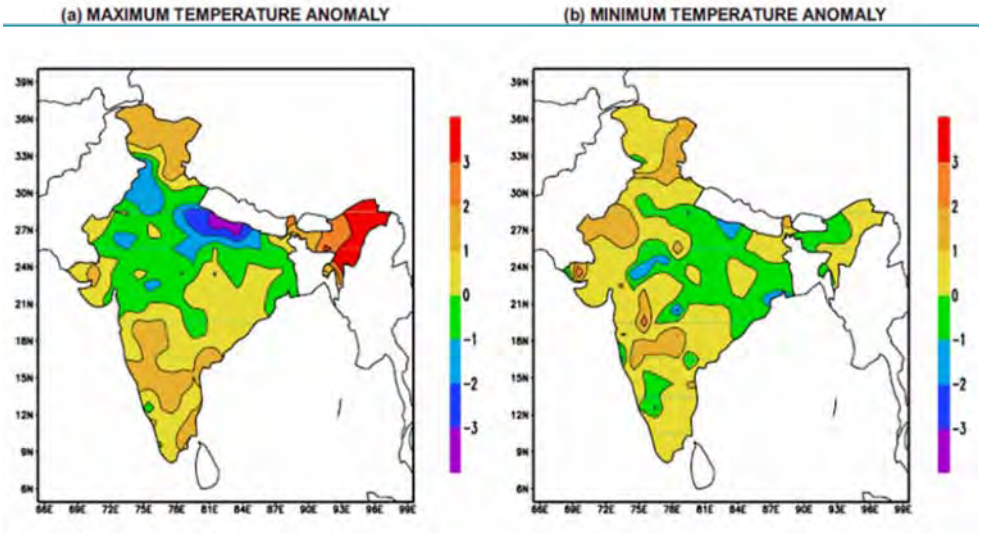


Fig. 3a & 3b. Mean seasonal Maximum and Minimum temperature Anomalies (°C) (Based on 1971-2000 Normals)

Minimum temperature anomaly was within + 1°C range over most parts of the country. However, positive anomaly exceeded 1°C over some parts of north peninsula, parts of Rajasthan, Himachal Pradesh and Jammu & Kashmir. Minimum temperature was below normal by over 1°C over parts of Madhya Pradesh, northern parts of East Uttar Pradesh, southern parts of Gangetic West Bengal and parts of Vidarbha.

Pre Monsoon Season (March, April & May)

Salient features

Heat wave / hot day conditions prevailed over northern parts of the west coast region of the country during the first ten days of March. Maximum temperature was above normal by more than 5°C over some stations of west coast viz. Naliya, Kandla, Porbandar, Dahanu, Mumbai, Harnai, Ratnagiri and Panjim on some occasions during this period. Hilly areas of northern and northeastern region of the country were also abnormally warmer during the month of March. During April, severe heat wave/heat wave conditions prevailed only for one or two days at isolated places over parts of East Uttar Pradesh during the second and fourth week, over parts of coastal Andhra Pradesh during the third week and over parts of Saurashtra & Kutch and Vidarbha

during the last week. During the first fortnight of May, severe heat wave/heat wave conditions prevailed over northeastern parts of the country for both the weeks, over central parts of the country during the first week and over the peninsular parts of the country during the second week. During the second fortnight of May, these conditions prevailed almost over the entire country during the first 10 days.

Temperature

Mean seasonal maximum and minimum temperature anomalies are shown in Figs. 4a & 4b respectively. Maximum temperature anomaly was within + 1°C over most parts of the country. However, over extreme northern/northwestern parts of the country viz., Punjab, Haryana, Chandigarh & Delhi, West Rajasthan, West Uttar Pradesh and Uttarakhand and also over extreme northeastern region of the country and some parts of peninsula, positive anomaly in maximum temperature exceeded 1°C. Over parts of Jammu & Kashmir and Himachal Pradesh, maximum temperature was above normal by about 2 to 3°C. However, it was below normal by about 1°C over some northern parts of Uttar Pradesh and parts of Gangetic West Bengal. Minimum temperature anomaly was also within + 1°C range over most parts of the country. However, positive anomaly in minimum temperature exceeded 1°C over parts of Himachal Pradesh, Jammu & Kashmir, Uttarakhand Punjab, Haryana, Rajasthan, Bihar, Sub-Himalayan West Bengal & Sikkim and some small parts of peninsula. Minimum temperature was below normal by over 1°C over some parts of Chhattisgarh, Vidarbha and Konkan & Goa.

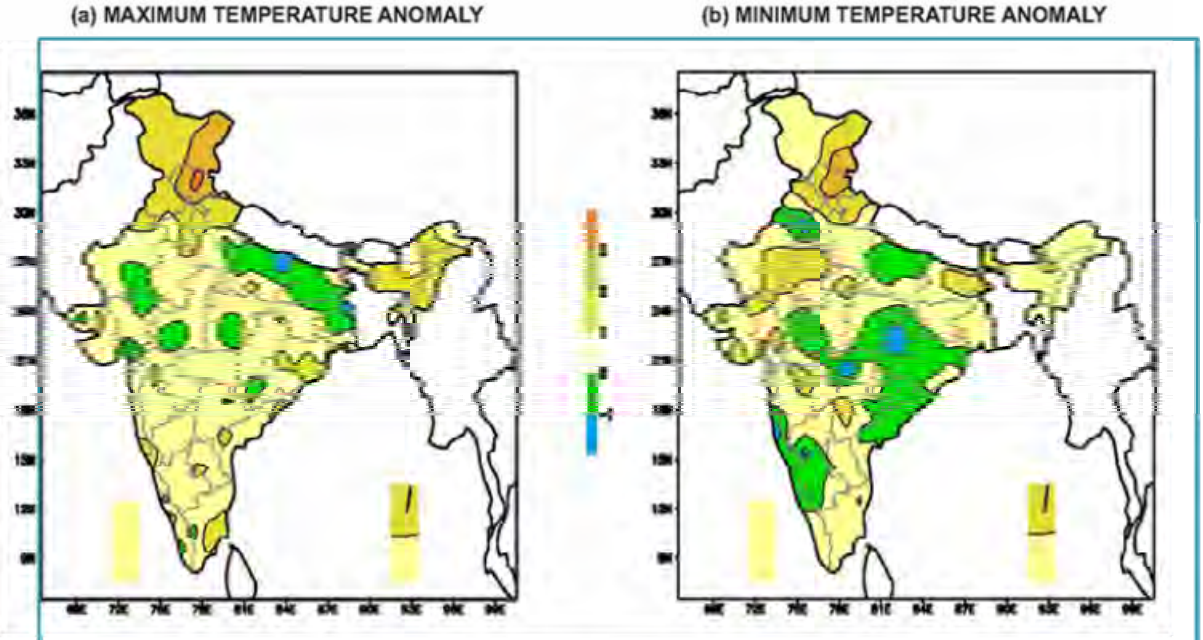


Fig. 4a & 4b. Mean seasonal Maximum and Minimum temperature Anomalies (°C) (Based on 1971-2000 Normals)

Rainfall Features

Rainfall activity over the country during the season as a whole was below normal. It was substantially below normal during March (49 % of LPA), below normal during April (77% of LPA) and was near normal during May (91 % of LPA). Meteorological subdivisions of Central, northeastern and some peninsular region of the country received excess/normal rainfall. Bihar and Gangetic West Bengal received about one and half times of its respective normal rainfall. During the season, out of 36 meteorological subdivisions, 4 received excess rainfall, 12 received normal rainfall, 13 received deficient rainfall and 7 received scanty rainfall (Fig. 5).

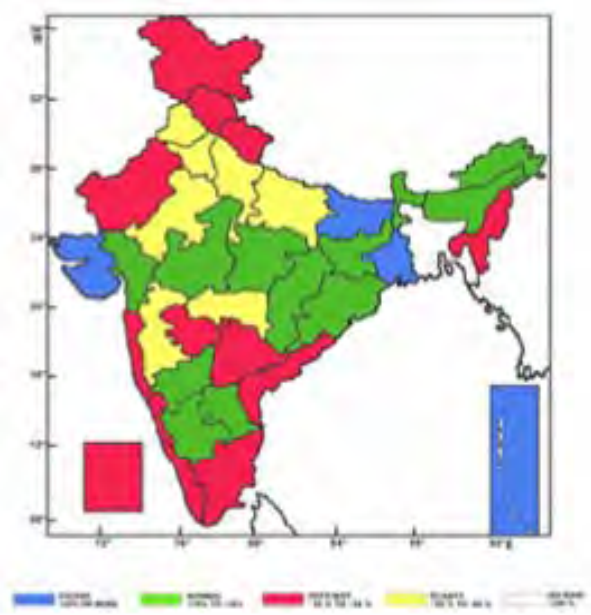


Fig.5. Sub-division wise rainfall percentage departures for the pre monsoon season 2013

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood is shown in Fig. 6. OLR anomaly was within + 10 W/m range over most parts of the Country. However, over parts of south peninsula and northeastern region of the country, negative OLR anomaly exceeded 10 W/m^2.

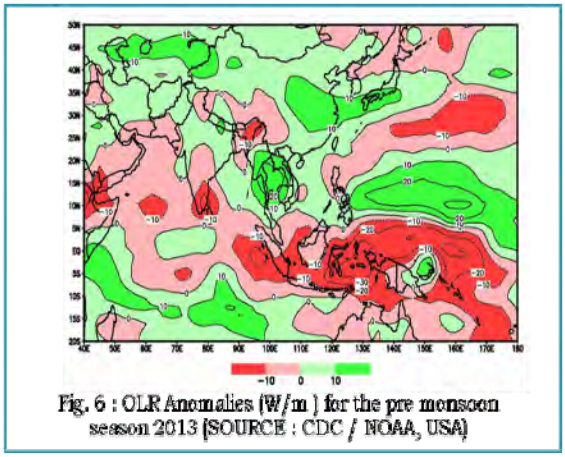


Fig. 6 : OLR Anomalies (W/m) for the pre monsoon season 2013 (SOURCE : CDC / NOAA, USA)

Monsoon Season (June, July, August & September)

Onset and Withdrawal of monsoon

The Southwest Monsoon set in over Kerala on its climatological normal date i.e., 1st June. It further advanced into Goa, south Maharashtra, Rayalaseema, Tamil Nadu, coastal & south interior Karnataka; most parts of the Bay of Bengal and some more parts of the Arabian Sea on 3rd June. It covered some more parts of central Arabian Sea, entire Goa, some parts of south Konkan, south Madhya Maharashtra, Telangana and south coastal Andhra Pradesh, remaining parts of south interior Karnataka and Rayalaseema, most parts of north interior Karnataka and some more parts of west central Bay of Bengal on 4. Monsoon rapidly advanced and covered entire south peninsula, northeastern states and most parts of central India in stages during the next week. As on 12, the NLM passed through Lat. 23°N / Long. 60° E, Lat. 23°N / Long. 65° E, Okha, Ahmedabad, Rajgarh, Satna, Ranchi, Berhampore, Jalpaiguri and Gangtok. With formation of low pressure areas over the northwest Bay of Bengal and its movement westwards, monsoon further advanced into remaining parts of north Arabian Sea and some more central and northern parts of the

country on 13 and remaining parts of West Bengal & Sikkim, Jharkhand, entire Bihar, Uttarakhand, Himachal Pradesh and Jammu & Kashmir, some more parts of east Madhya Pradesh and some parts of east Uttar Pradesh on 15. During the same period, a strong westerly system also moved across the northern parts of the country. The interaction of prevailing easterlies and extra tropical westerlies, helped monsoon to cover rapidly the remaining parts of Rajasthan, Madhya Pradesh, Uttar Pradesh, entire Haryana, Chandigarh, Delhi and Punjab. **Thus monsoon covered the entire country on 16 June, nearly a month ahead of the normal date on 15th July**. The isochrones of advance of southwest monsoon 2013 (Fig. 7).

Fig. 7. Advance of southwest monsoon 2013

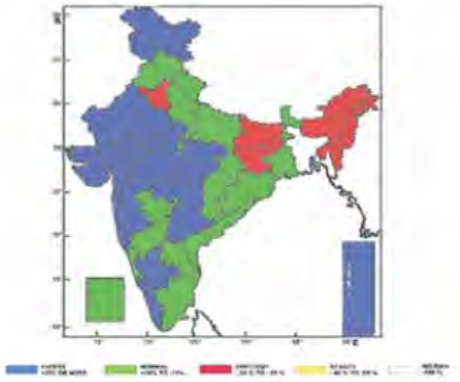


Fig. 8. Sub-division wise rainfall percentage departure for monsoon season (based on operational data)

The withdrawal of southwest monsoon form west Rajasthan commenced on 9 September. It further withdrew from entire Jammu & Kashmir, Himachal Pradesh, Punjab; some parts of Haryana; some more parts of Rajasthan and some parts of Kutch on 19. Monsoon did not withdraw further till the end of the month. **SW Monsoon 2013 has been one of the longest seasons with early onset in North west India on 16th June and late withdrawal on 17th October, 2013.**

Central and peninsular parts of the country received excess rainfall, northwestern parts of the country received normal rainfall, while eastern / northeastern parts of the country received deficient rainfall. Some sub-divisions of the central region viz. West Madhya Pradesh, Vidarbha and Gujarat state as a whole received about 40 % of its respective normal rainfall in excess. However, large rainfall deficiency (about 30 to 35%) prevailed over the subdivisions of northeastern region viz. Arunachal Pradesh, Assam & Meghalaya and Nagaland, Manipur, Mizoram & Tripura and Bihar. Also, during the first half of the season (1 June to 31 July) country received 117% of its Long Period Average (LPA) value, while during second half of season (1August to 30 September) it received 93% of its LPA value. At the end of season, out of 36 meteorological sub-divisions, 14 received excess rainfall, 16 received normal rainfall and the remaining 6 subdivisions received deficient rainfall (Fig. 8). The sub-division wise distribution of rainfall percentage departures for the four months of monsoon season (June to September) 2013 is depicted in Fig. 9. Number of sub-divisions receiving excess,

normal, deficient and scanty rainfall during each month of the season and monthly rainfall received as the percentage of Long Period Average (LPA) for each month is given in the Table 1.

Table 1

Month	Jun	Jul	Aug	Sept
Excess	25	13	8	9
Normal	8	12	18	10
Deficient	2	11	10	13
Scanty	0	0	0	4
(% OF LPA)	132	106	97	84

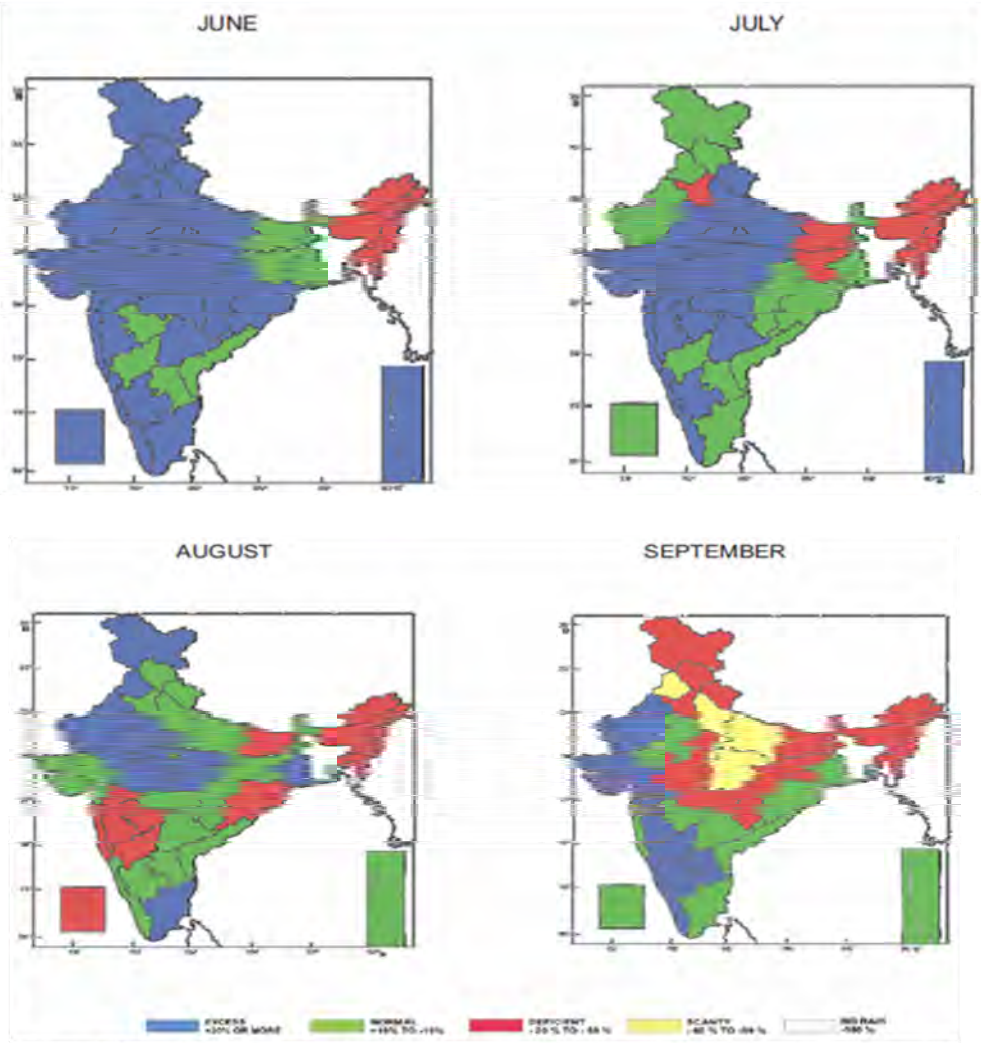
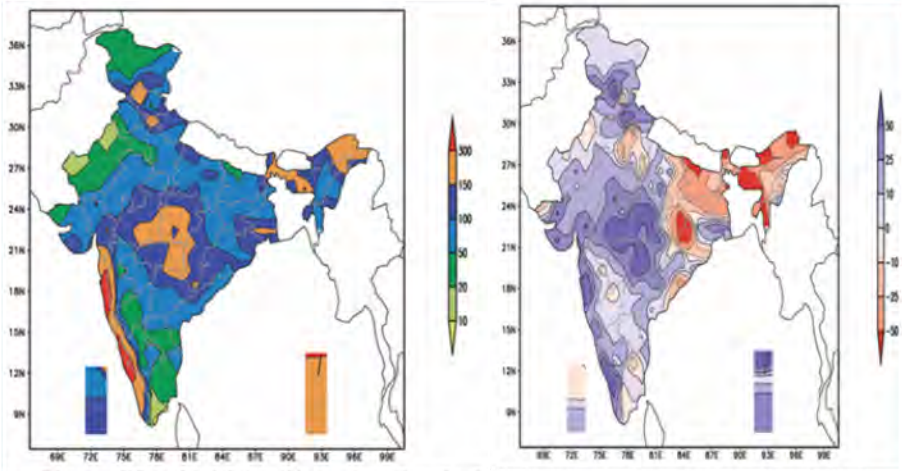


Fig. 9. Monthly sub-division wise distribution of rainfall percentage departures *(based on operational data)*

Fig. 10a & 10b show the spatial pattern of rainfall received during the season and its anomaly (cm) from the long-period average respectively Central, adjoining peninsular, some northern and extreme northeastern parts of the country generally received 100 to 150 cm of rainfall. Rainfall received over the west coast, some parts of Madhya Pradesh, Jammu & Kashmir, Himachal Pradesh, Sub-Himalayan West Bengal & Sikkim, Arunachal Pradesh, Meghalaya and Andaman &Nicobar Islands was more than 200 cm. Seasonal rainfall was above normal over most parts of the country except parts of eastern/northeastern region and parts of West Uttar Pradesh and adjoining Haryana. Over central and adjoining north peninsular parts of the country, parts of the West coast, some extreme northern parts of the country and Andaman & Nicobar Islands, positive rainfall anomaly generally exceeded 25 cm. Magnitude of negative rainfall anomaly over parts of Bihar Jharkhand, northern parts of Chhattisgarh and adjoining Odisha and parts of extreme northeastern region was more than 25 cm. Cumulative rainfall departure was positive throughout the season. The area weighted rainfall for the season was 106% of its LPA value (Fig. 11).



Figs. 10a & 10b. Seasonal rainfall (cm) and seasonal rainfall anomaly (cm)
(Based on 1951-2000 normals)

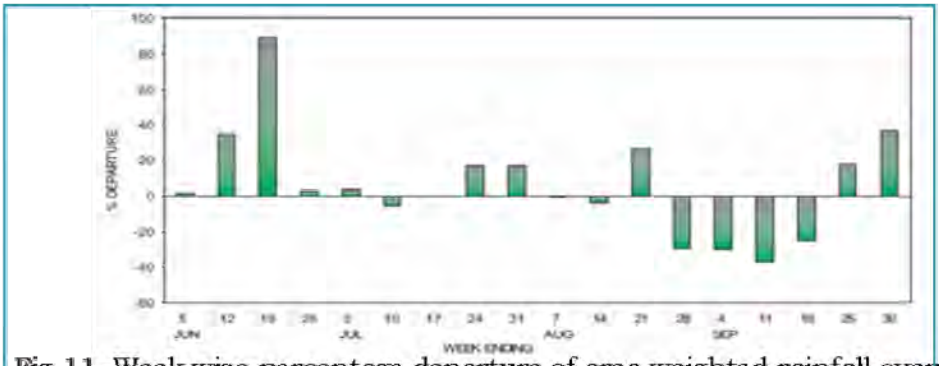


Fig.11. Week wise percentage departure of area weighted rainfall over the country as a whole

The rainfall for the season was above normal over Central India (123% of LPA) and South Peninsula (115% of LPA), near normal over the Northwest India (109% of LPA) and below normal over the East & Northeast India (72% of LPA).

Maximum temperature was considerably below normal during the first half of the season over central and adjoining northern and peninsular parts of the country. After the first ten days of June, it was substantially below normal over the central and northern parts of the country probably due to early onset of southwest monsoon. During July, it was below normal over central and peninsular parts of the country mainly due to prevalence of active monsoon conditions almost throughout the month over the region. The southwest monsoon season rainfall over the country as a whole was near normal. However, there was a marked spatial and temporal variability.

Post Monsoon season (October, November & December)

Southwest monsoon withdrew from the entire country on 21st October. The commencement of northeast Monsoon rains over the southern peninsular India occurred simultaneously on 21st October. The season was cyclogenetically very active for North Indian Ocean (Arabian Sea and Bay of Bengal). In the month of October, one Very Severe Cyclonic Storm (VSCS Phailin, 8th – 14th October) formed over Bay of Bengal which crossed Odisha-north Andhra coasts close to Gopalpur on 12th October. It caused severe weather in Odisha, West Bengal and Andhra Pradesh. Due to the timely and accurate warnings, the loss of life was minimal. A well-marked low pressure area (20th – 26th October) formed on over Bay of Bengal which caused extremely heavy rainfall over coastal Andhra Pradesh and Odisha. In the month of November, a Very Severe Cyclonic Storm (VSCS, Lehar, 23rd – 28th November), a Severe Cyclonic Storm (SCS, Helen, 19th – 23rd November) & a Depression (13th – 17th November) formed over Bay of Bengal and a Deep Depression (8th - 11th November) formed over the Arabian Sea. The VSCS Lehar and SCS Helen crossed Andhra Pradesh coast, close to Machilipatnam. The Depression over the Arabian Sea crossed Somalia coast and the Depression over the Bay of Bengal crossed Tamil Nadu coast near Nagapattinam. The tracks of the systems are given in Fig. 12. One Cyclonic Storm (CS, Madi, 6th -13th December) formed over the Bay of Bengal during the month of December. The system crossed Tamil Nadu coast once, close to Vedaranyam and subsequently, it emerged into Palk Strait and then again crossed near Tondi. Appreciably below to below normal night temperatures prevailed from the second week of November over major parts of north, east and central India and parts of south Peninsula. Cold wave conditions prevailed in some parts of Odisha, Haryana, Punjab, west Rajasthan, Saurashtra & Kutch, Madhya Maharashtra, Vidarbha and north interior Karnataka on a few days from the second week of December.

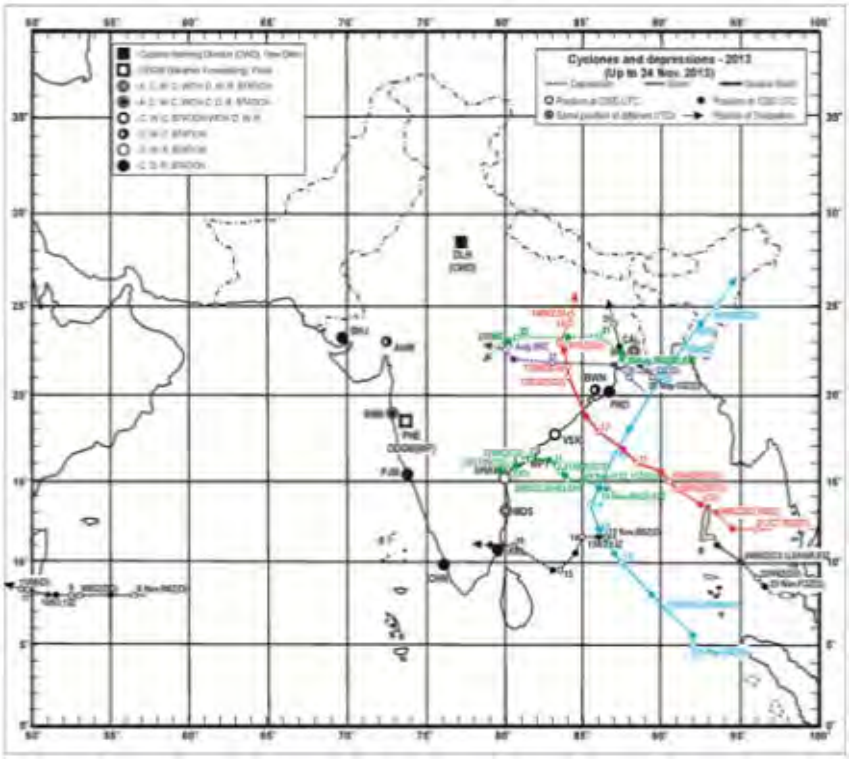


Fig. 12. Tracks of storm and Depressions during the yearwise percenage departure of area weighted rainfall over the country as a whole

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 drought and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. Cumulative SPI values of the season indicate, extremely wet/severely wet conditions over parts of Jammu & Kashmir, Punjab, Uttarakhand, East Rajasthan, Madhya Pradesh state, Vidarbha and adjoining parts Telangana, Gujarat Region, Saurashtra & Kutch, Konkan, north Madhya Maharashtra, Coastal Karnataka, South Interior Karnataka, Kerala and some adjoining parts of Tamil Nadu and Gangetic West Bengal, while extremely dry/severely dry conditions were observed over parts of Haryana, East Uttar Pradesh, Bihar, Jharkhand, north Chhattisgarh, West Bengal, north coastal Odisha, Assam and Meghalaya, Nagaland, Mizoram, Tripura, Coastal Andhra Pradesh and Tamil Nadu. Cumulative SPI values of the Year indicate, extremely wet/severely wet conditions over parts of Himachal Pradesh, Punjab, Uttarakhand, Haryana, East Rajasthan, East &West Madhya Pradesh, Gujarat Region, Saurashtra & Kutch, Vidarbha and adjoining north Telangana, Konkan, north Coastal Karnataka, and Kerala while extremely dry/severely dry conditions were observed over parts of Haryana, East Uttar Pradesh, Bihar, Jharkhand, north Chhattisgarh, Coastal Odisha, north Coastal Andhra Pradesh, Tamil Nadu and parts of extreme northeastern region viz. Sub-Himalayan West Bengal, and Assam & Meghalaya.

