वार्षिक प्रतिवेदन
Annual Report
2014

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

Dr. S. D. Attri

Shri U. P. Singh

ANNUAL REPORT 2014

by

Shri Dinesh Khanna

वार्षिक प्रतिवेदन

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INDIA METEOROLOGICAL DEPARTMENT

(MINISTRY OF EARTH SCIENCES, GOVT. OF INDIA)

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FOREWORD

It gives me immense pleasure to present the Annual Report 2014 of the Department which highlights phenomenal progress in discharging best meteorological services to various stake holders of society. Apart from developing latest forecasting technique and skill, the department's progressive strides towards further fulfilling its target to install, modernize and update its infrastructure for meteorological observations, communication and dissemination systems.

During the year, salient achievements include Improved skill in short and medium range weather forecast and extremes, Five days Tourist Forecast for 109 destinations & Public Weather Forecast for 318 cities, Nowcast for 130 cities and SMS alerts, Special Forecast issued for Amarmath ji Yatra, Char Dham Yatra, Sports, Defence & Para-military Forces, Accurate prediction of Hudhud, Nilofer and other cyclonic storms & Region-wise Severe Weather Warnings, Establishment of 'SMS based Cyclone Alert/Warning System' Establishment of 'RAPID' (Real-time Analysis of Products and Information Dissemination: A web based system for INSAT Data Products), Establishment of 'CRIS' (Customized Rainfall Information System: A GIS based system for processing Real-time rainfall data to generate rainfall products), SMS based Fog Dissemination service to Airlines, Model based QPF for river basins &design storm analysis of 37 projects, Dissemination of Agromet advisories to 70.6 lakh farmers through SMS, Environmental Impact Assessment of 1771 Development projects,125 Research publications, Augmentation of Doppler Weather Radars (1 installed, 6 under process), Development of Drishti for RVR (10 systems under installation), Development and installation of High Speed Wind Recorder (8), Installation of Cyclone Warning Dissemination Systems (134), Revenue of Rs 39.38 crores from aviation and data/forecast services, ISO9001:2008 Certification for 6 offices etc.

International cooperation is an integral part of Earth System Sciences. IMD has imparted training to 42 personnel from 27 countries. The department supported bilateral and multi-lateral programmes with WMO, Geneva. The collaboration with US (NOAA), Australia, U.K., China, Finland, Qatar and Indonesia has opened a path ahead for technical and scientific cooperation under various exchange programmes. The calibration and maintenance training for instrument has opened a path under International training programme. The department continued co-operation with many national agencies like Indian Space Research Organization, Indian Council of Agricultural Research, Geological Survey of India, Centre Water Commission, NCMRWF, INCOIS, NIOT, NCAOR, IITM SAC, NIDM, National Aeronautical Laboratory, Airport Authority of India, SASE, and singed MoU with Research Institutes/Universities.

The Department has been playing a leading role in the field of Earth and Atmospheric Sciences by providing efficient services in meteorology and

contributing to safety of life and property. Its monsoon forecast for 2014 came correct (Forecast-87%, Actual-88%). There is significant improvements in predicting genesis, track and intensification/weakening of cyclones. The cone of uncertainty has been reduced by about 20-32 % for 24-120 hr forecast period from VSCS HUDHUD. The landfall time error was also very less varying from 1 to 4 hrs. Accuracy in prediction of fog has increased from 60% to 94%. The generation of enhanced cyclone images from INSAT-3D satellite has led to further improvement in determining the centre and intensity of cyclone. Hon'ble Prime Minister of India, Global Meteorological Community and WMO have appreciated the role of IMD in accurately forecasting the extreme events.

The growth towards publishing research finding in national and International journals has embarked a new high by publishing one hundred twenty five research papers/publications during the year. Three scientists of department have been conferred upon ISES-2015 Merit Award, IMS, Mausam and Rajbhasha awards for their outstanding contribution.

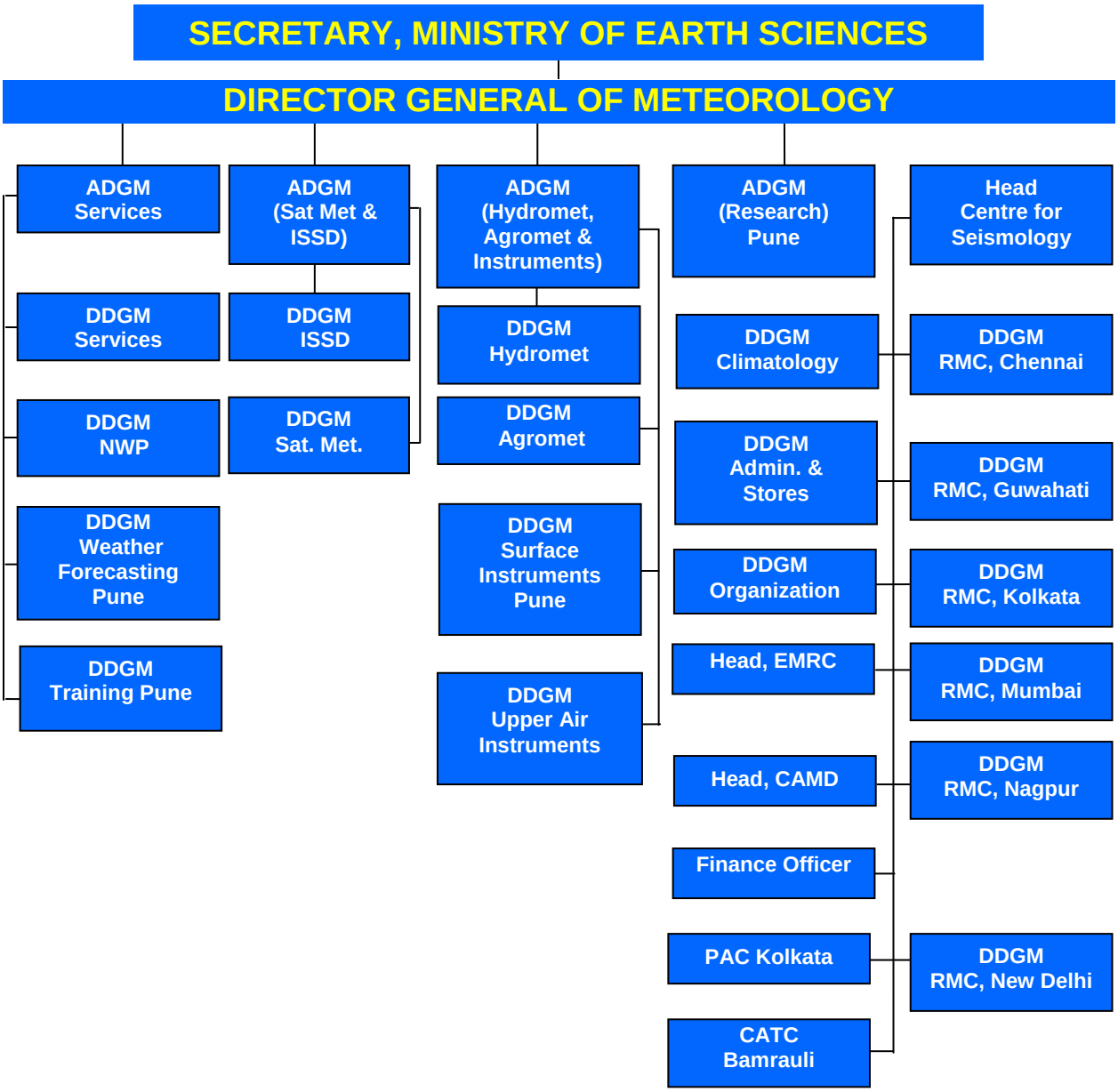
The department organized several users' conferences, workshops, seminars and symposia to create awareness about the weather among the people. The implementation of officials languages policy in popularizing use of Hindi in day-to-day officials works pursued and encouraged. The department has established its supremacy in sports during Inter-departmental/ Inter Ministerial tournaments and won seven prizes in Inter- Ministerial Drama Competition.

The Integrated Agromet. Advisory Services program of the Department has impact on livelihood & farming communities. Communication of Agro-advisory by SMS has resulted in cost effectiveness and increasing of productivity by farmers community. On the occasion of Good Governance Day, Dr. Harsh Vardhan, Hon'ble Minister of Ministry of Science & Technology and Earth Sciences dedicated the SMS Alert Service for Cyclones to the Nation. RAPID and CRIS are also being inaugurated on the occasion of 140th Foundation Day of IMD.

In conclusion, I am availing of this opportunity to put on record the appreciation for dedication and hard work of IMD personnel in improving the efficiency of the department and in taking a lead role in many National and International forum and enhance international credibility.

Dr. Laxman Singh Rathore
Director General of Meteorology

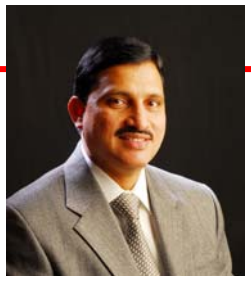
ORGANISATIONAL STRUCTURE



IMD ORGANIZATION CHART

INDIA METEOROLOGICAL DEPARTMENT
MINISTRY OF EARTH SCIENCES
GOVT. OF INDIA

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



Shri Y. S. Chowdary
Hon'ble State 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 A. K. 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' (Centre for Seismology)
Shri M. K. Bhatnagar, Scientist 'F' (Central Aviation Meteorology Division)
Dr. (Smt.) S. Kaur, Scientist 'F'/ DDGM (Hydrology)
Dr. Y. V. Ramarao, Scientist 'F' (Numerical Weather Prediction)
Shri S. K. Kundu, Scientist 'F' (Technical Aspects UAI & SI)
Shri B. K. Bandyopadhyay, Scientist 'F' / DDGM (Services)
Shri S. K. Peshin, Scientist 'F' (Environment Monitoring & Research Centre)
Shri Satish Bhatia, Scientist 'F' / DDGM (Upper Air Instruments)
Dr. K. K. Singh, Scientist 'F' (Agrimet.)
Shri Surya Bali, 'F' / DDGM (Procurement)
Dr. S. D. Attri Scientist 'E'/ DDGM (Organisation)

Regional Administrative & Technical Heads

Shri S. B. Thampi, Scientist 'F' DDGM (RMC, Chennai)
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)
Shri S. S. Singh, Scientist 'F' / DDGM (RMC, New Delhi)

Pune office

Shri B. Mukhopadhyay, Scientist 'F' / ADGM(R)
Dr. N. Chattopadhyay, Scientist 'E'/ DDGM (Agrimeteorology)
Dr. Somenath Dutta, Scientist 'E' / DDGM (Training)
Shri S. Krishnaiah, Scientist F, DDGM (Surface Instrument)
Dr. (Ms.) Medha Khole, Scientist 'E'/ DDGM (Weather Forecasting)
Dr. A. K. Srivastava
Scientist 'E', (NCC), Pune

CHAPTER 1

WEATHER SUMMERY DURING 2014

India is known as the "land of the endless growing season". The seasonal rhythm of varieties of weather and weather system is seen through out the year. The year is divided into four distinct seasons- Winter, Summer (Pre-monsoon), Monsoon & North-East Monsoon. January and February are main month of winter season when sun moves towards tropic of Capricorn after crossing the equator followed by summer season which commences from March to May when the sun crosses the equator and then moves towards tropic of Cancer. The south west monsoon is the main monsoon, comes in from Andaman Sea and starts making its way up India's Kerala coast from early June and cover most of the country by mid July. The North East Monsoon gradually starts after withdrawal of monsoon. The north-east monsoon affects India's east coast during November and December. The states of Karnataka, Tamil Nadu and Kerala receive most of their rainfall during the northeast monsoon.

1. Winter Season (JF)

Cold Wave Conditions

During the season, maximum temperature was below normal by over 5 °C at many stations over the plains of northern and adjoining central India. Cold day conditions also prevailed over the plains of northern India almost throughout January. In addition, severe cold wave/cold wave conditions prevailed over the northern and northwestern parts of the country during the first week of January and again over the northern/northwestern, central and eastern parts of the country during second and third week of February.

Rainfall Features

Rainfall activity over the country as a whole was slightly above normal during the season. It was near normal (102% of LPA) during January and above normal (123% of LPA) during February. Central and northern/northeastern region of the country and parts of north peninsular India in general received excess/normal rainfall and parts of South Peninsula and extreme northeast India received deficient/ scanty rainfall. During the season, out of 36 meteorological sub-divisions, 16 received excess rainfall, 5 received normal rainfall, 10 received deficient rainfall and remaining 5 sub-divisions received scanty rainfall (Fig. 1).

Northern, Central and eastern/ northeastern parts of the country and parts of extreme south peninsula in general received more than 25 mm of rainfall. Northern parts of Madhya Pradesh and adjoining southern parts of Uttar Pradesh, north Chattisgarh and adjoining parts of Bihar & Jharkhand received 75 to 100 mm of rainfall. Rainfall over parts of Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana,

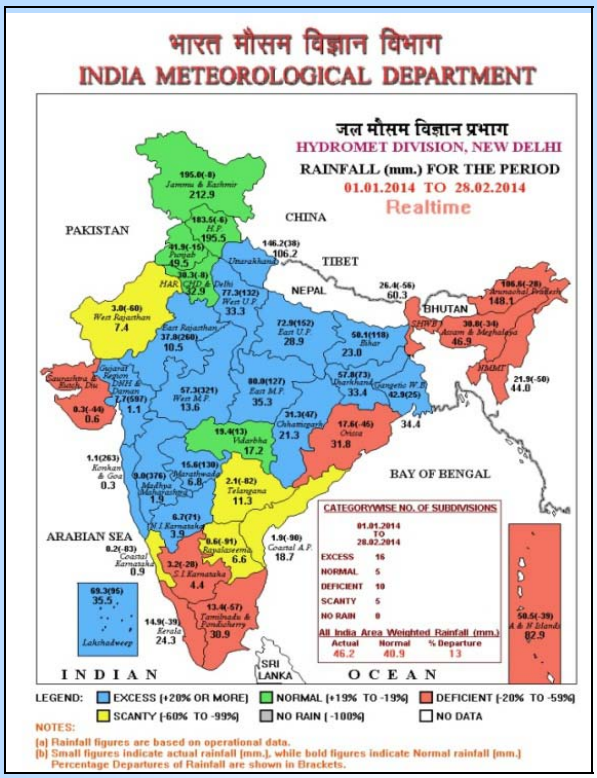


Fig. 1. *Meteorological sub-divisions wise rainfall (mm)*

Uttarakhand, West Uttar Pradesh and Arunachal Pradesh were more than 100 mm.

The rainfall the country as a whole for the winter season has been recorded as 46.2 mm (+13%) against the normal rainfall for the season as 40.9 mm. The rainfall for the country as a whole for the month of February, 2014 has been recorded as 27.2 mm (+23%) against the normal rainfall for the month as 22.1 mm. The sub-division-wise rainfall statistics is as under:

Period 01.02.2014 to 28.02.2014		
	No. of sub-divisional	
Category	Sub-divisions	% Area of country
Excess	16	48 %
Normal	07	16 %
Deficient	08	24 %
Scanty	05	12 %
No rain	0	0 %

The area weighted cumulative weekly rainfall percentage departure over the country as a whole during the season. ***For the winter season 2014, rainfall for the country as a whole was 113% of its Long Period Average (LPA) value.***

The area weighted rainfall series for the season over the four homogeneous regions since 1951was above normal over the Central India (185% of its LPA) and Northwest India (114% of its LPA), near normal over the East & North East India (91% of LPA) and below normal over the south peninsula (41% of LPA). The rainfall over the Central India (29.1mm) was the third highest since 2001 after the years 2005 (31mm) and 2003 (29.2mm).

Standardized Precipitation Index

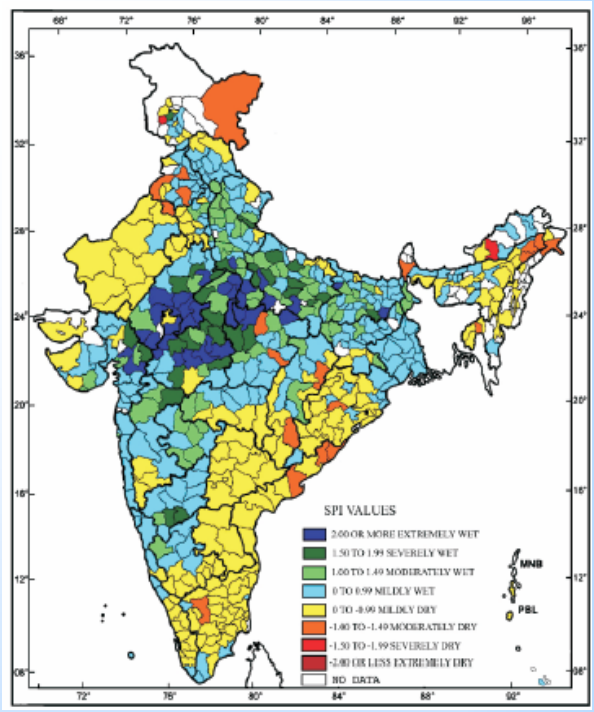


Fig. 2. *SPI for winter season (JF)*

The Standardized Precipitation Index (SPI) is an index used for measuring drought and is based on only precipitation. The Cumulative SPI

values of the season indicate, extremely wet/severely wet conditions over parts of Jammu & Kashmir, Rajasthan, Gujarat Region, Uttar Pradesh, Bihar, Madhya Pradesh state, Gujarat Region, Madhya Maharashtra and North Interior Karnataka while extremely dry/severely dry conditions were observed over parts of Jammu & Kashmir and Arunachal Pradesh (Fig. 2).

Temperature

Maximum temperature was below normal over the plains of northern India and adjoining central and north peninsular parts of the country, and was generally above normal over remaining parts of the country. It was below normal by about 2 to 4 °C over parts of East Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar and Gangetic West Bengal. Over the hilly

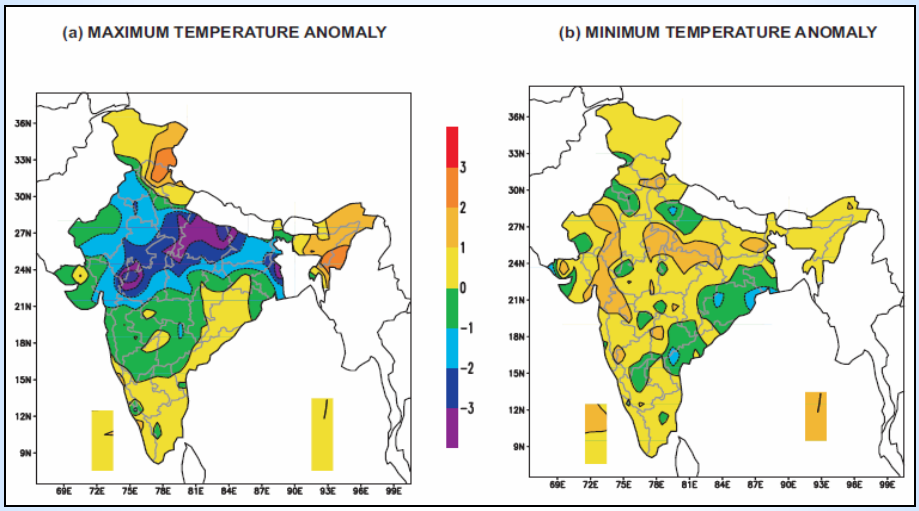


Fig. 3. *Mean seasonal maximum and minimum temperature anomaly (°C) (a) Maximum and (b) Minimum [Based on 1971-2000 NORMAL(S)]*

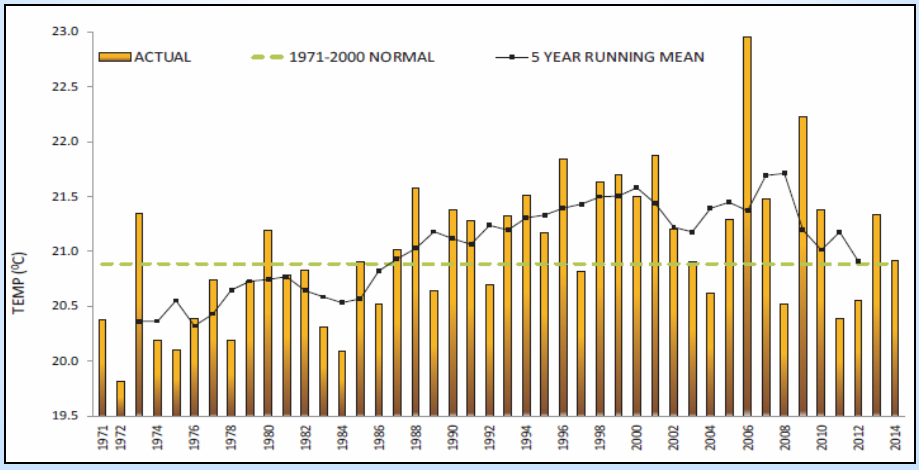


Fig. 4. *Mean temperature & five year running mean for Winter Season (1971-2000)*

areas of western Himalayas, *viz.*, parts of Himachal Pradesh and adjoining Jammu & Kashmir and over parts of extreme northeastern region, maximum temperature was above normal by about 1 to 2 °C.