3. OBSERVATION AND INFRASTRUCTURE

Atmospheric observation infrastructure forms the backbone of any meteorological service and intensive monitoring of various weather systems through different platform based observing systems provide not only the necessary information about current weather systems, their effective assimilation in numerical models provide important guidance for accurate forecasts. Further augmentation is ongoing for extensive weather observation acquisition and collection platform to supplement the existing infrastructure.

SURFACE & UPPER AIR OBSERVATION

Surface Instruments

IMD has upgraded its observational networks under the modernization programme and installed the state-of-art surface observational systems (Fig. 3.1).

During the year 2013, Digital Distant indicating wind equipments have been installed at Lengpui airport, Aizwal and Leelabari airport, North Lakhimpur. One High wind speed recorder has been installed at Goa. Three AWS observatories have been established at Pahalgam, Chandanwadi and Baltal enroute Shri Amarnathji Yatra (Fig. 3.2) during April 2013. A new Wind Tunnel (Fig. 3.3) having a speed range of 0-70 mps has been installed at AWS lab, Pune for calibration of Wind sensors and anemometers.

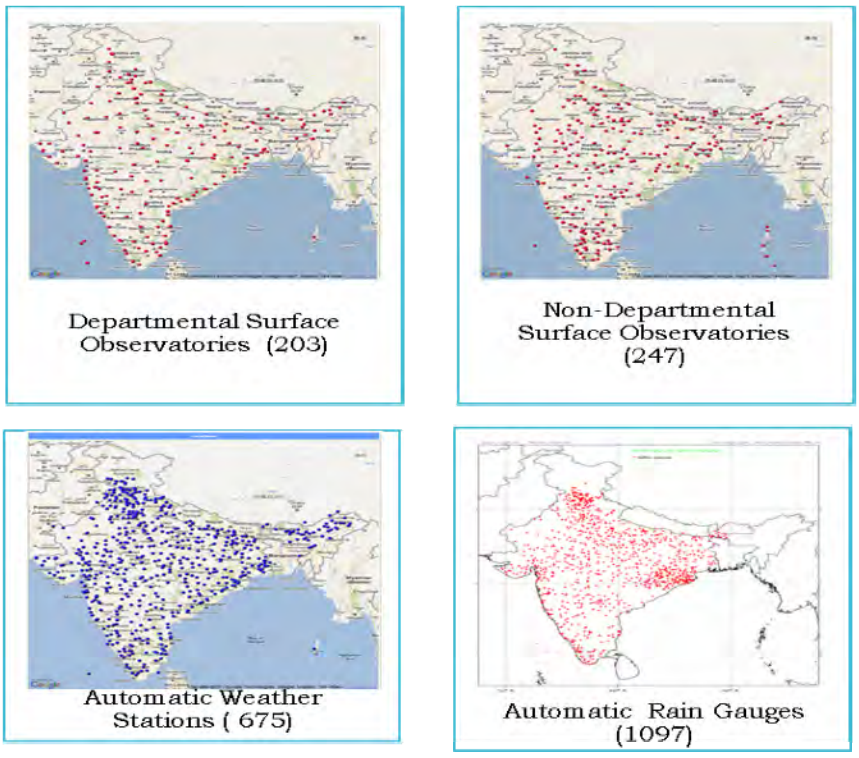


Fig. 3.1. Surface observation Network

Fig. 3.2. AWS installations enroute Shri Amarnathji Yatra.

Fig. 3.3. Wind Tunnel

Radiation Network

The spectral measurement of UV-B radiation (in the range 280 – 320 nm) assumes great importance which requires the measurements to be made in very narrow wavelength bands of the UV–B region by very sensitive photomultipliers. Forty five UV-B radiometers have been procured for augmentation of radiation network, out of these, twenty three UV-B radiometers have been installed (Fig. 3.4) and interfaced to data loggers at different network stations. Data loggers at these stations are also interfaced to GPRS modems, which acquire data from the data logger and transmit it on the website, at 10 minutes interval which can be accessed at any location. This has also helped in easy monitoring of data and health of the sensors at field stations. Radiation data of 13 selected stations were sent to World Radiation Data Centre (WRDC), Russia for publication.

Upper Air Instruments

IMD is operating a network of 39 Radiosonde/Radiowind (RS/RW) stations (Fig. 3.5), 62 Pilot Balloon Observatories (Fig. 3.6) on operational basis. One of the core activities of IMD is the weather forecasting that includes NWP modelling. Meteorological data thus

collected from all over the country are used on real time basis for operational forecasting. The upper air atmospheric profiles from the network are shared globally via the WMO telecommunications network. GPS based radiosounding systems (Fig. 3.7) were installed at 11 locations under the upper air network of IMD at Chennai, Hyderabad, Goa, Amini Divi, Thiruvananthapuram, Minicoy, Patna, Mohanbari, Portblair and Srinagar. MK-IV modified radiosonde by using digital pressure screen instead of barrow-switch has been implemented at RS/RW stations of Gwalior, Gorakhpur, Jaipur, Siliguri, Mumbai, Jagdalpur, Machilipatnam, Karaikal, Raipur, Guwahati and Ranchi. Procurement of different components initiated to start the production indigenous developed GPS based radiosonde developed based on TOT with M/S SAMEER, Mumbai.

Fig. 3.4. UV-B Radiometers

Fig. 3.5. RS/RW Network (39)

Fig. 3.6. Pilot Balloon Networks (62)

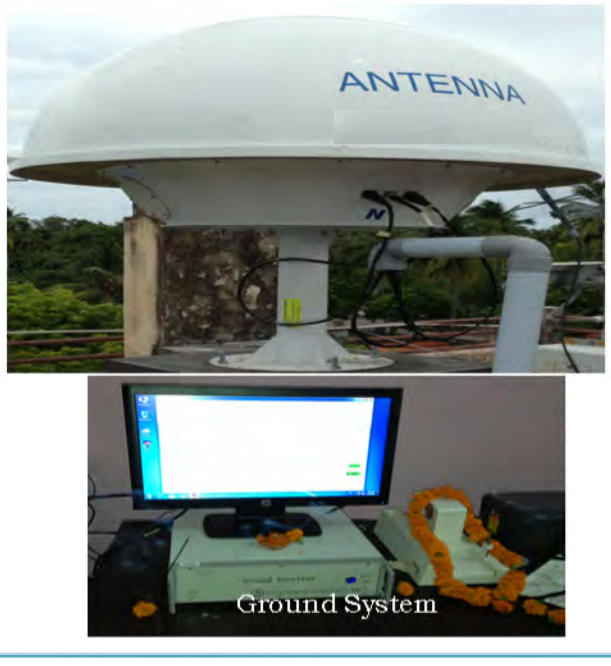


Fig. 3.7. Upper Air System

WEATHER RADAR NETWORKS

IMD now has a network of 16 Doppler Weather Radars (Fig. 3.8). During the year 2013, DWR has been inducted into the Radar network with the commissioning at Bhopal. DWR installation at Cherrapunjee through ISRO also completed and same will be inducted into the network soon. Security Audit also being carried by a High Level committee for installation at Paradip, Karaikal and Goa. Central DWR server is being tested with state of technology Open Source Server Virtualization Platform for easy portability and configuration using HP Z 800 96GB Machines. Real time DWR data reception and dissemination to end users improved. Pilot Data Archival Scheme implemented at Central server using NAS Box. Archival facility using NAS Box facility implemented in Patna, Agartala, and Hyderabad.

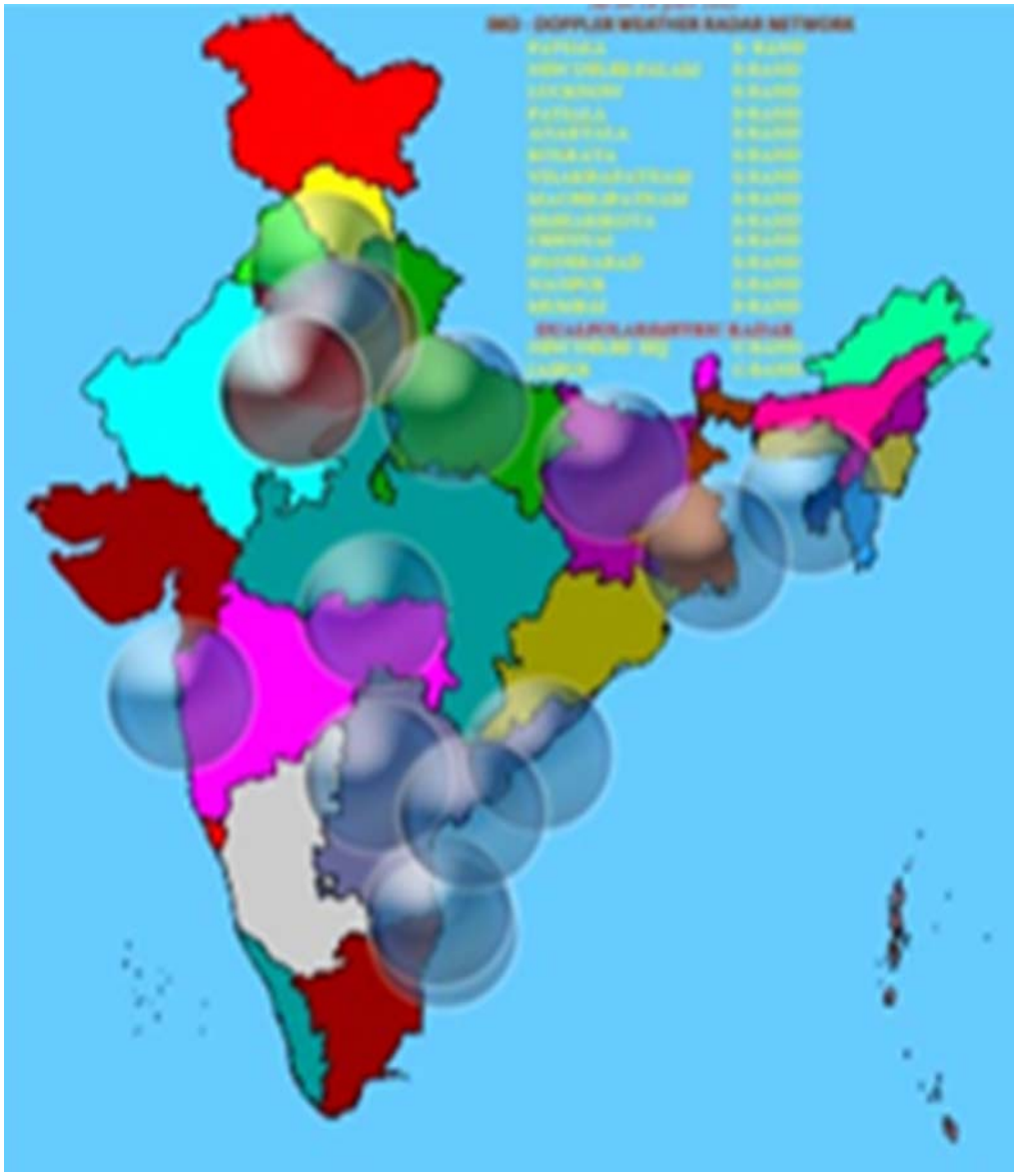


Fig. 3.8. Doppler Weather Radars

Radar products form a very important guiding tool for improving our nowcasting System. GIS based display system (Fig. 3.9) has been developed for the Radar products from the data of DWR stations. The raw data (Z, w & v) is received at the IRIS central server stationed at New-Delhi. This data is then processed and reflectivity based products (PPI, PCAPPI and Surface Rainfall intensity) is produced. This data is converted into png images, geo referenced and then put on Google maps using Java scripting. The real time data generates following products Plan Position Indicator (Z), Volume Velocity Processing, Surface Rainfall intensity and MAX (Z) Products Radar Winds at 1 km is put in online mode. The data is available as a Mosaic for all the stations for PPI, PC APPI and SRI. The information on the individual station is also made available on choosing the products. The data is put on the Google maps (using API key) with the facility to zoom and transparency - settings controlled by the user.

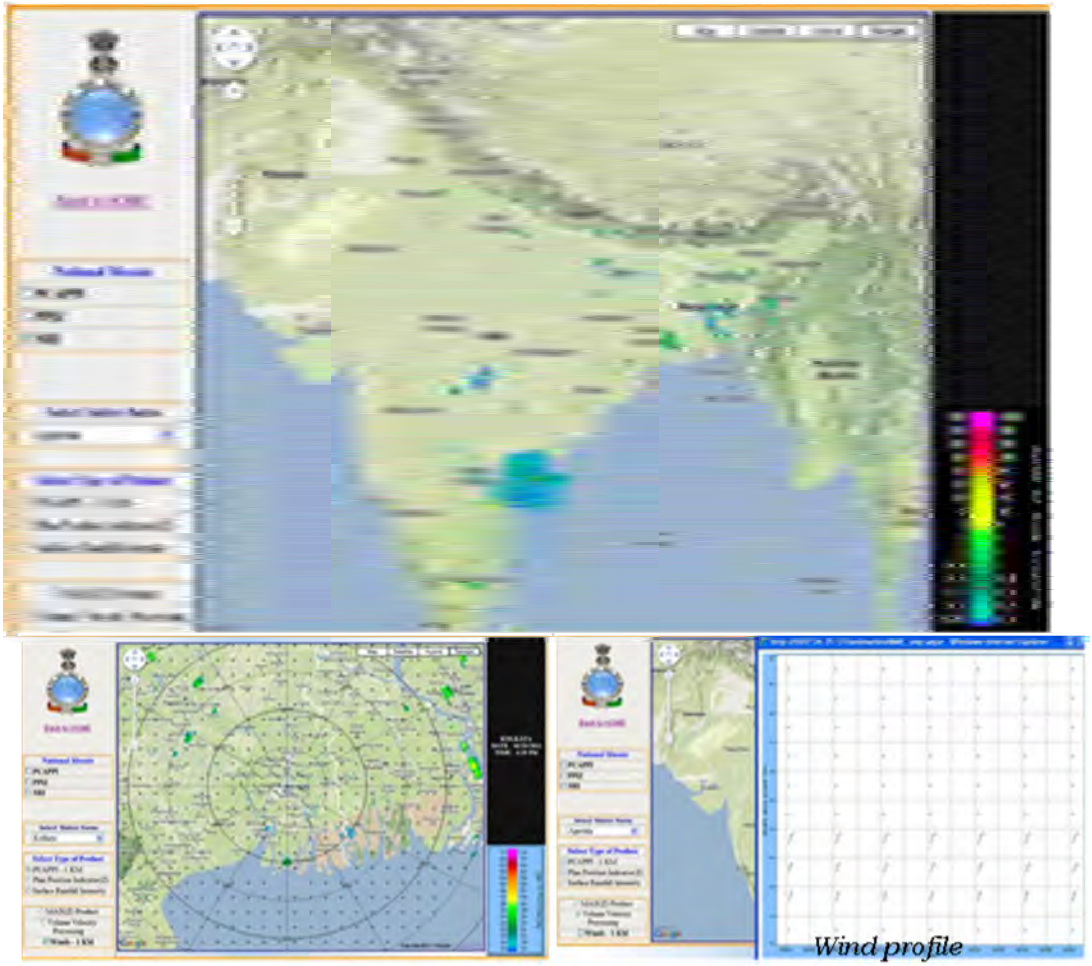


Fig. 3.9. *PCAPPI along with Radar winds at 1 kms for Kolkatta*

SATELLITE METEOROLOGY APPLICATIONS

The satellite images and data are a vital need for forecasting and their use in weather forecasting is increasing day by day. IMD receives and processes meteorological data from the meteorological payloads of INSAT satellites namely Kalpana-1, INSAT-3A and INSAT-3D. At present 48 nos. of satellite images are taken daily from Kalpana-1 VHRR which is the main operational satellite and twenty four images are taken from INSAT-3A VHRR. Imaging from CCD is done 5 times during daytime only. The qualitative products generated after processing the satellite data are transmitted to users for use in Weather forecasting.

INSAT-3D

A new satellite INSAT-3D (Fig. 3.10) was launched on 26th July, 2013 and is located at 82 degree East carrying 6 channel imager for imaging the earth in visible (0.55-0.75um), SWIR (1.55-1.70um) of resolution 1 km × 1 km, MIR (3.80-4.00um), TIR-1 (10.30-11.30um), TIR-2 (11.50-12.50um) of resolution 4 km × 4 km and WV (6.50-7.10um) of resolution

8 km × 8 km. INSAT-3D also carrying 19 channel sounder consisting of 7 channels of LWIR (14.71-12.02um), 5 channels of MWIR (11.03-6.51um), 6 channels of SWIR (4.572-3.74um) and one channel of visible (0.695um) each of resolution 10 × 10 km scan the atmosphere for derivation of profiles. The new generation advanced dedicated meteorological satellite INSAT-3D carries six channel imager, nineteen channel sounder, DRT & satellite aided search and rescue payloads with several advanced features such as it has higher spatial resolution in visible, thermal infrared band, yaw flipping on every six month basis and star sensor for achieving better navigation accuracy.

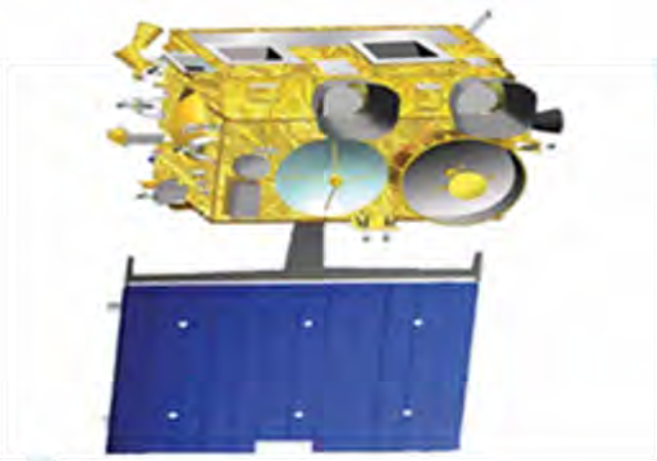


Fig. 3.10. satellite INSAT-3D

India,s most advanced Geosynchronous meteorological satellite INSAT-3D was launched on 26th July, 2013 carrying payloads Six Channel Imager, 19 Channel Sounder, Data Relay Transponder, Satellite Aided Search and Rescue (SAS & R) Transponder.

Additional shortwave IR channel for day time & middle infrared band to provide night time images of low cloud & fog. Splitting of thermal IR band into two channel for achieving better accuracy in estimating sea surface Temp. From sounder data, atmospheric profiles are derived for temp at 40 vertical pressure level from surface to about 70 km and for Water Vapour in 21 levels from surface to about 15 km along with several new products. Availability of INSAT-3D images and products will enhance the forecasting capabilities. After installation of upgraded software of INSAT-3D and initial In-Orbit testing the data reception and processing of INSAT-3D satellite has been started w.e.f. 15th September, 2013 on experimental basis. Reception of meteorological data in real time basis from INSAT-3D Earth Station has been made operational.

The products and resolution & accuracy give in brackets as derived from INSAT-3D are Multi Channel (0.5 deg × 0.5 deg), Sea Surface Temperature (MCSST) (1 pixel / 0.3 K), Brightness Temperature (Per Pixel), Snow cover (Per Pixel), Snow depth (NDSI) (Point), Fire (Point), Smoke (0.1 deg × 0.1 deg), Aerosol, CMV (IR Wind) (Point), WV Winds, Visible Wind (Point), MIR wind (Point), Fog (Per Pixel), Wind Index (3 × 3 pixels(Average), OLR (3 × 3 pixels (Average), Quantitative Precipitation Index (IMSRA Method) (0.25 × 0.25 deg), Quantitative Precipitation Estimate (GPI Method)

(1 deg × 1 deg), Cloud Mask (Per Pixel), Rainfall using Hydro Estimator (Per Pixel), Humidity profile (3 × 3 pixels (Average), Total Ozone (3 × 3 pixels (Average), Surface Skin Temperature (3 × 3 pixels (Average), Geo-Potential height (3 × 3 pixels(Average), Total Precipitable Water (3 × 3 pixels(Average), Lifted Index (3 × 3 pixels(Average), Dry microburst Index (3 × 3 pixels (Average), Maximum vertical θe differential (3 × 3 pixels(Average) Few of the sample images and products of INSAT-3D satellite are shown below (Fig. 3.11).

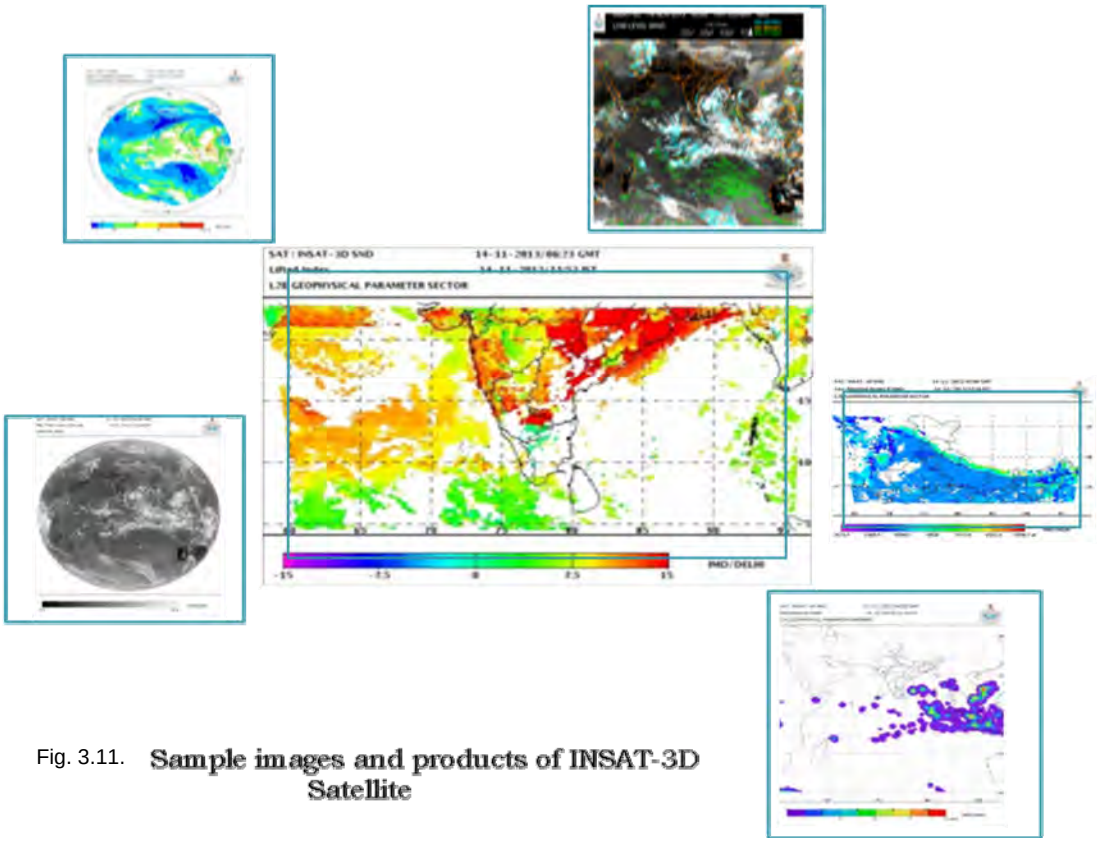


Fig. 3.11. **Sample images and products of INSAT-3D Satellite**

INFORMATION SYSTEMS, SERVICES & BASIC INFRASTRUCTURES

Meteorological telecommunication of India Meteorological Department (IMD) consists of an integrated network of point-to-point circuits and multipoint circuits which inter connect meteorological centers within the country and the world for receiving data and relaying it selectively. It is mainly organized on a two level basis, the meteorological telecommunication network within the Global Telecommunication System (GTS) of World Weather Watch (WWW) program of World Meteorological Organization (WMO), and the National Meteorological Telecommunication Network (Fig. 3.12). AMSS (Automatic Message Switching System) at Guwahati, Nagpur and Mirror RTH system at Pune commissioned.

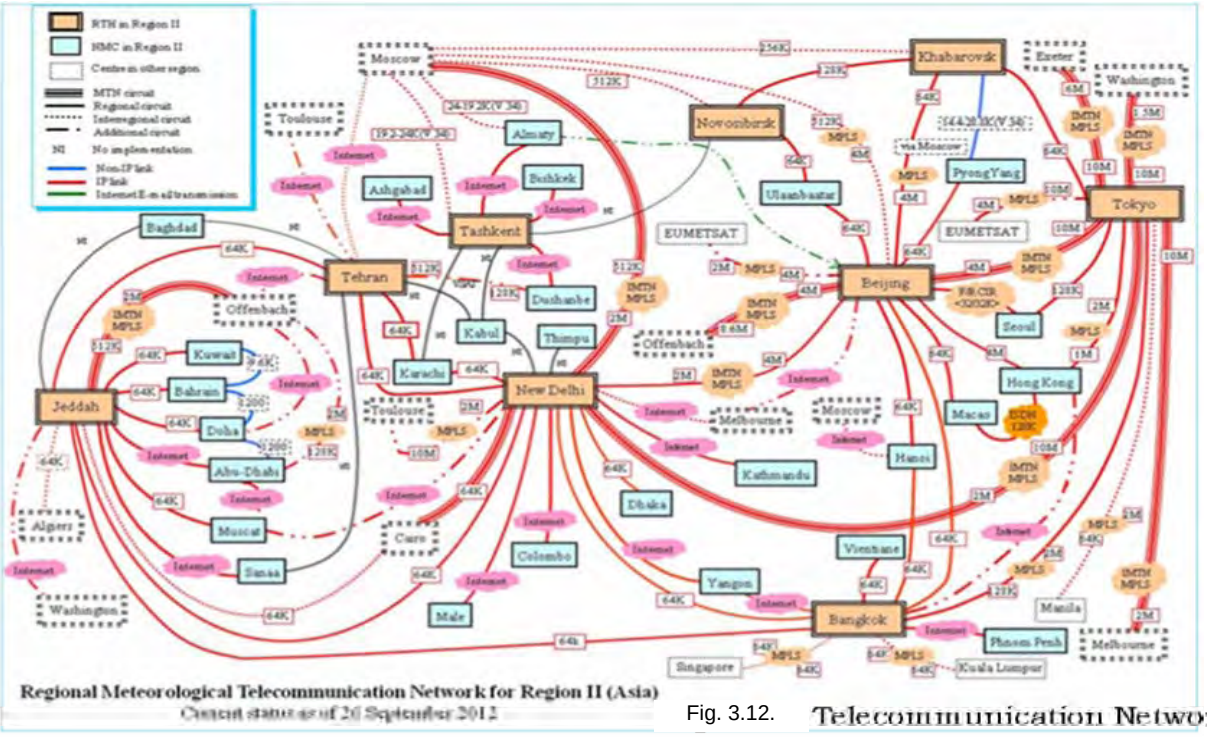


Fig. 3.12. Telecommunication Network

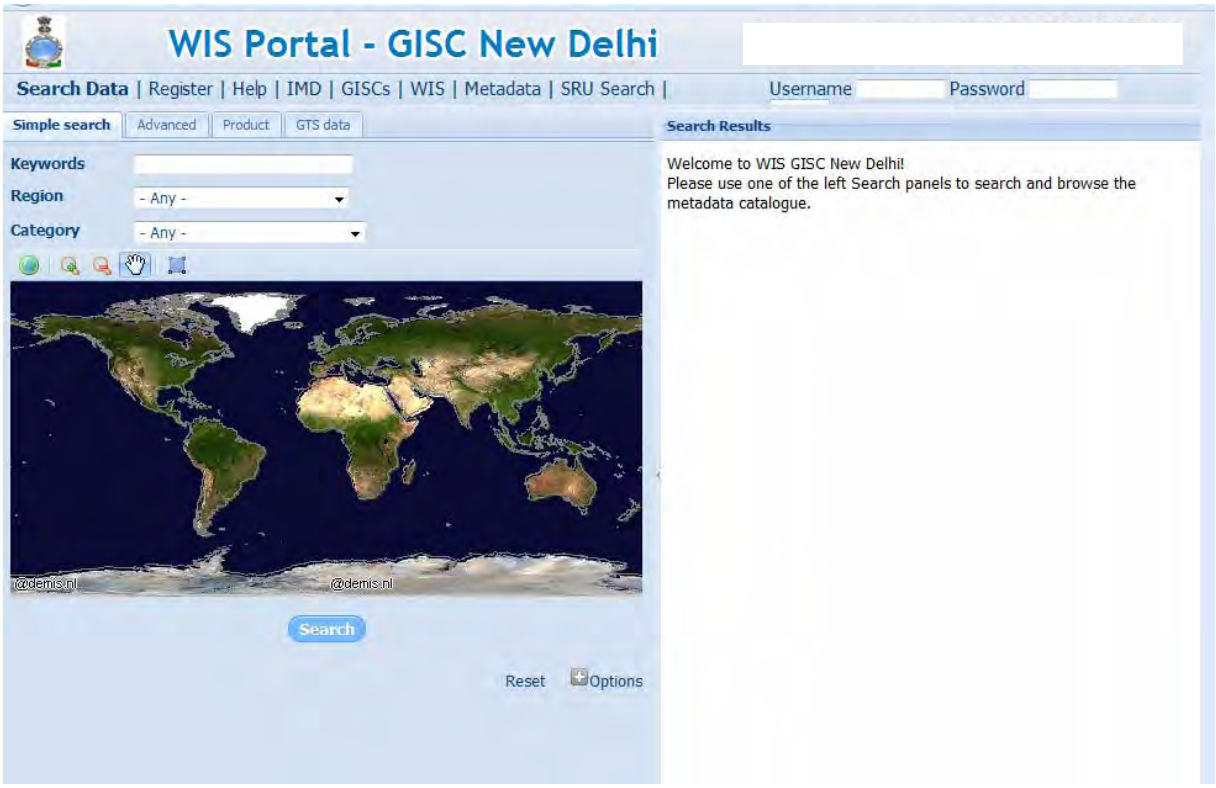


Fig. 3.13. WIS Portal

Primary RTH will meet all the functionality under WMO for meteorological data exchange. As per WMO recommendation, DRC (Disaster Recovery Centre) site at Pune has been commissioned in September 2013. The Mirror RTH shall act as a disaster recovery centre for RTH New Delhi and maintain all met data, products to meet the user

requirements in case of failure of RTH New Delhi to follow the best practices of met operations on 24 hour basis. Global Information System Centre (GISC) has been installed at Pune under WMO WIS (WMO Information System) programme. Audit team from WMO visited I.M.D Pune during 10th - 12th September 2013 in connection with WIS compliance System at Pune for consideration of Global Information System Centre (GISC) in India. The WIS portal www.wis.imd.gov.in (Fig. 3.13) has been launched meeting all WMO WIS specifications like metadata creation/upload, metadata synchronization with other GISCs. It has the provision for 24 hour cache data, authentication of other users etc. Now IMD status has risen from Regional to International level Global data dissemination centre. Agreement signed between I.M.D and ECMWF for up gradation of Moscow / Tokyo / Beijing/ Toulouse MPLS IP- VPN circuit from Orange Business to inter route communication Limited. All operational work for RTH New Delhi, AMSS etc. was conducted successfully for exchange of National & International data. WMO Monitoring of Data reception was conducted from 1 October 2013 to 15 October 2013 for national data. AMC for MFI has been awarded for a period of one year.

4. SYSTEMS OF FORECASTING

The operational forecasting services of IMD were called upon on several occasions in 2013 to deal with some major episodes of bad weather. Support was also given to public authorities, using operational tools to forecast the weather. Management of these episodes has improved the faith in public, thanks to advances in modelling of the atmosphere.

OPERATIONAL NUMERICAL WEATHER PREDICTION

With the commissioning of High Performance Computing System (HPCS) in December 2009, National Centre for Environmental Prediction (NCEP) based Global Forecast System (GFS T574/L64) has been made operation at the IMD, incorporating Global Statistical Interpolation (GSI) scheme as the global data assimilation for the forecast up to 7 days. Currently, it runs twice in a day (0000 UTC and 1200 UTC). In addition to this, the meso-scale forecast system WRF (ARW) with 3DVAR data assimilation is being operated daily twice, at 27 km, 9 km and 3 km horizontal resolutions for the forecast up to 3 days using initial and boundary conditions from the IMD GFS-574/L64 (horizontal resolution over the tropics ~22 km). At ten other regional centres, very high resolution mesoscale models (WRF at 3 km resolution) are made operational. Doppler weather and mesoscale dynamical model based nowcast system was made operational for the national Capital of Delhi. Polar WRF is implemented to provide day to day short range (48 hours) weather forecast for the Maitri region over Antarctica.

Recently under Indo-US joint collaborative program, IMD adapted Hurricane-WRF model for Tropical Cyclone track and intensity forecast for North Indian Ocean (NIO) region for its operational requirements. The basic version of the model HWRFV (3.2+) which was operational at EMC, NCEP, USA was ported on IMD IBM P-6/575 machine with nested domain of 27 km and 9 km horizontal resolution and 42 vertical levels with outer domain covering the area of 800 × 800 and inner domain 60 × 60 with centre of the system adjusted to the centre of the observed cyclonic storm.

As part of WMO Program to provide a guidance of tropical cyclone (TC) forecasts in near real-time for the ESCAP/WMO Member Countries based on the TIGGE Cyclone XML (CXML) data, IMD implemented JMA supported software for real-time TC forecast over North Indian Ocean (NIO). The Ensemble and deterministic forecast products from UKMO (50+1 Members), NCEP (20+1 Members), UKMO (23+1 Members) and MSC (20+1 Members) are available near real-time for NIO region for named TCs. These Products includes: Deterministic and Ensemble TC track forecasts, Strike Probability Maps, Strike probability of cities within the range of 120 kms 4 days in advance. The JMA provided software to prepare Web page to provide guidance of tropical cyclone

forecasts in near real-time for the ESCAP/WMO committee Members.

As a part of effort to translate research to operation, and to meet the need of the operational forecaster, IMD developed and implemented an objective NWP based Cyclone Prediction System for the operational cyclone forecasting work. The method comprises of five forecast components, namely (a) Cyclone Genesis Potential Parameter (GPP), (b) Multi-Model Ensemble (MME) technique for cyclone track prediction, (c) Cyclone intensity prediction, (d) Rapid intensification and (e) Predicting decaying intensity after the landfall.

District Level Quantitative five days weather forecasts based on Multi-Model Ensemble (MME) system are being generated to support Agro-Meteorological Advisory Service of India, making use of model outputs of state of the art global models from the leading global NWP centres. All these NWP products are routinely made available on the IMD web site www.imd.gov.in. Performance of NWP models (Fig. 4.1 & 4.2) to predict extremely heavy rainfall event of Uttarakhand during 17-18 June 2013.

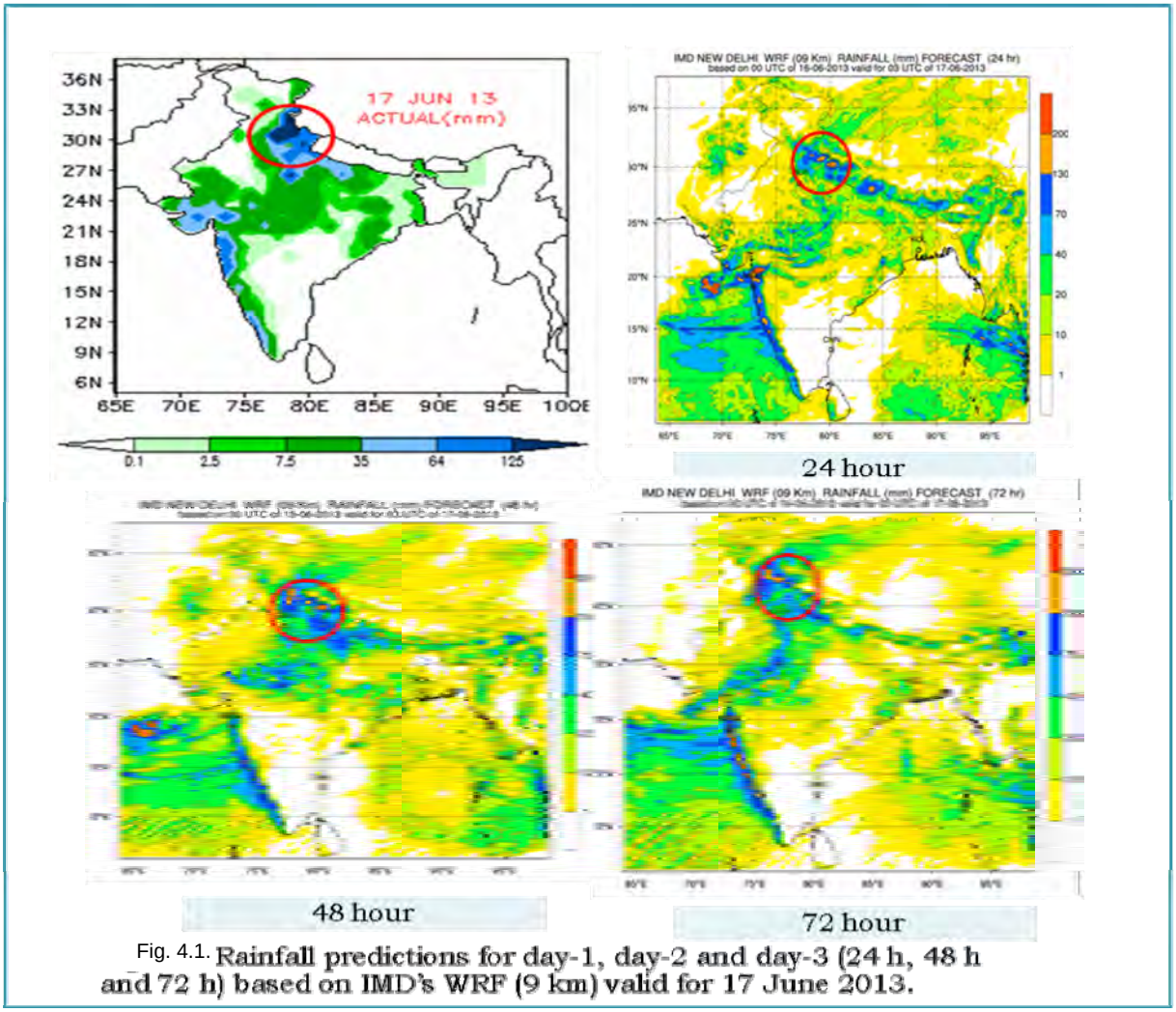


Fig. 4.1. Rainfall predictions for day-1, day-2 and day-3 (24 h, 48 h and 72 h) based on IMD's WRF (9 km) valid for 17 June 2013.

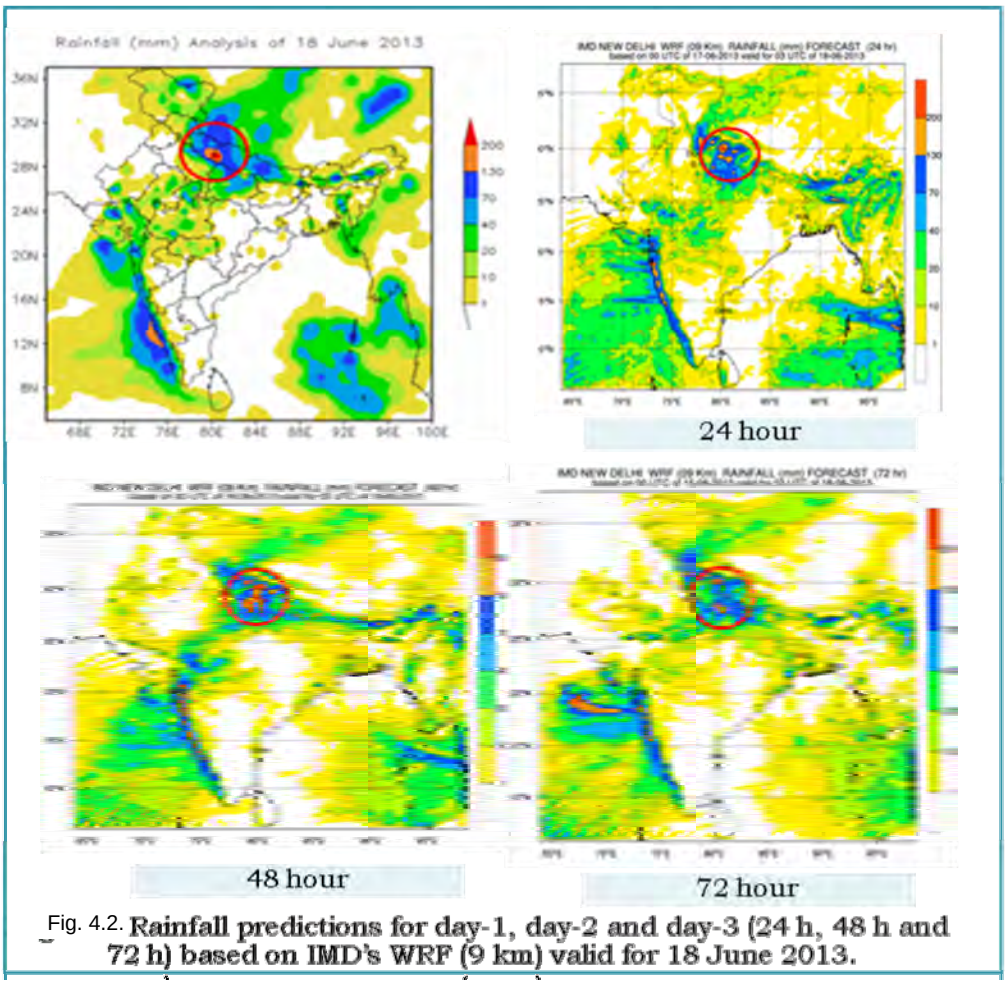


Fig. 4.2. **Rainfall predictions for day-1, day-2 and day-3 (24 h, 48 h and 72 h) based on IMD's WRF (9 km) valid for 18 June 2013.**

NWP models could perform capably to predict Very Severe Cyclonic Storm 'PHAILIN' over the Bay of Bengal (8-14 October 2013). 168 hour forecast of GPP (Fig. 4.3) valid for 00 UTC 08 October 2013 indicated the potential cyclogenesis zone, where Depression formed on that day. MME forecasts track based on different initial conditions (Fig 4.4) and Year wise MME track forecast error illustrated (Fig. 4.5).

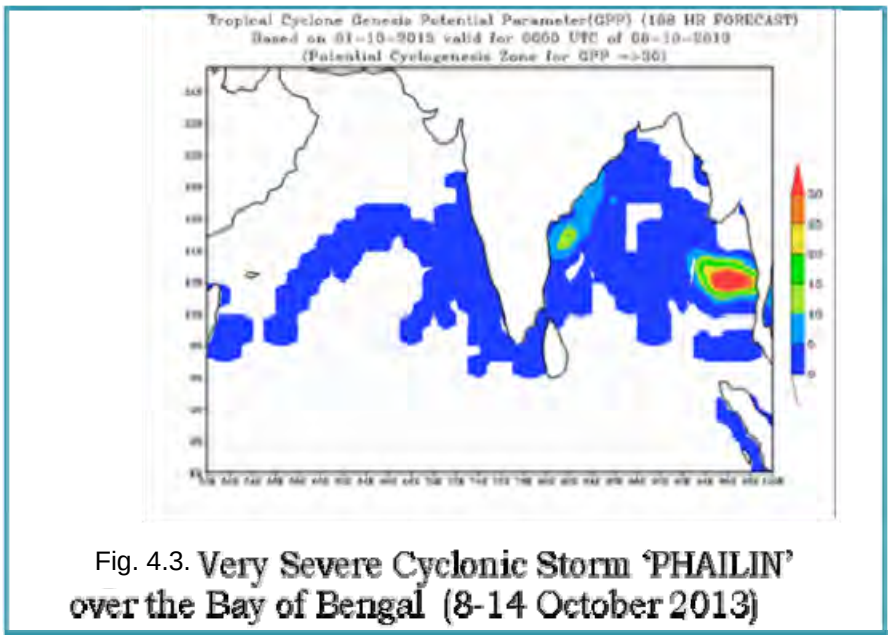


Fig. 4.3. **Very Severe Cyclonic Storm 'PHAILIN' over the Bay of Bengal (8-14 October 2013)**

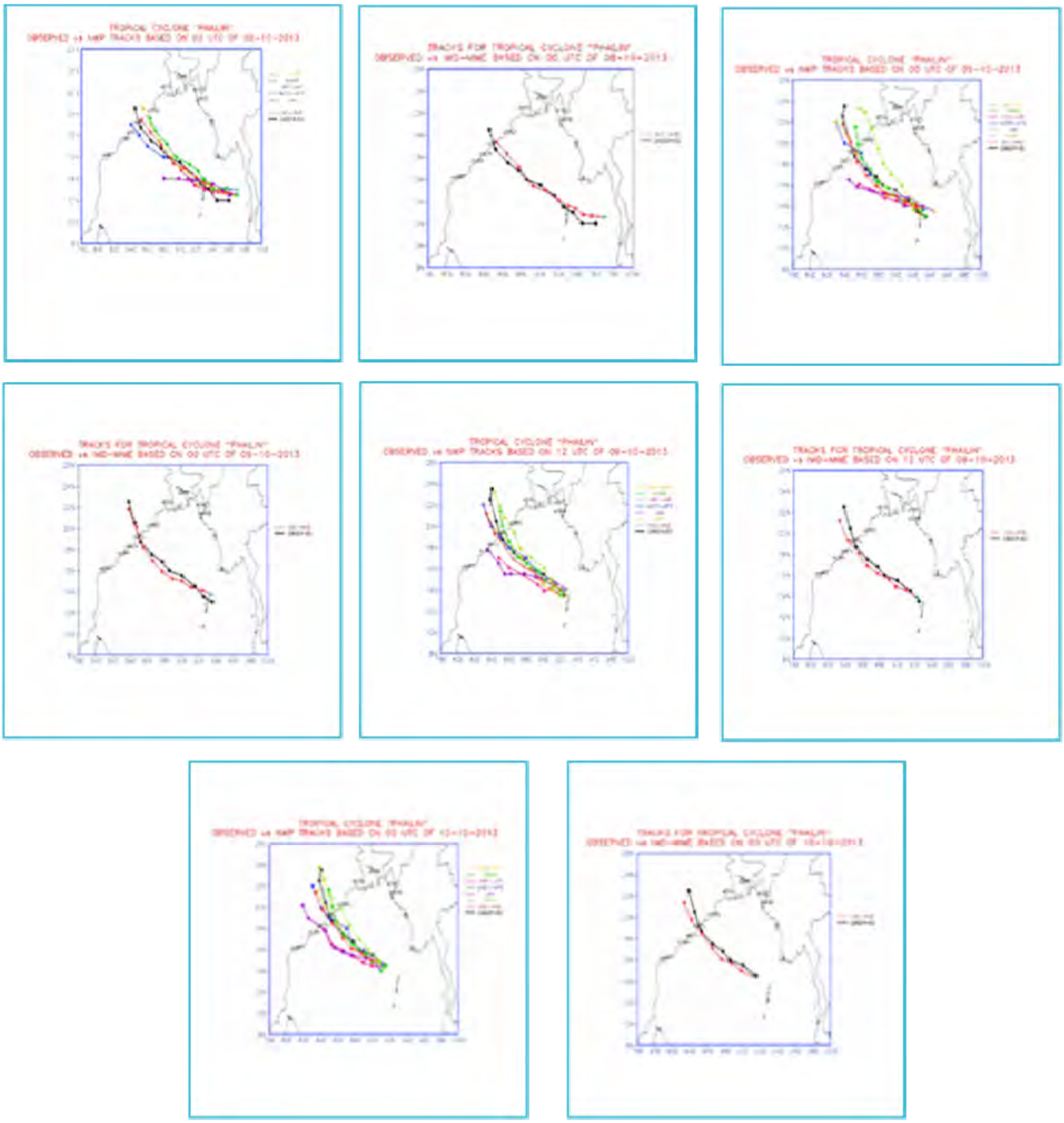


Fig. 4.4. MME forecasts track based on different initial conditions

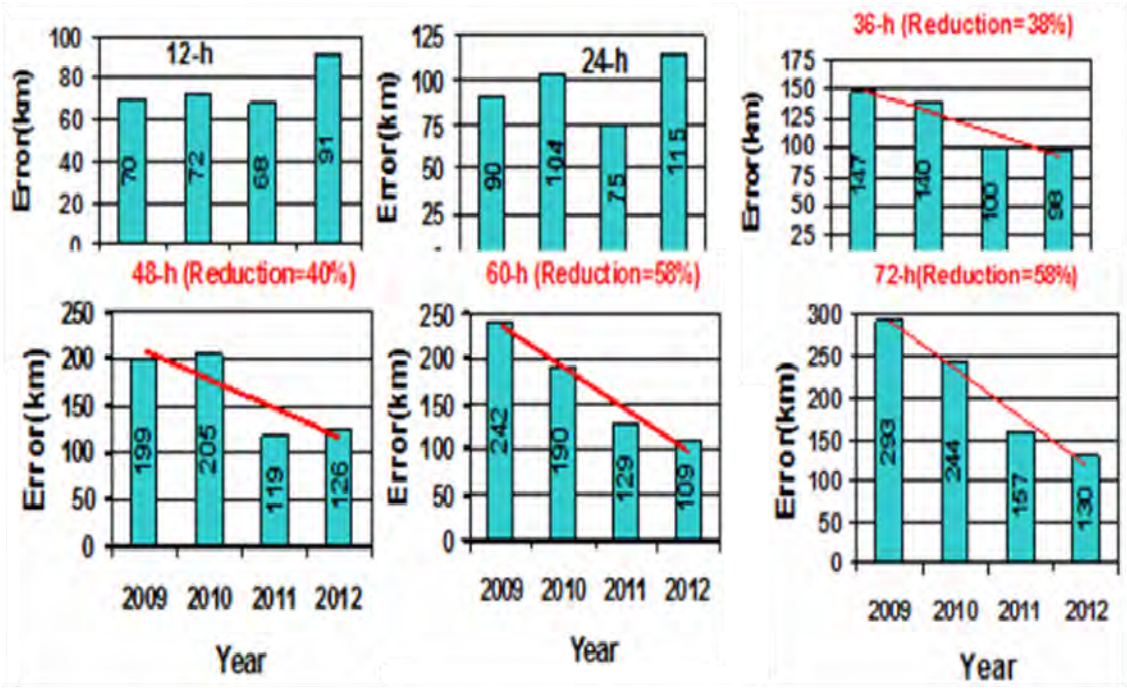


Fig. 4.5. Year wise MME track forecast error (km)

NOWCASTING

Nowcasting is based on the ability of the forecaster to assimilate great quantities of weather data, conceptualize a model that encompasses the structure and evolution of the phenomenon and extrapolate this in time. Nowcasts require high resolution of spatial and temporal meteorological data to detect and predict the occurrence of an event. Lack of data of the mesoscale imposes limit on ability to diagnose and predict an event. Nowcasting in India has benefited from major developments in observational meteorology and computer-based interactive data processing and display systems in IMD. In view of the recent improvement in monitoring and forecasting due to introduction of digital and image information at 10 minutes interval from a network of 14 Doppler Weather Radars, dense automatic weather station (AWS) network, half hourly satellite observations, better analysis tools in synergy system at forecaster's workstation, availability of mesoscale models, and computational and communication capabilities, IMD implemented nowcasting of thunderstorms, squalls and hailstorms. Considering the importance and reliability of DWR based information for nowcast of thunderstorm and associated weather, in the first phase, major stations/cities which come under the coverage of DWR were included for nowcasting of convective weather. A total of 120 stations within 200 km radius of various Doppler Weather Radars were selected and nowcast is uploaded every 3 hourly interval utilizing Synoptic Data, Model outputs, Satellite products and finally various Radar outputs. (Fig. 4.6).