Minimum temperature was slightly above normal throughout the country except over the parts of east coast and some isolated places. Over some western and northern parts of the country, *viz.*, parts of Rajasthan, Gujarat, Madhya Maharashtra, northern parts of Madhya Pradesh and adjoining southern parts of Uttar Pradesh and the Islands, it was above normal by more than 1 °C [Figs. 3(a&b)]. The mean temperature for the season this year was near normal (Fig. 4).

The minimum temperature series for the country as a whole and the four homogeneous regions during the season since 1971 was above normal by about 1 °C over the homogeneous region of south peninsula (Fig. 5).

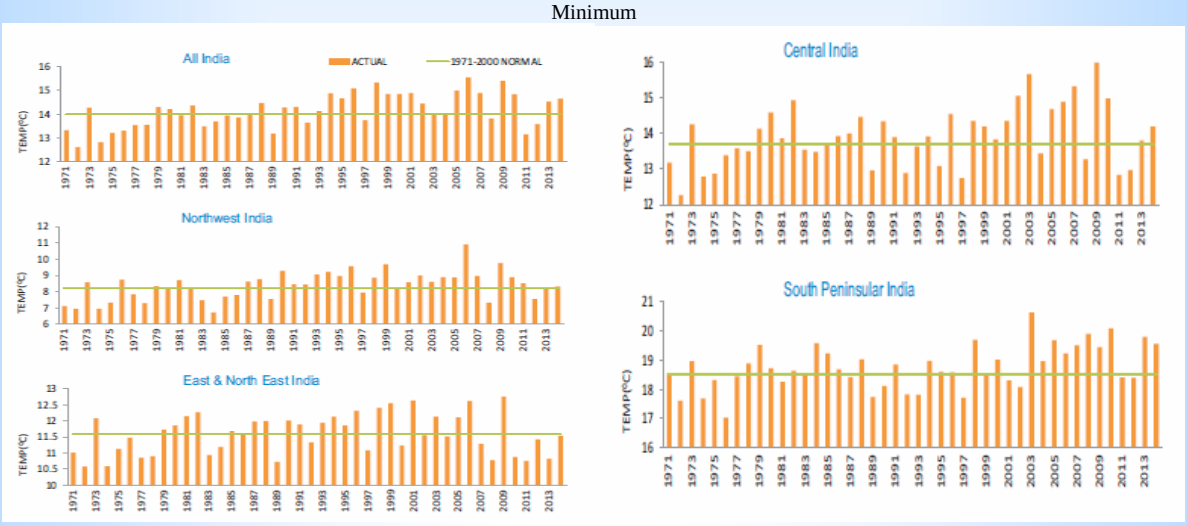


Fig. 5. *Minimum temperature for four homogeneous regions (1971-2014)*

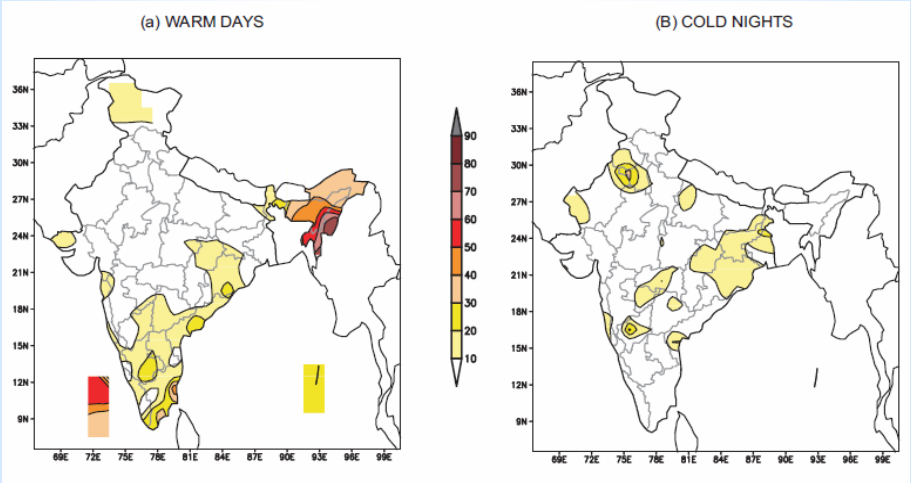


Fig. 6. *Percentage of days when (a) maximum temperature more than 90th Percentile (b) minimum temperature less than 10th Percentile*

Warm days/Cold nights

The percentage of days when maximum (minimum) temperature was more (less) than 90th (10th) percentile (Fig. 6).

Over parts of Assam & Meghalaya, parts of coastal Tamil Nadu and Lakshadweep Islands, maximum temperature was greater than 90th percentile for more than 40% of the days of the season and over parts of

Nagaland, Manipur, Mizoram and Tripura it exceeded 60%. For minimum temperature, no significant distribution was observed.

2. Pre-Monsoon Season (MAM)

Heat Wave Conditions

Heat wave conditions during the season as a whole this year were rather moderate in nature compare to the last ten years and prevailed generally at isolated places for short period of time. Heat Wave Conditions prevailed over some parts of Odisha, Gangetic West Bengal and Coastal Andhra Pradesh at isolated places during the last few days of March. However, during March, maximum temperature was below normal by about 5 to 8 °C over some stations of central and peninsular India on many days. During April, northeastern region of the country was abnormally warmer in the second fortnight of the month as maximum temperature was above normal by about 5 to 8 °C over some stations of the region. Heat wave conditions also prevailed over parts of hilly regions of Assam & Meghalaya and Arunachal Pradesh during the second week and over parts of Gangetic West Bengal, Odisha, Bihar, Gujarat, Rajasthan, Vidarbha and Konkan on a few occasions during the last ten days of the month. During May, heat wave conditions prevailed over parts of Rajasthan on some occasions during the first week, over eastern parts of the country viz. Gangetic West Bengal, Odisha, Bihar and Coastal Andhra Pradesh during the second and third week and over. Rajasthan, Madhya Pradesh, Saurashtra & Kutch, Vidarbha and Coastal Andhra Pradesh on some occasions during the last week of May.

Rainfall Features

Rainfall activity over the country during the season as a whole was near normal. It was above normal during March and May (116% and 115% of LPA respectively) and below normal during April (58% of LPA). Except for the meteorological sub-divisions of extreme northeastern region, some sub-divisions of western region and the Islands, most parts of the country received excess/normal rainfall. Jharkhand, Bihar, Haryana, Chandigarh & Delhi, Punjab, West Rajasthan, Madhya Maharashtra, Marathwada, Vidarbha, Telangana and North Interior Karnataka received about one and half times to two times of their respective normal rainfall. During the season, out of 36 meteorological sub-divisions, 15 received excess rainfall, 12 received normal rainfall, 7 received deficient rainfall and 2 received scanty rainfall (Fig. 7).

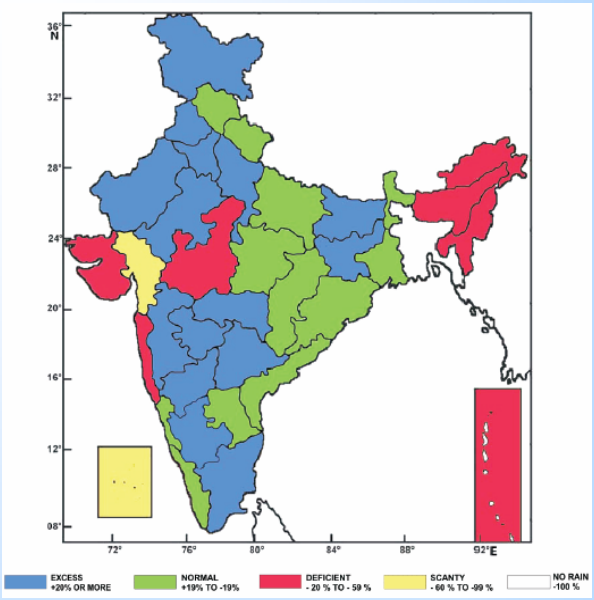


Fig. 7. *Sub-division wise rainfall percentage departure for the pre-monsoon season 2014*

Fig. 8(a) shows the spatial pattern of rainfall (mm) received during the season. Northern parts of the country, parts of south peninsula,

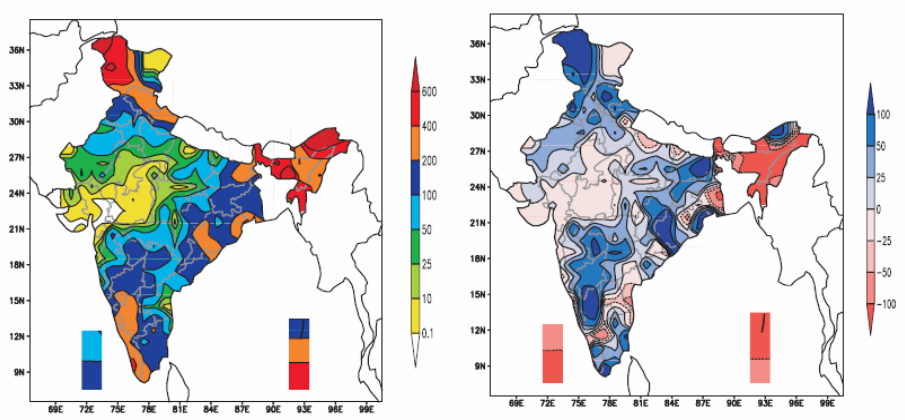


Fig. 8 (a&b). (a) *Seasonal rainfall (mm) and (b) Seasonal rainfall anomaly (mm) [Based on 1951-2000 NORMAL(S)]*

Fig. 9. *Time series of area weighted rainfall over the four homogeneous regions (1951-2014)*

eastern/northeastern region of the country and Andaman & Nicobar Islands received more than 100 mm of rainfall. Parts of extreme northeastern region of the country, Jammu & Kashmir, Kerala and the

Bay Islands received more than 400 mm of rainfall. Fig. 8(b) shows the spatial pattern of rainfall anomaly (mm) during the season. Positive rainfall anomaly of the order of 50 to 100 mm was observed over parts of Jammu & Kashmir, Punjab, Himachal Pradesh, Uttarakhand, Haryana, Bihar, Jharkhand, Odisha, Chattisgarh, Madhya Maharashtra, Marathwada, Telangana, South Interior Karnataka, Kerala and Tamil Nadu. Negative rainfall anomaly of the order of 50 to 100 mm was observed over most parts of extreme northeastern region of the country and the Islands.

During the season this year, the rainfall was deficient by 28% over the East & Northeast India, while over the other three homogeneous regions it was excess by about 20% (Fig. 9).

Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for measuring drought and is based on only precipitation. Cumulative SPI values for the Pre-Monsoon season indicate, extremely wet/severely wet conditions over parts of Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, Chattisgarh, Odisha, north Coastal Andhra Pradesh Madhya Maharashtra, Marathwada, Vidarbha, Telangana, north and South Interior Karnataka and Tamil Nadu while extremely dry/severely dry conditions were observed over parts of Jammu & Kashmir, northern parts of Uttar Pradesh, Small part of Jharkhand and adjoining Chattisgarh, Sub-Himalayan West Bengal and parts of extreme northeastern region, *viz.*, Assam & Meghalaya, Nagaland, Manipur and Mizoram.

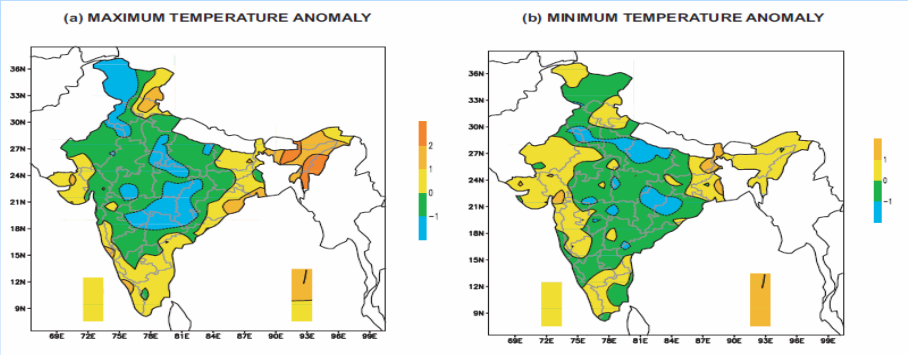
Outgoing Longwave Radiation (OLR)

Over the northwestern parts of the country, part of extreme south peninsula and east equatorial Indian Ocean region, negative OLR anomaly exceeding 10 W/m^2 was observed. Positive OLR anomaly exceeding 10 W/m^2 was observed over eastern parts of Bay of Bengal.

Temperature

Mean seasonal maximum and minimum temperature anomalies are shown in Figs. 10 (a&b) respectively. Maximum temperature was above normal over the Hilly regions of western Himalayas, some western, eastern/northeastern and peninsular parts of the country and was generally below normal elsewhere. Over parts of north Coastal Odisha and adjoining southern parts of Gangetic West Bengal, Assam & Meghalaya, Manipur, Mizoram, Jammu & Kashmir and Himachal Pradesh it was above normal by about 1 to 2 °C. Over parts of Chattisgarh and adjoining east Madhya Pradesh, Vidarbha, Telangana, Marathwada, northern parts of Madhya Pradesh and adjoining southern parts of Uttar Pradesh, Jammu & Kashmir, Punjab and Haryana, it was below normal by more than 1 °C.

Minimum temperature was also below normal over most parts of the country, except some parts of western and northeastern region and some parts of peninsula. Over parts of West Bengal, Bihar, Sikkim, Gujarat Region and Andaman & Nicobar Islands, it was above normal by about 1 to 2 °C. Over parts of Odisha, Chattisgarh, Madhya Pradesh, Vidarbha, Uttar Pradesh,



Figs. 10(a&b). *Mean seasonal temperature anomaly (°C) (a) Maximum and (b) Minimum [Based on 1971-2000 NORMAL(S)]*

Fig. 11. *Time series of temperature for the country and four homogeneous regions (1971-2014)*

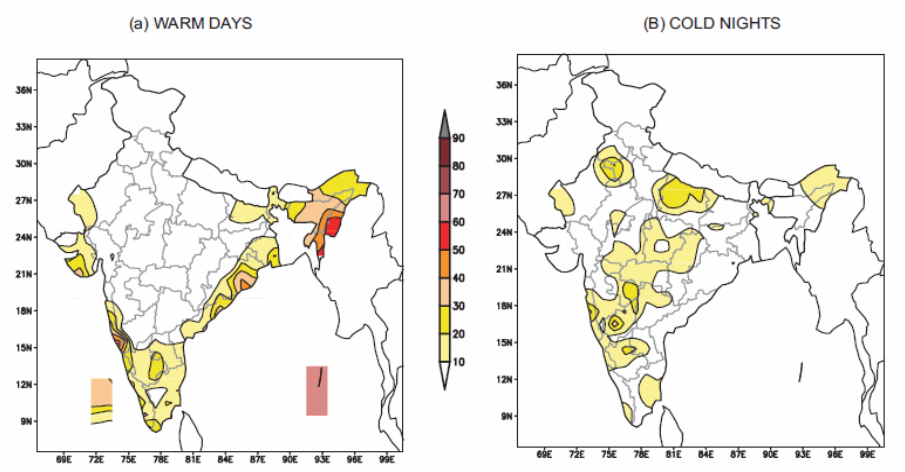
Haryana and north Rajasthan, it was below normal by about 1 to 2 °C.

As per time series of mean temperature for the country as a whole during the Pre-monsoon season (1971-2014) (Fig. 11). Five year moving average values are also shown. Mean temperature for the season this year was slightly

below normal. It was second lowest (28.65 °C) since the year 2001 after the year 2005 (28.59 °C). Maximum temperature for the season this year over the Northwest India (33.1 °C) was the third lowest since 1971 after the years 1982 (31.8 °C) and 1983 (32.1 °C). Both maximum and minimum temperature was near normal over the other three homogeneous regions.

Percentage of Warm days/Cold nights

Over southern parts of Konkan & Goa and adjoining northern parts of Coastal Karnataka, parts of coastal Odisha and parts of extreme northeastern region, maximum temperature was greater than 90th percentile for more than 40% of the days of the season and over parts of



Figs. 12 (a&b). *Percentage of days when (a) maximum temperature more than 90th Percentile (b) minimum temperature less than 10th Percentile*

Andaman & Nicobar Islands it exceeded 90 percentile for over 60% of the days. Figs. 12(a&b) show the percentage of days when maximum (minimum) temperature was more (less) than 90th (10th) percentile [Figs. 12(a&b)].

3. Southwest Monsoon (JJAS)

Onset and Advance of SW Monsoon

The conditions which were favorable for onset of monsoon over Kerala coast follows :

- The rainfall over Kerala had been fairly widespread to widespread on 5 and 6 June. Out of the 14 rainfall monitoring stations for Monsoon onset over Kerala, more than 70% of stations reported rainfall more than 2.5 mm for consecutive two days *i.e.* on 5th June and 6th June (Fig. 13).

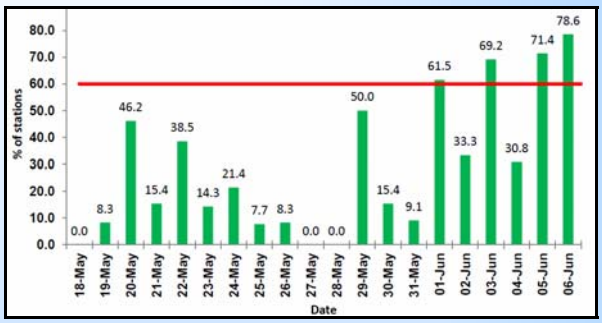


Fig. 13. *Percentage of stations reporting rainfall ≥2.5 mm*

- Westerly / West-southwesterly winds of the order of 40-50 kmph were prevailing upto 600 hPa over south Arabian Sea between Lat. 0°N to 10° N and Long. 55° E to 80° E.

➢ The INSAT–3D derived Outgoing Long wave Radiation value in the box confined by Lat. 5-10°N, Long. 70-80°E was less than 200 W/m^2 for consecutive last 2 days *i.e.* on 5th June and 6th June.

➢ The onset of southwest monsoon over Kerala signals the arrival of monsoon over the Indian subcontinent and represents beginning of rainy season over the region. The normal date of onset of monsoon over Kerala is 1st June. The forecast for onset of monsoon over Kerala was predicted to set on 5th June with a model error of ± 4 days. The monsoon was set over Kerala on 6th June 2014.

During 17 - 18 May, an easterly wave trough embedded in the northern hemispheric equatorial convergence zone developed into a cyclonic circulation over south Andaman Sea and neighbourhood. Associated with this, low level cross equatorial monsoon flow strengthened over the region resulting in the advance of southwest monsoon over Andaman Sea and some parts of southeast Bay of Bengal and east central Bay of Bengal on 19th. Thus the southwest monsoon current reached over south Andaman Sea 2 days before normal date of 20th May (Fig. 14).

However, the southwest monsoon set in over Kerala on 6th June, 5 days later than its normal date of 1st June. Same day, monsoon also advanced into most parts of south Arabian Sea, some parts of Tamil Nadu, most parts of southwest Bay of Bengal and some parts of west central Bay of Bengal. Thereafter, though not rapid, it consistently advanced and by 18th June, it covered central Arabian Sea, some parts of north Arabian Sea, south Gujarat, entire

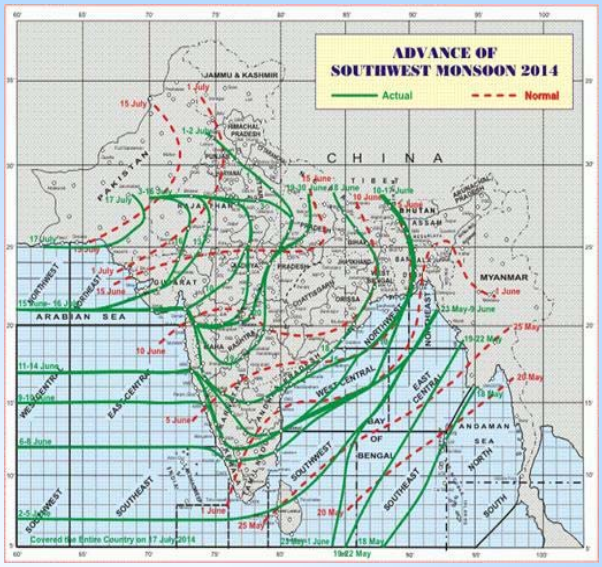


Fig. 14. *Advance of SW monsoon 2014*

Konkan & Goa, some parts of south peninsula, Odisha, Jharkhand and Bihar, entire northeastern states and most parts of Gangetic West Bengal. The Arabian Sea branch of the monsoon current was aided by the formation of a Cyclonic Storm (Nanauk) over the Arabian Sea. The eastward propagation of Madden Julian Oscillation (MJO) over maritime continent led to the development of convection over north Bay of Bengal and the subsequent formation of season's first low pressure area over coastal areas of Bangladesh and neighborhood on 19th June. This aided the advance of Bay of Bengal branch of the southwest monsoon over northeastern states. Subsequently it further advanced into most parts of south peninsula, east and adjoining parts of central India by 20th June.