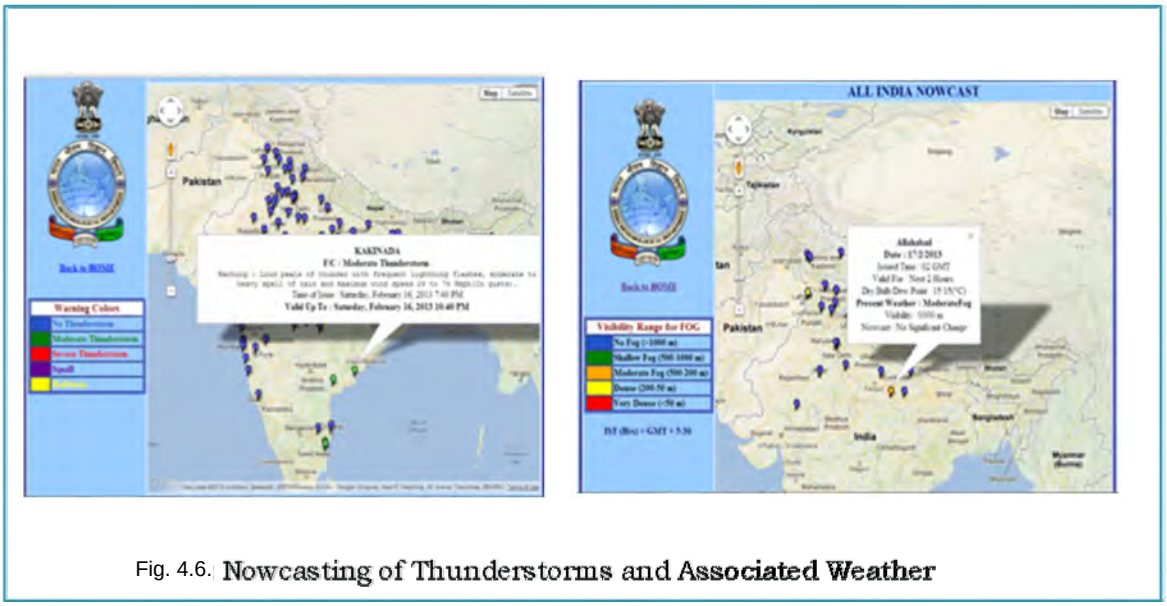


Fig. 4.6. Nowcasting of Thunderstorms and Associated Weather

Verification of Nowcasts

Various statistical parameters like probability of detection (POD), false-alarm ratio (FAR) Critical success index (CSI) and Equitable Threat Score (ETS) were evaluated for each DWR station. The results indicate that the Ratio score was very high for all months due to high number of nowcasts for "No thunderstorm" and "None" that was observed. Average probability of detection (POD) was 0.7 to 0.8 for all months except May when it was 0.6. The average FAR was lowest for March and May (0.2 and 0.3 respectively). Both average ETS and CSI were above 0.5 for all months. Average statistical score for Nowcast of cities covered by various Doppler weather Radar stations. The Ratio score (RS) was 0.9 and above for DWR Agartala, Chennai, Jaipur, Hyderabad and Patiala. It was as low as 0.7 for DWR New Delhi in August and DWR Lucknow in June. Average POD values were very high (>0.8) in DWR Jaipur, DWR Chennai and DWR Patiala. It was lower than 0.5 in September for DWR Kolkata and in May for DWR New Delhi. In all months DWR Agartala gave POD lower than equal to 0.4. Average FAR was lower than 0.4 for DWR Kolkata, Chennai, Jaipur and Patiala and Very high (>0.8) for DWR, New Delhi, DWR Lucknow and DWR Agartala. The average ETS was very low (less than 0.4) for DWR, New Delhi, DWR Agartala, DWR Lucknow and DWR Hyderabad. CSI score gave similar results. It was concluded that the performance of RMC, New Delhi, M.C Lucknow, M.C. Hyderabad and M.C. Agartala was very low as compared to other stations.

Fig. 4.7. shows the various statistical parameters compiled for India as a whole. The results indicated that the average POD for all months remained above 0.6 and average FAR was below 0.5. Similarly ETS and CSI both were between 0.5 and 0.9 for all months. Fig. 4.8. shows that False Alarm Ratio is between 0.1 and 0.4 for more than 50 % stations. It was particularly high for stations covered by Doppler weather radar in Hyderabad, New Delhi and Lucknow. It was also high for DWR Agartala during Monsoon months. Probability of detection (POD) was more than 0.8

in more than 45 % stations (Fig. 4.9). POD values were very high (>0.8) in DWR Jaipur, DWR Chennai and DWR Patiala for all Nowcasts, while they were >0.7 for DWR Kolkata in Pre-monsoon months. The Ratio score was greater than 0.8 for more than 80 % stations (Fig. 4.10). The ETS and CSI scores (Fig. 4.11 and 4.12) were also more than 0.5 for more than 50 % stations. They were particularly high for DWR Patiala, Jaipur and Chennai. The verification of Squalls and Hailstorm events was done separately and it was found that none of the events could be predicted by the IMD Centre.

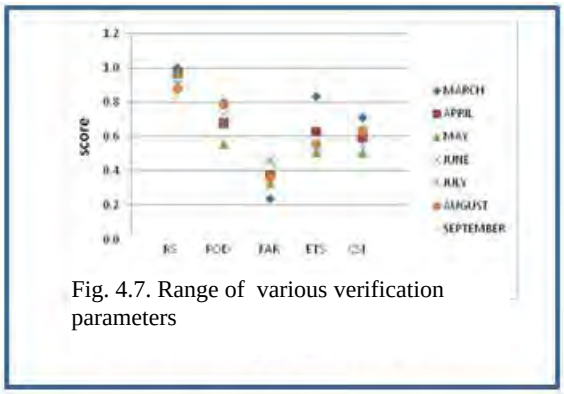


Fig. 4.7. Range of various verification parameters

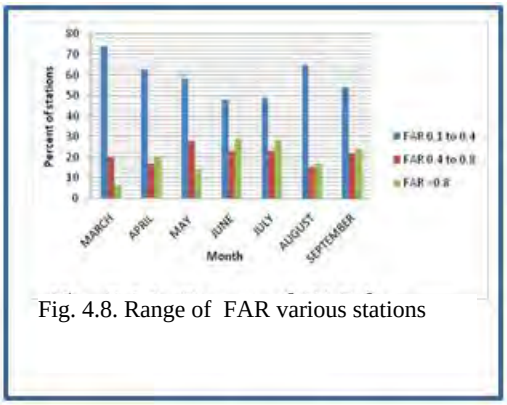


Fig. 4.8. Range of FAR various stations

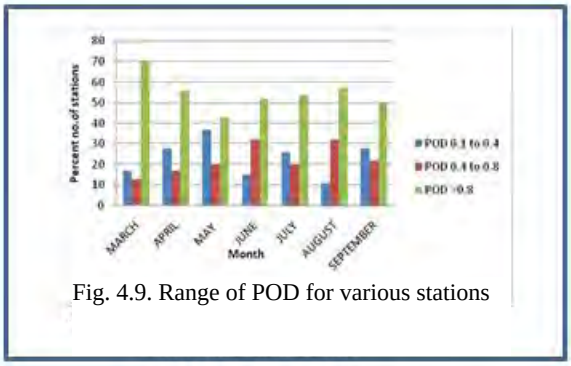


Fig. 4.9. Range of POD for various stations

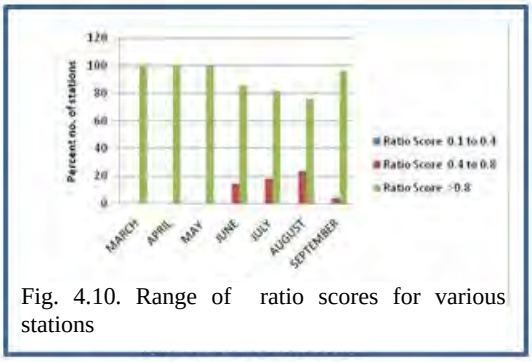


Fig. 4.10. Range of ratio scores for various stations

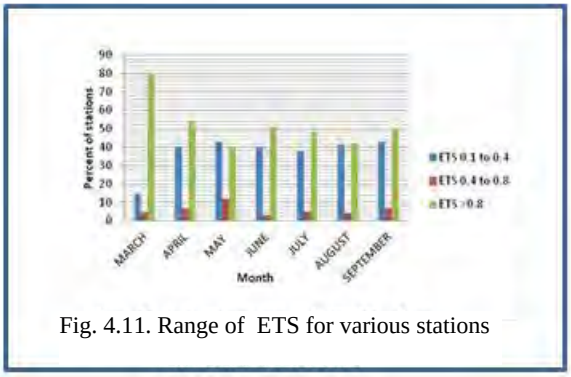


Fig. 4.11. Range of ETS for various stations

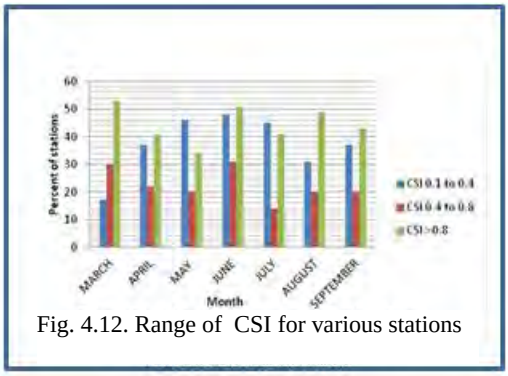


Fig. 4.12. Range of CSI for various stations

SHORT & MEDIUM RANGE FORECASTING

IMD monitors and provides weather and climate services to the nation on all India basis, round the clock. National Weather Forecasting Centre (NWFC) issues forecast & warnings in short and medium range for 36 meteorological sub-divisions of the

country while Regional Meteorological & State Meteorological Centres provide weather services on district levels. In addition, forecast for major cities & Tourist locations are also provided on 24 × 7 basis. Special weather services for mountaineering expeditions, sports, pilgrimage, highways, transport and special events of national importance etc. are also provided. Warnings for heavy rainfall, snowfall, heat wave, cold wave, fog, frost, thunder squall, hailstorm, etc. are sent to all the stake holders including disaster managers, media and public in general, in textual as well as in graphical forms and posted in real time basis on IMD websites at HQ and regional levels. The general forecast & warnings issued by NWFC on 27 December, 2013 are depicted below (Fig. 4.13).

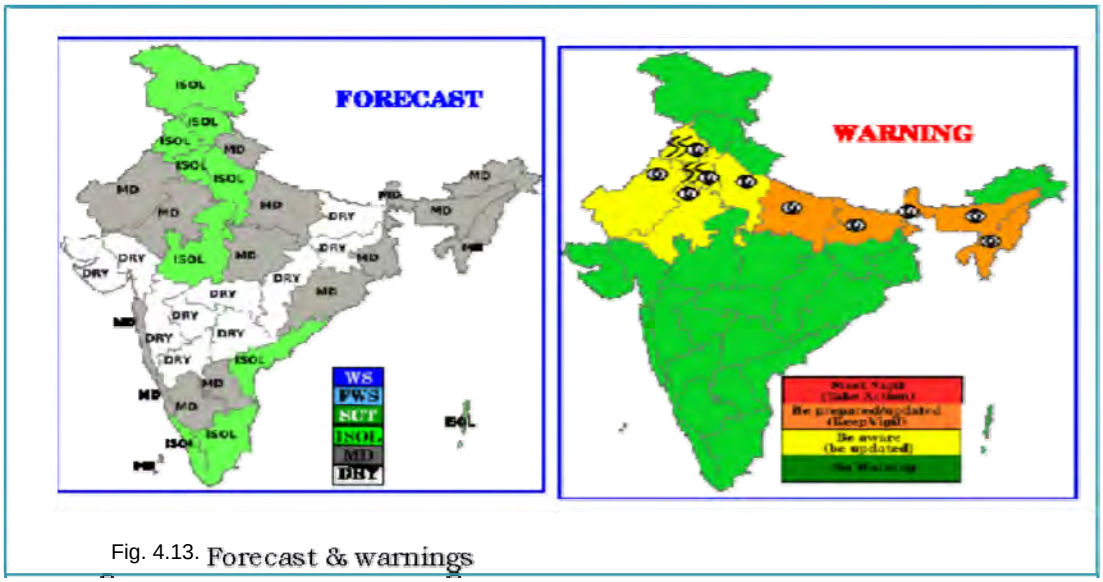


Fig. 4.13. Forecast & warnings

Skill of weather forecast

Verification of the forecast & warnings is being done as per WMO norms by IMD. A significant improvement in skill scores is found in recent years in various types of forecasts & warnings for extreme weather events. Skill scores of heavy rainfall events over India as a whole in the recent years indicate that critical success index (CSI), False Alarm Rate (FAR) and Heidke Skill Score (HSS) have improved by 42%, 52% and 43% from their respective mean between 2002 to 2013. Trends of FAR and CSI for the period between 2002 to 2013 are given below (Fig. 4.14).

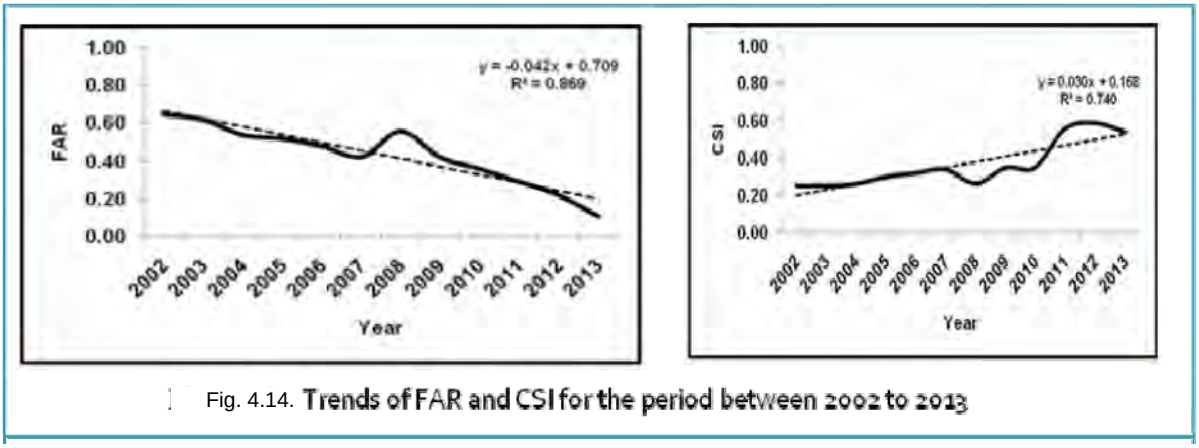


Fig. 4.14. Trends of FAR and CSI for the period between 2002 to 2013

SEASONAL FORECASTING

India Meteorological Department (IMD) issues various monthly and seasonal operational forecasts for the rainfall during the south-west monsoon season based on statistical forecasting system. At present, the forecast for the South-West monsoon rainfall is issued in two stages, in April and June. Forecast for seasonal rainfall over four broad geographical regions of India and July and August rainfall over country as a whole are also issued in June. Ensemble technique is employed in predicting monsoon rainfall wherein, instead of relying on a single model, all possible models based on all the combination of predictors are considered. For April (June) forecast With 5 (6) predictors, 31 (63) different models are developed. Verification of the results with the past data showed that the ensemble method performed better than the individual models.

Operational Statistical Forecast System for forecasts for 2013

The first stage forecast in the ESSO-IMD's Ensemble Statistical Forecasting system for the 2013 South-west monsoon rainfall for the country as a whole was issued on 26th April 2013 for five pre-defined rainfall categories. These are deficient (less than 90% of LPA), below normal (90-96% of LPA), normal (96-104% of LPA), above normal (104-110% of LPA) and excess (above 110% of LPA). The climatological probabilities for the above categories are 16%, 17%, 33, 16% and 17%, respectively, The second stage Long range forecast update for 2013 southwest monsoon rainfall was issued on 14th June 2013. Rainfall over the country as a whole for the month of July and August 2013 and that for four broad geographical regions of the country, namely North-West India, Central India, South Peninsula, and North-East India was also issued in 2nd Stage. Details of long range forecasts and realized rainfall for monsoon 2013 is shown in (Table 4.1).

Table 4.1

Region	Period	Date of Issue	Forecast (% of LPA)	Actual Rainfall (% of LPA)
All India	June to September	26th April	98 ± 5	106
All India	June to September	22st June	98 ± 4	
Northwest India	June to September		94%± 8	109
Central India	June to September		98%± 8	123
Northeast India	June to September		98%± 8	72
South Peninsula	June to September		103%± 8	115
All India	July		101%± 9	106
All India	August		96%± 9	98
All India	August to September	2nd August	96%± 8	94
All India	September	1stSeptember	96%± 13	86

HIGHLIGHTS

- For the country as a whole, the rainfall for the season (June-September) was 106% of its long period average (LPA).

- Seasonal rainfall was 109% of its LPA over Northwest India, 123% of its LPA over Central India, 115% of its LPA over south Peninsula and 72% of its LPA over Northeast (NE) India.

- Monthly rainfall over the country as a whole was 132% of LPA in June, 106% of LPA in July, 98% of LPA in August and 86% of LPA in September.

- Out of the total of 641 districts, 100 were affected by moderate meteorological drought (seasonal rainfall deficiency of 51% to 99%).

- Southwest monsoon set in over Kerala on its normal date of 1st June. The southwest monsoon covered the entire country by 16th June, about 1 month earlier than its normal date of 15th July.

- The withdrawal of monsoon from west Rajasthan commenced on 9th September compared to its normal date of 1st September.

- The forecast for monsoon onset over Kerala for this year was correct.

- The operational long range forecasts for the 2013 southwest monsoon season rainfall over the country as whole and that over 3 broad geographical regions i.e. Northwest India, Central India and South Peninsula were an underestimate and for Northeast India, it was an overestimate.

- However, forecast for the rainfall over the country as a whole during the monsoon months of July, August and September and that for the second half of the monsoon season were within the forecast limits and accurate.

Forecast for 2013 winter season (Jan-Feb-Mar) rainfall over North India

The 2013 winter season (Jan to March) rainfall over North India is most likely to be normal [≥ -15 to ≤ +15 of the Long Period Average (LPA)] with a tendency to be in the negative half of the normal. The normal rainfall is defined as the rainfall ≥ -15 to ≤ +15 % of the Long Period Average (LPA).

Forecast outlook for NE Monsoon Rainfall for South Peninsula

IMD operational forecast for the 2013 North-east monsoon season (October-December) is that the northeast monsoon season rainfall over south Peninsula is most likely to be normal (89-111% of long period average) and over Tamil Nadu, it is most likely to be above normal (>112% of LPA).

5. WEATHER SAFETY

Weather and climate hazards such as storms, heat waves, cold waves, floods and droughts cause economic damage and loss of life. Natural hazards cannot be avoided, but timely, accurate prediction of extreme weather helps societies to prepare for and mitigate disasters and to reduce losses in infrastructure and productive activities. Early warning systems and forecasts provide lead time, which together with public awareness, education and preparedness, can allow people to act quickly in response to hazard information, thereby increasing human safety and reducing the human and economic losses from natural disasters.

FROM WEATHER MONITORING TO CRISIS MANAGEMENT

As a national weather service provider, most essential role of IMD is nurture the science and technology of meteorology to provide increasingly more efficient weather and climate services and to contribute to the cause of national development. The Department provides current weather and weather forecasts / meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc. and warnings 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, agriculture etc. The meteorological services have significant societal impact. Early warning systems coupled with response, mitigation, awareness and preparedness are essential for crisis management.

Heavy rainfall over Uttarakhand during 16-18 June 2013

During 16-18 June 2013, widespread very heavy rainfall activities with a few extremely heavy rainfall (more than 24.5 cm) were reported at many stations over Uttarakhand. Heavy rainfall activities were also reported at some stations over Himachal Pradesh, Delhi & Haryana and Punjab during 16 June to18 June 2013. During the period, on 16 June, 16 stations reported heavy rainfall with 11 stations ≥ 10 cm and 1 stations ≥ 20 cm; on 17 June 23 stations reported heavy rainfall with 18 stations ≥ 10 cm and 7 stations ≥ 20 cm and on 18 June 16 stations reported heavy rainfall with 9 stations ≥ 10 cm and 2 stations ≥ 20 cm. The rainfall distribution shows that heavy to extremely heavy rainfall occurred on 15 June and 16 June (reported at 0300 UTC of next day) over the western districts of Uttarakhand (Uttarkashi, Dehradun, Haridwar, Tehri, Rudraprayag and Pauri) with a maximum rainfall of 37 cm reported on 17 June at

Dehradun. Thereafter the heavy rainfall belt gradually shifted towards eastern part of Uttarakhand. Heavy to extremely heavy rainfall reported on 17 June and 18 June over the districts of eastern parts of Uttarakhand (Almora, Nainital, Udham Singh Nagar, Champawat, Bageshwar, Pithoragarh and Chamoli) with a maximum rainfall of 28 cm reported on 18 June at Haldwani of Nainital district. Despite prior information of the likelihood of disturbed weather, more than one lakh pilgrims were stranded in these pilgrimage sites. Numerous deaths took place due to exposure and starvation. Countless others died due to flash floods and landslides in the Mandakini River, especially in the vicinity of Kedarnath temple.

The analysis suggests that due to strong interaction between an oncoming trough in the westerlies and the strong southeasterly monsoon wind flow in association with a monsoon low pressure system over the North Indian region, resulting development of lower tropospheric wind convergence over the Uttarakhand and neighbouring regions. This, with strong orographic effect due to high terrain when coupled by the strong moisture feeding from both the Arabian Sea and Bay of Bengal triggered heavy rainfall activity downstream of the trough, over the North Indian region. The episode was unique in that, the line of convergence of the two weather systems was nearly stationary for hours at a time, resulting in huge amount of accumulated rainfall over parts of North India causing widespread flooding.

Verification of Operational forecasts over Uttarakhand

IMD provides operational weather forecasts and warnings to various users through a three-tier forecast set up of National Weather Forecast Centre (NWFC), New Delhi, Regional Weather Forecast Centre (RWFC) located at respective Regional Meteorological Centres and State Weather Forecast Centres (SWFC), located at respective Meteorological Centre. SWFC is responsible to provide weather forecast and warnings to the State Government for the respective states. Heavy Rainfall Warnings issued by Meteorological Centre (SWFC) Dehradun, RWFC New Delhi and NWFC New Delhi(HQ) for Uttarakhand and Himachal Pradesh during the period 14-17 June 2013 along with realized weather (Table 5.1).

Meteorological Centre, Dehradun had also specified the areas of heavy to very heavy rainfall for the chardham yatra and issued the advisories.

Table 5.1 Rainfall warnings issued for Uttarakhand

Forecast issued on	Warning by MC Dehra Dun	Warning by RWFC, New Delhi	Warning by NWFC, New Delhi	Realized Weather next day
14.06.2013	Isolated rather heavy to heavy rainfall during next 48 hours.	Nil	NIL	Dehradun-5, Tehri-3, Jakholi -7, Kashipur -6.5 Dunda -8.0
15.06.2013	Isolated heavy to very heavy rainfall during next 72 hours.	Isolated heavy rainfall would occur during next 48 hours.	Isolated Heavy to very heavy rainfall would occur during next 48 hours.	Dehradun-22 Purola-17 Deoprayag-13 Uttarkashi-13, Tehri-12
16.06.2013	Heavy to very heavy rainfall at few places during next 36 hours.	Isolated heavy to very heavy rainfall may occur during next 48 hours.	Heavy to very heavy rainfall would occur at a few places during next 48 hours.	Dehradun-37 * Mukteshwar-24 Hardwar-22 Uttarkashi-21 Kosani-21
17.06.2013	Isolated heavy to very heavy rainfall during next 24 hours.	Isolated heavy to very heavy rainfall during next 48 hours.	Heavy to very heavy rainfall would occur at a few places during next 48 hours.	Haldwani-28, Champawat-22, Mukteshwar-18, Nenital-17, Ranikhet-12

Floods in Gujarat and south Rajasthan (22-30 September 2013)

Normally second half of September is the period of retreating southwest monsoon. However, this year in a sudden burst, parts of central and northwest India particularly Gujarat & south Rajasthan received very heavy rainfall amounts even breaking all time records. The rainfall received at Rajkot in Saurashtra during the 24 hours period ending at 0830 hrs IST of 26th September was 39.2 cm, which was an all time record.

The main cause of this rainfall was due to a system over Gujarat & neighbourhood which exhibited mixed characteristics of a monsoon low and also that of a mid-trpospheric cyclonic circulation (MTC). Some of the salient features are enlisted below.

- The cyclonic circulation was quite strong both in the wind and pressure fields in the lower and mid-tropospheric levels.
- It remained quasi-stationary over Gujarat State during 23rd – 27th Sept. before re-curving northeast-wards.
- Vorticity field in mid troposhhere was highly concentrated over the system.
- Also strong low level convergence and upper level divergence persited over the region for all these days.
- Strong moisture influx occurred from the Arabian Sea.
- Many stations reported extremely heavy rainfall (amount exceeding 25cm reported during the 24 hour period) consecutively for 6 days ending on 28th Sept. while the rainfall activity remained subdued over the remaining parts of the country.

Verification of Operational forecasts over Gujarat and south Rajasthan

Revival of monsoon during second half of September was well captured in operational short and medium range forecast. Warnings for heavy rainfall over Gujarat and Rajasthan was issued at least 48 to 72 hours in advance by NWFC New Delhi and Met Centre Ahmedabad & Rajasthan.

Cyclone warning services

The Regional Specialized Meteorological Centre (RSMC)-Tropical Cyclone, IMD, New Delhi with monitoring and prediction of cyclonic disturbances over the north Indian Ocean issues 3 hourly *warning*/advisory bulletins to national disaster management agencies including National Disaster Management (NDM), Ministry of Home Affairs (MHA), concerned state Governments and other users in regular intervals. It also issues advisories to World Meteorological Organization (WMO)/Economic and Social Cooperation for Asia and the Pacific (ESCAP) Panel member countries including Bangladesh, Myanmar, Thailand, Pakistan, Oman, Srilanka and Maldives during cyclone period. As Tropical Cyclone Advisory Centre (TCAC), it also issues tropical cyclone advisories with effect from the stage of cyclone for international civil aviation purpose as per the requirement of International Civil Aviation Organization (ICAO).

Cyclone track & intensity forecast valid for 120 hours has been introduced in 2013 from the Cyclonic Storm 'MAHASEN'. Coastal inundation warning has also been introduced experimentally from this year. This is based on the coastal inundation model ADCIRC run at INCOIS, Hyderabad. An example of the coastal inundation model output is shown in Fig. 5.1 issued during VSCS PHAILIN.

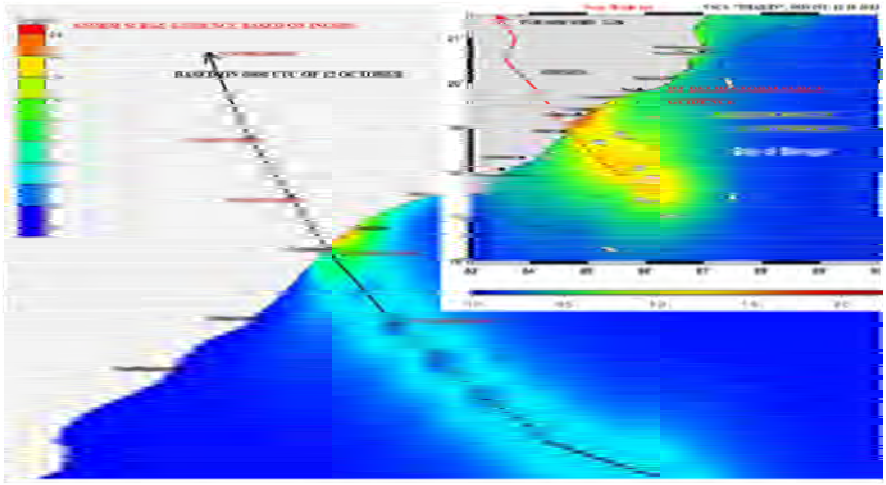


Fig. 5.1. Storm surge guidance from INCOIS and IIT, Delhi model based on 0000 UTC of 12 October initial condition

Cyclonic disturbances

During the year 2013, 10 cyclonic disturbances developed over north Indian Ocean including one deep depression over Arabian Sea, one land depression and 8 cyclonic disturbances over Bay of Bengal. Out of 8 disturbances 3 intensified into Very Severe Cyclonic Storm (VSCS), one each into a Severe Cyclonic Storm (SCS) & Cyclonic Storm (CS), three up to depression. Considering season-wise distribution, out of 10 disturbances, 2 developed during pre-Monsoon, 2 during monsoon and 6 during post-monsoon season. Salient features of cyclonic disturbances during 2013 were as follows:

- There were five cyclones over the Bay of Bengal and no cyclone over the Arabian Sea against the long period average of 5.5 per year over the entire north Indian Ocean including Bay of Bengal and Arabian Sea.