After a hiatus of 10 days, monsoon started reviving. Subsequently, a favourable interaction of the southwest monsoon current with the mid-latitude westerly's aided the advance of southwest monsoon into the western Himalayan region and

adjoining plains of northwest India. It advanced into entire Uttarakhand, Himachal Pradesh and Jammu & Kashmir, some more parts of Uttar Pradesh and parts of Haryana) and Punjab on 1st July.

During the first week of July, the presence of anticyclone over the peninsular region resulted in subdued rainfall activity over parts of north, central and peninsular region. But the formation of a low pressure area over north Bay of Bengal and adjoining coastal areas of Bangladesh and Gangetic West Bengal (during 1 - 7 July) and a cyclonic circulation over west Uttar Pradesh and neighbourhood (during 3 - 6 July) caused further advance of the monsoon into some more parts of Uttar Pradesh, remaining parts of Haryana (including Delhi) and Punjab and some parts of north Rajasthan on 3 July and subsequently into most parts of Vidarbha, remaining parts of east Madhya Pradesh and Uttar Pradesh, some parts of west Madhya Pradesh and some more parts of northeast Rajasthan on 7. Subsequent to the formation and west northwestwards movement of a low pressure area (during 11 - 16 July), an off shore trough at mean sea level extending from Gujarat coast to Kerala coast (10 - 16 July) and the cyclonic circulation extending between 3.1 & 5.8 kms a.s.l. over northeast Arabian Sea during (14 - 16 July) during the second week, the monsoon activity revived gradually over central India and west coast thereby causing further advance of southwest monsoon over remaining parts of central India and most parts of northwest India on 16th and remaining parts of north Arabian Sea, Saurashtra & Kutch, Gujarat Region and west Rajasthan and thus the entire country on 17th July 2014 ***(2 days ahead of its normal date 15 July***.

Withdrawal of southwest monsoon

The weather over the western parts of Rajasthan remained mainly dry from 17th September. A change in the lower tropospheric circulation pattern over the region from cyclonic to anti cyclonic during 16 - 17 September also made conditions favorable for the withdrawal of southwest monsoon from the region.

Subsequently, withdrawal of monsoon from northwestern most parts of the country commenced on 23 September. It withdrew from some parts of west Rajasthan and Kutch on 23 September. and from some parts of Punjab, Haryana and Gujarat Region, some more parts of Kutch area and remaining parts of west Rajasthan on 26. On 28 September, it further withdrew from remaining parts of Punjab, Haryana, Chandigarh & Delhi and east Rajasthan; some parts of Jammu & Kashmir, Himachal Pradesh, east Uttar Pradesh, Madhya Pradesh and Saurashtra; most parts of west Uttar

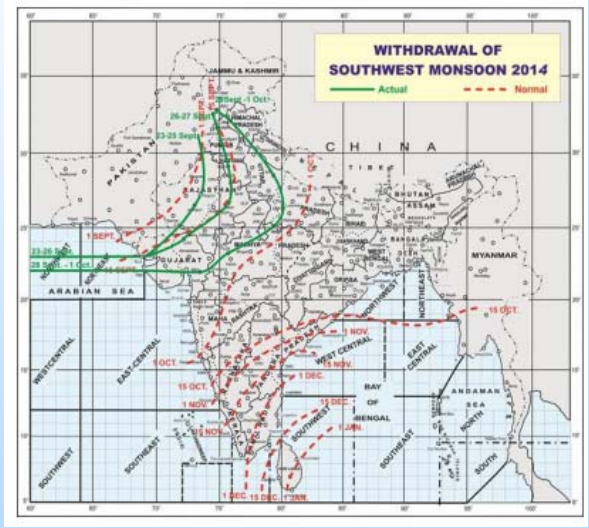


Fig. 15. *Isochrones of withdrawal of SW monsoon 2014*

Pradesh and some more parts of Gujarat Region, Kutch and north Arabian Sea. As on 30 September, the withdrawal line passed through Jammu, Una, Bareilly, Kanpur, Nowgong, Ujjain, Vadodara, Porbandar, Lat. 22° N/ Long. 65° E and Lat. 22° N / Long. 60° E (Fig. 15).

Rainfall Features

The southwest monsoon season rainfall over the country as a whole was below normal. Moreover, it was characterized by spatial and temporal variability. Central, peninsular and eastern/northeastern parts of the country received normal rainfall, while northwestern parts of the country received deficient rainfall. Some subdivisions of the northern region *viz.* Uttar Pradesh, Uttaranchal, Haryana, Chandigarh & Delhi, Punjab, Himachal Pradesh as a whole received only about 45% of its normal rainfall. Also, during the first half of the season (1 June to 31 July) country received 78% of its Long Period Average (LPA) value, (June deficiency alone was 42%), while during second half of season (1 August to 30 September) it received 97% of its LPA value [Figs. 16 (a&b)].

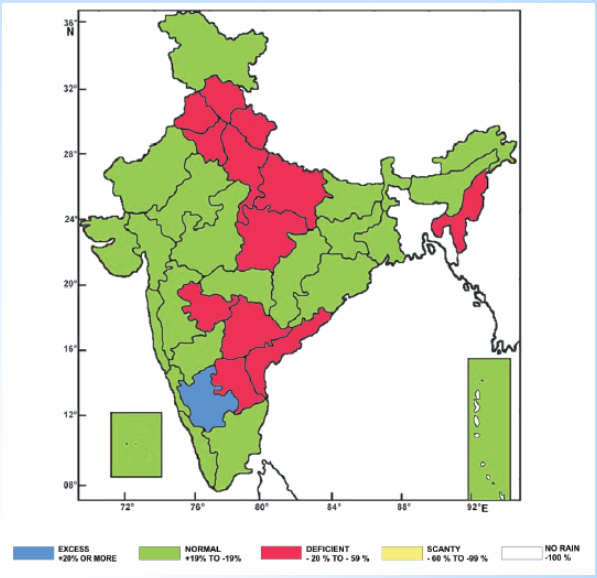


Fig. 17. *Sub-divisions wise rainfall percentage departures for the monsoon season 2014*

Out of 36 meteorological sub-divisions, only one subdivision (South Interior Karnataka) received excess rainfall, 23 received normal rainfall and the remaining 12 sub-divisions received deficient rainfall (Fig. 17).

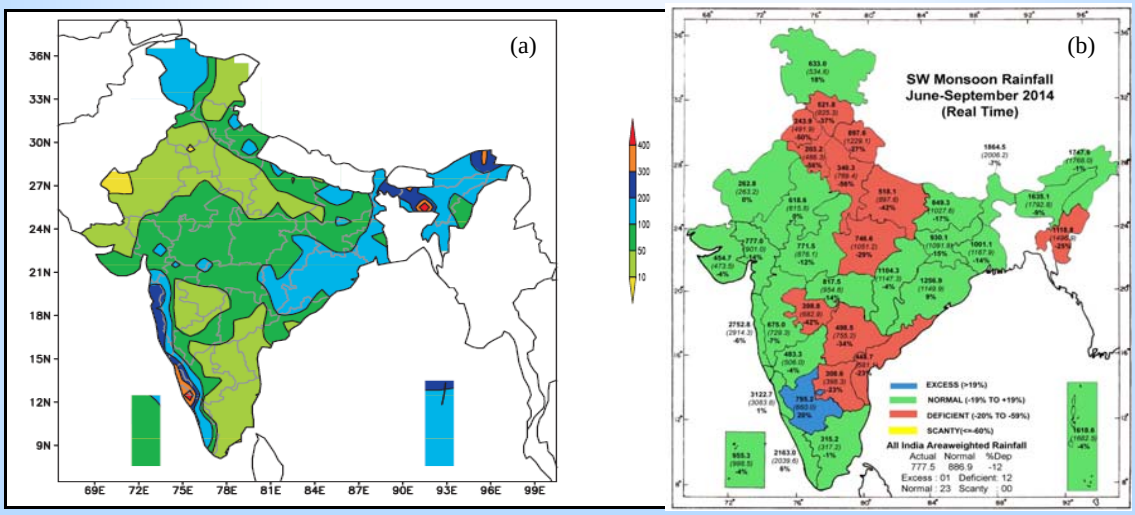


Fig. 16 (a&b). *(a) Seasonal rainfall (cm) and (b) All India area weighted rainfall*

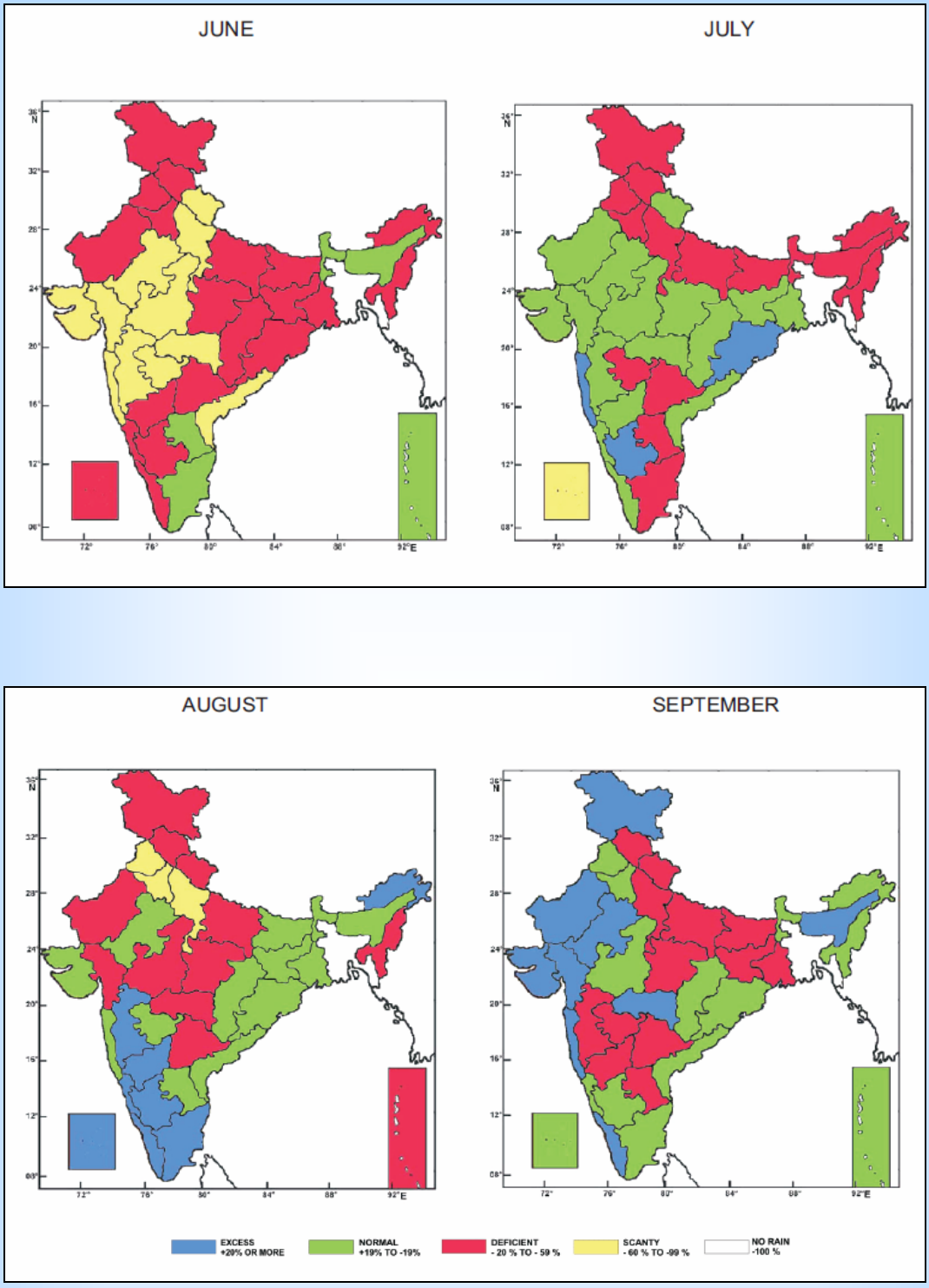


Fig. 18. *Monthly sub-divisions wise distribution of rainfall percentage departures*

Fig. 18 shows the sub-division wise distribution of rainfall percentage departures for the four months of monsoon season (June to September) 2014. 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 below:

Seasonal rainfall (June to September)

Region	LPA (mm)	Actual Rainfall	
		Rainfall (mm)	Rainfall (% of LPA)
All India	886.9	777.5	88
Northwest India	615.0	483.1	79
Central India	974.2	879.7	90
Northeast India	1437.8	1267.7	88
South Peninsula	715.7	665.4	93

Monthly & second half of the monsoon season rainfall over the country as a whole (All India)

Month	LPA (mm)	Actual Rainfall for 2014 SW Monsoon Season	
		Rainfall (mm)	Rainfall (% of LPA)
June	163.5	92.4	57
July	288.9	259.0	90
August	261.0	234.6	90
September	173.5	187.5	108
August + September	434.5	422.1	97

Month		Jun	Jul	Aug	Sep
Number of subdivisions in different categories	Excess	0	3	8	9
	Normal	6	17	13	14
	Deficient	19	15	12	13
	Scanty	11	1	3	0
Rainfall (% of LPA)		58	90	90	108

The spatial pattern of rainfall received during the season and its anomaly (cm) from the LPA respectively. Central, north peninsular, eastern/northeastern and some northern parts of the country and parts of west coast generally received 50 to 100 cm of rainfall. Rainfall received by parts of Konkan & Goa, Coastal Karnataka, Sub-Himalayan West Bengal & Sikkim, Assam & Meghalaya and Arunachal Pradesh was more than 200 cm.

Seasonal rainfall was below normal over most parts of the country except some parts of Jammu & Kashmir, Uttarakhand, Bihar, East Rajasthan, Gujarat Region, parts of west peninsula and Odisha. Magnitude of negative rainfall anomaly over parts of Punjab, Harayana, Chandigarh & Delhi, Uttar Pradesh, west Bihar, Madhya Pradesh, Vidarbha, Marathwada, Telangana, parts of west coast and parts of extreme northeastern region was more than 25 cm. Similarly, over parts of Jammu & Kashmir, Uttarakhand, East Rajasthan, Bihar, Odisha, Konkan & Goa, Karnataka and Kerala, positive rainfall anomaly generally exceeded 10 cm.

The daily area weighted rainfall (in mm) for the country as a whole, rainfall averaged was below normal on most of the days till second week of July, afterwards it was above normal till first week of August, again it was below normal till the end of August. During September, it was above normal for first nine days, and afterwards it was generally below normal till the end of season. It was nearly half (55%) of its normal value, at a stretch from 22 June to 13 July. However, during the period from 14 July to 7 August and again from 31 August to 8 September, it was above normal on many days and even exceeded twice its normal value on some occasions.

The area weighted weekly and cumulative rainfall percentage departure respectively for the country

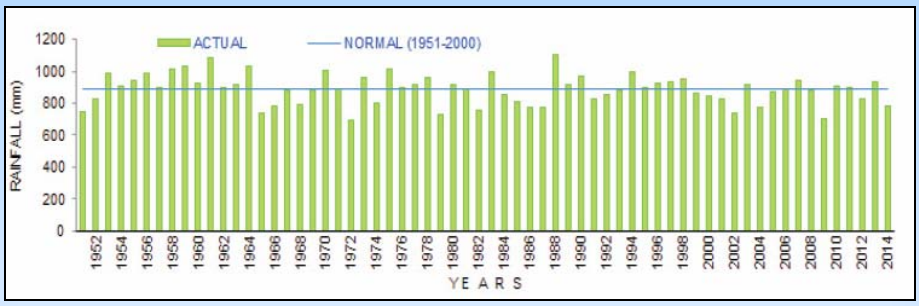
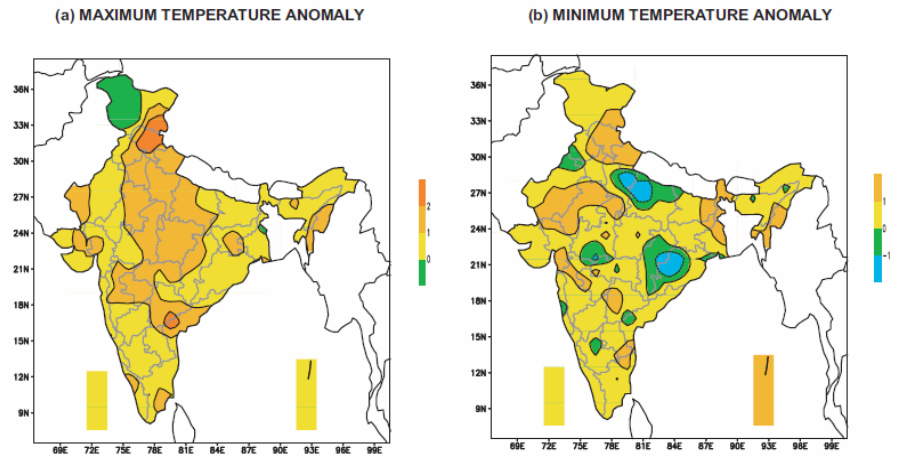


Fig.19(a). *Time series of area weighted rainfall over the country as a whole for the monsoon season (1951-2014)*

Fig. 19(b). *Time series of area weighted rainfall over the four homogeneous regions for the monsoon season (1951-2014)*

as a whole during the season. Cumulative rainfall departure was negative throughout the season. However, the rainfall deficiency exceeding 40% till second week of July, reduced to about 10% by second week of September. ***The area weighted rainfall for the season this year was 87.7% of its LPA value.***



Figs. 20(a&b). *Mean seasonal temperature anomaly (ºC) (a) Maximum and (b) Minimum [Based on 1971-2000 NORMAL(S)]*

Fig. 19(a) shows the all India area weighted rainfall series for the season since 1951. Fig. 19(b) shows the area weighted rainfall series for the season over the four homogeneous regions since 1951. The rainfall for the season was below normal over northwest India (78.6% of LPA) and East & Northeast India (88.2% of LPA), while it was normal over Central India (90.4% of LPA) and south peninsula (93% of LPA).

Temperature

Mean seasonal maximum and minimum temperature anomaly is shown in Figs. 20(a&b).

Maximum temperature was above normal over most parts of the country during the season. It was above normal by about 1 °C over central, northern and north peninsular over parts the country. Over parts of Himachal Pradesh and adjoining Jammu & Kashmir and parts of Coastal Andhra Pradesh and adjoining Telangana, it was above normal by more than 2 °C.

Minimum temperature was also above normal over most parts of the country. It was above normal by more than 1 °C over parts of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Rajasthan and some northeastern parts of the country. It was below normal over parts of Uttar Pradesh, Odisha and Chattisgarh by about 1 °C.

The mean temperature for the country as a whole for the season since 1971. Five year moving average values are also shown. The mean temperature (28.82 °C) for the season this year was above normal by 0.86 °C and was the second highest since 1971 after the year 2009 (29.03 °C).

The maximum and minimum temperature series respectively for the country as a whole and the four homogeneous regions during the season since 1971. Maximum temperature was above normal by over 1 °C over the three homogeneous regions, *viz.*, Northwest India, Central India and South Peninsular India. The maximum temperature (33.13 °C) for the country as a whole was above normal by about 1 C which is the third highest since 1971 after the years

2009 (33.30 °C) and 1987 (33.25 °C). Over the homogeneous region of South Peninsula, minimum temperature was also above normal by about 1 °C.

Standardized Precipitation Index

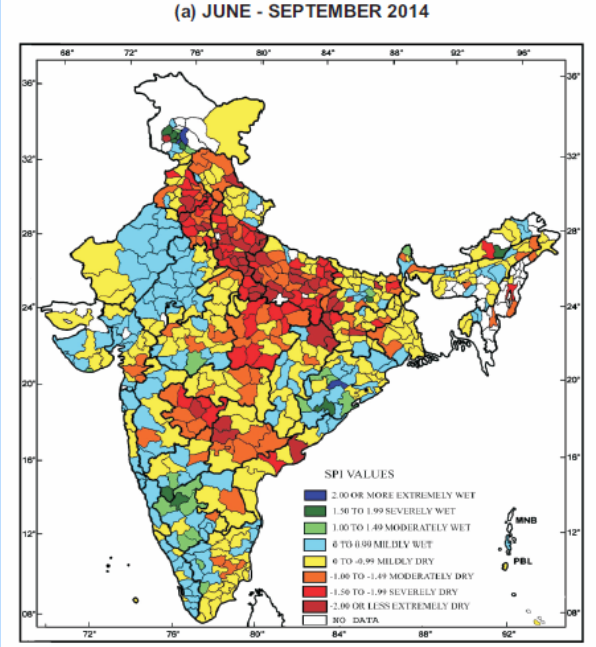


Fig. 21. *SPI for four months*

The SPI values for the monsoon season and the year since January 2014 respectively (Fig. 21). Cumulative SPI values of the season indicate, extremely/severely wet conditions over small parts of Arunachal Pradesh, Odisha, Bihar, Jammu & Kashmir, West Madhya Pradesh, North & South Interior Karnataka, while extremely/ severely dry conditions were observed over most parts country *viz.* Arunachal Pradesh, Nagaland, Manipur, Mizoram & Tripura, Bihar, Jharkhand, East & West Uttar Pradesh, Uttaranchal, Haryana, Chandigarh & Delhi, Punjab, Himachal Pradesh, Jammu & Kashmir, East Madhya Pradesh, Marathwada, Chattisgarh, Coastal Andhra Pradesh and Telangana.

Pressure & Wind

The pressure anomaly was positive over most parts of the country except for the parts of eastern region. Both positive and negative pressure anomaly was generally of the order of 0.5 hPa. At 850 hPa level, an anomalous cyclonic circulation was observed over northwest Arabian Sea and neighborhood. This anomalous cyclonic circulation was observed at 500 hPa level also. At both the levels anomalous light westerly's, suggesting weak monsoon flow, were observed through out the country. At 250 hPa level, an anomalous cyclonic circulation was observed over the extreme northern parts and adjoining extra tropical region.

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood. OLR anomaly was positive over most parts of country, Bay of Bengal and Arabian sea and negative over extreme northeastern parts of country and equatorial Indian Ocean region. Positive OLR anomaly exceeding 10 to 20 W/m^2 was observed over most parts of country and south Bay of Bengal. Negative OLR anomaly over extreme northeastern parts of the country exceeded 10 W/m^2.

CHAPTER 2

VERIFICATION OF WEATHER FORECASTS

Reliable weather forecasts are key element to the safety and economy development. The decision-makers require an accurate weather predictions and timely weather warnings in order to save lives and reduce damage to property and infrastructure from the hazards influenced by weather. Accurate, usable and reliable weather forecast is the only answer through which society can be advised for safety from aberrant weather and to minimize their losses. Therefore verification of weather prediction has a significant role to improve our accuracy and reliability.

1. Verification of the long range forecasts

This year, the long range forecast for the 2014 southwest monsoon rainfall was issued in 3 stages. The first stage long range forecast issued on 24th April consisted of only forecast for season (Jun-Sep) rainfall over the country as a whole. In the second stage (9th June), along with the first update for the April forecast, forecast for season rainfall over the four broad geographical regions (northwest India, central India, south Peninsula and northeast India) and that for monthly rainfall over the country as a whole for the months of July and August were issued. In the 3rd stage (12th August), along with the forecast for the rainfall during the second half of the monsoon season over the country as a whole, second update for the season rainfall over the country as a whole and first update for the season rainfall over the four broad geographical regions were issued.

The update forecast for the Southwest monsoon season (June-September) rainfall over the country as a whole is issued using a 6-parameter Ensemble Forecasting System. The 6 predictors used are:

- **NE Pacific to NW Atlantic SST Anomaly Gradient (December + January),**
- **Southeast equatorial Indian Ocean Sea Surface Temperature (February),**
- **East Asia Mean Sea Level Pressure (February + March),**
- **Central Pacific (Nino 3.4),**
- **Sea Surface Temperature Tendency (March to May – December to February),**
- **North Atlantic Mean Sea Level Pressure (May) and North central Pacific 850 zonal wind gradient (May).**

2nd Stage Long Range Forecast Update for 2014 Southwest Monsoon Rainfall was issued on 9th June 2014 by the Hon'ble Minister for Science & Technology and Earth Sciences Dr. Jitendra Singh at a press

conference which was attended by a large number of Electronic & Print Media. The highlights of forecast are:

- **Rainfall over the country as a whole for the 2014 southwest monsoon season (June to September) is likely to be below normal (90-96% of LPA).**

- **Quantitatively, monsoon season rainfall for the country as a whole is likely to be 93% of the long period average with a model error of ±4%.**

- **Region wise, the season rainfall is likely to be 85% of LPA over North-West India, 94% of LPA over Central India, 93% of LPA over South Peninsula and 99% of LPA over North-East India all with a model error of ± 8%.**

- **The monthly rainfall over the country as a whole is likely to be 93% of its LPA during July 2014 and 96% of LPA during August 2014 both with a model error of ± 9%.**

On Set of Monsoon

Based on an indigenously developed statistical model, it was predicted on 15th May 2014 that monsoon will set in over Kerala on 5th June with a model error of ±4 days. The forecast came correct as the actual monsoon onset over Kerala took place on 6th June, 1 day later than the forecasted date. Thus this is the tenth consecutive correct operational forecast for the date of monsoon onset over Kerala since issuing of operational forecast for the event was started in 2005.

Verification of LRF

The first stage forecast for the season (June-September) rainfall over the country as a whole issued in April was 95% of LPA (below normal) with a model error of ± 5% of LPA). This forecast was downgraded to 93% ± 4% of LPA (below normal) in the first update in June, and further downgraded to 87% ± 4% of LPA (deficient) in August. The actual season rainfall for the country as a whole is 88% of LPA, which is less than the first stage forecast issued in April by 7% of LPA. On the other hand, it is less than the first update by 5% of LPA and more than the second update by just 1% of LPA. Thus the actual season rainfall over the country as whole is within the limits of second forecast update Considering the four broad geographical regions of India, the forecast issued in June (August) for the season rainfall over northwest India was 85% (76%) of LPA, that over Central India was 94% (89%) of LPA, that over northeast India was 99% (93%) of LPA, and that over South Peninsula was 93% (87%) of LPA all with a model error of ± 8%. The actual rainfalls over northwest India, central India, northeast India and south Peninsula were 79%, 90%, 88% and 93% of the LPA respectively. The actual season rainfall over northwest India is 6% less than the forecast issued in June and 3% more than that its August update. Similarly, the actual season rainfall over Central India is 4% less than the forecast issued in June and 1% more than that its August update. In case of south Peninsula, the actual season rainfall is exactly equal to the forecast issued in June and 6% more than that its August update. On the other hand, the season rainfall over northeast India is less than forecasts issued in both June and August by 11% and 5% of LPA respectively. Thus the actual season rainfalls over

northwest India, central India and south Peninsula are within the limits of the forecasts issued in both June and August. In case of northeast India, though the actual season rainfall (88% of LPA) is within the limits of forecast (93% ± 8%) issued in August, it is less than its lower limit of forecast (91 (99-8)% of LPA) issued in June.

The forecasts for the monthly rainfall over the country as a whole for the months of July & August issued in June were 93% & 96% respectively with a model error of ± 9%. The actual monthly rainfall during July and August is 90% of LPA each. Thus the forecasts for the July and August rainfalls are underestimate to the realized rainfall by 3% of LPA and 6% of LPA respectively and are within the forecast limits.

The forecast for the second half of the monsoon season (August – September) for the country as a whole was 95% with a model error of 8% of LPA against the actual rainfall of 97% of LPA. Thus the forecast for the rainfall during the second half of the monsoon season over the country as a whole is also within the forecast limits.

The Table below gives the summary of the verification of the long range forecasts issued for the 2014 Southwest monsoon. As seen in the table, the season rainfall over the country as a whole and that over four broad geographical regions (north-west India, central India, northeast India and south Peninsula) are within the limits of the forecasts updated in August and accurate. Similarly, the forecasts for the monthly rainfall (for July and August) as well as that for the rainfall during the second half of the monsoon season over the country as a whole are also accurate.

The observed rainfall deficiency of about 7-12% of LPA in all the four broad geographical regions was mainly caused by the large rainfall deficiencies over most parts of the country during June resulted from the delayed progress of the monsoon over these areas. The delayed monsoon progress in turn was caused by the below normal heating of the Indian subcontinent during the pre-monsoon season resulting in weaker than normal monsoon flow into the region.

Region	Period	Forecast (% of LPA)			Actual rainfall (% of LPA)
		24th April	9th June (1st Update)	12th August (2nd Update)	
All India	June to September	95 ± 5	93 ± 4	87 ± 4	88
Northwest India	June to September		85 ± 8	76 ± 8	79
Central India	June to September		94 ± 8	89 ± 8	90
Northeast India	June to September		99 ± 8	93 ± 8	88
South Peninsula	June to September		93 ± 8	87 ± 8	93

However, subsequent weak air-sea coupling over the region led to the weakening of El Nino conditions from early July resulting in ENSO neutral conditions during remaining part of the monsoon season. This helped monsoon to remain more or less normal thereafter. However, the season also witnessed strong intra seasonal variation in the rainfall activity with long break monsoon spell in the middle of August caused by unfavourable phase of Madden Julian Oscillation (MJO) and short active monsoon spells during middle of July and early part of August caused by passage of low pressure systems along the monsoon trough region. In the early part of September, the interaction between the western disturbances moving across north India and monsoon low pressure systems caused increased rainfall activity over north, northwest India and central India.

The country received near normal rainfall (94% of LPA) during the period July to September period. But due to the large rainfall deficiency in June, the 2014 season rainfall over the country as a whole (88% of LPA) ended as deficient (<90% of LPA).

2. Severe weather events and improvement in skill of heavy rainfall prediction

2.1. Severe weather events

National Weather Forecasting Centre of IMD and its field offices have issued accurate forecasts/warnings of various severe weather events in 2014. Some of these are summarized below:

Hailstorm : District-wise forecast of hail storms during February and March, 2014 were issued for Maharashtra and Madhya Pradesh, 24-48 hours in advance.

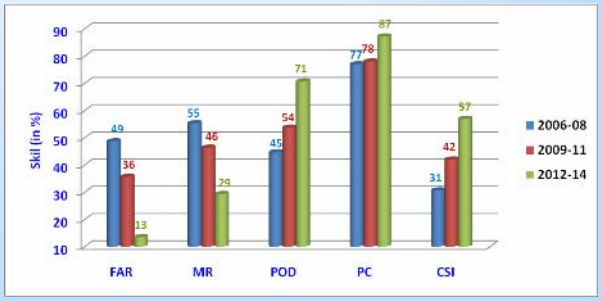
Serve heat wave : Warnings of unusual severe heat wave conditions during first half of July 2014 were issued for central and adjoining peninsular & northwest India.

Very Heavy Rainfall : District-wise/Meteorological Subdivision-wise very heavy rainfall warnings were issued well in advance for Jammu & Kashmir during September 2014. Similarly, Heavy rainfall events in Northeastern States, Odisha, Madhya Pradesh, Maharashtra, Gujarat and Uttar Pradesh during monsoon 2014 were predicted accurately 24 to 72 hour advance.

Post landfall warnings for very severe cyclonic storm HUDHUD : Heavy to very heavy rainfall warnings were issued 72 hours in advance for the States of eastern & adjoining central India in association with tropical cyclone HUDHUD.

2.2. Heavy rainfall prediction Skill

There has been consistent improvement in the accuracy and skill of Operational Forecasts and Warnings issued by IMD in the recent past as shown in figures given below.



- Percentage Correct (PC) for Heavy Rainfall Warnings during monsoon 2014 was 88%.

- Probability of Detection (PoD) & Critical Success Index (CSI) during monsoon 2014 was 73% & 58%, respectively.

- False Alarm Rate (FAR) was only 8% and Missing Rate (MR) was 27% which is the best performance so far.

- PoD and CSI has improved by 40% and 52% in 2014 as against mean of 2002 to 2014.

- FAR and MR has improved by 80% and 44% in 2014 as against mean of 2002 to 2014.

CHAPTER 3

WEATHER MONITORING AND PREDICTION

India Meteorological Department has been continuously improving their monitoring, forecasting, warning skill and risk management systems to reduce risk from natural disaster. After many challenges, the impact of extreme weather events and disasters caused by tropical cyclones have been reduced drastically.

3.1. Cyclonic monitoring & Prediction

Brief descriptions of cyclones

During the year 2014, 8 cyclonic disturbances developed over north Indian Ocean including one Very Severe Cyclonic Storm (VSCS) and one Cyclonic Storm (CS) over Arabian Sea, one land depression (D) and 5 cyclonic disturbances over Bay of Bengal. Out of 5 disturbances over Bay of Bengal, one intensified into Very Severe Cyclonic Storm, two into Deep Depression (DD) and two into Depression. Considering season-wise distribution, out of 8 disturbances, one developed during winter season, one in pre-monsoon, 3 during monsoon and 3 during post-monsoon season. Salient features of cyclonic disturbances during 2014 are given below:

(i) There were one cyclone over the Bay of Bengal and 2 cyclones over the Arabian Sea against the long period average of 5 per year over the entire north Indian Ocean including about four over Bay of Bengal and one over Arabian Sea. Thus the cyclonic activity was subdued in the Bay of Bengal during the year 2014. However, the frequency of very severe cyclonic storms was near normal (two).

(ii) Though there were three cyclones, only one cyclone (Hudhud) crossed coast and other two (Nanauk and Nilofar) dissipated over the Sea.

(iii) The cyclone Hudhud recurved northwards after landfall, Nilofar recurved northeastwards after attaining maximum intensity and only the remnant of the Cyclone Nanauk recurved northeastwards.

(i) Cyclonic Storm 'Nanauk' over Arabian Sea (10-14 June 2014)

Brief life history

A Cyclonic Storm 'NANAUK' originated from a low pressure area over eastcentral Arabian Sea which developed on 9th June, 2014. It concentrated into a depression over the same region in the afternoon of 10th June, 2014. Moving northnorth-westwards, it intensified into a cyclonic storm, 'NANAUK' in the early morning of 11th June 2014. It weakened into a deep depression in the afternoon of 13th June, 2014 over west central Arabian Sea and into a depression in the evening of 13 June, 2014 and further into a well marked

low pressure area over the same region in the morning of 14th June, 2014. The track of the cyclone is shown in Fig. 1 and the typical satellite in shown in Fig. 2.

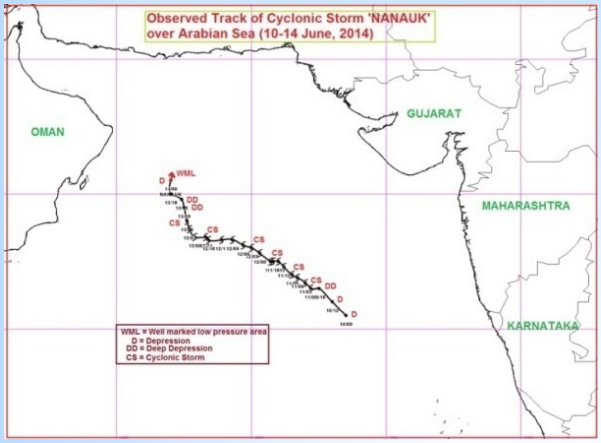


Fig.1. *Track of Cyclonic Storm 'Nanauk' over the Bay of Bengal (10-14 June, 2014)*

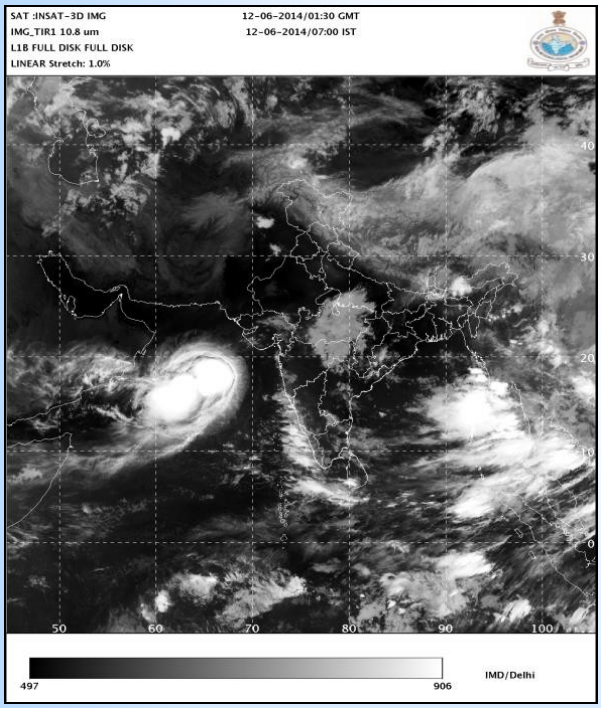


Fig. 2. *INSAT 3-D Satellite imageries of cyclonic storm Nanauk at 0130 UTC of June, 2014*

The salient features of this cyclone are given below.

(i) It developed in association with the southwest monsoon surge over Arabian Sea during the onset phase.

(ii) It caused temporary hiatus in progress of monsoon over south India.

(iii) It weakened over the northwest Arabian Sea on 14th June and its remnant moved northeastwards leading to revival and progress of monsoon along the west coast of India.

(ii) Very Severe Cyclonic Storm (VSCS) Hudhud over the Bay of Bengal (7-14 October 2014)

Brief life history

The Very Severe Cyclonic Storm 'HUDHUD' (7-14 October, 2014) developed from a low pressure area which lay over Tenasserim coast and adjoining North Andaman Sea in the morning of 6th October, 2014. It concentrated into a *Depression* in the morning of the 7th October, over the North Andaman Sea. Moving west-northwestwards it intensified into a Cyclonic Storm in the morning of 8th October, and crossed Andaman Islands close to Long Island between 0830 and 0930 hrs IST of 8th October. It then emerged into Southeast Bay of Bengal and continued to move west-northwestwards. It intensified into a *Severe Cyclonic Storm* (SCS) in the morning of 9th October, and further into a *Very Severe Cyclonic Storm* in the afternoon of 10th October. It continued to intensify while moving northwestwards and reached maximum intensity in the early morning of 12th with a maximum sustained wind speed (MSW) of 180 kmph over the West Central Bay of Bengal off Andhra Pradesh coast. It crossed north Andhra Pradesh coast over Visakhapatnam (VSK) between 1200 and 1300 hrs IST of 12th October with the same wind speed.

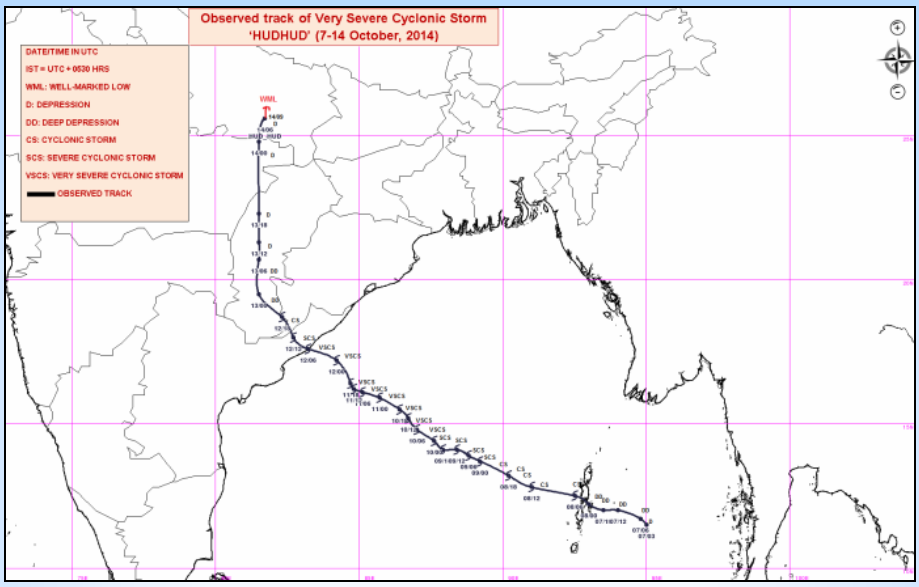


Fig. 3. *Observed track of VSCS Hudhud during 7-14 October, 2013*

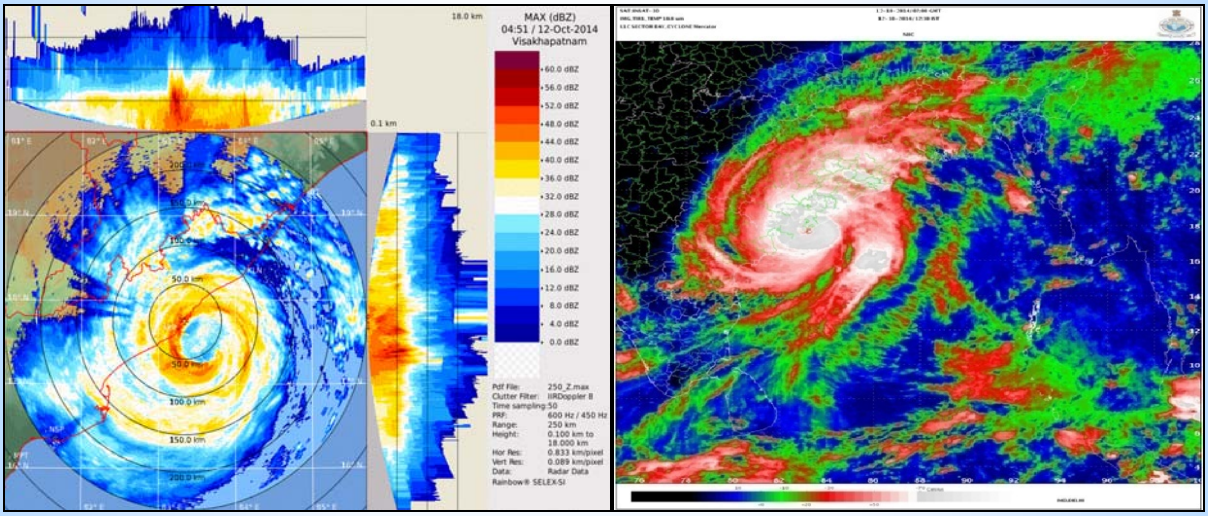


Fig. 4. *Typical RADAR and satellite imagery of VSCS, Hudhud*

After landfall, it continued to move northwestwards for some time and weakened gradually into *SCS* in the evening and further into a *CS* in the same midnight. It then, weakened further into a *Deep Depression* in the early morning of 13th and weakened into a depression in the evening of 13th. Thereafter, it moved nearly northward and weakened into a well-marked low pressure area over East Uttar Pradesh and neighbourhood in the evening of 14th October, 2014.