- Five cyclones developed over the Bay of Bengal for the first time after 1987. Considering north Indian Ocean as a whole, five cyclones occurred in 2010.

- Four severe cyclonic storms developed over Bay of Bengal for the first time since 1982. Considering north Indian Ocean as a whole, four such severe cyclonic storms occurred in 2010.

- Three very severe cyclonic storms occurred over north Indian Ocean for the first time since 1999.

- Post-monsoon season was very active, especially over the Bay of Bengal with the formation of three very severe cyclonic storm and one severe cyclonic storm.

- Though there were five cyclones, only one cyclone (Phailin) crossed coast as very severe cyclonic storm and other two (Mahasen and Helen) as cyclonic storms. Other two cyclones (Lehar and Madi) crossed the coast as depressions. However, cyclone Lehar crossed Andaman and Nicobar Islands as a severe cyclonic storm. Such a severe cyclonic storm crossed Andaman and Nicobar Islands for the first time since November 1989.

- While track of Lehar was straight moving, tracks of all other cyclones were recurving in nature. While Phailin recurved after landfall, cyclone Mahasen recurved northeastwards over the sea, cyclone Helen recurved west-southwestwards just before landfall and cyclone Madi recurved southwestwards over the sea. Comparing the tracks, the track of Madi was most unique in nature and had a rare analogue with past records.

- The total period of cyclonic disturbances during 2013, was maximum as compared to previous years (1990-2012).

- The annual cyclone energy over the north Indian Ocean, has also been maximum in 2013 as compared to previous years (1990-2012).

Details of the disturbances

a. Cyclonic Storm 'Mahasen' (10-13 May 2013)

A cyclonic storm, Mahasen (Fig. 5.2) crossed Bangladesh coast near lat.22.8^{0}N and long. 91.4^{0}E, about 30 km south of Feni around 1330 hrs. IST of 16th May 2013 with a sustained maximum wind speed of about 85 -95 kmph.

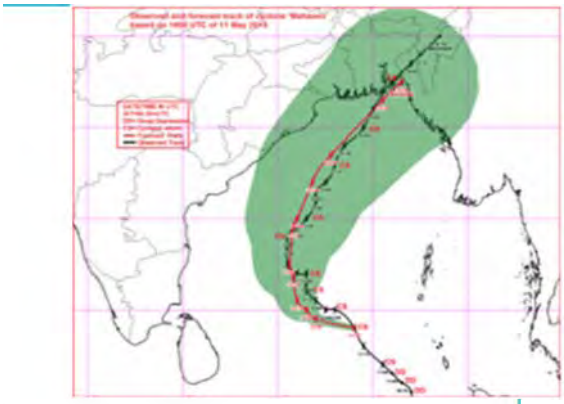


Fig. 5.2. Observed & forecast Track of Cyclonic Storm 'Mahasen' based on 1800 UTC of 11 May, 2013

b. Very Severe Cyclonic Storm (VSCS) PHAILIN (08-14 October 2013)

A Very Severe Cyclonic Storm (VSCS) PHAILIN originated from a remnant cyclonic circulation from the South China Sea. The VSCS, PHAILIN crossed Odisha & adjoining north Andhra Pradesh coast near Gopalpur (Odisha) around 2230 hrs IST of 12th October 2013 with a sustained maximum surface wind speed of 200-210 kmph gusting to 220 kmph.

VSCS PHAILIN is the most intense cyclone that crossed India coast after Odisha Super Cyclone of 29th October 1999. It caused very heavy to extremely heavy rainfall over Odisha leading to floods, and strong gale wind leading to large scale structural damage and storm surge leading to coastal inundation over Odisha. Maximum rainfall occurred over northeast sector of the system centre at the time of landfall. Maximum 24 hour cumulative rainfall of 38 cm has been reported over Banki in Cuttack district of Odisha. Based on post-cyclone survey report, maximum of storm surge of 2-2.5 meters above the astronomical tide has been estimated in the low lying areas of Ganjam district of Odisha in association with the cyclone and the in-land inundation of saline water extended up to about one kilometer from the coast. The numerical weather prediction (NWP) and dynamical statistical models provided good guidance with respect to its genesis, track and intensity. Though there was divergence in model guidance with respect to landfall point in the initial stage, the consensus among the models emerged as the cyclone moved closer to the coast. IMD accurately predicted the genesis, intensity, track and point & time of landfall (Fig. 5.3) and also the adverse weather like heavy rainfall, gale wind and storm surge 4 to 5 days in advance.

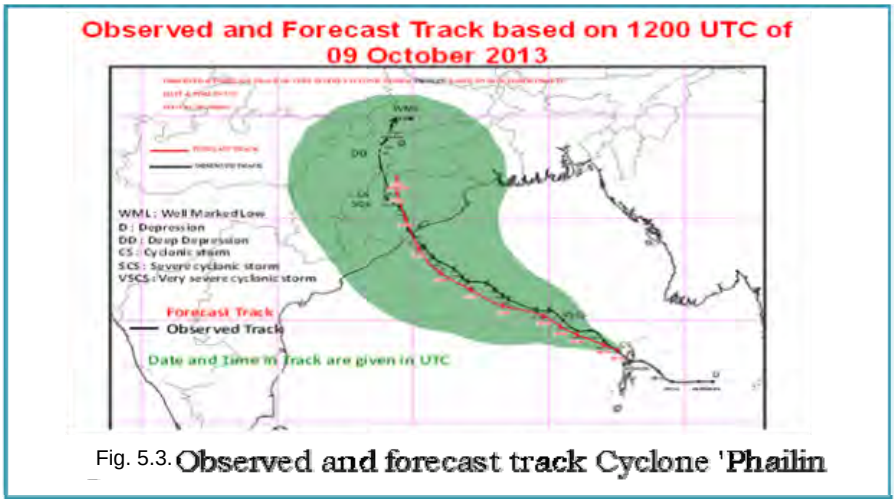


Fig. 5.3. Observed and forecast track Cyclone 'Phailin

c. Severe Cyclonic Storm 'HELEN (19-23 Nov 2013)

Under the influence of active inter-tropical convergence zone (ITCZ), a depression formed over the west central Bay of Bengal in the early morning of 19th Nov, 2013. It continued to move west-northwestwards and intensified into a severe cyclonic storm in the early morning of 21st November at a distance of 260 km east-southeast of Machilipatnam. On 22nd November, it moved initially westwards and then west-southwestwards and crossed Andhra Pradesh coast close to south of Machilipatnam between 1330-1430 hrs IST of 22nd November 2013 as a cyclonic storm with a wind speed of 80-90 kmph gusting to 100 kmph. It then weakened gradually while moving west-southwestwards across Andhra Pradesh and lay as a low pressure area over coastal Andhra Pradesh. Under its influence rainfall at most places with isolated heavy to very heavy rainfall occurred over coastal Andhra Pradesh. The observed & forecast track of the system is shown in Fig. 5.4.

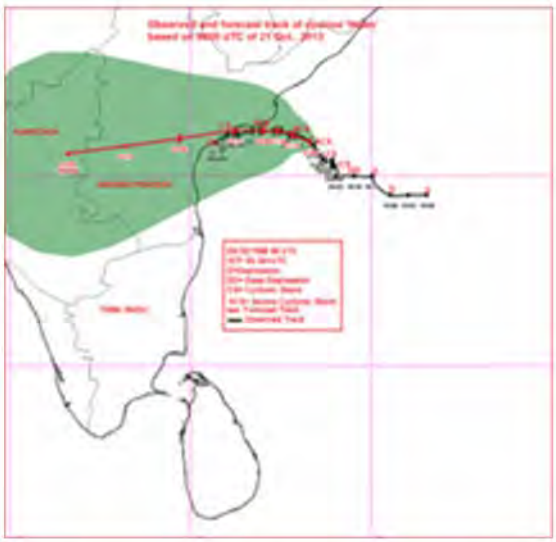


Fig. 5.4. Observed & forecastTrack of severe cyclonic storm Helen based on 0600 UTC of 21 November, 2013

d. Very Severe Cyclonic Storm VSCS 'Lehar' (23-28 Nov 2013)

The very severe cyclonic storm, Lehar developed over south Andaman Sea from a remnant cyclonic circulation from South China Sea on 23rd evening when it lay as depression located about 550 km south-southeast of Port Blair. It gradually intensified into a severe cyclonic storm and crossed Andaman & Nicobar Island near Port Blair in the morning (around 0630 hrs IST) of 25th Nov. 2013 with a wind speed of about 110-120 kmph. It caused extremely heavy rainfall and coastal inundation leading to uprooting of trees, damage to structures and flooding of low lying areas. On 25th it emerged into southeast Bay of Bengal and moved west-northwestward, intensified into a very severe cyclonic storm in the early hours of 26th Nov. near southeast Bay of Bengal. It then came under the influence of colder Sea, high vertical wind shear and entrainment of dry & cold air into the cyclone field. As a result it rapidly weakened into a deep depression by early morning of 28th. It crossed Andhra Pradesh coast close to south of Machilipatnam around 1400 hrs IST of 28th November 2013. The observed and forecast track of the system is given in Fig. 5.5.

Fig. 5.5. Observed & forecast Track of Very Severe Cyclonic Storm 'Lehar' based on 0000UTC of 27 Nov. , 2013

e. Very Severe Cyclonic Storm VSCS 'MADI' (06-13 Dec 2013)

A low pressure area formed over southeast Bay of Bengal on 1st December 2013. It moved very slowly northward and intensified into a cyclonic storm, 'Madi' in the morning of 7th December. It continued to move slowly and intensified into a severe cyclonic storm in the afternoon of 7th December and into a very severe cyclonic storm in the forenoon of 8th December 2013. However due to entrainment of cold air, colder sea and increase in vertical wind shear, the very severe cyclonic storm weakened into severe cyclonic storm in the evening of 9th Dec. It further weakened into cyclonic storm in the early hours 11th December and crossed Tamil Nadu coast near Vedaranniyam around 1900 hrs IST of 12th Dec, emerged into Palk strait around 2030 hrs IST and again crossed Tamil Nadu coast near Tondi around 2230 hrs IST. The observed and forecast track of the system is given in Fig. 5.6.

Forecast performances: Annual average error

The annual average track, intensity and landfall forecast errors during 2013 over the north Indian Ocean are shown in Table 5.2 and 5.3 respectively. The annual average track forecast errors for the year 2013 are 107, 153 and 188 km for the lead periods 24, 48 & 72 hrs respectively. The errors have been significantly less than the long period average. The average landfall forecast point error are about 29, 101 & 109 km and landfall time error are 5, 5.7 and 3 hrs for 24, 48 & 72 hrs lead period respectively. Comparing with the long period average of past five years (2008-12), the track and land fall forecast errors have been significantly less during 2013. However, the intensity error is slightly higher than long period average as the NWP models usually are not capable to predict intensity accurately.

Fig. 5.6. Observed & forecast Track of Very Severe Cyclonic Storm 'MADI' based on 1200 UTC of 10 December, 2013

Table 5.2. Annual Average track (km) and intensity forecast error (knots) during 2013

	Track forecast error (km)		Intensity error (km)			
Lead Period (Hours)	Annual Track error	Long period average (2008-2012)	Absolute Error (knots)	Long period Average (2008-2012) AE	RMSE (knots)	Long period Average (2008-2012): RMSE
			6.2	7.3	8.3	9.9
24	107	132.6	10.3	10.4	14.2	13.5
36	133	190.2	13.8	12.7	17.6	16.1
48	153	253.6	15.2	13.4	18.8	17.8
60	170	308.9	15.9	13.4	19.3	15.3
72	188	376.1	16.7	19.0	20	24.0
84	197	-	19.4	-	23.7	-
96	241	-	17.4	-	20.9	-
108	289	-	15.5	-	16.2	-
120	281	-	13.1		14.3	

Table 5.3. Annual Average landfall point and landfall time error during 2013

Lead Period (Hours)	Landfall point error (km)	Long period average landfall point error(km) during 2008-2012	Landfall time error (hours)	Long period average landfall time error(hrs.) during 2008-12
12	31	41.6	2.7	2.5
24	29	90.8	5	5.5
36	70	102.7	4.7	8.5
48	101	95.8	5.7	7.3
60	108	67.7	5.0	2.2
72	109	134.8	3.0	
84	99	-	1.7	
96	170	-	6.3	
108	156	-	1	
120	131	-	4.7	

Trend in Forecast Performance

The tropical cyclone forecasts issued by IMD have been verified for the period 2003-13. It is observed that the tropical cyclone track forecast errors have decreased significantly in recent years. The rate of decrease in 24 hrs track forecast error is about 7 km/year. The average 48 and 72 hrs. track forecast errors over the north Indian Ocean during 2003-2013 have decreased more significantly during the same period (Fig. 5.7). The landfall point forecast errors are shown (Fig. 5.8). The landfall point forecast error has reduced significantly in recent years. The 24 hrs. landfall point forecast errors have decreased at the rate of about 30 km per year during 2003-2013. Rate of decrease is higher in case of 48 and 72 hrs. forecasts.

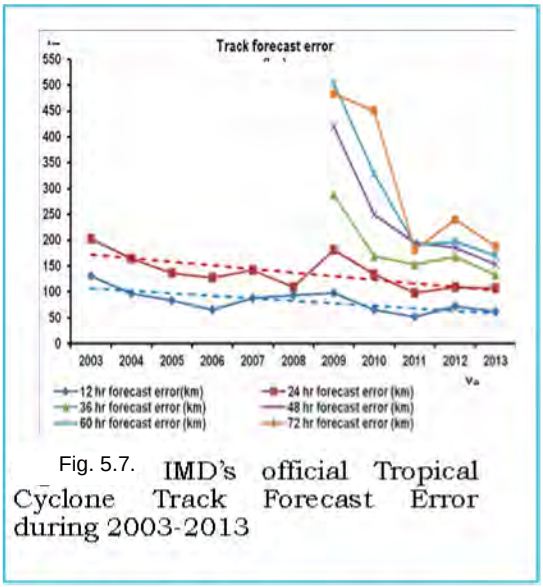


Fig. 5.7. IMD's official Tropical Cyclone Track Forecast Error during 2003-2013

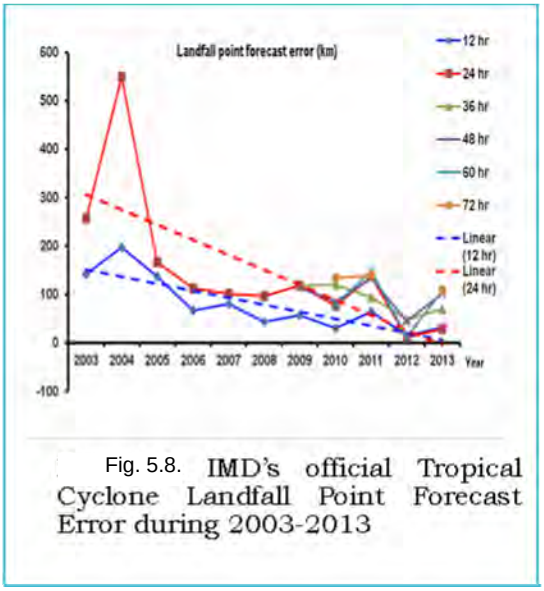


Fig. 5.8. IMD's official Tropical Cyclone Landfall Point Forecast Error during 2003-2013

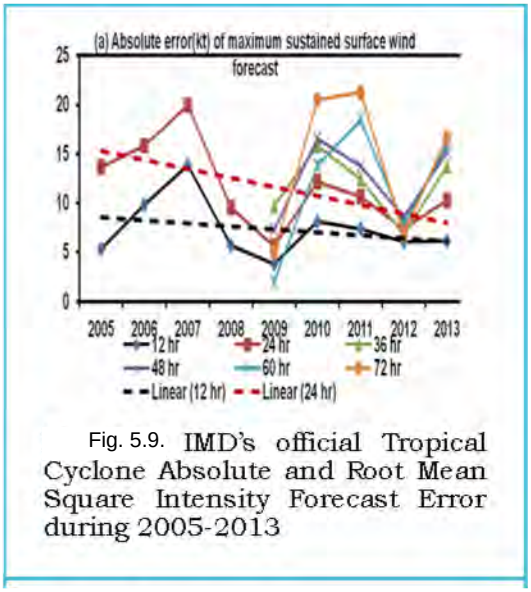


Fig. 5.9. IMD's official Tropical Cyclone Absolute and Root Mean Square Intensity Forecast Error during 2005-2013

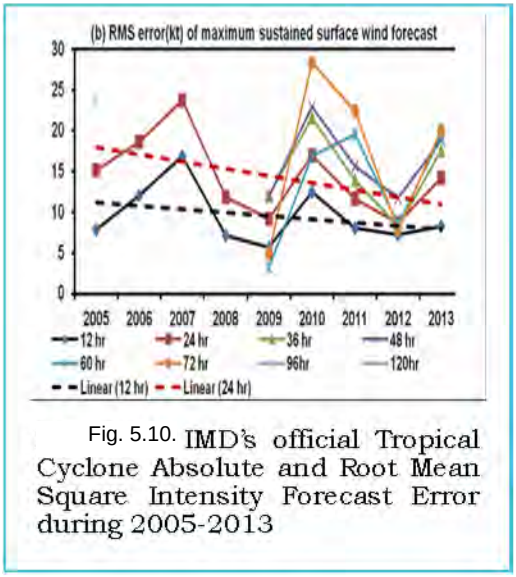


Fig. 5.10. IMD's official Tropical Cyclone Absolute and Root Mean Square Intensity Forecast Error during 2005-2013

The tropical cyclone intensity (maximum sustained surface wind) forecast has improved significantly with decrease in intensity forecast error during 2005-2013 (Fig. 5.9). However, the rate of improvement in intensity forecast is significantly less than that in case of track forecast. The intensity forecast has decreased at the rate of about 01 knot in 24 hour forecasts (Fig. 5.10).

6. SERVICES TO THE FARMERS

Agriculture is the backbone of the Indian economy and farming has always held a crucial place in the Indian economy and culture. The farmer is producing the most basic goods for human livelihood and providing social stability through his hard work and the particular structure of the rural society but his production is subject to the volatility of weather conditions. Even with large scale improvements in farming practices, genetic engineering, water technology and irrigation facilities, agriculture in India continues to be dependent on climate. Farming is still a gamble for the Indian farmers because of year to year large variability in the monsoon rains. In case of deficient monsoon rains, crops over large parts of the country are adversely affected reducing total food grains and fodder production, which in turn affect the individual farmers as well as the economy of the country.

AGROMETEOROLOGICAL ADVISORIES SERVICES

In order to serve the farmers, Agromet Advisory services (AAS) are provided for 127 agro-ecological zones of the country in collaboration with Agromet Field Units (AMFUs) located at State Agricultural Universities, ICAR institutes, IITs, etc.

Generation of weather forecast & Agromet advisory

Based on the medium range weather forecast, AAS bulletins are being prepared for 598 districts and issued on every Tuesday and Friday. State Composite bulletins (23) and national AAS bulletins are also issued simultaneously. Efforts are being made to prepare AAS bulletins for all the districts of the country. On pilot mode block level weather forecast for the parameters like rainfall, maximum and minimum temperature, cloud amount, maximum and minimum relative humidity, wind speed and wind direction for 342 blocks in the country considering one district per state is issued. As such, this forecast has been started for 37 selected districts (2 each from UP and Haryana) in the country. By the end of XII FYP, block level forecast along with advisories will be scaled up to cover the maximum districts in the country.

IMD in collaboration with IITM, Pune has started experimental National Agromet Advisory bulletins based on Extended Range Weather Forecast during southwest monsoon 2013 to fulfill the needs of farmers and other users. Bulletin was prepared and issued for the next fortnight with update on every Friday. Successful implementation of this initiative would help the farmer to get more lead time to manage his weather based farm management. Besides attempts were made to generate monthly AAS bulletins based on monthly weather forecast generated by IIT, Bhubaneswar.

Dissemination of Weather Forecast, Agromet advisories and extension activities

Dissemination of agromet advisories to the farmers through different

multi-channel system of All India Radio (AIR) and Doordarshan, Private TV and radio channels, Mobile phones / SMS / IVRS, Newspaper and Internet, SMS and IVR (Interactive Voice Response Technology) through Reuter Market Light, IFFCO Kisan Sanchar Limited (IKSL), NOKIA, Handygo, National Bank for Agricultural and Rural Development (NABARD) and State Department of Agriculture is being continued. In addition to these a number of AMFUs have started sending agromet advisories through SMS in collaboration with NIC/ATMA/KVK/ NABARD/ Internet. In addition, agromet advisories are also disseminated in both regional and English languages through "Kisan SMS", a portal (http://farmer.gov.in) to help the farming community, launched by the Ministry of Agriculture, Government of India during July 2013. At present 4.7 million farmers are benefitted by this service. Weather forecast and advisories under alerts and warnings through SMS now enable farmers in planning farming operations effectively to deal with adverse weather conditions.

In addition, Central Silk Board and IMD have plans to send SMS to sericulture farmers in the country. Currently, the services are being provided on pilot basis to silk growers in Andhra Pradesh and it will be scaled up to the whole country gradually. Besides, there are number of firms in the pipeline in collaborating with IMD in dissemination of advisories.

Generation of new products for GKMS:

A number of new products for agromet services are being generated recently. IMD in collaboration with Space Application Centre (SAC), Ahmedabad is using the Normalized Difference Vegetation Index (NDVI), derived from INSAT 3A CCD data, for agromet advisories. Besides, IMD has started preparing the maps for Standardized Precipitation Index (SPI) on weekly, bi-weekly and seasonal basis. In addition to that IMD also started preparing aridity anomaly maps on weekly basis.

Farmers' Awareness Programme

105 Farmers' awareness programmes were organized at different AMFUs across the country. During this year, six AMFUs namely Karimganj, Akola, Khargone, Chhindwara, Kieri and Bachua have organized farmers' awareness programmes. Besides, the Nodal Officers/Technical Officers have participated in number of awareness programme and popularize the GKMS. Besides, AMFUs also arranged field visits, field demonstration, farmers' interaction and also participated in Rabi and Kharif Kisan Melas in different States.

Outreach Programs

IMD participated in field demonstration on 'Agromet Advisory for *kharif* potato cultivation' at Satgaon Pathar Area, Tal-Khed and Ambegaon on 28th August 2013. The programme was documented for Doordarshan telecast under the scheme "Mass Media Support to Agriculture Extension". They discussed and interacted with the local farming community regarding usefulness of the district level AAS bulletins and got the feedback that the same is very useful for cultivation of potato.

FASAL Programme

IMD develops crop yield forecasting models based on statistical techniques under Forecasting Agricultural Output Using Space, Agrometeorology and Land Based Observations (FASAL). The crop yield forecasts are being provided by IMD at different stages of the growth period viz., mid-season (F2) and pre-harvest (F3), stages using agromet models, to Department of Agriculture & Cooperation (DAC). Crop yield forecast for (i) wheat for Madhya Pradesh, Rajasthan, Punjab, Haryana, Bihar and Uttar Pradesh, (ii) rabi rice for West Bengal, Odisha, Karnataka and Andhra Pradesh, (iii) jute for Assam, Bihar and West Bengal, (iv) kharif rice for Andhra Pradesh, Assam, Bihar, Chhattisgarh, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Uttar Pradesh, West Bengal, Punjab, Haryana has been developed and communicated to DAC.

IMD organized regional review meetings under FASAL at the following six places namely ANGRAU, Hyderabad during 5-6 November 2012 for South region, IARI, New Delhi during 8-9 November 2012 for North region, IGKV, Raipur during 5-6 December 2012 for Central region, AAU, Anand during 21-22 December 2012 for Western region, OUAT, Bhubaneswar during 15-16 January 2013 for Eastern region and AAU, Jorhat during 4-5 March 2013 for Northeast region. IMD in coordination with Acharya N.G. Ranga Agricultural University (ANGRAU) has organized 4th ARM on FASAL during 18-19 March 2013 at ANGRAU, Hyderabad to review the progress made in the scheme at various centres and map the future plan.

Outreach programme

Economic Impact of the Agrometeorological services

Agromet Field Units have been carrying out economic impact of AAS bulletins issued based on feedback/interaction with the selected GKMS farmers. Timely forecast of rainfall and subsequent postponement of irrigation advised by many AMFUs saved water, labour and money in different regions. Advisories have also been beneficial in rescheduling application of farm inputs like fertilizers and pesticides Farmers could also adopt better farm management operations like pre-monsoon sowing, propping, delayed harvesting etc. based on the agromet

advisories issued. Feedback collected by AMFUs regarding the economic impact of AAS indicated that the farmers utilizing the AAS service have been benefited better than those farmers who are not utilizing AAS services.

At present, only 10 to 15 percent of the farmers are benefitting from the mobile phone services and about 24 perfect of farmers are aware of it. The economic benefit of these services, however, has been estimated by India's National Council of Applied Economic Research (NCAER) to be Rs.50,000 per year. If the country's entire farming community were to tap this resource, that amount would more than quadruple, to Rs. 211,000 crores.

OPERATIONAL TOOL FOR AGROMETEOROLOGY

IMD in collaboration with IIIT, Hyderabad is generating a software for automation of preparation of advisory bulletin under the scheme "e-Agromet software for automated AAS bulletin preparation" to prepare district level AAS bulletins. It simplifies the preparation of district level AAS bulletin as it acts as an organizing tool for weather forecasts and agromet advisories with the help of repository of past AAS bulletins. A server has been launched by IIIT for the said purpose. Number of AMFU scientists has already been trained and remaining AMFU scientists will be trained in utilization of the software and it will be implemented in GKMS.

IMD is developing the software "Operationalization of Satellite Data Based Soil Moisture Monitoring System in India" in collaboration with IIT, Roorkee and "Determination of Soil Moisture over India using Space Borne Passive Microwave Sensors on board SMOS" in collaboration with ICRS, Jodhpur. Soil moisture data generated using these software will be used in water balance, irrigation scheduling and determination of sowing dates etc. for AAS.

6. SERVICES TO AIR NAVIGATION

As a service provider designated by the Government, IMD is tasked with providing weather services to air navigation within Indian airspace, covering en-route and airfield weather forecasts. Service provision is subject to continuous service quality monitoring and cost management.

IMD AS THE SERVICE PROVIDER OVER INDIAN AIRSPACE

IMD provides a crucial service to the national and international civil aviation sector in fulfilment of the requirements prescribed by the International Civil Aviation Organization (ICAO) and the Director General of Civil Aviation of India (DGCA). These services were provided through 18 Aerodrome Meteorological Offices (AMO) and 54 Aeronautical Meteorological Stations (AMS) located at national and international airports across the country. Aerodrome Meteorological Offices functioning at Mumbai, Kolkata, Delhi and Chennai airports also served as Meteorological Watch Offices (MWOs) watched the weather in respective Flight Information Regions (FIR) and issued timely warnings against adverse weather which would have otherwise affected flight safety, regularity, and economy.

The ICAO designated Tropical Cyclone Advisory Centre (TCAC) monitored the development of tropical cyclones in Indian seas and provided advisory information on tropical cyclones to the Meteorological Watch Offices in India and to the MWOs of the neighbouring countries in fulfilment of its international responsibilities. Based on these advisories MWOs issued SIGMET warnings on tropical cyclones, an important responsibility of MWOs of the region.

The IMD establishment at CATC Bamrauli is full time engaged in training of the aviation personnel. Also, IMD offered resource persons to the AAI training centre in Gondia as part of its human resource development activities.

Through the provision of meteorological services to aviation, a revenue of 40 Crores was earned by IMD for the year.

Delivery of the weather services to the aviation sector and cooperation with its counterparts in building meteorological service provisions. A fully automated on line Briefing and Product Dissemination System for briefing, consultation and documentation of aviation meteorological services has been commissioned at Delhi and Chennai Airport. IMD's aviation met organization also needed to expand to meet the requirements of the growing aviation industry. Technical assistance and consultation was provided to upcoming Durgapur Airport in West Bengal and Kannur Airport in Kerala for setting up the aviation meteorological facilities.

IMPACT OF AVIATION METEOROLOGICAL SERVICES

National Council of Applied Economic Research (NCAER) carried out a comprehensive study to understand the perspectives of the main stakeholders on Aviation Meteorological Services, Sea Water Desalination, Ornamental Fish Culture, and Lobster and Crab Fattening: Economic Benefits, Project Impact Analyses and Technology Policy.

The major finding from the informed stakeholder's field survey on qualitative aspects of provision of meteorological aviation services are that the weather forecast information provided by the IMD is quite useful to take quick and correct decision for flight planning as well as for flight safe landing and takeoff. The weather forecast provided by IMD in severe weather condition are adequate. The weather information is disseminated now-a-days over internet and telephone. Online briefing system over the IMD website has also been adopted.

Operational models for provisions of Met services: International Evidence

The evidence based analysis suggests that it is not prudent to commercialize provision of Met services. IMD should continue to enjoy monopoly rights in provision of Met services. Many countries which experimented with commercialization have moved away from it towards a more focused public service mission. The intent has been to maximize social benefits rather than to maximize revenue collection. For instance, the Single European Sky concept overcomes the regulatory hurdles by eliminating ownership restrictions of the airlines thereby reaping economics of scope in obtaining Met services for aviation.

Economic value of Met services

Economic analysis was used for an estimation of the fair share of Route Navigation Facilities (RNFC) that can be apportioned to IMD for provision of meteorological services. The first one is known as "Evidence-Based-Approach". The World Bank found that when meteorological services provided by the public sector, Meteoagency, in Russian Federation, were commercialized, it could cover 15 percent of National Meteorological Services Budget. Extrapolating the evidence to Indian conditions it emerges that AAI should earmark Rs. 85 crores RNFC rates (in 2011-12 prices) or 6 percent of RNFC to IMD for provision of Met services. The second step is the cost recovery approach. It validates the findings from evidence-based approach. A levy of 6 percent of RNFC towards Met services may not affect the "fair returns" (12 percent return on gross block or capital employed) for AAI at current levels of RNFC levy.

R&D IN AVIATION METEOROLOGY

In order to ensure that the meteorological services provided in support of the aviation operation meets customer satisfaction, implementation of Quality Management System is underway in CAMD and at the three MWOs, namely, Mumbai, Kolkata, and Chennai. IMD took part in the ICAO Coordinated Validation Mission (ICVM) held as part of the latter's

Aviation Weather Observation System for Helicopter operation

safety oversight audit programme. In the effort to support low level flights and helicopter operations to unmanned stations, especially to difficult terrains, implementation of fully automated Aviation Weather Observation System (AWOS) has been conceived. A fully automated Aviation Weather Observation System for Helicopter operation has been installed at Juhu Airport Mumbai as a pilot project. The data generated by the system and feedback of the Pilots and ATCO are being collected to access the utility of such system for future operation.

8. OTHER SERVICES

In addition to weather & forecasting services, IMD has diversified various services in the field of environment monitoring, positional astronomy & marine meteorology. Environmental monitoring is used in the preparation of environmental impact assessments, as well as in many circumstances in which human activities carry a risk of harmful effects on the natural environment. On the recommendations of the Calendar Reforms Committee under the chairmanship of the late Professor Meghnad Saha, astronomical services started in 1955 for scientific and general purposes. India is one among the 8 responsible members of the Marine Climatological Summaries Scheme (MCSS) with the responsibility of the Indian Ocean area.

POSITIONAL ASTRONOMICAL SERVICES

Positional Astronomy Centre Kolkata is the nodal office of the Govt. of India to generate data on Positional Astronomy and to publish the same in the form of annual publications viz. The Indian Astronomical Ephemeris. It is also performing pivotal role in implementing the recommendations of two committees, one as Calendar Reform Committee and other one constituted later on and named as Peer Review Committee, through publication of Rashtriya Panchang in 14 languages. India is one of the 7 countries in the world having an ephemeride office like this centre and publishing the Indian Astronomical Ephemeris. The centre issues the following 16 publications annually.

- The Indian Astronomical Ephemeris
- Tables of Sunrise-Sunset, Moonrise-Moonset
- Rashtriya Panchang in 14 languages namely-English, Hindi, Urdu, Sanskrit, Assamese, Bengali, Gujarati, Kannada, Malayalam, Marathi, Oriya, Punjabi, Tamil & Telugu.

The centre also fixes up dates of all India festivals for all communities for declaration of holiday by Central & State Government. The centre also meets specific data requirements of a large number of users including Govt. organizations, non Govt. organizations, professional astronomers, research scholars, various panchang makers, general public etc.

The centre acts as national agency for attending all matters concerning to calendars. This centre also provides five years advance accurate calendric data to many leading panchang makers of the country for preparation of their own Panchangs. The centre also contributes to a great extent in popularizing astronomy through publication of monthly

astronomical bulletin and star charts (presently star charts are being prepared on computer), issuing press release on different astronomical events through various print media, attending live discussions on various electronic media etc. This centre takes observation on special astronomical events from time to time with the help of its portable telescopes at different places of the country.

Publications

(i) The Indian Astronomical Ephemeris for the year 2014, an annual publication of Positional Astronomy Centre, which mainly contains positional data of the Sun, Moon and planets, basic data on yearly positions of fundamental stars, diary of celestial events, calendric data, eclipse data, explanatory text and other useful information on astronomy has been published on 16th September 2013.

(ii) Fourteen language editions of Rashtriya Panchang of 1935 SE (2013-14 AD) and Sunrise-Sunset and Moonrise- Moonset tables for 2014 have been published during the year 2013. These are important regular publications of the centre catering to daily need of users of almanac, Panchang makers and other users.

(iii) A pocket-type, card-size calendar containing brief information on important celestial events during the year 2013 was published for the benefit of users.

(iv) The centre has prepared monthly star charts and astronomical bulletins for 12 months during the year 2013 for giving useful guidance for watching celestial objects in the night sky. The bulletins contain brief texts explaining positions of objects in the sky and celestial diagrams showing positions for practical demonstrations

Standing Advisory Committee (SAC) Meeting

24th meeting of the Standing Advisory Committee (SAC) was held on 18th November 2013 at Positional Astronomy Centre, Kolkata under the chairmanship of Prof. G. M. Ballabh of Osmania University, Hyderabad. The meeting was attended distinguished members of the committee. The made several recommendations for overall improvement in the functioning of the centre in future.

Public awareness

A colloquium on 'COMETS AND APPROACHING ISON' was held on 19th November 2013.

R&D activities

A new website has been designed and launched on NIC server where facility of downloading e-version of English and Hindi Rashtriya Panchang has been provided for all users along with other usual astronomical data.

Lunar Eclipse

A partial eclipse of the moon was occurred after midnight of April 25th i.e. on April 26th from 01 hrs 22 min to 01 hrs 53 min hrs IST with a small magnitude 0.20. The eclipse was visible in Australia Asia Africa, Europe and Antarctica and throughout India. The beginning of the umbral phase was visible from Eastern part of Australia, Japan and Korea. The duration of eclipse was 31 minutes.

ENVIRONMENT MONITORING

Environmental monitoring is critical to knowing whether the quality of our environment is getting better or worse. Information gathered through environmental monitoring is important to many different decision makers, inside and outside the government. IMD has taken initiatives to establish the environmental monitoring networks for environmental impact assessments and harmful effects on the natural environment.

Surface Ozone Monitoring Network

IMD established Surface Ozone Monitoring Network (Fig. 8.1) by installing Surface UV Absorption Ozone Photometer at New Delhi, Ranichauri, Varanasi, Nagpur, Pune, Kodaikanal, Thiru'puram, Port Blair, Guwahati, Maitri (Antarctica) to determine O3 concentration by measuring the attenuation of UV light due to O3 in the absorption cell. Monitoring of Columnar Ozone and Vertical distribution is also continued at various stations. One minute average observations are recorded at the stations. Each station is also equipped with the standard Ozone calibrator for onsite calibration.

Aerosol Monitoring Network

IMD also established Aerosol Monitoring Network (Fig. 8.2) by installing skyradiometer at twelve locations New Delhi, Ranichauri, Varanasi, Nagpur, Pune, Port Blair, Visakhapatnam, Guwahati, Kolkata , Jodhpur, Rohtak, Trivandrum to measure optical properties of aerosols such as Aerosol Optical Depth, Single Scattering Albedo, Size Distribution, Phase Function etc. Sky radiometers make measurements in eleven narrow wavebands in the ultraviolet, visible and infrared parts of the solar spectrum. The observing scheme is to take measurements in the almucantar geometry every ten minutes, while taking direct solar measurements every minute.

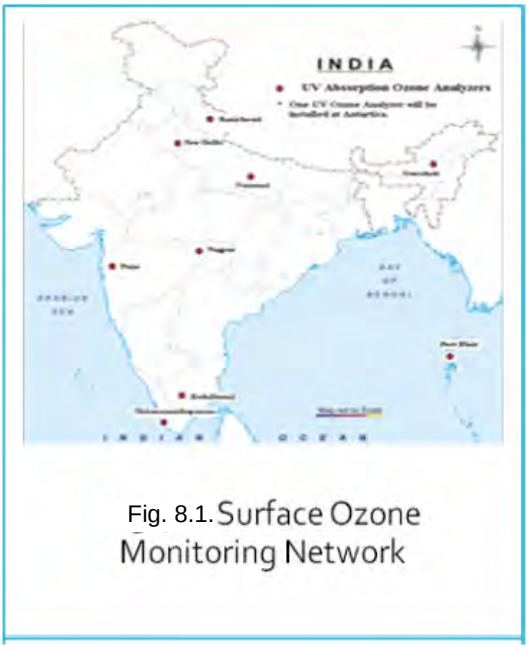


Fig. 8.1. Surface Ozone Monitoring Network

Fig. 8.2. Aerosol Monitoring Network

Air quality forecasting

The system for air quality forecasting and research (SAFAR) has been operationalized by IMD to monitor and forecast air quality in Delhi. This is a joint project of IITM and IMD. The similar air quality monitoring and prediction system is being implemented at Mumbai, Kolkata, Chennai, Bengaluru, Jaipur and Ahmedabad. Some results (Fig. 8.3) are as shown.

Environment Impact Assessment

IMD has evaluated 156 Thermal Power, 675 Industrial, 143 Coal Mine and 694 Mining projects referred by Ministry of Environment & Forests. Dr. S. K. Peshin, Head EMRC served as Member, Expert Committee (Mining), while Dr. S. D. Attri, DDGM (O) served as Member, Expert Committees (Thermal Power Plants, Industries and Coal Mining) of the MoE&F.

Precipitation Chemistry Network

All the 11 stations of Precipitation Chemistry Network have been equipped with Automatic Wet Only Precipitation Collectors during 2013 (Fig. 8.4).

Fig. 8.4 Precipitation Chemistry Network

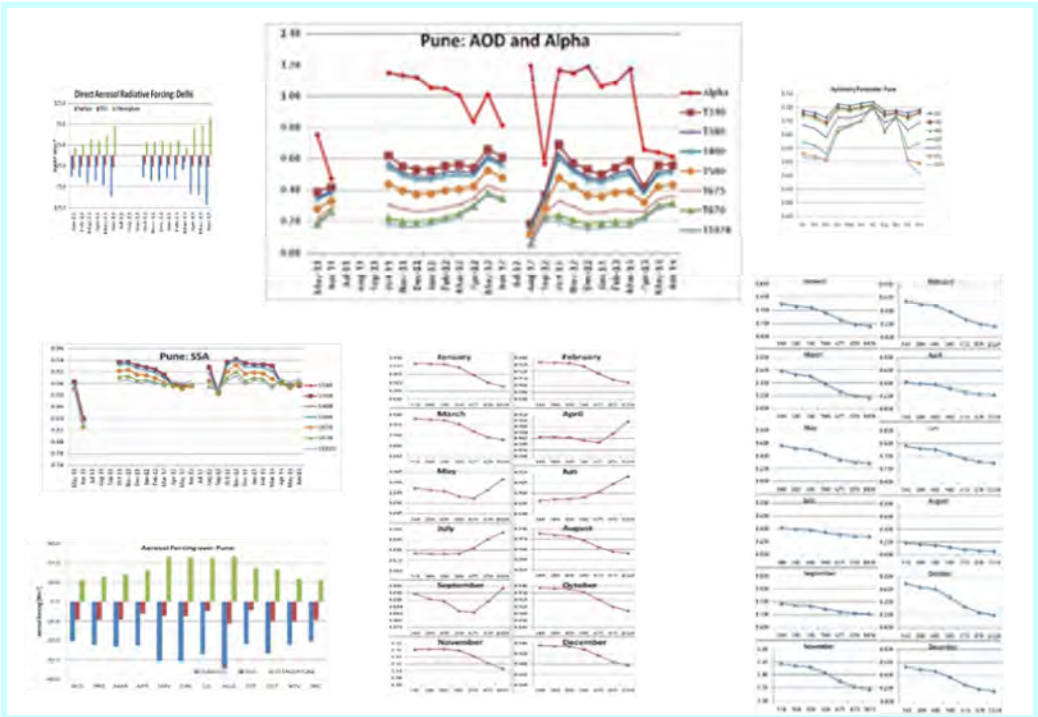


Fig. 8.3. Air quality forecasting

MARINE METEOROLOGICAL SERVICES

The Fourth Congress of WMO in 1963 apportioned the responsibilities of collecting and processing the meteorological observations to the eight responsible member countries. India is one among the 8 responsible members of the Marine Climatological Summaries Scheme (MCSS) with the responsibility of the Indian Ocean area north of 15°S bounded by the longitudes of 20°E and 100°E, providing services since 1971.

Indian Voluntary Observing Fleet (IVOF) are maintained through six Port Met. Offices *viz.*, Kolkata, Visakhapatnam, Chennai, Kochi, Goa and Mumbai. IVOF consists of ships of Merchant Navy, Indian Navy and Foreign ships. Meteorological Observations from the oceanic area are being collected on real time basis for operational forecasting. The ship weather logs are scrutinized and data is archived.

IMD is also supporting various ongoing WMO programmes like Global Ocean Observing System (GOOS), Global Maritime Distress Safety System (GMDSS), Marine Pollution Emergency Responses Support System (MPERSS) and Ships of Opportunity (SOT) etc.

9. EARTHQUAKE MONITORING

Center for Seismology is primarily responsible for monitoring seismic activity in and around the country. The operational task of the Center is to quickly estimate the earthquake source parameters immediately on occurrence of an earthquake and disseminate the information to all the user agencies including the concerned State and Central Government agencies responsible for carrying out relief and rehabilitation measures. The information relating to under-sea earthquakes capable of generating tsunamis on the Indian coastal regions is also disseminated to all concerned user agencies including the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad for issue of tsunami related messages and warnings. The earthquake information is transmitted to various user agencies including public information channels, press, media etc. using different modes of communication, such as SMS, fax, email, IVRS and also posted on IMD's Website *(www.imd.gov.in).*

FROM EARTHQUAKE MONITORING TO CRISIS MANAGEMENT

A total of 2865 earthquake events were detected and auto-located during the period January-October, 2013. These include 1406 events of magnitude 5 and above. Information pertaining significant events was transmitted to all concerned state and central government agencies dealing with relief and rescue operations in the region. During this period, the Indian subcontinent witnessed a large magnitude earthquake of M: 7.4 in Pakistan on 24th September, 2013, which was felt in parts of western India including Delhi. Also, the Doda district of J&K witnessed another moderate earthquake of magnitude 5.8 on 1st May, 2013 followed by intense aftershock activity. In collaboration with Bhaskaracharya Institute of Space Applications and Geoinformatics (BISAG), Gandhinagar, the Center has developed a prototype application for generating dynamic earthquake damage scenarios, depicting the likely expected intensities, ground accelerations, etc. The prototype is under test and shall soon be made operational. Under the project 'Archival and vector digitization of seismic analog charts', the quality checks of the delivered raster scans and vector digitized seismic events are being carried on regular basis.

The seismological data from the network stations is compiled, processed, analyzed and archived systematically at the National Seismological Database Centre (NSDC) on a regular basis. The earthquake bulletins are prepared on monthly basis and archived vis-à-vis also sent to the International Seismological Center. On request basis, the earthquake data and site specific seismicity reports are supplied to industrial units, power houses, river valley projects etc. Seismological data and earthquake related information is supplied to various user agencies dealing with relief and rehabilitation measures, earthquake disaster mitigation and management related matters, seismic zoning, etc. Earthquake data is also being supplied to various scientific,

academic and R&D institutions for research purposes.

SEISMOLOGICAL OBSERVATIONAL NETWORK

Center for Seismology is maintaining a country-wide seismological network consisting of a total of 82 seismological stations. This includes: a) 16-station V-SAT based digital seismic telemetry system around National Capital Territory (NCT) of Delhi, b) 20-station VSAT based real time seismic monitoring network in North East region of the country and (c) 17-station Real Time Seismic Monitoring Network (RTSMN) to monitor and report large magnitude under-sea earthquakes capable of generating tsunamis on the Indian coastal regions. The field stations data is received at CRS at IMD HQ, New Delhi and INCOIS Hyderabad. As part of an international commitment, continuous real time seismic waveform data of three seismic stations viz., Portblair, Minicoy and Shillong is being transmitted to Incorporated Research Institutions of Seismology (IRIS), Washington, USA, for early warning of tsunamis. The National Seismological Network is in successful operation.

Under the project 'Setting up VSAT / terrestrial link to Seismic and GPS network\ stations operated by various agencies', being implemented by INCOIS and IMD, a state-of-art Data Centre has been established in IMD HQ comprising of 20 Intel Servers and two storage systems of 50 TB each for online and off-line processing of incoming waveform data from about 170 seismic 60 GPS stations maintained by various national agencies (Fig. 9.1).

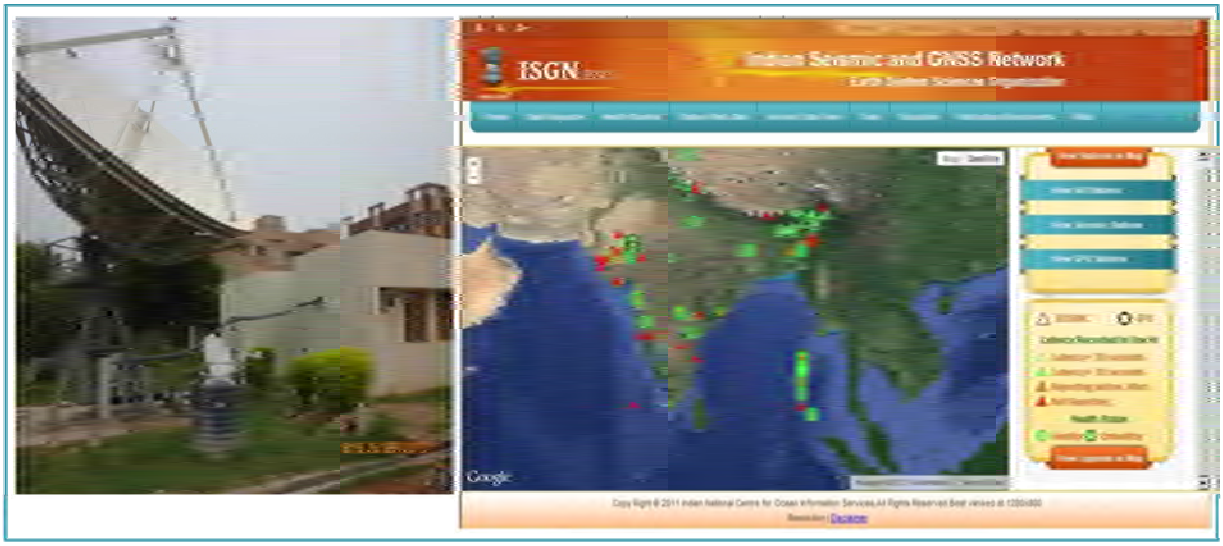


Fig. 9.1. Seismological systems & network

The data collected at IMD will be online replicated to INCOIS over MPLS-VPN Link and vice versa. Similarly data from regional centers, such as NGRI, ISR, NEIST, and WIHG will be collected at IMD and INCOIS. The data centre has capabilities such as, storing of continuous waveform data in standard SEED format, retrieval as per user criteria, Seed Link protocol for connectivity with auto-location software etc. The Data Centre has a web portal (http://www.isgn.gov.in), which gives

access to the registered users for downloading the waveform data for research purposes.

MICROZONATION & HAZARD ANALYSIS

Seismic Hazard Microzonation of NCT Delhi on 1:10,000 scale has been completed for (a) 2% probability of exceedence of an earthquake in 50 years (return period 2475 years) based on MCE and (b) 10% probability of exceedence of an earthquake in 50 years (return period 475 years) based on DBE (Fig. 9.2). The comments received from the members of the Advisory and Monitoring Committees and other experts are being suitably incorporated and the final report is proposed to be published by December, 2013. A copy of the report has also been forwarded to Bureau of Indian Standards for formulating strategies of implementation of seismic hazard microzonation products in Building codes of NCT Delhi. As part of another project on 'Seismic Hazard Microzonation of 30 targeted cities in the country', preparatory actions, such as, collection of base and geological maps for the targeted 30 cities, preparation of approach paper and draft MoU to be signed with GSI, constitution of expert group, floating of tenders for seeking EoI for assessing the available capabilities/ resources in the country and convening of the pre-bid meeting, etc. have been completed.

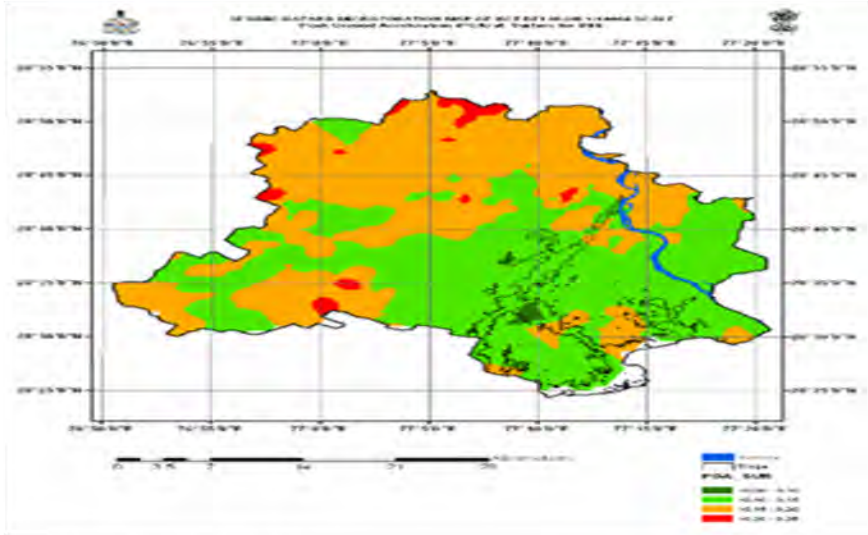


Fig. 9.2. Microzonation map

10. TEACHING METEOROLOGY, DISSEMINATING KNOWLEDGE

Teaching and training in meteorology are an integral part of the activities of IMD. The Meteorological Training Institute (MTI), Pune is responsible for coordinating these activities for IMD, as it is for a wider audience. It relies both on in-house resources and numerous contacts made in academia. Amateurs, students or professionals, the young and the not so young, all come to gain knowledge, both theoretical and practical, in meteorology, by vocation, but also to optimize their decision-making in operational contexts, for which the weather-climate factor is important - and to some extent predictable.

STAFF

Human resource development has always been one of the prime thrust areas of the IMD for capacity building and to keep pace with the latest trends in various activities of the Department. The Meteorological Training Institute (MTI) of the IMD is a World Meteorological Organization (WMO) rated Regional Training Centre (RTC) situated at Pune. Facilities for meteorological training at Pune and New Delhi have been recognized by the WMO to function as Regional Meteorological Training Centre (RMTC) in all the four main disciplines namely, General Meteorology, Radio-meteorology, Telecommunication and Agro-meteorology.

MTI of IMD has a distinguished history dating back to 1942 when it had a humble beginning as an outcome of World War II. In 1943 a full-fledged training school started in Pune, India. Since then the training institute has undergone dramatic changes in its training capabilities, composition, objectives, contents, etc., in catering to personnel covering all levels from Class I to Class IV. IMD also opened training centres at New Delhi for Upper Air Instrumentation and Meteorological Telecommunication in mid-seventies. Since its inception its mission has always been to achieve excellence in education, research and service to meteorological community and thereby to the society. Forecasters Training course, Advanced Met. Training Course (Non-Departmental) Intermediate Met. Training course. Integrated Meteorological Training course. Radio Mechanic Course and LA's Modular Course were conducted and persons were trained during the year. To develop trained manpower, Meteorological Training Institute, Pune conducts regular training courses in General Meteorology for the nominated officials from the department as well as from the non-departmental Government organizations and International Meteorological Services. Personnel trained in various courses during the year 2013 are given below (Table 10.1).

Table 10.1

S. No.	Departmental/ Non- Departmental courses	Duration	Training centres	No. of personnel trained in 2013
1.	Advanced Met. Training Course: IMD,NCMRWF, IAF, Navy, and Met personnel from Asia and Africa	1 Year	Pune	11
2.	Forecasters Training Course	6 Months	Pune	21
3.	Intermediate Meteorological Training Course	3 Months	Pune & Delhi	88
4.	Integrated Meteorological Training Course	4 Months	Pune, Delhi, Chennai & Kolkata	179
5.	Radio Mechanic Course	3 Weeks	Pune	Nil
6.	LA's Modular Course	2 Months	Delhi, Chennai & Kolkata	3

Visit to CHO at HQ

Visit to RMO Ayanagar

Short Term Training Course in "Operational Meteorology" for NCMRWF scientists.

SHORT TERM TRAINING IN OPERATIONAL METEOROLOGY

A Short Term Training Course in "Operational Meteorology" for scientists of NCMRWF was organized by India Meteorological Department (IMD) during 02 to 20 September, 2013 at IMD HQ, New Delhi. Scientist of NCMRWF who were already working in different NWP aspects of atmospheric sciences, were given adequate exposure to various aspects of Operational Meteorology ranging from observation generation / transmission to their processing and finally to operational weather and

climate services. A total of 17 scientists were deputed by the NCMRWF to undergo the course. Lectures on different subjects/topics were delivered by experts all from IMD. Also, Dr M. Rajeevan, Sc G, MoES delivered a special lecture. Operational aspects of Meteorological Instruments and Observations, Synoptic Meteorology, Climatology, Physical Meteorology and Dynamic Meteorology were included in the syllabus. "Special Lectures" on some topics of operational importance were also included in this training. Visits to some Observatories/Centers were included to give full exposure to various practical aspect of operational meteorology. Performance of the trainees was assessed on the basis of an objective type test and Certificate of completion of training were distributed to the successful trainees.