The salient features of this system are:

i. HUDHUD is the first cyclone that crossed Visakhapatnam coast in the month of October, after 1985 and it made landfall on the same day.

ii. At the time of landfall on 12th October, the estimated maximum sustained surface wind speed in association with the cyclone was about 100 kt.

iii. The estimated central pressure was 950 hPa with a pressure drop of 54 hPa at the centre compared to surroundings.

iv. It caused very heavy to extremely heavy rainfall over North Andhra Pradesh and South Odisha and strong gale winds leading to large scale structural damage over North Andhra Pradesh and adjoining districts of South Odisha and storm surge over North Andhra Pradesh.

v. Maximum 24 hour cumulative rainfall of 47 cm ending at 0830 hrs IST of 13 October was reported from Elamanchili Mandal (dist Visakhapatnam) in Andhra Pradesh. Maximum of storm surge of 1.4 meters above the astronomical tide has been reported at Visakhapatnam.

The track of the cyclone is shown in Fig. 3 and the typical RADAR and satellite imagery is shown in Fig. 4.

(iii) Very Severe Cyclonic Storm 'Nilofar' over Arabian Sea (25-31 October 2014)

Brief life history

The very severe cyclonic storm, Nilofar developed from a low pressure area which lay over southeast Arabian Sea in the morning of 21st October. It moved northwestwards and concentrated into a Depression in the early morning of 25th over westcentral and adjoining southwest Arabian Sea. It intensified into a Cyclonic Storm over the same region in the morning of 26th. It then moved nearly northwards and further intensified into a Severe Cyclonic Storm (SCS) over westcentral ArabianSea in the early morning of 27th and into a Very Severe Cyclonic Storm (VSCS) around noon of the same day. It continued to move nearly northwards and reached its maximum intensity around midnight of 28th with wind speed of 205 kmph. It then moved north-northeastwards and started to weaken rapidly under the influence of high vertical wind shear, entrainment of dry and cold air from the north and relatively lower ocean thermal energy. It weakened into a Severe Cyclonic Storm during early hours of 30th October and into a Cyclonic Storm in the afternoon of 30th October. It weakened into a Deep Depression in the early hours and into a Depression in the early morning of 31st October. It weakened into a well marked low pressure area over northeast Arabian Sea off north Gujarat coast in the forenoon of 31st October. The track and satellite imagery of the system are shown in Fig. 5 and 6 respectively.

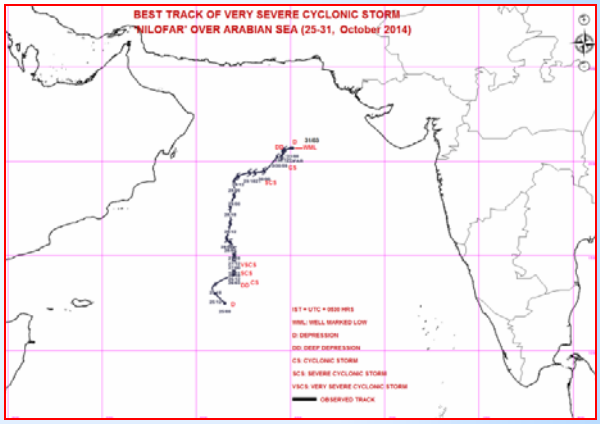


Fig. 5. *Track of VSCS Nilofar (25-31 October 2014)*

The salient features of this storm are as follows:

(i) The track of the system was unique, as it initially moved northwestward on the day of formation and then re-curved northeastwards.

(ii) The estimated maximum sustained surface wind speed in association with the cyclone was about 110 kt (205 kmph).

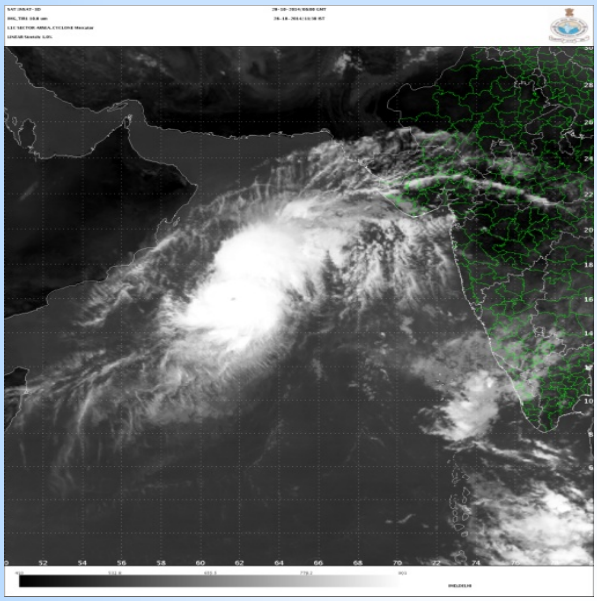


Fig. 6. *Typical INSAT 3D Satellite imagery of VSCS Nilofar at 0600 UTC of 28 October, 2014*

(iii) The estimated central pressure was 950 hPa with a pressure drop of 56 hPa at the centre compared to surroundings.

(iv) It exhibited Rapid Intensification as well as Rapid Weakening. The maximum sustained wind increased from about 100 kmph in the early morning of 27th to about 205 kmph in the early evening of 28th (in 36 hours). It weakened rapidly from VSCS (wind speed of about 200 kmph) in the morning of 29th into SCS (wind speed of about 110 kmph) in the morning of 30th and further into a low pressure area (wind speed < 30 kmph) on 31st morning.

(v) The genesis, track and intensification/weakening were predicted by IMD with reasonable accuracy five days in advance.

3.1.1. Monitoring & Predicted of Cyclones

The Cyclonic disturbances were monitored & predicted continuously since their inception by the India Meteorological Department. The forecast of their genesis, track, intensity, point & time of landfall, as well as associated adverse weather like heavy rain, gale wind & storm surge were predicted exceedingly well with sufficient lead time which helped the disaster managers to maximize the management of cyclone in an exemplary manner. At the genesis stage, the systems were monitored mainly with satellite observations, supported by meteorological buoys and coastal and island observations. As the systems lay within radar range, the DWRs were utilized and continuous monitoring by the radars continued. In addition, the observations from satellite and coastal observations conventional observatories and Automatic Weather Stations (AWS) ware used. While coastal surface observations were taken on hourly basis, the half hourly INSAT3D imageries and every 10 minute DWR imageries, available microwave imageries and scatterometry products were used for monitoring of cyclonic disturbances. Various national and international NWP models and dynamical-statistical models including IMD's global and meso-scale models, dynamical statistical models for genesis and intensity were utilized to predict the genesis, track, intensity and rapid intensification of the storms. Tropical Cyclone Module, the digitized forecasting system of IMD was utilized for analysis and comparison of various models guidance and decision making process and warning product generation.

TABLE 1

Operational average track forecast error of IMD of 'NANAUK'

Lead Period	Track Forecast Error (km)	Long period average (2009-2013)	Track forecast skill	Long period skill (2009-2013)
12	48.0(11)	68.5	43.8(11)	**31.2**
24	78.8(10)	124.1	54.1(10)	**35.9**
36	81.2(08)	163.8	67.9(08)	**43.9**
48	89.0(06)	202.1	74.1(06)	**52.6**
60	77.5(04)	233.8	84.2(04)	**58.1**
72	**94.2(02)**	**268.2**	**84.9(02)**	**61.8**

Figures in the parentheses show the number of six hourly forecasts verified

TABLE 2

Operational average intensity forecast error of IMD of 'NANAUK'

Lead Period	Intensity Forecast Error (knots)		Long period Average (2009-2013)		Skill in term of Absolute Error (%)	Skill in term of RMS Error (%)
	Absolute error	Root mean square error	Absolute Error (knots)	RMS Error (knots)		
12	6.1(11)	7.5(11)	10.4	14.0	-19.6(11)	**1.3**
24	13.2(10)	14.1(10)	15.7	20.5	9.0(10)	**12.4**
36	20.4(08)	21.6(08)	20.5	25.2	16.7(08)	**13.3**
48	30.2(06)	32.0(06)	22.5	27.6	27.0(06)	**25.9**
60	33.1(04)	34.5(04)	23.5	26.4	51.5(04)	**49.4**
72	**28.4(02)**	**28.4(02)**	**26.7**	**30.8**	**66.4(02)**	**66.7**

3.1.2. Forecast performances:

(i) Cyclonic Storm 'Nanauk'

Average Track Forecast Error and Skill

The average track forecast error and skill is shown in Table 1. The track forecast error was about 79 km, 89 km and 94 km respectively for 24, 48 and 72 hr forecast respectively against the long period average of 124, 202 and 268 km based on the period of 2009-2013. The operational track forecast skill was about 54%, 74% and 84% for 24, 48 and 72 hr forecasts respectively.

Intensity forecast error

The intensity forecast errors and skill [average absolute error (AAE) and root mean square error (RMSE)]

TABLE 3

Operational landfall point and time forecast errors of VSCS 'HUDHUD'

Lead Time (hrs)	Landfall Point Error (km)	Landfall Time Error (hrs)	Long period average landfall point error (km)	Long period average landfall time error (hrs)
12	10	0 h	38.8	2.3
24	20	0 h	75.0	4.2
36	17	4 h early	94.5	7.8
48	04	4 h early	97.5	6.9
60	08	3 h early	83.8	3.5
72	02	1 h early	123.7	1.9
84	24	3 h early	-	-
96	40	3 h early	-	-

of IMD for cyclonic storm, **'NANAUK'** are shown in Table 2. The AAE Figures in the parentheses show the number of six hourly forecasts verified was about 13, 30 and 28 knots against the long period average of 16, 23 & 27 knots based on the period of 2009-2013 for 24, 48 & 72 hr forecasts respectively. The average RMSE was about 14, 32 and 28 knots against the long period average of 21, 28 and 31 knots respectively for the same period. Though the AAE was higher than long period average for 36-72 hr forecasts and RMSE was higher for 48-72 hr forecasts, the forecast was skillful as compared to persistence forecast. The higher intensity error in the lead period of 36-72 hrs may be attributed to the poor guidance from numerical models, as most of the models could not predict intensity accurately. The Skill in terms of improvement in AAE with respect to persistence forecast is about 9%, 27% and 66% respectively for 24, 48 and 72 hr forecasts. Similarly, the Skill in terms of improvement in RMSE with respect to persistence forecast is about 12%, 26% and 67% respectively for 24, 48 and 72 hr forecasts.

(ii) Very Severe Cyclonic Storm (VSCS) Hudhud

Operational landfall forecast error and skill

The operational landfall forecast error varied from 2 to 20 km for 12 to 72 hrs forecast (Table 3). Considering the size of the eye of the cyclone as 40 km, the landfall error was negligible for all forecast time scales.

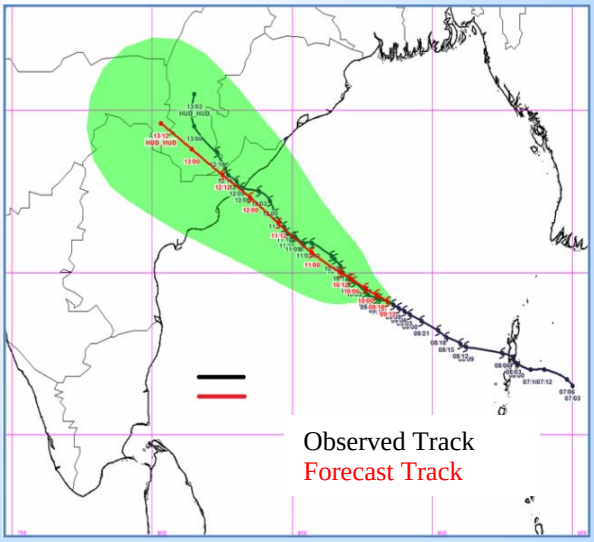


Fig. 7. *An example of forecast track along with cone of uncertainty issued on 9th October 2014*

The landfall time error was also very less varying from 1 to 4 hrs. An

TABLE 4

Operational Track Forecast Error (km) and skill of VSCS HUDHUD

Lead Period (hrs)	Track forecast error (Official)	Long period Average track forecast error (km) based on 2009-13	Skill (%) with reference to climatology and persistence forecast	Long period Average skill (%) based on 2009-13
12	50.8 (21)	68.5	43.8	31.2
24	63.4 (19)	124.1	63.8	35.9
36	67.2 (17)	163.8	74.9	43.9
48	78.0 (15)	202.1	79.6	52.6
60	88.1 (12)	233.8	82.2	58.1
72	84.9 (11)	268.2	86.8	61.8
84	90.7 (9)	-	88.7	-
96	98.0 (7)	-	90.0	-
108	90.8 (5)	-	92.3	-
120	203.0 (3)	-	92.5	-

TABLE 5

Operational Intensity forecast errors and skill (%)

Lead period (hrs)	Absolute Error (knots)	Root mean square (RMS) Error (knots)	Long period Average (2009-2013)		Skill (%) with reference to persistence forecast		Long period average Skill (%) based on 2009-2013	
			Absolute Error (knots)	RMS Error (knots)	Absolute Error	Root mean square (RMS) error	Absolute Error	RMS Error
12	8.8	12.5	10.4	14.0	22.8	30.9	10.4	14.0
24	8.9	11.3	15.7	20.5	55.5	65.5	15.7	20.5
36	9.2	12.3	20.5	25.2	64.5	69.6	20.5	25.2
48	10.7	14.7	22.5	27.6	58.8	59.9	22.5	27.6
60	13.3	16.4	23.5	26.4	49.2	53.1	23.5	26.4
72	15.3	18.0	26.7	30.8	40.0	42.5	26.7	30.8
84	15.7	19.1	-	-	58.5	61.6	-	-
96	19.7	22.0	-	-	54.8	53.2	-	-
108	18.8	21.1	-	-	50.0	66.8	-	-
120	16.9	17.4	-	-	15.5	32.6	-	-

example of forecast & actual track showing accurate prediction of landfall point & time is shown in Fig. 7.

Operational track forecast error and skill

The operational track forecast errors are shown in Table 4. It was less than 100 km for all forecast time scales upto 108 hrs. The skill was also significantly less than 100 km for all forecast time scales upto 108 hrs. It was significantly less than the long period average errors based on 2009-13. The track forecast skill varied from 44% to 93 % for various time scales and was significantly higher than long period average.

TABLE 6

Operational average track forecast errors and skill

Lead Period (hrs)	Track forecast error(km)	Track forecast skill (%) with reference to climatology and persistence forecast	Long period Average based on 2009-13	
			Track forecast error (km)	Track forecast skill (%)
12	64.7(17)	59	68.5	31.2
24	90.5 (15)	72	124.1	35.9
36	80.4 (13)	84	163.8	43.9
48	94.1 (11)	86	202.1	52.6
60	93.8 (9)	89	233.8	58.1
72	166.1 (7)	83	268.2	61.8
84	223.5 (5)	81	-	-
96	221.7 (3)	83	-	-
108	275 (1)	74	-	-

TABLE 7

Operational Intensity forecast errors and skill (%)

Lead period (hrs)	Absolute Error	Root mean square (RMS) Error	Long period Average (2009-2013)		Skill (%) with reference to persistence forecast		Long period average Skill (%) based on 2009-2013	
			Absolute Error	RMS Error	Absolute Error	RMS error	Absolute Error	RMS Error
12	10.0	12.8	10.4	14.0	16.9	24.8	10.4	14.0
24	17.1	19.6	15.7	20.5	31.7	47.5	15.7	20.5
36	23.7	27.4	20.5	25.2	34.4	54.1	20.5	25.2
48	23.9	27.4	22.5	27.6	57.9	67.1	22.5	27.6
60	21.6	25.4	23.5	26.4	58.7	59.1	23.5	26.4
72	17.4	19.3	26.7	30.8	75.4	77.0	26.7	30.8
84	15.3	17.5	-	-	84.1	83.5	-	-
96	22.2	22.5	-	-	11.9	76.4	-	-
108	21.8	21.8	-	-	75.8	75.8	-	-

120 hr forecast has been introduced in 2013. Hence, no long period average is available for 84-120 hrs.

Operational Intensity forecast error and skill

The operational intensity forecast error in terms of absolute error (AE) and root mean square error (RMSE) are presented in Table 5. The AE varied from about 9 knots to 20 knots in different time scales. The error was significantly less than the long period average error based on 2009-2013. However, comparing the skill, the skill in intensity forecast compared to persistence forecast varied from 23% to 65% for different lead periods and has been

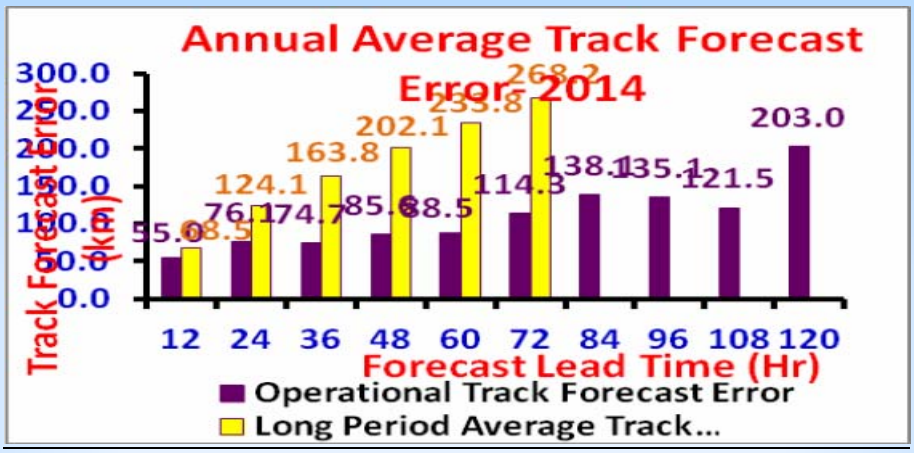


Fig. 8(a). *Annual Average Track Forecast Error-2014*

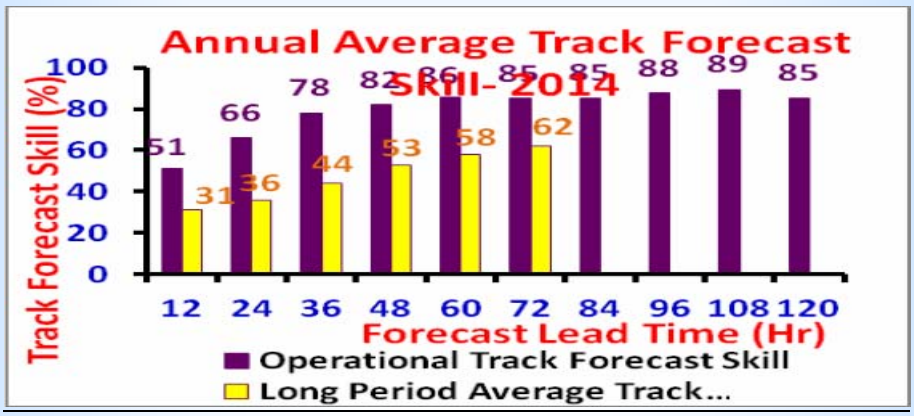


Fig. 8(b). *Annual Average Track Forecast Skill-2014*

significantly higher as compared to long period average skill. Considering the RMSE, it varied from 11 knots to 22 knots for different forecast time scales and was significantly less than long period average RMS errors. The skill varies from 31% to 67% and is significantly higher than the long period average skills.

(iii) Very Severe Cyclonic Storm 'Nilofar'

Operational track forecast errors and skill (%)

The operational average track forecast errors and skill are shown in Table 6. It was less than 100 km for the forecast time scales upto 60 hrs. The track forecast skill varied from 59% to 89 % for various time scales and was significantly higher than long period average.

120 hr forecast has been introduced in 2013. Hence, no long period average is available for 84-120 hrs. Number of six hourly forecasts verified. 120 hr forecast could not be verified as the cyclone dissipated over the sea.