Livestock Production and Management Training

Another training programme was organized on "Weather based Agromet
Advisories for livestock production and management" from 18th to 23rd February, 2013. Twenty three participants from Agromet Field Units located in different parts of the country attended the training programme. Eminent Scientists from, IMD, Indian Veterinary Research Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Central Institute of Fisheries Education, Mumbai, State Veterinary University, Veterinary College, Animal Husbandry Department acted as faculties and delivered lectures. The course covered the topics related to weather and livestock management. Field trip was also arranged at Gowardhan dairy farm, Parag milk Ltd. Manchar, Pune. Participants interacted with the scientists at the Institute and understood various processes involved in milking and allied activities.

Trainees from Asia Pacific Region

Fourteen participants from 8 countries in Asia-Pacific region, undergoing training in "Satellite Meteorology and Global Climate" of SATMET-8 course at Space Applications Centre (ISRO), Ahmedabad visited DWR Chennai, along with two staff members, as part of their south India study tour on 27 February, 2013 and were explained about the functions of DWR and utility of its products.

Microwave Satellite Data Training

A training program was conducted on "Microwave Satellite data and its applications" under Advance Professional Knowledge Course for Air Force trainees during 4 -5 March, 2013.

Agromet Observers' Training

Agricultural Meteorology Division, IMD, Pune conducted two batches of Agromet Observers' course of three weeks duration from 20 May to 7 June, 2013 and 10-28 June, 2013. Participants from the network of various Agromet and other observatories under different State Agricultural Universities/ ICAR Institutions, State Department of Agriculture etc. participated in the course.

NWP training

Two Research Officers of SMRC Dhaka received NWP training at IMD New Delhi for 15 days from 21 October 2013.

DISSEMINATING KNOWLEDGE AND INFORMATION

Workshop on "Storm Surge and Coastal Inundation"

Workshop on "Storm Surge and Coastal Inundation"

A national workshop on "Storm surge and Coastal Inundation modelling and Forecasting" over North Indian Ocean region was held on 11 February, 2013 at IMD, New Delhi. The workshop was inaugurated by Dr. Shailesh Nayak, Secretary, MoES and Chairman, Earth System Science Organization (ESSO). Around 30 delegates from IMD, NCMRWF, TERI, ICMAM, IAF, Indian Navy participated in this workshop.

Brainstorming Workshop

Review of SW Monsoon

Brainstorming Workshop on "Review of Southwest Monsoon 2012" was organized on 26 March, 2013 at Arnav Hall Prithvi Bhawan, Lodi Road, New Delhi. The workshop was designed to assess the performance of various aspects of statistical & NWP models for monsoon rainfall 2012 in different ranges and to formulate the strategy for prediction of monsoon 2013. The workshop was inaugurated by Dr. Shailesh Nayak, Chairman ESSO and Secretary MoES. Dr. L. S. Rathore, DG, IMD presided over the function. It was attended by scientists from MoES and other institutions like IIT Delhi, IITM Pune, CMMACS Bengaluru, SAC Ahmedabad, NCMRWF, C-DAC Bengaluru, NAL Bengaluru, INCOIS Hyderabad, IISc Bengaluru, Indian Air Force and Indian Navy. A special session was arranged to get feedback & assess future requirements of user organizations, i.e., CWC, Ministry of Agriculture and Ministry of Home Affairs.

Meteorological Services in the field of Aviation

Workshop on "Meteorological Services in the field of Aviation"

Workshop on "Meteorological Services in the field of Aviation" organized by MWO Kolkata on 18th September, 2013 at RMC Kolkata. Shri Shantanu Palodhi, ADG, PIB Kolkata was the chief guest of the inaugural session. Presentations on Aviation Meteorological Services were made by different officials of IMD and users' participants also presented their views and provided valuable feedback which will not only improve the quality/quantity of aviation forecast

but will provide much better friendly relations between IMD and Aviation Community .

Workshop on "Doppler Weather Radar and its utilization in Weather Prediction"

Workshop on "Doppler Weather Radar"

Five day's training workshop on "Doppler Weather Radar and its utilization in Weather Prediction" was organized by DWR Kolkata for Indian Air Force, Indian Navy and IMD from 23- 27th September, 2013. The lectures were delivered on the DWR products and their utilization in Nowcasting as well as Forecasting. Sufficient exposure is given in the actual occurrence of thunderstorm observed by DWR.

User Meet on the topic "Weather Services rendered"

The User Meet on the topic "Weather Services rendered by India Meteorological Department to U/T of Puducherry" was organized by ACWC, RMC, Chennai on 6th September, 2013 at Conference hall, Planning & Research Department, Saram, Puducherry. Around 40 delegates from 19 organizations who are directly benefitted by the weather services provided by IMD participated in the User Meet.

User Workshop on DWR

A User workshop on "Utilization of DWR products in Nowcasting of Severe Weather Phenomena" was conducted at DWR, Kolkata on 18-19 February, 2013 for the forecasters from various MCs and RMCs all over India.

AMR, ACR & ATR Meeting

The Annual Monsoon Review (AMR), Annual Cyclone Review (ACR) and Annual Technical Review (ATR) meetings were conducted at Meteorological Centre, Goa during 23 – 25 January, 2013. The meetings reviewed the activities of the department pertaining to cyclones, monsoons and administrative aspect during the past year and future plans to improve the weather services provided to various users.

ACR, AMR and ATR meeting

Annual Review Meeting of Gramin Krishi Mausam Sewa

17th Annual Review Meeting of Gramin Krishi Mausam Sewa (GKMS)" was held during 20 to 22 November, 2013 at Udaipur and was participated by scientists from IMD, ICAR, IITs and invitees from different organizations and private companies which was inaugurated by Dr. L. S. Rathore, DGM.

Exhibitions

IMD participated in Ministry of Earth Sciences' **"Exhibition on Wheels"** at 36 places in Uttrakhand, Andhra Pradesh, Kerala, Karnataka, West Bengal, Odisha, Maharashtra, Assam and India International Trade Fair in New Delhi.

Communicating information about meteorology among the public

Industrial Training of 6-8 weeks was provided to 155 Students of Engineering Colleges, Universities and other organizations. 5 M. Sc. students from different institutes also pusued research in meteology and environmental science.

Industrial Training at IMD

4590 Students / Scientists / Professors/ Doctors / other visitors from different School/ Colleges / Universities/ NDMA/Army/ IAF/ Navy/Agriculture & other Research Institutes visited IMD New Delhi and other Observatories in the country in 2013.

Visit of Secretary MoES to Palam

Dr. Shailesh Nayak, Secretary, MoES visited MWO IGI Airport (IGIA) on 21 June, 2013 and formally interacted with senior officials of IMD, DIAL and ATC where respective organization explained their activities and achievements during 2008-2013. IGI Airport has reached to the hall of the fame with rank two in the best airports in the world. They also visited the site of Met equipments and RVRs at RWY 29-11.

11. UNDERSTANDING CLIMATE

Knowledge and understanding climate change are of a major interest for society. IMD contributes to documenting present climate, reconstituting past changes and predicting future trends. The development of climate services is going to be a major challenge for the next few years, particularly in response to the needs of mitigation and adaptation policies. This service must cover a wide spectrum, from diagnostics to projections, with a goal of transparency and quality of the basic datasets. It is with this aim that IMD is continuing its work, particularly in the direction of rescuing old data and the production of future scenarios under the global framework of climate services.

CLIMATE MEMORY

The total holding of meteorological data at the data centre as of date is 215.7 billion records of which around 2.4 billion records have been updated to the archives in the current year. This also includes data from the project of data rescue scheme under which around 2.0 million records were scrutinized and archived during this year. 'Annual Summary 2012' and 16 issues of monthly and seasonal 'Climate Diagnostics Bulletin of India' were brought out during the year. Climate monitoring and forecast products for South Asia are being generated since March 2013 and uploaded on IMD website. Six new climate monitoring products were introduced since January 2013:

- Monthly area-average mean temperature time series (Fig. 11.1).
- Monthly area-average of total precipitation anomalies expressed as percentages (Fig. 11.2).
- Monthly area-average of standardised precipitation index (SPI) calculated for each station (Fig. 11.3).
- Monthly area-averaged Percent of Time Tmax > 90th Percentile of Daily Maximum Temperature 71-00 period for standardisation (Fig. 11.4).
- Monthly area-averaged Percent of Time Tmin < 10th Percentile of Daily Minimum Temperature 71-00 period for standardisation (Fig. 11.5).
- Significant climate and weather event relevant to the area or region (Fig. 11.6).

Model climatology of Seasonal Forecast Model (SFM) (dynamical model freely available for research purpose) for all the 12 months. Monthly & seasonal forecast in respect of temperature and precipitation are being regularly issued and put on website

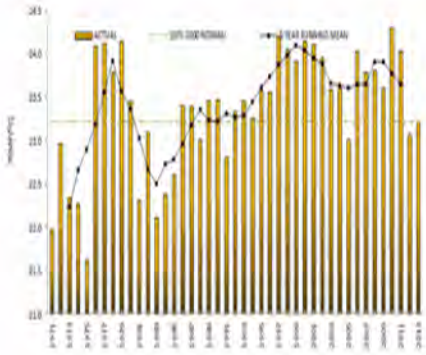


Fig. 11.1. Monthly area-average mean temperature time series

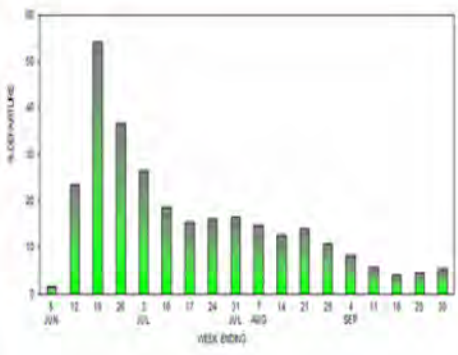


Fig. 11.2. Monthly area-average of total precipitation anomalies expressed as percentages.

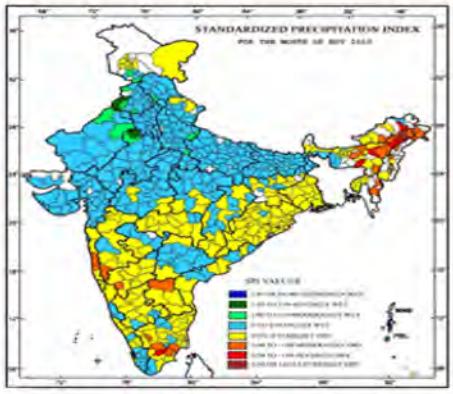


Fig. 11.3. Monthly area-average of standardised precipitation index (SPI) calculated for each station.

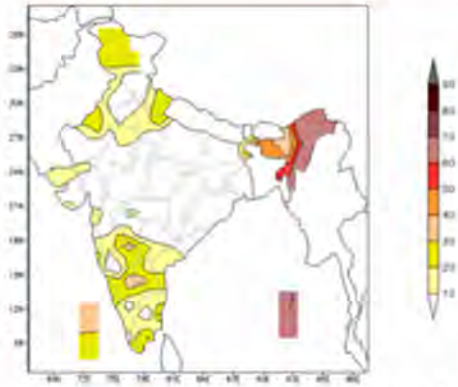


Fig. 11.4. Monthly area-averaged Percent of Time Tmax > 90th Percentile of Daily Maximum Temperature 71-00 period for standardisation.

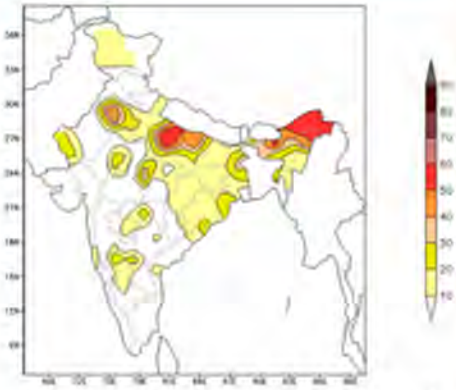


Fig. 11.5. Monthly area-averaged Percent of Time Tmin < 10th Percentile of Daily Minimum Temperature 71-00 period for standardisation.

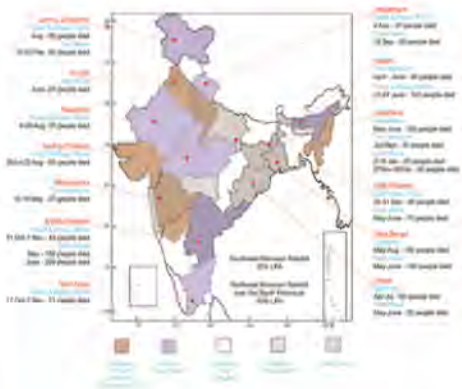


Fig. 11.6. Significant climate and weather event relevant to the area or region during the year

Weekly Drought Outlook Maps prepared and uploaded on website. Computation and generation of Standardized Precipitation Index (SPI) maps were introduced since January 2013 on monthly and weekly time scale for effective drought monitoring. Monthly rainfall data series for districts, states, Met sub-divisions and India were computed as whole based on data from 1901 onwards using uniform methodology. The product is available in soft copy for departmental use and for the sale. So far 114 CD's have been supplied.

Investigations regarding the observed changes in district rainfall pattern & seasonality index over Maharashtra for the period 1901-2006 were carried out and the report was sent to the Chief Minister's office of Maharashtra. Climate data products viz., daily gridded rainfall and temperature CDs were supplied to different national and international institutes. Total no. of 59 CDs were supplied (55 National institutes and 04 International institutes). CDs of daily district wise normal of meteorological parameters were supplied to 15 national parties. An amount of Rs. 2,11,000/- and US $ 1000 were collected towards supply of CDs.

FUTURE CLIMATE SCENARIOS

Considering the future challenges and global framework of climate services, new initiatives were taken on climate Information and data management system

- To establish the state-of-the–art climate data management system for on-line archival, quality control and supply.
- Digitizing all the climatological records (including data rescue efforts) and creating web based interface with the users.
- To develop climate services information system for different user agencies on GIS platform.
- Build specialized regional climate datasets with statistical tools for generating various diagnostics.
- Provide climate database and archiving service, to various user agencies.

Archival of about 5 lakh analyzed weather charts into electronic media have completed and same have been loaded into NAS for access by remote users and undertaken the archival of another 2.5 lakh charts. It is also being considered to outsource for cataloguing the 5 lakhs archived weather charts accordingly to synoptic events so that the same could be referred and used for operational forecasting purposes. The product will facilitate online analogy of charts based on Synoptic parameters. In the first phase of data rescue, about 4.5 million data charts were scanned and 28 million data records were keyed.

SASCOF

South Asian Climate Outlook Forum held its first three meetings during 2010-12 in Pune jointly organised by IMD and IITM and co-sponsored by WMO. the meeting and attended by representatives from NMHSs and WMO Global Producing Centres of Long Range Forecasts. IMD supported Nepal in hosting 4th SASCOF in Nepal.

12. RESEARCH & DEVELOPMENT

RESEARCH PUBLICATIONS

IMD has pursued R&D for improving weather and climate services including technological development. It has published 100 research papers in reputed National and International Journals and 23 scientific Reports and Books.

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- Climate monitoring and forecast products for South Asia are being generated since March 2013 and uploaded on IMD website.

- The updated "Rainfall Atlas of India" was brought out.

- 100 Years "Monthly Rainfall Data (1901-2000) for the Districts, States, Met-Sub divisions and Country as a whole" was prepared and the same are available in soft copy.

- A book entitled 'Cyclone Warning in India, A standard Operation Procedure, Climate of Bihar.

- A book entitled 'Monitoring and Prediction of 'Tropical Cyclones in the Indian Ocean and Climate Change' edited by Prof. U. C. Mohanty, IIT Bhubaneswar, Dr. M. Mohapatra, Sc. 'E', Dr. O. P. Singh, Sc. 'F' Shri B. K. Bandyopadhyay, Sc. 'F' and Dr. L. S. Rathore, DGM, IMD has been published jointly by Springer and Capital Publishing Company, New Delhi.

Higher Research Degree

Dr. R. S. Dattatrayam, Sc. 'F' and Head (Center for Seismology) has been awarded the Ph.D. degree in Geology by University of Delhi in its 90 Annual Convocation held on 19 March, 2013 in the presence of Shri Pranab Mukherjee, the Hon'ble President of India as Chief Guest.

Best Poster Presentation

Ms. Barnali Das was awarded for Best Poster Presentation for the paper "Weather based yield forecast of kharif rice for districts of Jharkhand" at IMSP Annual Workshop during 19-20 February, 2013.

Hon'ble President of India Shri Pranab Mukherjee during convocation of Dr. Dr. R. S. Dattatrayam,

FORECAST DEMONSTRATION PROJECT

Several national institutions participated for joint observational, communicational and NWP activities in the final phase of Forecast Demonstration Project on landfalling cyclones over Bay of Bengal during 15 October-13 December, 2013. Four spells of Intense Observational Periods (IOPs) were observed during 18-22 October, 09-15 November, 18-27 November and 30 November-13 December 2013. As a whole 36 days of IOP were observed during FDP-2013.

The STORM Fields Experiments covered the whole SAARC region in 2013. In Phase-III of SAARC STORM Programme which started in 2013, STORM Field Experiments were also executed in southern peninsular India, Maldives and Sri Lanka to study maritime and continental convective storms during pre-monsoon season of 2013..As per recommendations of 5th Meeting of International Programme Committee (IPC) of SAARC STORM Programme (Islamabad, Pakistan, 3-4 September 2012) and 18th Meeting of Governing Board of SMRC (11-12 September, 2012), the STORM Field Experiments were conducted in SAARC regions as per the following schedule.

- STORM Phase I: (Bangladesh, Bhutan, east & northeast India and Nepal) - 01 April- 31 May 2013.
- STORM Phase-II: (Afghanistan, northwest India and Pakistan) – 15 April-15 June 2013.
- STORM Phase-III: (southern peninsular India, Maldives and Sri Lanka) - 15 March - 15 May 2013.

In order to have effective STORM Field Experiments, The Weather Advisory Committees (WACs) at the Indian national level was constituted by DG, IMD & Chairman WAC. To decide about Intensive Observation Period (IOP) dates, the WAC members or the nominated members participated in the weekly meetings during the period 15th March 2013 to 15th June, to assess the large scale synoptic and mesoscale environment and decide about the beginning and cessation of IOPs.

Storm experiments were conducted in three regions of the country as per the following schedule:

- Northwest India. (15 April-15 June 2013)
- East and Northeast India. (01 April- 31 May 2013)
- Southern Peninsula. (15 March - 15 May 2013)

A report was prepared at the end of the experimental period and released during the SAARC Seminar on 'High Impact Weather Events and their Prediction over the SAARC Region' held during 2-4 December, organized jointly by IMD and SMRC, Dhaka. The report refers to the action taken by India towards the implementation of the program. The report briefly covers the background of the SAARC STORM programme and its implementation for the 2013 pre-monsoon season. It also addresses some climatological aspects about the thunderstorm season over the four regions of India comprising of a) Northeast Indian states b) East India c) Northwest India and d) Southern Peninsula. The period of Intensive observation differed from region to region. The report provides the frequency of thunderstorm events over different regions, as well as thunderstorms accompanied with squalls and hailstorms. Instructions about the launching of IOP were sent to each region separately for different dates and the verification of the incidence of thunderstorms for each IOP over different regions have been evaluated. The report also provides typical case studies one each for India as a whole, for Northwest India, for Northeast India, for East India and southern Peninsular India. Since the program was carried out in three different phases, covering different regions of India, daily STORM bulletins for each region are also provided as Appendix in the report. The report finds that on large majority of the occasions the incidents of thunderstorms as provided in the IOP have been well realized, this was primarily due to the intensive monitoring provided by IMD set up and utilization of NWP guidance. The Report has discussed in detail the RADAR products, conventional IMD data, NWP products and satellite data.

13. THE INTERNATIONAL DIMENSIONS

THE WORLD METEOROLOGICAL ORGANIZATION (WMO)

India is a founder member of the International Meteorological Organization (IMO), which was later, constituted as World Meteorological Organization (WMO), a specialized agency of the United Nations. Members of the WMO are grouped into 6 Regional Associations. India is grouped with other Asian Countries in Regional Association-II. Director General of Meteorology acts as permanent Representative (PR) of India with WMO and representing on WMO Executive Council, which is the highest Executive Body of the WMO, continuously since its inception. Dr. L. S. Rathore, DG, IMD and PR of India with WMO, is an elected Member of Executive Council of WMO. The WMO Executive Council is responsible for implementation and coordination of the Programmes of WMO and its constituent bodies i.e. Regional Associations, Technical Commissions and the Congress.

The Department is actively participating in the international Cooperation Programme of Meteorology and allied subjects between the Government of India and the Governments of USA, Russia, Japan, China, Australia, Mauritius, France, Sri Lanka, Bangladesh, Maldives, Nepal, Iceland, Myanmar, etc. India is participating in the implementation of the strategic plan for further enhancement of services of National Meteorological Services (NMSs) in the Asian Region.

65th Executive Council of WMO

Dr. L. S. Rathore, DGM was elected as **Member of Executive Council of WMO**.

65th Executive Council Meeting of WMO

DGM meeting with South Africa Delegations

DGM meeting with Finland Delegations

Meeting of Working Sub-Group of Meteorology of India and Russia

DGM meeting with delegations during 65th session of EC at Geneva during 15-23 May 2013

Global Framework for Climate Services

Dr. L. S. Rathore, DGM was elected as **Co-Vice Chair** of Inter-Government Board for Global Framework for Climate Services during its 1st meeting held at Geneva during 1-5 July 2013 which was convened as per decision of the Extra-ordinary Session of WMO Congress.

1st Meeting of IGB of GFCS of WMO

High Level Meeting on National Drought Policy

Dr. L. S. Rathore, DGM represented India in "High Level Meeting on National Drought Policy" at WMO Geneva (Switzerland) during 11-15 March, 2013.

Dr. L. S. Rathore, DGM during HLMNDP at Geneva

Commission for Atmospheric Sciences of WMO

Dr. S. D. Attri, DDGM (O) was elected as Member of Management Group of Commission for Atmospheric

Dr. S. D. Attri, DDGM (O) at Antalya, Turkey

Sciences of WMO during its 16th Session held in Antalya, Turkey during 20-26 November, 2013. The Session was preceded by TECO of WMO during 18-19 November, 2013. The events were participating by 103 experts from different countries and WMO.

CAPACITY BUILDING OF ASIA AND AFRICA PERSONNEL

Operational Agromet Training

IMD in collaboration with the World Meteorological Organization (WMO) organized training programme on "Operational Agrometeorology for serving end users requirement" during 28th January to 9th February, 2013 for capacity building in the agriculture sector of the Global Framework for Climate Services (GFCS). Ideally the training was drawn upon those scientists working

in operational Agro-Meteorological Advisory Services and those who provide climate/weather information products and services. The training was specially designed for the professionals in East African (Burundi, Ethiopia, Kenya, Rwanda, Tanzania) and Asian participants (Bangladesh, Myanmar, Sri Lanka, and Thailand). The training was conducted at Meteorological Training Institute, Pune, India.

Capacity building for Agrometeorological Services

Capacity building workshop for Agrometeorological Services

India Meteorological Department, Ministry of Earth Sciences & World Meteorological Organization, Geneva, jointly organized international Workshop on "Capacity building for Agrometeorological Services" on 28th - 29th October-2013. The overall objective of the workshop was to review the existing training, capacity building practices, activities for agrometeorological services and to make recommendations on how to improve these activities. Another objective was to start the process of reviewing guidelines on 'Education and Training' in Agricultural Meteorology and make specific recommendations to 16th Session of CAgM in April 2014. The workshop brought together the participants from many countries in the world to share their ideas and experiences. The participants were the members of WMO Commission for Agricultural Meteorology's Implementation / Coordination Team in Agrometeorological Services, representatives from WMO Regional Training Centers (RTCs) and other experts.

Tropical Cyclone Forecasting Training

Training on Operational Tropical Cyclone Forecasting was organized by RSMC-Tropical Cyclone, New Delhi during 1-12 April, 2013. The forecasters from WMO/ESCAP countries viz. Bangladesh, Oman and Myanmar participated in the training. Also forecasters from Area Cyclone Warning Centres, Cyclone Warning Centres and RSMC, New Delhi participated in the training. The trainees were also attached to different divisions of IMD, NCMRWF and NIDM to be familiarized with activities relating to Cyclone prediction and disaster management. The course completion certificates were distributed to the trainees during the valedictory function held on 12 April, 2013.

Tropical Cyclone Forecasting Training

Cooperation with SAARC

The Department is actively associated with South Asian Association for Regional Cooperation (SAARC) Programme and is a member of its Technical Committee on Science and Technology & Meteorology. DGM, IMD is member of Governing Board of SAARC Meteorological Research Centre (SMRC), Dhaka, Bangladesh and has also served as its Chairman.

National Working Group on SAARC Monsoon Initiative Program

The first meeting of the National Working Group on SAARC Monsoon Initiative Program (NWGM) was held on 13 September 2013 at India Meteorological Department, New Delhi under the Chairmanship of Dr L.S. Rathore, DG IMD. The meeting was attended by the experts/scientist from various national organizations and user agencies, which include IMD, IITM, NCMRWF Ministry of Earth Sciences (MoES), Ministry of Agriculture, SAARC Disaster Management Centre, Ministry of Health and Family Planning etc.

SAARC International Seminar

IMD hosted SAARC International Seminar on 'High Impact Weather Events and their Prediction over the SAARC Region' in New Delhi during 2-4 December, 2013 which was inaugurated by Dr. Shailesh Nayak, Secretary, MOES participated by scientists from various SAARC countries and institutes in India.

Bhutan Met. Personnel training course

A special training course was conducted at Pune for seven personnel from Bhutan Aviation Met. Services of the Civil Aviation Department of Bhutan during the period from 15th October 2012 to 11th January, 2013.

Training for Bhutan Met. Personnel

VISIT OF INTERNATIONAL DELEGATION / EXPERTS

Dr. Mike Bonell, Professor, Univ. of Dundee and Dr. Ravi Bhalla, Sr. Research Fellow Foundation for Ecological Research, Advocacy and Learning (FERAL) visited RMC Chennai and had a meeting with Dr. Y. E. A. Raj, DDGM, RMC Chennai on 11 February, 2013 in connection with his Changing Water Cycle Research Programme.

Dr. Mike Bonell and his colleagues discussing with Dr. Y. E. A. Raj

Dr. P. K. Aggarwal, Regional Programme Leader, South Asia, Climate Change, Agriculture and Food Security (CCAFS), International Water Management Institute (IWMI), New Delhi visited Agrimet Division and discussed on the aspects and collaboration with IMD on "Climate Smart Village" on 14 February, 2013.