Operational intensity forecast errors and skill (%)

The operational intensity forecast error in terms of absolute error (AE) and root mean square error (RMSE) are presented in Table 7. The AE varied from about 10 knots to 24 knots in different time scales.

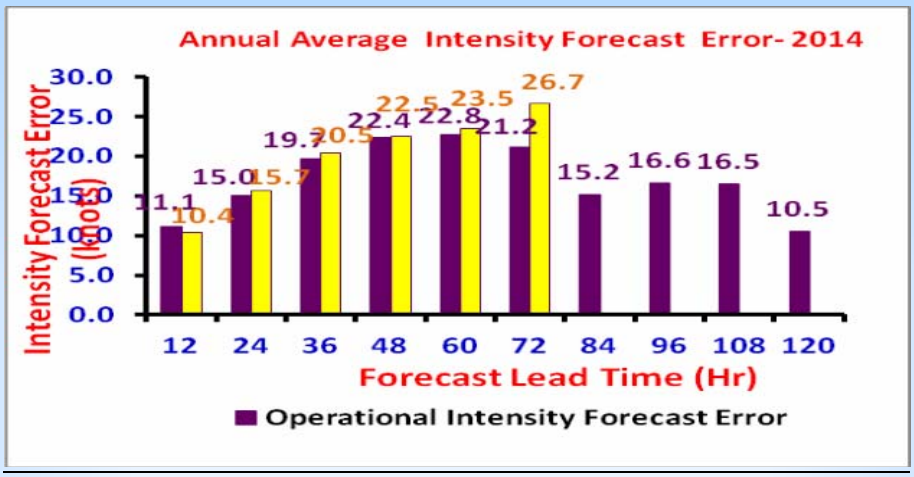


Fig. 9(a). *Annual Average Intensity Forecast Error-2014*

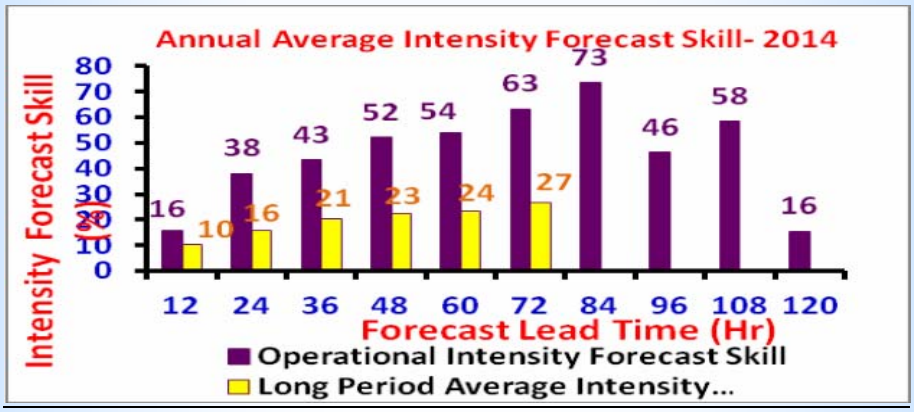


Fig. 9(b). *Annual Average Intensity Forecast Skill-2014*

TABLE 8

Operational landfall point and time forecast errors

Lead Time (Hrs)	Landfall Point Error (km)	Landfall Time Error (hrs)	Long period average landfall point error(km)	Long period average landfall time error(hrs)
19	10	0 h	39	2
31	20	0 h	75	4
43	17	4 h early	95	8
55	04	4 h early	97	7
67	08	3 h early	84	4
79	02	1 h early	124	2
91	24	3 h early	-	-
103	40	3 h early	-	-

However, comparing the skill, the skill in intensity forecast compared to persistence forecast varied from 17% to 84% for different lead periods and has been significantly higher as compared to long period average skill. Considering the RMSE, it varied from 13 knots to 27 knots for different forecast time scales. The skill varies from 25% to 83% and is significantly higher than the long period average skills.

Annual average error

The annual tropical cyclone track forecast error has been calculated for the year 2014. The annual average track forecast error [Fig. 8(a)] has been 76 km, 86 km and 114 km, respectively for 24, 48 and 72hrs against the long period average error of 124, 202 and 268 km based on data of 2009-2013. The 96 and 120 hr track forecast error were 135 and 203 km respectively which are also very less. Also the track forest skills compared to climatology and persistence forecast [Fig. 8(b)] are 66%, 82% and 85% respectively for the 24, 48 and 72 hrs lead period which is much higher than long period average of 2009-2013 (36%, 53% & 62% respectively). The landfall forecast error varied from 2 to 20 km for 12 to 72 hrs forecast (Table 8). The landfall time error was also very less varying from 1 to 4 hrs. Similarly. The annual average intensity forecast error Fig. 9(a) has been 15 nautical miles per hour (knots), 22 knots and 21 knots respectively for 24, 48 and 72 hrs lead period of forecast against the long period average of 16, 23 and 27 knots. The skill compared to persistence forecast [Fig. 9(b)] were 38%, 52% and 63% respectively which is also much higher than the long period average of 16%, 23% and 27% respectively.

Inter-annual variation

Landfall forecast error

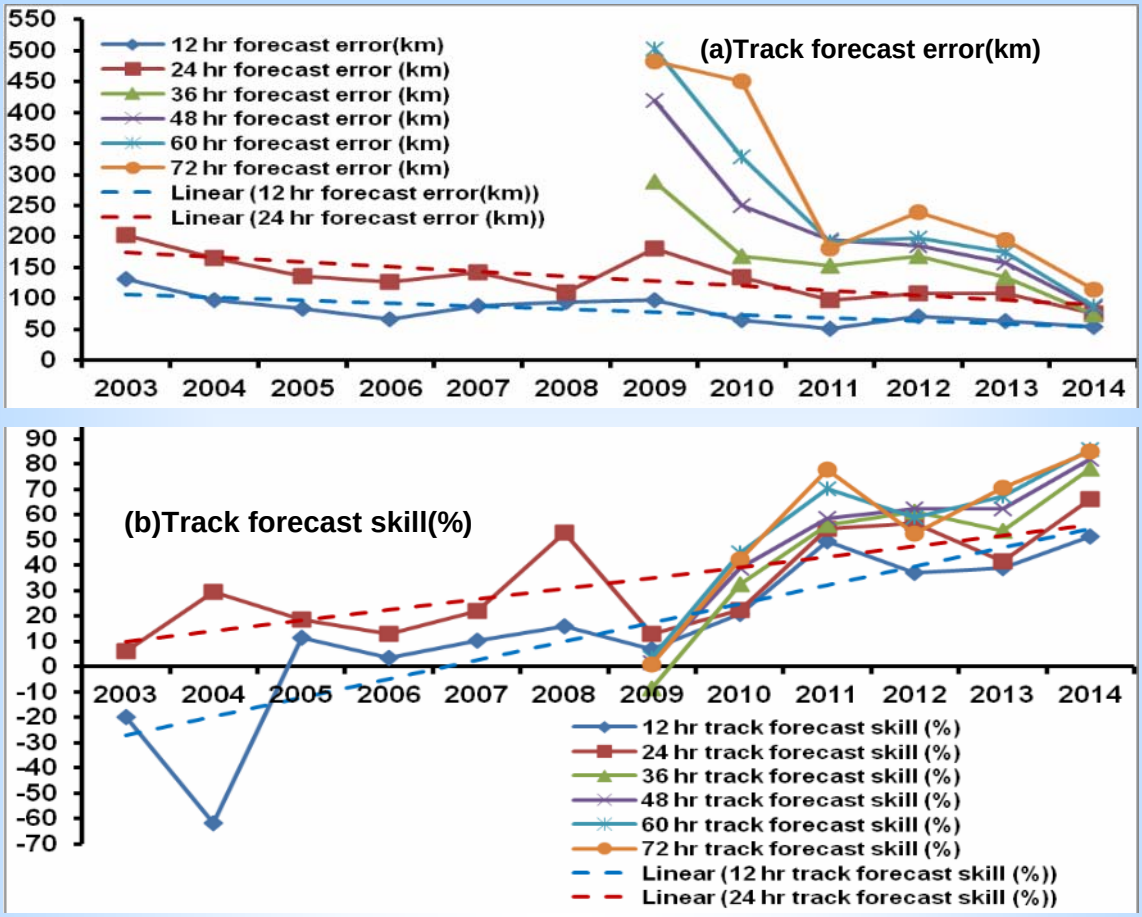
The error for landfall point and time forecast of cyclones over north Indian Ocean during 2003-14 are decreasing significantly in recent years. The 12 and 24 hr landfall point forecast errors have reduced at the rate of 14 and 29 km per year. Similarly the landfall time forecast error has reduced at the rate of 0.2 and 0.5 hr per year for 12 and 24 hr forecasts respectively during 2003-14.

Track forecast error and skill

The track forecast errors and skill as compared to climatology and persistence model based forecast errors of cyclones over north Indian Ocean during 2003-14 are shown in Figs.10 (a&b). The errors are decreasing significantly in recent years. The 12 & 24 hr track forecast errors have reduced at the rate of 4.7 and 7.6 km per year. Similarly the track forecast skill has improved at the rate of 7.4% and 4.2% per year for 12 and 24 hr forecasts respectively during 2003-14.

Intensity forecast error and skill

The intensity forecast errors and skill as compared to persistence based forecast errors of cyclones over north Indian Ocean during 2003-14, are decreasing in recent years. However, the rate of decrease is less than that of track forecast error. The 12 and 24 hr track forecast skills have improved at the rate of 5% per year considering both absolute and root mean square errors during 2003-14.



Figs. 10(a&b). *Annual average track forecast error(km) and skill (%) of cyclones over the north Indian Ocean*

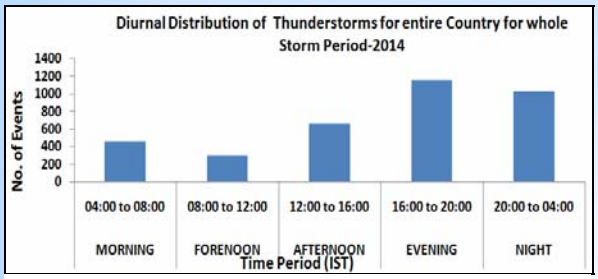
3.2. Nowcasting of Thunderstorms squalls & Hailstorms

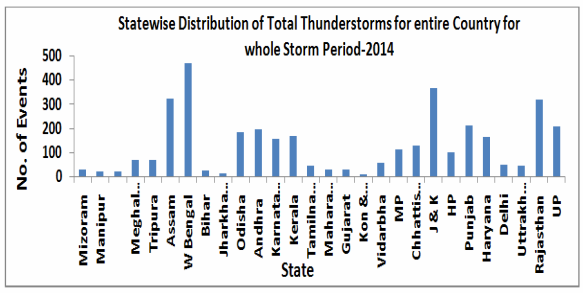
Nowcasting is based on the ability of the forecaster to assimilate great quantities of weather data, conceptualize a model that encompasses the structure and evolution of the phenomenon and extrapolate this in time. Nowcasts require high resolution of spatial and temporal meteorological data to detect and predict the occurrence of an event.

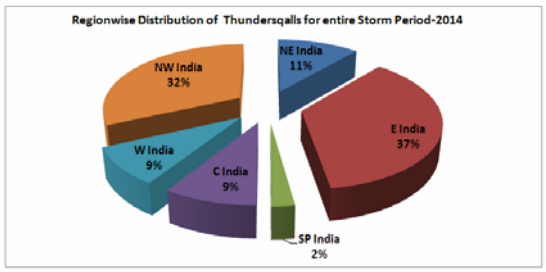
SAARC Storm Project

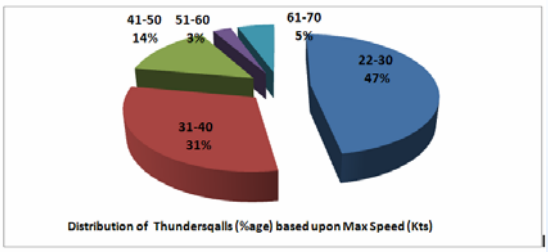
The STORM program was conceived as a multidisciplinary nationally co-ordinated research and development programme and has been carried out as a multi-year observational-cum modelling campaign with an objective to build appropriate operational early warning systems. In Phase-III of SAARC STORM Programme which started in 2013, the STORM Fields Experiments covered the whole SAARC region. This year Storm field experiments covered whole India. A Weather Advisory Group, established at the India Meteorological Department (IMD), New Delhi was set up by Nowcast Unit with main task to watch the development of daily weather situation over the STORM campaign area during March-June-2014. A total of 39 Bulletins were issued during the period. Nowcast Unit prepared a storm report document that contains information

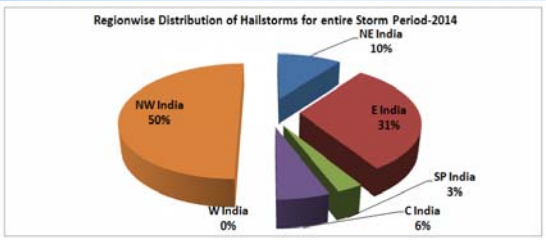
on daily weather situation, important weather charts, severe weather events all through the campaign period, case studies and the bulletins issued during the period. Some of the important results are:

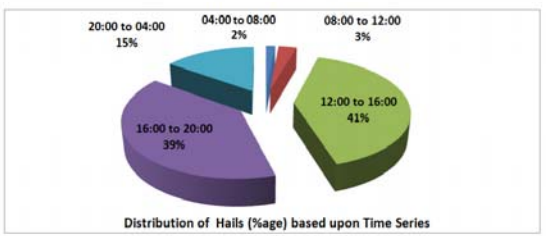


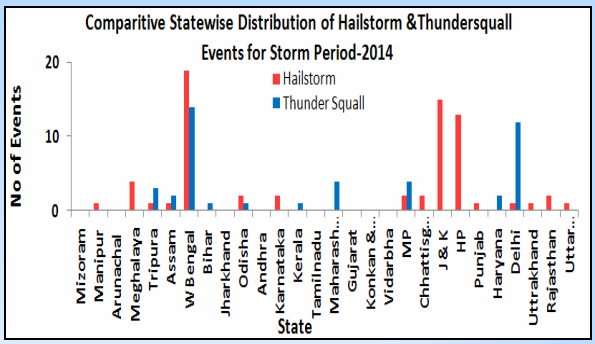








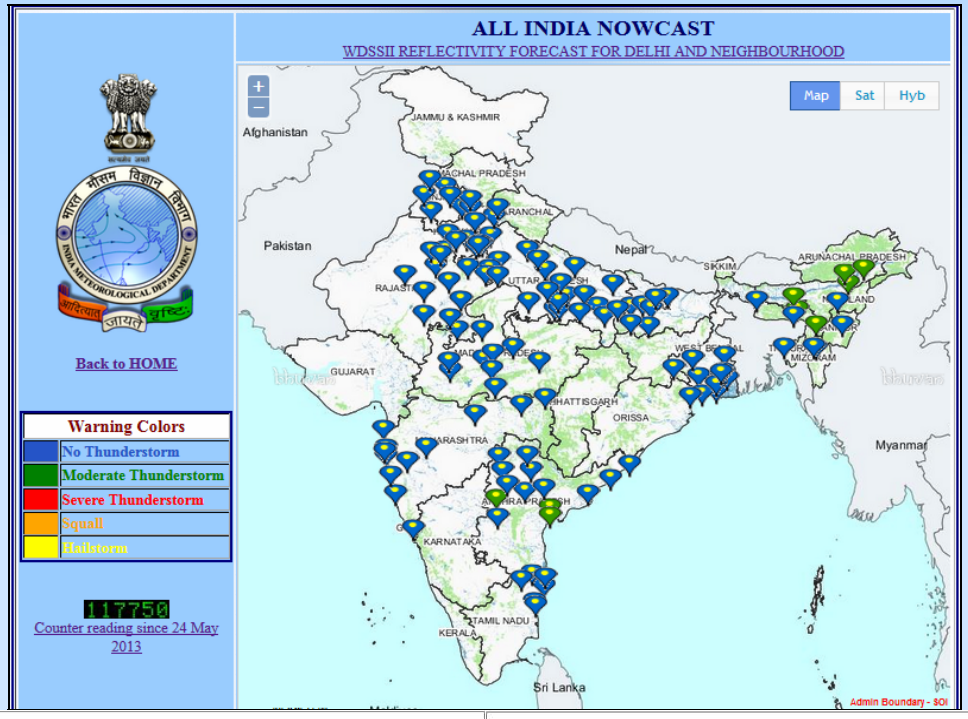


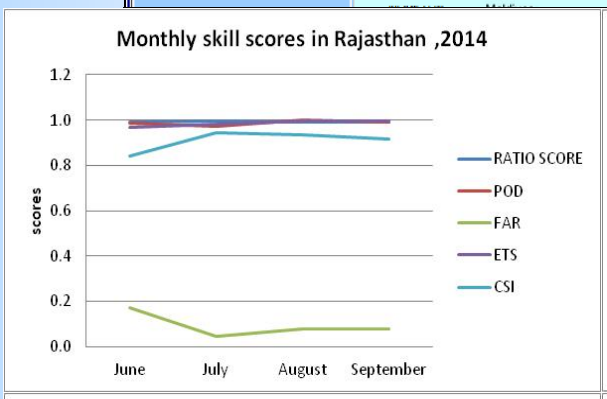


Skill Score of Nowcasting

In view of the recent improvement in monitoring and forecasting due to introduction of (i) digital and image information at 10 mins interval from a network of 14 Doppler Weather Radars, (ii) dense automatic weather station (AWS) network, (iii) half hourly satellite observations from Kalpana and INSAT satellites, (iv) better analysis tools in synergy system at forecaster's workstation and (v) availability of mesoscale models, (vi) 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 148 stations within 200 km radius of various Doppler Weather Radars were selected and nowcast is uploaded every 3 hourly interval utilising Synoptic Data, Model outputs, Satellite products and finally various Radar outputs. The forecast was operational from December 2012 and the verification for 2014 for various regions is given in fig.


ALL INDIA NOWCAST
WDSSII REFLECTIVITY FORECAST FOR DELHI AND NEIGHBOURHOOD
Map
Sat
Hyb
Back to HOME
Warning Colors
No Thunderstorm
Moderate Thunderstorm
Severe Thunderstorm
Squall
Hailstorm
Counter reading since 24 May 2013
Afghanistan
Pakistan
Nepal
Myanmar
Sri Lanka
JAMMU & KASHMIR
GUJARAT
KARNATAKA
TAMIL NADU
KERALA
ORISSA
SIKKIM
Admin Boundary - SOI


Monthly skill scores in Rajasthan ,2014
scores
RATIO SCORE
POD
FAR
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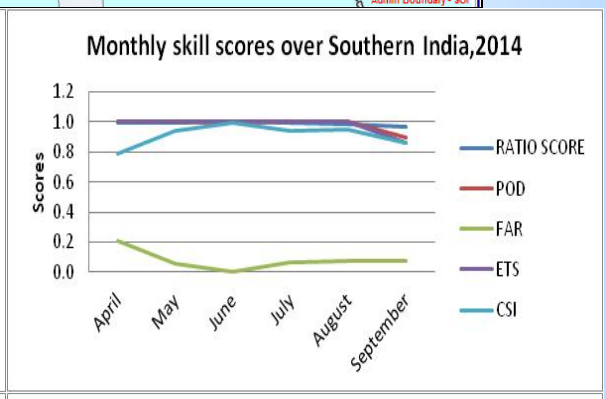
CSI
June
July
August
September


Monthly skill scores over Southern India,2014
Scores
RATIO SCORE
POD
FAR
ETS
CSI
April
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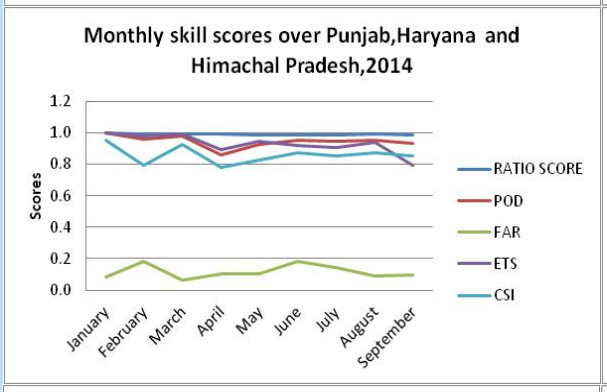
Monthly skill scores over Punjab,Haryana and Himachal Pradesh,2014
Scores
RATIO SCORE
POD
FAR
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CSI
January
February
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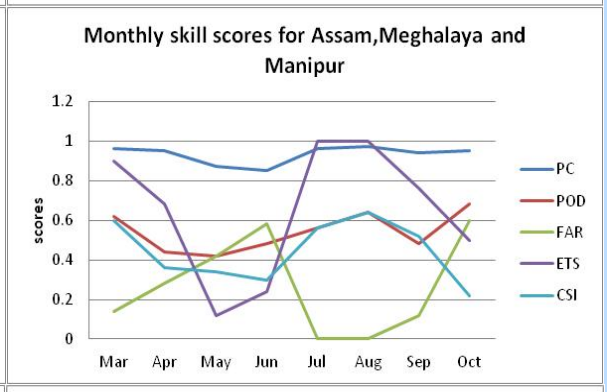
Monthly skill scores for Assam,Meghalaya and Manipur
scores
PC
POD
FAR
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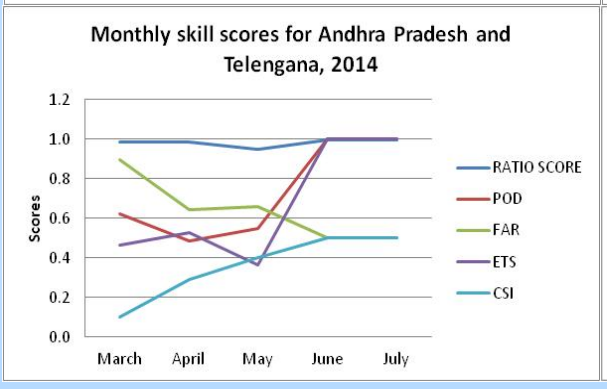
Monthly skill scores for Andhra Pradesh and Telengana, 2014
Scores
RATIO SCORE
POD
FAR
ETS
CSI
March
April
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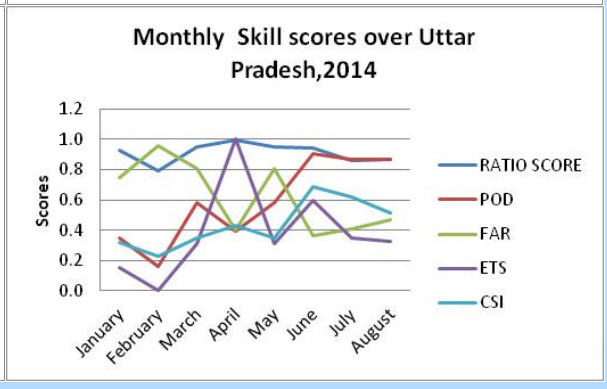
July


Monthly Skill scores over Uttar Pradesh,2014
Scores
RATIO SCORE
POD
FAR
ETS
CSI
January
February
March
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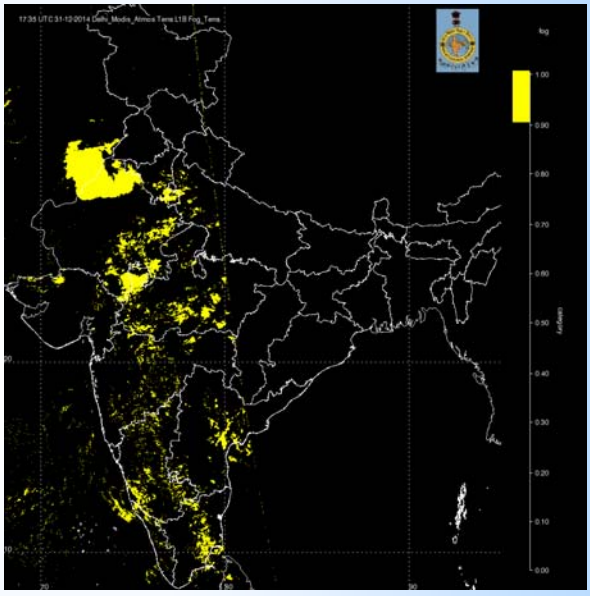
3.3. Fog Monitoring and Prediction

Fog occurrences during Dec to Feb in every winter across northern plains of India severely affect aviation, surface transport, Railway, agriculture and human health. Its severity has added now completely a new concern, when on a single date's evening of 5 Jan 2014 by 0730pm the IGI Airport was closed for operation as fog suddenly had descended and kept covered it, at such very early evening hours causing immediate zero visibility at airport, which then was continued most parts of following night. As a result, 52 number of flight were diverted a highest in this airport's aviation history. The fog layer was so huge that it was simultaneously prevailed at most Indo-Gangetic plains when other nearby airports like Jaipur, Lucknow, Agra, Gwalior were also closed, adding new challenges and very worst experience that night for pilots of these aircrafts in skies, who were critically looked for alternate dense fog free airports in the region, so that they could land these diverted flight safely. The most critical aspects was how to manage fuel emergency in such large scale dense fog Layer.

Since 2008, there has been significant progress in IMD for its understanding as well as implementation of new techniques/ checklist from time in each fog season for improving its real time fog monitoring and forecasting system including their on-line implementation of new techniques/ checklist from time in each fog season for improving its real time fog monitoring and forecasting system. There also have been a continuous efforts with an integral approach from Met office IGI Airport to have a close interaction of users group IMD through multi-institutional coordination of IAF, NAL and CMMACS, which has not only helped in bringing attention of all met communities for helping in improving this vital fog forecast system, but indigenization of fog monitoring instruments *e.g.* replacing all existing RVR by NAL's Drishti RVRs and development of empirical and dynamical fog models for improving fog forecast onset and lifting timings and intensity of fog at Delhi Airport.



MODIS Fog Images

For Delhi airport, it also presently uses around twenty fog forecast checklists/methods and an empirical fog models with inputs from real time synopt and upper air data and NWP model forecasted products. The support from satellite has been very impressive, where methods of night detection has been improved and area of formation, spreading/ weakening of fog coverage in satellite imageries at real time are monitored critically, to issue a spatial fog forecast both at airport and for states. **Though, the skill of forecasting during 2008-2014 at 6-18 hours in advance, for a night-**

morning to bedense fog (yes/no forecast, WMO verification method), increased from 60% to 94%, the actual timing of onset, lowest *vis* reached and time of lifting of fog of visibility <500m and < 200m at 24-hour to 36-hours in advance which are now new needs of the hour, still remain a challenge. By such system, the zero diversion policy to be implemented by India will be achieved at earliest with safety at first.

Live RVR are continued to be made available for Delhi and Current visibility and weather of other 52 airports are now made available in flight to pilots.

The accuracy (percentage correct) of daily forecast of occurrences and non-occurrences of dense fog for Feb 2014, have been verified to be 96% which include 4 hits, 23 correct rejections and one missed(under warning) with no False Alarm. It also shows the differences of forecasted onset and lifting timings of these fogs against those observed, are within 0-2 hours for 75 % of dates out of total dates respectively when dense fogs were observed and air traffic were disrupted partially. The verification of lowest visibility forecasted during these dates against the lowest observed shows during 75% of these dates, when their differences are within 100m.

CHAPTER 4

OPERATIONAL NWP

The operational forecasting services of IMD were called upon on several occasions in 2014 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.

The 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 ~23 km). At ten other regional centres, very high resolution mesoscale models (WRF at 3 km resolution) are made operational. Polar WRF is implemented to provide day to day short range (48 hours) weather forecast for the Indian stations Maitri and Bharati region over Antarctica. Doppler weather Radar (DWR) data based Nowcast system (WDSS-II) was made operational at NCR Delhi, Chennai and Hyderabad. This model will provide Maximum Reflectivity field (ZMax) at T+10, 30, 60, 90, 120 minutes forecast for local severe storm and Aviation applications updated at every 10 min. Mesoscale dynamical high resolution model ARPS (9 km horizontal resolution) based now cast system was made operational for the national Capital of Delhi, northeast, northwest and South peninsular Indian region for local severe storms forecast up to 12 hours.

Under Indo-US joint collaborative program, IMD adapted Hurricane-WRF model for Tropical Cyclone track and intensity forecast for North Indian Ocean (NIO) region, 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 $80^0 \times 80^0$ and inner domain $6^0 \times 6^0$ 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 ,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.

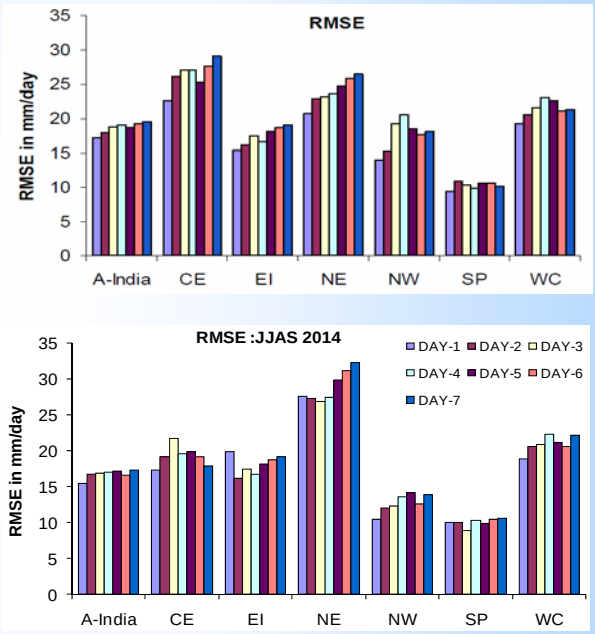
NWP forecasts during 2014

The comparison of GFS forecast during monsoon-2014 with monsoon-2013 shown [Figs. 2(a&b)] the model forecast shown a significant reduction of RMSE in rainfall during 2014 as compared to the same during 2013 over all the *sub-division* of India in all day-1 -to day-7 forecast. More improvement is noticed over Central India in all day-1 -to day-7 forecast during monsoon 2014. There is also a significant improvement in monsoon rainfall special correlation coefficient (CC) around 17% to 28% in day-4 to day-7. This improvement is mainly with the improved assimilation of more observations from various new Indian satellites.

Translate Research to Operation

As a part of effort to translate research to operation, and to meet the need of the operational forecasters, IMD developed various user based products for day to day operational weather forecast upto 7 days and NWP based data services provided to public weather services, Aviation, Agro-met Services, Hydrological services and customised Cyclone Services. 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.

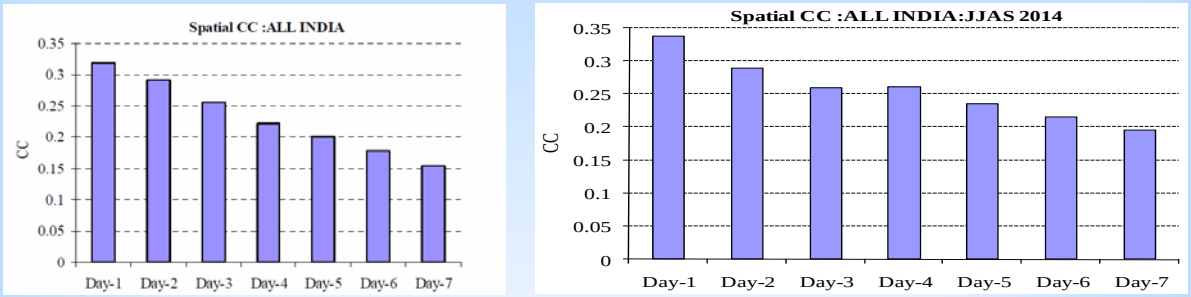
District Level Quantitative five days weather forecasts based on Multi-Model Ensemble (MME) system are being generated to support Agro-Meteorological Advisory Service of India, making use of model outputs of state of the art global models from the leading global NWP centres. All these NWP products are routinely made available on the IMD web site www.imd.gov.in. Performance of NWP models (GFS, WRF) 24, 48 h rainfall forecast to predict extremely heavy rainfall event of J&K during 06 September 2014 is given in Figs. 1 (a&b).



Figs. 1 (a&b). *Seasonal mean RMSE of GFS T574 Day-1 to Day-7 forecast over Indian monsoon region for the period from 1 June 30 September 2013 (Fig a) and 2014 [Fig (a)]*

With the improvement of NWP models (GFS and HWRF) and Statistical-dynamical models, significant improvement was seen 5-days in advance prediction of Tropical cyclone track and intensity of Very Severe Cyclonic Storm 'HUDHUD' (7-14 October 2014) over Bay of Bengal and "NILOFAR' (25-31 October 2014) over Arabian Sea. The 72 hour forecast of GPP (Fig. 4.) valid for 1200 UTC 07 October 2014 indicated the

potential cyclogenesis zone, where Depression formed on that day. MME forecasts track based on different initial conditions (Fig. 5) and MME track forecast error reduction during 2014 illustrated. (Fig. 6).



Figs. 2(a&b). *Seasonal all India mean spatial CC of day-1 to day-7 forecast of GFS T574 during monsoon 2013 (left) and 2014 (right)*

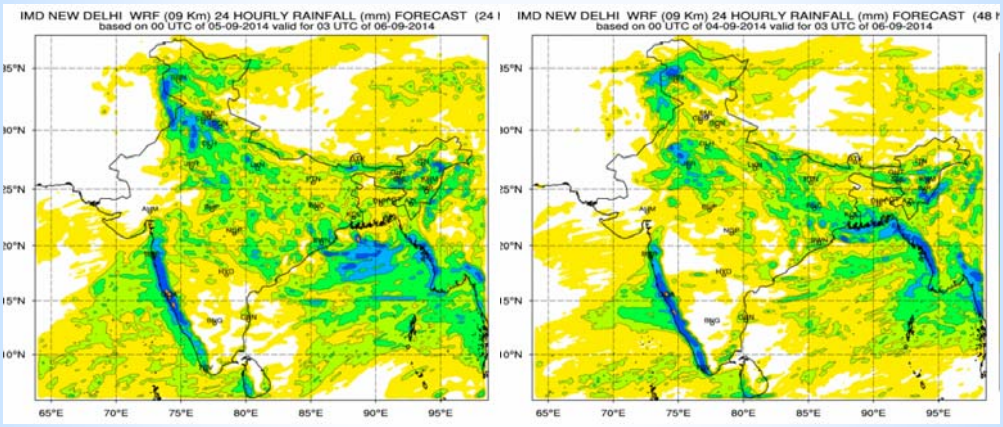


Fig. 3. *Observed and predictions rainfall (cm) for day-1 and day-2 (24 h and 48 h) forecast based on IMD's GFS and WRF (9 km) valid for 06 September 2014*

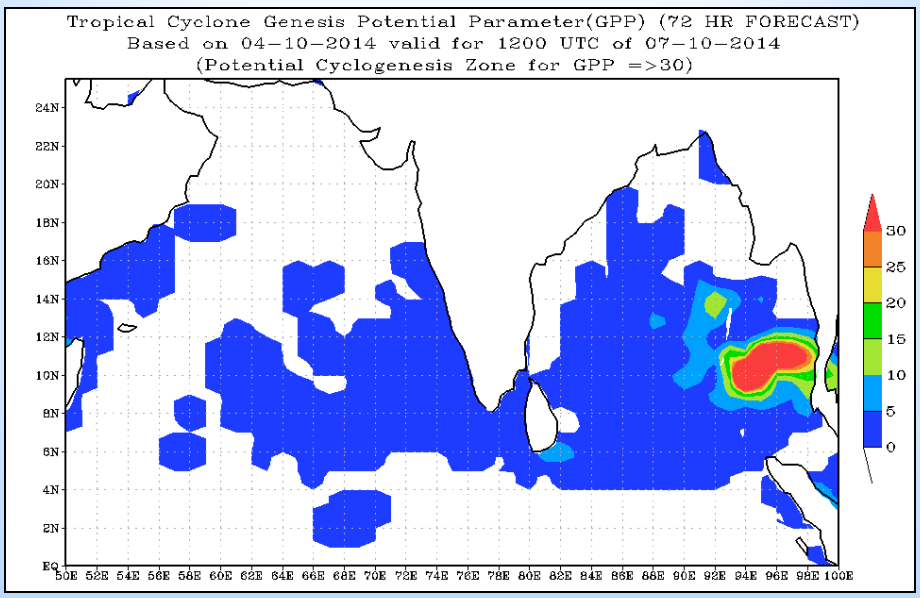


Fig. 4. *GPP of cyclone HUDHUD*

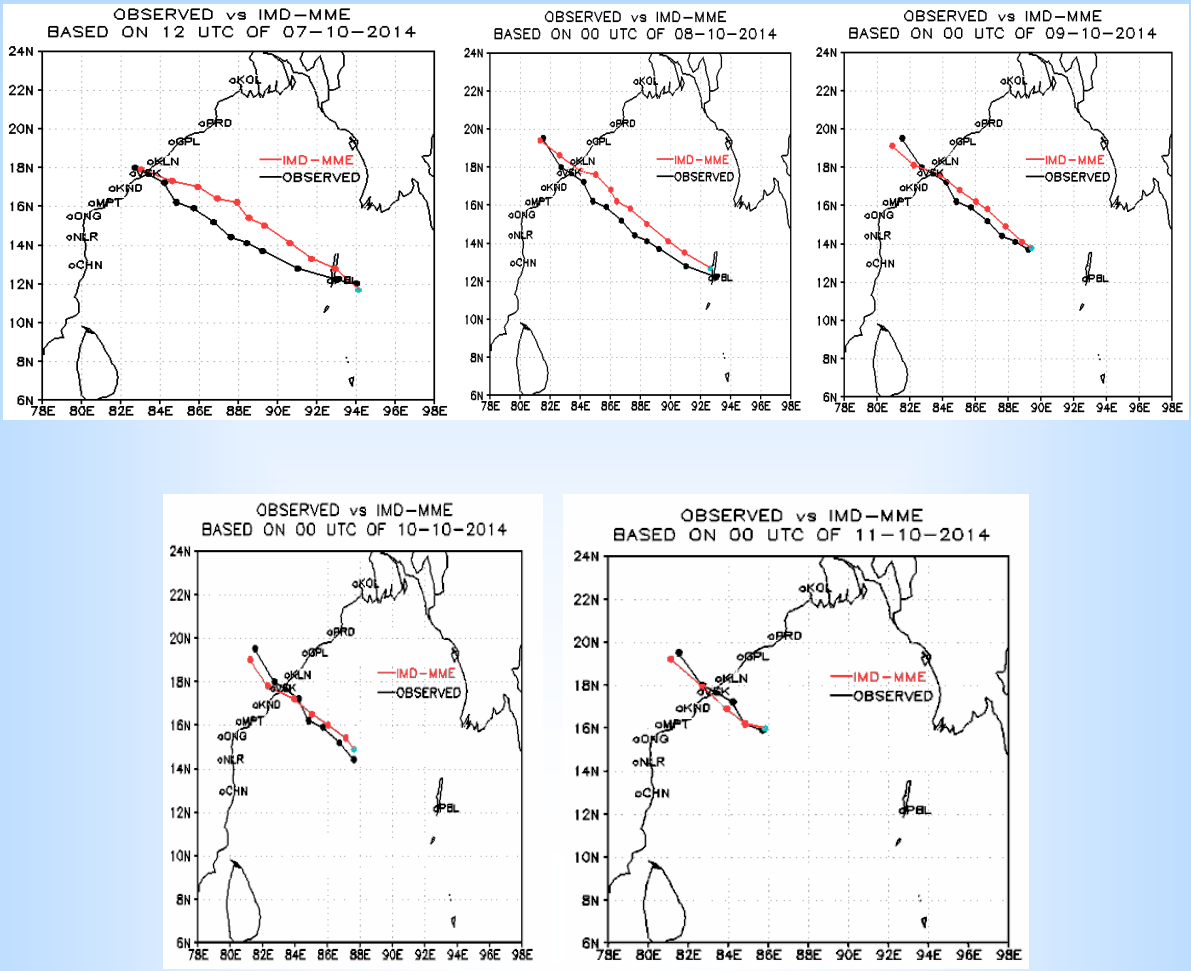


Fig. 5. *MME forecast track for cyclone HUDHUD at different initial conditions*

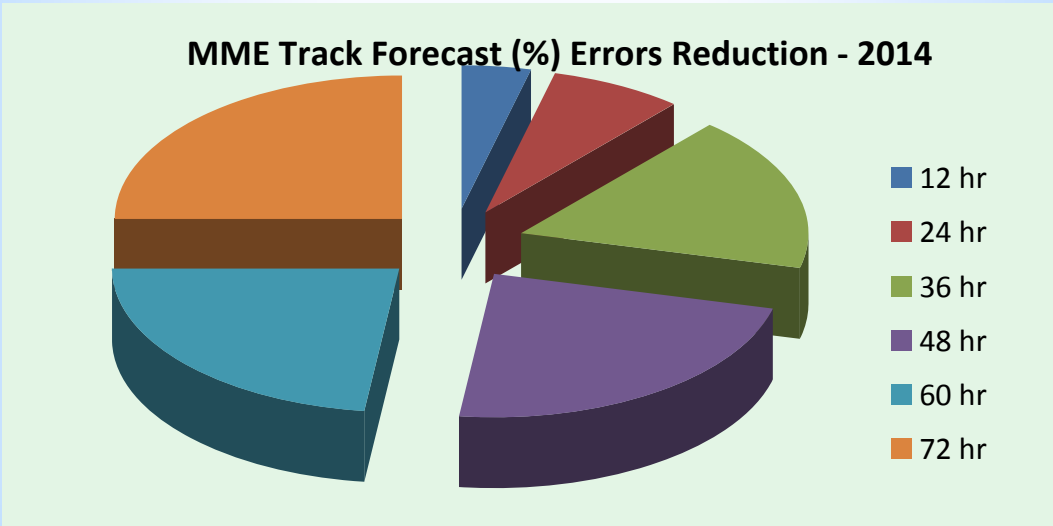


Fig. 6. *MME track forecast error reduction (km) during 2014*

CHAPTER 5

MAJOR SERVICES OF THE DEPARTMENT

5.1. **Hydrometeorological Services**

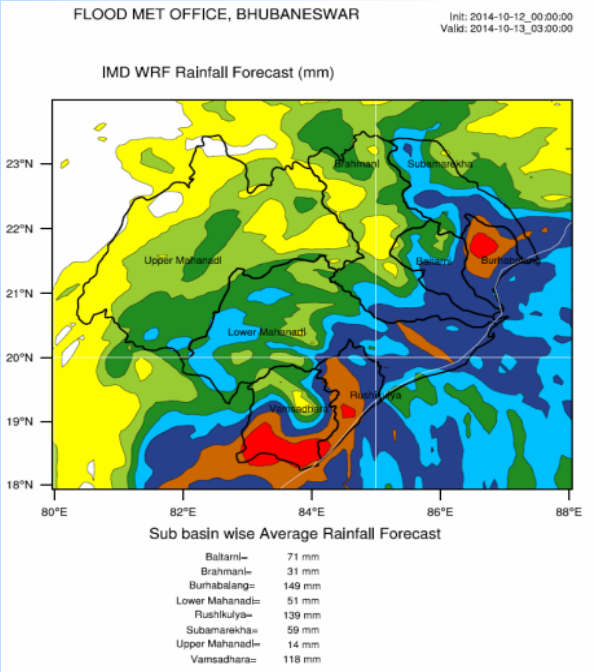
The Hydrometeorological Division is providing the necessary technical and operational support to various Central/State Govt. organization and other agencies in the field of Flood Forecasting, Hydromet Design, Rainfall Monitoring for water management and agricultural planning purposes etc. This division carried out compilation of rainfall statistics, hydrometeorological analysis of different areas/river catchment for project authorities and provides meteorological support for flood warning and flood control operations to field units of Central Water Commission. The main annual activities of this division are :