Discussion for climate project at RMC, Chnnai

Prof. Mark Howden, Chief Research Scientist, Commonwealth Scientific and Industrial Organization (CSIRO), Australia, Dr. Uday visited RMC Chennai along with Dr. A. Arivudai Nambi and three officials from M. S. Swaminathan Research Foundation, Chennai visited RMC Chennai on 20 March, 2013. DDGM convened an interactive session with senior officers and officers-in-charge at RMC Chennai during the visit to discuss on climate project of CSIRO, Australia.

UAE Delegation

UAE Delegation led by Mr. Mohd. Hasan Al Harmoudi, Director and consisting of Mr. Yousuf Nasir Al Kalbani, Head, Mr. Khamis Saif Al Shamsi, Chief and Mr. Ibrahim Khamis Husani, Expert from from the National Centre for Meteorology & Seismology (NCMS), Government of UAE visited IMD facilities during 8-9 April, 2013 and held discussion for co-opetaion in meteorology and seismology in a meeting attended by officials from MoES, IMD, NCMRWF and MEA.

14. RESOURCE MANAGEMENT

FINANCIAL RESOURCES AND MANAGEMENT PROCESS

Budget Estimates

Budget provisions for the department during the financial year 2013-14 were as follows:

Budget Estimates (Plan)

B.E. (Revenue) Rs.70 Crores
B.E. (Capital) Rs.130 Crores

Budget Estimates (Non-Plan)

B.E. (Revenue) Rs. 300.06 Crores
B.E. (Capital) Rs. 3.01 Crores

Plan Schemes

This year has been remarkable in obtaining the approval of the plan schemes. The upgradation of weather forecasting capabilities to an optimum level was one of the major priority programs launched during 11th Five Year Plan. It has improved forecasting capabilities significantly. To further upgrade the capabilities, various plan schemes were processed to be taken up during XII Five Year Plan as follows:

- The scheme "Atmospheric Observations Systems Network" has been approved at total estimated cost of Rs. 700 Crore to deal with sustenance of observational networks covering Doppler Weather Radars (DWRs), Automatic Rain Gauges (ARGs), Automatic Weather systems (AWSs), Upper air, surface and environmental observatories etc. on 24 × 7 basis along with provision of adequate communication system for data & product transmission and maintenance of operational forecast system, delivery system for forecast and other services, conduct of special campaigns for improving Cyclone, Thunderstorm and Fog forecasting, etc.

- The scheme "Satellite meteorology" has been approved for continuation at total estimated cost of Rs. 70 Crore to receive, process, derivation of products from imager and sounder payloads data of INSAT-3D, INSAT-3A, KALPANA-1 & polar satellites along with establishment of state-of-art National satellite data centre & GPS stations for measurement of integrated precipitable water vapor (IPWV).

- The scheme "Gramin Krishi Mausam Sewa" approved for continuation at total estimated cost of Rs.165.25 Crore to improve the existing district level Agromet Advisory Services (AAS) to sub district level and in pilot mode at block level and creation of cell for Research Excellence in Agro-Meteorology.

- The scheme "Augmentation of Aviation Meteorological Services" approved for continuation at total estimated cost of Rs. 115 Crore for upgradation of Airport Meteorological Instruments (AMIs) at runway locations for the major airports by commissioning of Airport Weather Observing Systems, Transmissometers, Aviation Weather Decision Support Systems etc.

- The scheme "Climate Services" approved at total estimated cost of Rs. 55.40 Crore to create facilities for providing Climate Services through the establishment of a Regional Climate Centre (RCC)-South to cater to the need of a comprehensive set of specialized climate services for the country and for South Asia region.

- The scheme "Metropolitan Air Quality and Weather Service" approved at total estimated cost of Rs. 90 Crore taken up jointly with IITM to provide near real time and 1-2 day advance forecast for weather and air quality information for several Metropolitan cities and to forecast weather in now-cast and short range scales over different sections of the Metropolitan cities including severe weather warnings.

- Another new scheme "Modeling of changing water cycle and climate" approved at total estimated cost of Rs. 89.90 Crore jointly with NCMRWF to understand the water cycle process.

- The Scheme "Training in Operational Meteorology" approved at total estimated cost of Rs. 55.81 Crore to upgrade training & capacity building to provide essential knowledge base in atmospheric.

- The scheme "Integrated Himalayan Meteorology Programme for Western & Central Himalayas" proposed for Rs. 110 crores covering four states namely Jammu & Kashmir, Himachal Pradesh, Uttarakhand, and Sub Himalayan West Bengal to improve mountain weather and climate monitoring and forecast services over the Himalayan region.

- Another scheme "Integrated Meteorological Services for Northeastern Region" submitted to Ministry of Development of North Eastern Region (DoNER) to improve weather forecast services over the northeastern region covering states namely, Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Mizoram, Tripura & Sikkim.

- Another new scheme "Severe weather warning system" processed for NCR.

Results-framework document (RFD)

To move the focus from process-orientation to result-orientation and to provide an objective and fair basis to evaluate department's overall performance at the end of the year, various activities of the department were quantified and results-framework document was prepared and submitted to Performance Management Division, Cabinet Secretariat to Government of India for the performance monitoring and evaluation of the department.

Innovation Action Plan

An innovation action plan was finalized to receive, collate, encourage and facilitate innovation ideas from officers/staff for improvement in Weather Forecast, Severe Weather Warnings, Monitoring of Earthquakes and timely Dissemination of information to Citizen/Clients/ Stakeholders.

Citizen's/Client's Charter

Citizen's/Client's Charter was finalized highlighting the standards of service delivery that it subscribes to, availability of choice for public and avenues for grievance redress and other related information as follows:

No.	Our Services and Transactions	How we measurer our performance in this area	Our service standard
1	Weather Forecasts and Warnings	Timely release of Weather Forecast and Warnings	6 Hours
2	Agro-meteorological advisories at district level	Issue of Agro-meteorological advisories at district Level	4 Days
3	Meteorological support for Civil Aviation purpose	Meteorological support for Civil Aviation purpose	60 Minutes
4	Rainfall monitoring	Rainfall Monitoring (District/subdivision wise)	1 Day
5	Monitoring of Earthquakes	Reporting of Earthquakes of magnitude 6.5 and above of Tsunami-genic potential in Indian Ocean region.	10 Minutes
		Reporting of Earthquakes of magnitude less than 6.5 within the country and neighborhood	20 Minutes
6	Environment Monitoring	Reporting of Air quality, Aerosols etc.	60 Minutes
7	Supply of Meteorological/ Climatological information.	Supply of data after receiving the payment	4 Weeks
8	Supply of Indian Astronomical Ephemeris & Rashtriya Panchang.	Supply of Indian astronomical ephemeris after receiving the Payment.	4 Weeks
		Supply of Rashtriya Panchang after receiving the payment	4 Weeks
9	Grievance Redressal	Timely redressal of public grievance (a) Acknowledgement	7 Days
		(b) Final response	60 Days

HUMAN RESOURCES & MANAGEMENT PROCESS

The employees of the department are its most valuable resources. The human resource management process of the department playing a significant role in managing its personnel matters, especially in respect of issues concerning to recruitment, training, career development and welfare. It also created an enabling environment for the development and management of human resources of the department for efficient, effective, accountable, and responsive governance by attracting the best talent for the department, providing due career-advancement opportunities, encouraging competence and innovation, adopting a dynamic framework of personnel policies and procedures, ensuring capacity building at all to make the department more responsive, effective and efficient.

Commencement of Integrated Meteorological Training Course (IMTC) for newly recruited Scientific Assistants

A Four months curriculum for Integrated Meteorological Training Course for newly recruited Scientific Assistants was designed merging the Basic & Intermediate Training Course in General Meteorology, Meteorological Instrumentation and Telecommunication keeping in view the changed requirements of the office. First Batch of IMTC training commenced in the month of March 2013 at all the four training centres viz. New Delhi, Pune, Chennai and Kolkata.

Review of Training Curriculum

Training curriculum of Intermediate Course in Instrumentation / Telecommunication was reviewed and both these courses are now combined together as "Intermediate Training in Meteorological Instrumentation and Information Systems" of four months duration as Meteorological Instrumentation, data processing and communication are now inseparable parts of Meteorological services. This merger would help in development of a more effective and versatile human resources base for new requirements of IMD.

Promotions & Recruitments

Recruitment to the cadre of Meteorologist Grade-II/ Scientist B through UPSC and Scientific Assistants through SSC could be initiated after the gap of more than ten years. Three hundred ten (310) new Scientific Assistants (SAs) have joined the department against the nominated 433 persons and processing for filling up of another 220 vacancies of SA has been initiated. Process for filling up of various other posts of also initiated. Following promotions were made during the year 2013.

Name of the Post	Number of the official promoted
Scientist 'E' to Scientist 'F'	05
Scientist 'D' to Scientist 'E'	14
Scientist 'C' to Scientist 'D'	36
Asstt. Meteorologist Gr.II to Asst. Met. Gr.I	349
Scientific Assistant to Assistant Meteorologist Gr. II	314
Admin. Officer Gr. III to Admin. Officer Gr.II	21
Assistant to Admin. Officer Gr. II	51
Private Secretary to Senior P.S.	01
Steno Gr. I to P.S.	03
Hindi Translator Gr. I to Hindi Officer	01
UDC to Assistant	24
Steno Gr. II to Steno Gr.I	02
Staff Car Driver Gr.I to Car Driver Special Grade	04
Mech. Gr. II (Ind) to Mech Gr. I (Ind)	05
Mech Gr. I (Ind) to Mechanical Asstt (Ind)	06
Mech. Gr.I (Non.Ind) to Mechanical Asstt. (Non.Ind.)	03
LDC to UDC	03
Group D (MTS) to LDC	07
L.A. III to L.A. II	11
Staff Car Driver Gr. II to Staff Car Driver Gr. I	03
Staff Car Ordinary Grade to Staff Car Driver Gr. II	03

QUALITY ASSURANCE OF METEOROLOGICAL SERVICES

Standards make an enormous and positive contribution to most aspects of our lives. Standards ensure desirable characteristics of products and services such as quality, environmental friendliness, safety, reliability and efficiency. ISO 9001 is a generic quality management system. It codifies quality standards in every area of organization's functioning. IMD has successfully obtained ISO 9001:2008 certification for its five offices viz. Meteorological Office (MO) Palam, Radar Palam, MO Safdarjung, RS/RW Ayanagar and Meteorological Centre (MC) Hyderabad during 2012-13.

In the field of aviations, meteorological services provided at the 16 international airports at Lucknow, Bangalore, Patna, Hyderabad, Jaipur, Thiruvananthapuram, Ahmedabad, Kochi, Coimbatore, Mangalore, Calicut, Amritsar, Varanasi, Gaya, Thiruchirappilly, and Madurai. Meteorological services provided are designed to meet the requirements of the stakeholders concerning safety, efficiency, regularity and economy of the national and international operations carried out through by providing services and products that will be timely, accurate, and reliable by following procedures as given in "Manual on Meteorological Services for Aviation in India" and through user feedbacks to support corrective and preventive actions and continual improvement. The infrastructure facilities and meteorological services provided at the Aviation Meteorological Offices at the international airports of Chennai, Kolkata, Mumbai and Central Aviation Meteorological Division (CAMD), New Delhi have been undertaken for implementation of ISO certification process during 2013-14.

METEOROLOGICAL ACTIVITIES IN HINDI

राजभाषा नीति का कार्यान्वयन-2013

1. बैठकें

गृह मंत्रालय,राजभाषा विभाग द्वारा जारी वार्षिक कार्यक्रम के अनुपालन में बैठकें नियमित रूप से आयोजित की गई जिनकी अध्यक्षता महानिदेशक महोदय ने की। राजभाषा कार्यान्वयन समिति की बैठकें दिनांक 25.03.2013,21.06.2013, 21.10.2013 को आयोजित की गईं ।

2. रिपोर्ट

मुख्यालय की राजभाषा हिंदी के प्रगामी प्रयोग से संबंधित 31 दिसम्बर 2012,31 मार्च 2013,30 जून 2013 और 30 सितम्बर 2013 को समाप्त तिमाही की तिमाही प्रगति रिपोर्टें राजभाषा विभाग और पृथ्वी विज्ञान मंत्रालय को भेजी गईं। मुख्यालय की हिंदी शिक्षण योजना से संबंधित छमाही रिपोर्ट हिंदी शिक्षण योजना के कार्यालय को भेजी गई। राजभाषा हिदीं के प्रयोग संबंधी मुख्यालय की वार्षिक मूल्यांकन रिपोर्ट राजभाषा विभाग, क्षेत्रीय कार्यान्वयन कार्यालय (उत्तर क्षेत्र) को भेजी गई ।

3 प्रशिक्षण

राजभाषा विभाग,केंद्रीय हिंदी प्रशिक्षण संस्थान द्वारा कम्प्यूटर पर हिंदी में कार्य करने के लिए आयोजित बेसिक प्रशिक्षण कार्यक्रम में मुख्यालय के 23 कार्मिकों ने प्रशिक्षण प्राप्त किया ।

4 निरीक्षण

संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 17.01.2013 को प्रादेशिक मौसम केंद्र, मुंबई का निरीक्षण किया गया जिसमें महानिदेशक महोदय डॉ .एल.एस.राठौड़, वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा उपस्थित रहे ।संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 28.05.2013 को मौसम कार्यालय भुंतर (प्रादेशिक मौसम केंद्र नई दिल्ली का अधीनस्थ कार्यालय) का निरीक्षण किया गया। वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा ने दिनांक 18.01.2013 को मौसम कार्यालय सांताक्रुज तथा 21.01.2013 को आर .एस .आर .डब्ल्यू विले पार्ले कार्यालयों को राजभाषा संबंधित निरीक्षण किया । दिनांक 24.05.2013 को वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा ने मौसम कार्यालय भुंतर का राजभाषायी निरीक्षण किया ।

6. पुरस्कार

दिनांक 15.01.2013 को भारत मौसम विज्ञान विभाग के 138वें स्थापना दिवस पर माननीय मंत्री महोदय श्री जयपाल रेड्डी द्वारा वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा को सर्वश्रेष्ठ अधिकारी समूह 'क' के पुरस्कार से सम्मानित किया गया।

7. प्रकाशन

विभागीय हिंदी गृह पत्रिका 'मौसम मंजूषा ' के 18 वें अंक का प्रकाशन किया गया । मौसम से जुड़ी कविताओं का काव्य विशेषांक 'मौसमी बयार' का प्रकाशन किया गया। राजभाषा हिंदी की गतिविधियों से संबंधित न्यूज लैटर 'राजभाषा बुलेटिन' का प्रकाशन किया गया। भारत मौसम विज्ञान विभाग की अखिल भारतीय विभागीय हिंदी निबंध लेखन प्रतियोगिता के अन्तर्गत वर्ष 2011 से 2013 तक के पुरस्कृत निबंधों और प्रोत्साहन प्राप्त निबंधों को 'निबंध सागर 2013 पुस्तक में संकलित किया गया।

8. विभागीय योजनाएँ

अखिल भारतीय विभागीय हिंदी निबंध लेखन प्रतियोगिता में प्रथम पुरस्कार श्री अशोक कुमार, वैज्ञानिक सहायक, द्वितीय पुरस्कार श्री रामहरि शर्मा,वैज्ञानिक सहायक,तृतीय पुरस्कार श्री कर्मवीर सिंह, सहायक, प्रोत्साहन पुरस्कार क्रमशः, श्री

कु.वै.बालसुब्रमणियन, सहायक मौसम विज्ञानी-I, श्री आर.शहनवाज, मौसम परिचर और श्री आर.बी.एस.नारायण, सहायक मौसम विज्ञानी को दिए गए। सरकारी कामकाज मूलरूप से हिंदी में करने की योजना के अन्तर्गत हिंदी में किए गए कार्य के लिए मुख्यालय के चार कार्मिकों को कुल 4,400/-रू. और उपकार्यालयों के 05 कार्मिकों को कुल 6,400/-रू. की राशि स्वीकृत की गई ।

बाल कलाकरों द्वारा प्रस्तुत 'देश भक्ति गीत'

'मौसम-मंजूषा' के 18वें अंक का विमोचन

9. हिंदी दिवस एवं हिंदी पखवाड़ा

भारत मौसम विज्ञान विभाग के महानिदेशक के कार्यालय, नई दिल्ली में हिंदी पखवाड़ा/हिंदी दिवस 2013 समारोहपूर्वक मनाया गया। हिंदी पखवाड़ा 2013 के दौरान हिंदी निबंध, हिंदी टिप्पण और मसौदा लेखन, हिंदी टंकण, स्वरचित हिंदी कविता पाठ, हिंदी वाद-विवाद, हिंदी स्लोगन और कार्टून प्रतियोगिताएँ आयोजित की गई । हिंदी दिवस समारोह 16 सितम्बर 2013 को फूलों से सुसज्जित वृष्टि सभागार में आयोजित किया गया। समारोह की अध्यक्षता मौसम विज्ञान के महानिदेशक डॉ. लक्ष्मण सिंह राठौड़ ने की। हिंदी दिवस के अवसर पर माननीय गृह मंत्री श्री पी.चिदंबरम द्वारा भेजे गए संदेश को सुश्री रेवा शर्मा ने सभागार में पढ़कर सुनाया । इसके बाद विभागीय हिंदी गृह पत्रिका 'मौसम-मंजूषा' के18वें अंक और पहले काव्य विशेषांक 'मौसमी-बयार' का महानिदेशक महोदय द्वारा विमोचन किया गया। वर्ष 2012-2013 में हिंदी में सबसे अधिक पत्राचार करने के लिए इस बार भी मौसम विज्ञान के उपमहानिदेशक, प्रादेशिक मौसम केंद्र नई को राजभाषा चल-शील्ड प्रदान की गई। हिंदी पखवाड़ा 2013 के दौरान आयोजित की गई प्रतियोगिताओं के विजेताओं को नकद पुरस्कार तथा प्रमाण पत्र प्रदान किए गए। भारत मौसम विज्ञान विभाग के 26 उपकार्यालयों में हिंदी पखवाड़ा/हिंदी दिवस समारोहपूर्वक मनाया गया जिसके लिए कुल 2,28,050/-रू. की राशि की स्वीकृति संसूचित की गई।

10 अनुवाद कार्य

अनुवाद के सभी प्रमुख नेमी कार्यो के अलावा 'मौसम' के 38 शोध पत्रों के सारों, विश्व मौसम विज्ञान दिवस 2013 की प्रेस विज्ञप्ति, दक्षिणी पश्चिमी मानसून वर्षा 2013 के दीर्घावधि पूर्वानुमान की प्रेस विज्ञप्ति और विभागीय वेबसाइट के अंतर्गत भूकंप अनुभाग, उपग्रह अनुभाग से प्राप्त प्राय: पूछे जाने वाले प्रश्नों,40 स्टैटिक पृष्ठों का हिंदी अनुवाद संबंधित अनुभागों और आई एस एस डी को उपलब्ध कराया गया ।

15. APPENDIXES

EVENTS OF THE YEAR

IMD Foundation Day Celebration

The 138th Foundation day of India Meteorological Department was celebrated on 15 January, 2013, to highlight the achievements of the department and to promote awareness about new initiatives taken and also to focus on the future plans for improving the weather and climate services of the department.

Lighting of lamp by Hon'ble Minister, Secretary MoES and DG IMD

Hon'ble Minister presenting memento to former DGM Dr. R. R. Kelkar

Shri S. Jaipal Reddy, Hon'ble Minister for Earth Sciences was the Chief Guest and the function was presided over by Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences. A new feather in IMD's cap was added with the launch of 'Weather on mobile service' by Hon'ble Minister. He said that the department has progressed in different fields of atmospheric science but the increased needs of the society for timely, authentic and directly usable information on weather and climate have thrown up new challenges and assured full support. Dr. Shailesh Nayak, Chairman ESSO and Secretary, Ministry of Earth Sciences appreciated the new initiative of the department in the development of an application called “Indian-Weather” for android based smart phones and TABs. Dr. L. S. Rathore, Director General of Meteorology highlighted various achievements of the department. He also elaborated new initiatives taken for modernization and up-gradation of equipment, observatories, computing facilities, technology, services, human resource development, significant improvement in accuracy of weather forecast has been achieved by using latest technology etc.

Shri S. Jaipal Reddy the Hon'ble Minister for Science and Technology and Earth Sciences also felicitated and presented memento to Dr. R. R. Kelkar, an eminent scientist and former DG, IMD, released three departmental publications were released and gave away prizes to Best Employee of IMD and school children. An exhibition highlighting IMD's history and development was also arranged for visitors.

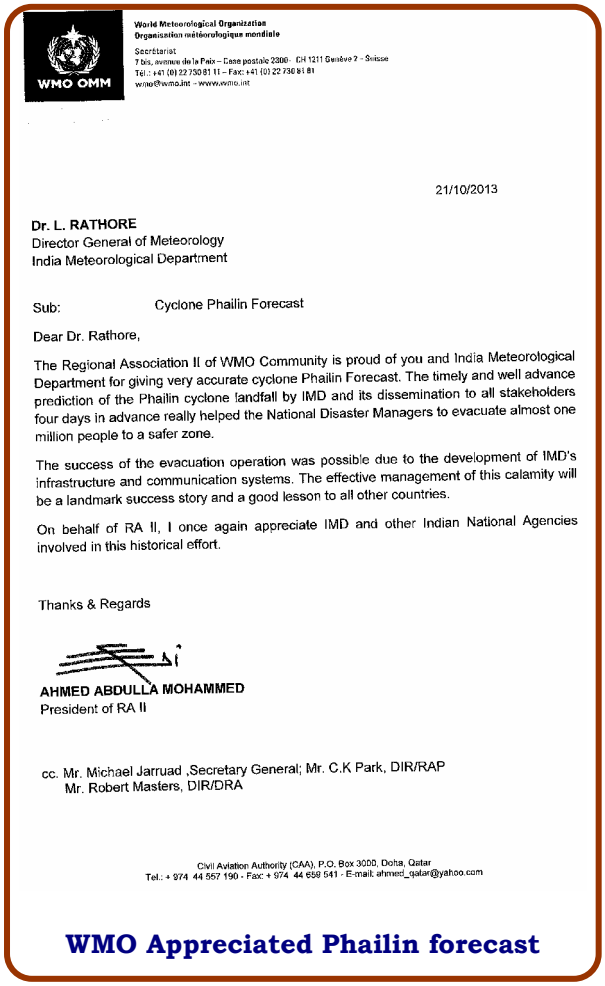
ICHL 2013 Award for Excellence in Humanitarian Action

An International Conference on Humanitarian Logistics (ICHL) was organized by Indian Institute of Management (IIM) Raipur during 2nd & 3rd December 2013. IIM Raipur conferred ICHL 2013 award for Excellence in Humanitarian Action to India Meteorological Department, Government of India in the field of Early Warning, Forecasting and Dissemination on 3rd Dec 2013.

Award Certificate

National Science Day

National Science Day is celebrated in India on 28 February each year to mark the discovery of the Raman Effect by Indian physicist the Sir Chandrasekhara Venkata Raman on 28 February, 1928. For his discovery Raman was awarded the Nobel Prize in Physics in 1930. The first National Science Day was celebrated on 30 May, 2000. IMD has celebrated this day at H. Q., New Delhi and other offices of the department located all over India. On this occasion the exhibitions were arranged in office premises. Many students, scientists, scholars, journalists and general public attended the exhibitions and marked their comments with a great enthusiasm.



World Meteorological Organization
Organisation météorologique mondiale
WMO OMM

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21/10/2013

Dr. L. RATHORE
Director General of Meteorology
India Meteorological Department

Sub: Cyclone Phailin Forecast

Dear Dr. Rathore,

The Regional Association II of WMO Community is proud of you and India Meteorological Department for giving very accurate cyclone Phailin Forecast. The timely and well advance prediction of the Phailin cyclone landfall by IMD and its dissemination to all stakeholders four days in advance really helped the National Disaster Managers to evacuate almost one million people to a safer zone.

The success of the evacuation operation was possible due to the development of IMD's infrastructure and communication systems. The effective management of this calamity will be a landmark success story and a good lesson to all other countries.

On behalf of RA II, I once again appreciate IMD and other Indian National Agencies involved in this historical effort.

Thanks & Regards

AHMED ABDULLA MOHAMMED
President of RA II

cc. Mr. Michael Jarruad ,Secretary General; Mr. C.K Park, DIR/RAP
Mr. Robert Masters, DIR/DRA

Civil Aviation Authority (CAA), P.O. Box 3000, Doha, Qatar
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WMO Appreciated Phailin forecast

World Meteorological Day

World Meteorological Day 2013 was celebrated on 23rd March, 2013 at all offices of IMD. The theme for WMO day -2013 was "Watching the weather to protect life and property"- Celebrating 50 years of World Weather Watch. Exhibitions were organized in various offices, sub-offices of IMD. Observatories were kept open for general public & school children. On this occasion, tele-talk, live program and interviews were given to various electronic and print media at H. Q., New Delhi and Regional Meteorological Centres/ Meteorological Centre in different states. Students from schools, Colleges, University and other Institutions visited IMD offices and observatories throughout the countries.

All India IMD Sports Meet

The 12th All India IMD Sports Meet 2012-13 was organized to promote the spirit of competition, harmony and brotherhood among the participants. It was hosted by M. C., Bhopal at Sports Authority of India Campus, Bhopal during 7 to 10 March, 2013. The officers and staff of IMD and other Earth System Science Organization presented their skills in various Sports events, i.e., Cricket, Volley Ball/Shooting Ball, Carrom, Chess, Table Tennis, etc. Dr. L.S. Rathore, DG, IMD inaugurated the Sports Meet on 7 March, 2013 in the presence of Chief Guest Shri Ishwar Das Lohani, Hon'ble Speaker, Vidhan Sabha, Madhya Pradesh and Special Guest Shri R. K. Naidu, Regional Director, SAI, Bhopal. The vote of thanks to all the guests was given by Shri Arvind Kumar Singh, Honorary Secretary, NOC. Dr. L. R. Meena, Sc. 'F' & Chairman, NOC presented the prizes to the winners & runners-up of different sports events including Team Trophies during closing ceremony held at SAI campus.

Dr. L. S. Rathore, DG, IMD, Dr. L.R. Meena Chaiman NOC along with Shri Ishwar Das Lohani, Hon'ble Speaker, Vidhan Sabha M.P. and other distingushed guests during inauguration

Long Range Forecast of Summer Monsoon

A Press Conference was organized by Meteorological Department on Long Range Forecast on 26 April, 2013 at Arnav Conference Hall of MoES. Hon'ble Minister, Shri S. Jaipal Reddy, Union Minister for Science & Technology and Earth Sciences released Long Range Forecast for South-west monsoon season rainfall for the year 2013. Dr. Shailesh Nayak, Chairman, ESSO and Secretary, MoES, Dr. L. S. Rathore, Director General of Meteorology were also present and gave briefing to the media persons. Dr. D. S. Pai gave a brief presentation on atmospheric phenomena on background of Long Range Forecast.

DG, IMD briefing to media about SW monsoon

Hon'ble Minister MoES, Secretary MoES, DG, IMD during Press Conference

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Shri Gajendra Kumar
Shri U. P. Singh
Dr. S. D. Attri
Shri B. Mukhopadhyay

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