Flood Meteorological Service

Flood Meteorological Service of IMD provides the following inputs to Central Water Commission (CWC) through their 10 Flood meteorological Offices (FMO) established in different parts of India for operation flood forecasting. Input comprises in terms of Hydromet Bulletin which contains Synoptic situations, spatial and temporal distribution of rainfall, QPF, heavy rainfall warnings, realized rainfall etc. Forecasts are issued for a lead time of 5-days (forecast for 2 days and outlook for subsequent 3

days). Hydromet Bulletins were also issued by concerned FMOs during cyclones Phialin, Lehar, and Helen FMO's are located at Agra, Ahmedabad, Asansol, Bhubaneswar, Guwahati, Hyderabad, Jalpaiguri, Lucknow, New Delhi and Patna in the flood prone areas which caters to the river catchments Lower Yamuna, Betwa, Ken and Chambal, Narmada, Tapi, Deman Ganga, Sabarmati, Banas and Mahi, Ajoy, Mayuraksi and Kangasbati, Mahanandi, Brahmani and Subernarekha, Brahmaputra, Dehand, Lohit, Subansiri, Manas, Dhansiri and Barak, Godavari and Krishna, Teesta, Upper Ganga, Ghaghra, Gomati, Rapti and Sharada, Upper Yamuna and Sahibi, Lower Ganga, Kosi,

Baghmati, Gandak, Burhi Gandak and Sone respectively. During the last monsoon 2014 more than 22,951 numbers of QPFs were issued by different FMOs. There are operational run of sub-basin-wise WRF (0000 UTC & 1200 UTC) and MME (0000 UTC) models' output (1-day, 2-day and 3-day) for rainfall are generated and uploaded on IMD website for 122 sub-basins under Flood Meteorological Offices which is an additional guidance to FMOs for issuing QPF. The same products are also generated and uploaded on IMD website for Damodar Valley Corporation, Durgapur and Bhakra Beas Management Board (BBMB) on their request. The samples of NWP models' output for rainfall maps are shown below :



Design Storm Studies

Design Storm Studies are being carried out to evaluate design storm estimates (rainfall magnitude and time distribution) for various river catchments/ projects in the country for designing hydraulic structures. From January to December 2014, design storm studies of Thirty Seven (37) projects were completed. An amount of more than Rs 15 lakhs has been levied to carry out the design storm studies in respect of projects received from private/profit earning agencies. Intensity Duration Frequency (IDF) curves for Madhepura and Supaul station, Bihar have been supplied to the concerned authority.

Rainfall Monitoring Unit

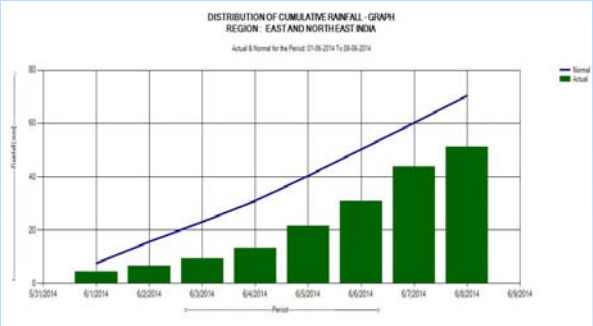
The rainfall statistics for India as a whole and subdivision-wise rainfall statistics were prepared for South West Monsoon Season (June-September)-2014.On an average, the rainfall data of about 3300 stations have been used for the preparation of rainfall statistics.

Upgradation of Hydromet Services'

Servers alongwith customized software for 'Hardware and Software Solution for customized GIS based Rainfall Information System' is received and installed under the project 'Upgradation of Hydromet Services'.

Customised Rainfall Information System (CRIS)

The department is upgrading the Rainfall data processing and analysis related work with state of art technology using Geographic Information System (GIS) at spatial and temporal scales. CRIS is a customised GIS based Rainfall Information System capable of processing Real-time rainfall data to generate state-wise, sub division-wise, district-wise and river basin-wise and many more rainfall products on operational basis. The



products generated by CRIS will be uploaded on the portal integrated within the system which is linked with the IMD website. The information will be useful to various stakeholders *viz*. MoAg, MoWR, MHA, State Governments, Disaster Management Authorities, various Higher Authorities etc. The real time short duration (hourly and cumulative for a day) rainfall distribution, a product of CRIS, will be very useful for disaster management including urban flooding.

5.2. Cyclone Warning Services

The Cyclone Warning Division/ Regional Specialised Meteorological Centre (RSMC)-Tropical Cyclone, IMD, New Delhi with all its resources for 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 Govt. 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). In addition to existing 3 hourly monitoring, hourly monitoring and analysis was carried out on the date of landfall.

Observations and Prediction Technique

During VSCS HUDHUD, Hurricane Weather Research Forecast (HWRF) model was run by IMD and IIT Delhi with 27/9/3 km resolution based on 0000 and 1200 UTC observations and products were made available to Cyclone Warning Division. Hourly updates on the movement and intensity of VSCS HUDHUD were made available to the National and State level disaster managers and media persons on the day of landfall from 0530 hrs IST of 12th till landfall.

In view of the improvements in operational track forecast during last five years, the cone of uncertainty has been reduced by about 20-32 % for 24-120 hr forecast period w.e.f. VSCS HUDHUD. The new radii of cone of uncertainty are 120, 200, 270, 320 and 360 km for 24-, 48-, 72-, 96- and 120- hrs respectively.

Warning Dissemination

During VSCS Hudhud, Agricultural Meteorology Division, IMD, Pune in coordination with Agromet Field Units and Cyclone Warning Division, IMD, New Delhi disseminated Alert and Agromet Advisory in the affected districts of Andhra Pradesh, Odisha

from 9th October onwards and for the states of Telangana, Bihar, Chattisgarh, Jharkhand, East Uttar Pradesh, East Madhya Pradesh and Gangetic West Bengal from 11th onwards. Overall 1,91,4872 SMSs were sent to the farmers and local people of affected states. The advisories were also sent during VSCS Nilofar.

A new dedicated website for cyclone (www.rsmcnewdelhi.imd.gov. in) has been developed and was fully operational during the systems w.e.f. VSCS Huhud.

The Direct to Home (DTH) service through cable service operators has been installed at 178 places out of proposed 500 stations for cyclone warning communication in the coastal regions. Internet Lease Line Bandwidth was upgraded from 60mpbs to 100 mpbs during the cyclonic storm 'HUDHUD' for IMD website failure free accessibility.

New Services

Based on Radar observations Hourly updates on the movement and intensity of VSCS HUDHUD were made available to the National and State level disaster managers and media persons on the day of landfall from 0530 hrs IST of 12th till landfall.

RSMC, New Delhi commenced issuing of Probabilistic forecast for cyclogenesis valid for next 72 hours, over the Bay of Bengal and Arabian Sea from 1st June 2014.

SMS Alerts Services

The dissemination of thunderstorm forecasts to the users is a challenge considering the short lead time and perishable nature of the generated information into the public domain to support decision making by users, automatic dissemination of warnings for disastrous weather events like severe thunderstorms, hail, squalls etc. to all mobile users of that particular area, for which warning is issued, through SMS alerts to be initiated.

One of the important initiatives towards the above outcome has been dissemination of Cyclone Alerts/ Warnings through SMS to Disaster Managers, Fishermen and farmers in the affected areas. To further enhance this initiative, India Meteorological Department has taken the leverage of Digital India Programme to utilise "Mobile Seva" of Department of Electronics and Information Technology, Ministry of Communication and Information Technology, Govt. of India for SMS based Cyclone Alerts/ Warnings for wide range of Users', including Disaster Managers, targeted users and general public. A provision is being made for issue of SMS alerts to General Public who would be required to register in India Meteorological Department website (www.rsmcnewdelhi@imd.gov.in) for this purpose.

Dr. Harsh Vardhan, Hon'ble Union Minister for Ministry of Science & Technology and Ministry of Earth Sciences in the presence of Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences and Chairman, ESSO and Dr. L. S. Rathore, Director General of Meteorology has dedicated 'SMS based Cyclone Alert/Warning System' to the nation, on the occasion of 'Good Governance Day', the 25th December 2014. SMS to fishermen through Indian National Centre for

Ocean Information Services network has been introduction.

5.3. Agro meteorological Services

Agriculture represents a core part of Indian economy and provides food and livelihood activities to much of the Indian population. Uncertainties of weather and climate pose a major threat to food security of the country. Tough challenges are ahead in understanding the impact of weather and climate on growth and yield of crops. Exciting opportunities exist today to help the agricultural community through Agrometeoro-logical Services. Gramin Krishi Mausam sewa is an extension of on-going project "Integrated Agromet Advisory Services" launched with different collaborating organizations in the country for providing real time crop and location specific Agromet services even up-to district level and also planned to extend these services upto sub district and ultimately up to block level in reducing the weather and climate related risks in agriculture.

Graminkrishi Mausam Sewa

Integrated Agromet Advisory Service project renamed as Gramin krishi Mausam Sewa under the aegis of India Meteorological Department/ Ministry of Earth Science (MoES) is being operated in the country successfully from XIth Five year plan with an objective to serve the farming community at different parts of the country. Agrometeorlogical services are rendered jointly by India Meteorological Department, State Agricultural Universities, Indian Council of Agricultural Research, Indian Institute of Technology etc., is a step to contribute to weather information based crop / livestock management strategies and operations dedicated to enhance crop production and food security. Under this service district level agro advisories are prepared using five day weather forecast which are disseminated to the farming community through mass media as well as IT based information dissemination mechanisms. Its value and utility can be further improved on accounts of reducing the spatial domain of forest, extending the temporal range of weather forecast and also enhancing the outreach through deploying modern modes of dissemination and setting up off dedicated extension mechanism. The various activities under the project are as follows:

Generation of Agromet Advisory

Based on the medium range weather forecast, AAS bulletins are being prepared for 608 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.

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 is being issuedfor all the blocks in the country. To develop block level agromet advisories District Agromet Units (DAMU) will be established in 240 districts of the country in phased manner at Krishi Vigyan Kendras of Indian Council of Agriculture (ICAR). Technical and Administrative details for establishment of DAMUs are being finalized with ICAR.

This Division in collaboration with Indian Institute of Tropical Meteorology (IITM), Pune has started operational National Agromet Advisory bulletins based on Extended Range Weather Forecast for southwest monsoon 2014 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. Efforts are being made by the Division to issue monthly AAS and Seasonal AAS bulletins based on the monthly and seasonal climate forecast.

Dissemination of Forecast & Agromet advisories

Agromet advisories are being disseminated to the farmers through various multi-modal dissemination system under PPP mode, print and mass media both in regional and English languages. In addition to this Agromet Field units are also disseminating the extreme weather information in advance to minimize the crop losses. At present around 7.07 million farmers are being benefited by the 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 to the above, many pilot projects have been undertaken for dissemination of agromet advisories with collaborating agencies like Mahindra Samriddhi in Pune and Reliance Foundation in the States of Andhra Pradesh, Kerala, Madhya Pradesh, Maharashtra, Tamilnadu and Puducherry in the form of IVR system and Central Silk Board for Sericulture farmers in the Northeaster States of India.

Out -reach & Publicity

(i). Farmer Awareness Programme has been organised at Agromet Field Units in Jhabua, Ambikapur, Raipur, Portblair, Ananthapuram, Hyderabad, Chennai, Aduthurai, Varanasi, Delhi, Navasari, Coimbatore, Solan. Besides, the Nodal Officers/Technical Officers have participated in number of awareness programme and popularise the GKMS. Besides, AMFUs also arranged field visits, field demonstration, farmers' interaction and also participated in Kisan Melas. The objectives of these programmes is to make farmer self-reliance, through helping them better by informing about effective weather and climate risk management by sustainable use of natural resources for agricultural production and to increase the interaction between the farmers and the Agrometeorological Service providing agencies i.e. IMD, SAUs, ICAR etc.

(ii). Scientists from Agricultural Meteorology Division, Pune participated 'Krishi Vasant 2014 - A National Agriculture Fair cum Exhibition' held at Central Institute of Cotton Research (CICR), Nagpur during 9 to 13 February, 2014. More than one lakh farmers visited the IMD's stall. Feedback on Agromet Advisory Services from about 350 farmers of different regions of the country has also been collected.

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 adopt better farm management operations like pre-monsoon sowing, propping, delayed harvesting etc. based on the agromet advisories issued. By utilising the agromet advisories, some small and marginal farmers have been benefitted by these services. Some success stories are as follows:

- A farmer in Nekpur village in Bulandshar in the state of Uttar Pradesh was planning to apply fertilizer during September. An SMS text under this service alerted that there would be rains within the next two days, it convinced him the time was not right to apply fertilizer. If he had ignored the message, rain would have washed away all the fertilizer.

- Muneshwar Prasad, Nawada in Bihar was informed that low temperature would cause infestation of blight disease in potato and also advised to maintain optimum moisture in the field and spray Mancozeb + Metalaxyl (Redomil-72) @ 1 kg/acre. As a result, productivity was increased to 59 q/acre and there was increase in net income of the order of Rs. 31300/acre.

- Vikas, a farmer in Nizampur village near Delhi was about to sow carrot seeds, but upon receiving an SMS that heavy rains were forecasted, he postponed the sowing. Had he not received the message and gone ahead with sowing, he would have lost Rs. 25,000/-.

FASAL

IMD in collaboration with Agromet Field Units and SAMC develops crop yield forecasting models based on statistical techniques under 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 and communicated to Department of Agriculture & Cooperation (DAC). Crop yield forecast are being issued for wheat for Madhya Pradesh, Rajasthan, Punjab, Haryana, Bihar and Uttar Pradesh, rabi rice for West Bengal, Odisha, Karnataka Tamilnadu and Andhra Pradesh, jute for Assam, Bihar and West Bengal, kharif rice for Andhra Pradesh, Assam, Bihar, Chhattisgarh, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Uttar Pradesh, West Bengal, Punjab, Haryana, rapeseed and mustard for Assam, Gujarat, Haryana, Madhya Pradesh, Rajasthan, Uttar Pradesh and West Bengal, potato for Bihar, Punjab, Uttar Pradesh and West Bengal, and cotton for Andhra Pradesh, Gujarat, Haryana, Maharashtra, Madhya Pradesh, Punjab, Telengana and Rajasthan.

5.4. Aviation Meteorological Services

IMD provides a crucial service to the national and international civil aviation sector in fulfillment of the requirements prescribed by the International Civil Aviation Organisation (ICAO) and the Director General of Civil Aviation of India (DGCA). The guidelines for meteorological service to aviation in India are given in “Manual on Procedures for Meteorological

Services for Aviation in India" published by CAMD, which is an extension of Annex 3 and includes national practices also. The Aviation Weather Code Book, also published by CAMD closely resembles "Manual on Codes- WMO No.306". These two publications are updated and revised from time to time in order to incorporate all the amendments and changes by WMO and ICAO.

The planning, technical coordination and overseeing of the aviation meteorological services is being done by Central Aviation Meteorological Division (CAMD), at DGM New Delhi, which is headed by a Scientist F. The required training for the Aeronautical Meteorological Personnel is being provided by Meteorological Training Institute (MTI), Pune.

Aviation Meteorological Network

The aviation meteorological services are provided through 18 Aerodrome Meteorological Offices (AMO) and 54 Aeronautical Meteorological Stations (AMS) located at various national and international airports of the country. Aerodrome Meteorological Offices functioning at Mumbai, Kolkata, Delhi and Chennai airports also serve as Meteorological Watch Offices (MWOs) for the respective Flight Information Regions (FIR). The ICAO designated Tropical Cyclone Advisory Centre (TCAC) functioning at IMD, New Delhi issues tropical cyclone advisories for the cyclones formed in the Indian Seas to the Meteorological Watch Offices in India and neighboring countries and also to ICAO designated centers including the two World Area Forecast Centers (WAFC).

The basis of the weather reports and aviation forecasts and warnings are the current weather observations made at various airfields. For this, specific instruments known as Airport Meteorological Instruments (AMI) are installed at ICAO specified locations in the airfields. The installation, calibration and maintenance of AMI are done by DDGM (SI), Pune. In addition to the primary channel of AAI for communication of Operational Meteorological (OPMET) Messages, the telecommunication requirements for aviation are met by IMD's telecommunication network established and managed by ISSD functioning at New Delhi.

The briefing and documentation to the operators is provided either through manual or automated means. The web based information dissemination system known as On-line Briefing System (OLBS) of IMD is being maintained by the meteorological offices functioning at the international airports at Chennai, and New Delhi, through which the registered users can directly download the forecast products as desired. Apart from the primary communication channels of AAI, the department has all advanced communication modes for the dissemination of aviation meteorological information.

Other Activities

Initiated for the procurement of Aviation Weather Observation System (AWOS) and Drishti transmissometer during the 12th Five year plan (2012-2017) under the Scheme "Augmentation of Aviation Meteorological Services". An agreement between CSIR - National Aerospace Laboratory, Bangalore and IMD was signed at IMD (HQ) for fabrication, installation and

commissioning of Drishti transmisso-meter.

ISO Certification was obtained for the aviation meteorological services provided by aviation meteorological offices under MWO Chennai.

User interaction

IMD interacts with its users on various levels. The most common way is through the aviation met offices for the immediate redressal of issues related to met information. Quarterly Regional Operators Committee (ROC) meetings are held regularly by all the stake holders of aviation industry, of which IMD is also a member. Issues related to meteorological services are also discussed at these meetings for the timely and effective disposal, especially when the involvement of many agencies are necessary. An example of the interaction of IMD with its users is the workshop on 'Meteorological Support for Helicopter Operations' which was organised on 12th September 2014 at ONGC helibase, Juhu Airport, Mumbai. This workshop was based on the request from the helicopter operators and was aimed at keeping the operators updated about IMD's meteorological products and tools in support of helicopter operations, and can be considered as a last mile connectivity for the users of IMD's services. The response from the helicopter operators was overwhelming and more such workshops will be organized in the future.

5.5. Astronomical services & National Calendar

Positional Astronomy Centre 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 already mentioned earlier 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.

(i) The Indian Astronomical Ephemeris.

(ii) Tables of Sunrise-Sunset, Moonrise-Moonset.

(iii) Rashtriya Panchang in 14 languages namely-English, Hindi, Urdu, Sanskrit, Assamese, Bengali, Gujrati, Kannada, Malayalam, Marathi, Oriya, Punjabi, Tamil & Telegu.

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 also 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.

This centre also takes observation on special astronomical events from time to time with the help of its portable telescopes at different places of the country.

Astronomical Publications during 2014

(i) The Indian Astronomical Ephemeris for the year 2015, 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.

(ii) Fourteen language editions of Rashtriya Panchang of 1936 SE (2014-15 AD) and Sunrise-Sunset and Moonrise- Moonset tables for 2015 have been published during the year 2014. 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

(iv) The centre has prepared monthly star charts and astronomical bulletins for 12 months during the year 2014 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.

CHAPTER 6

UPPER AIR ATMOSPHERIC OBSERVATIONAL NETWORK

The weather observations are important because they help satisfy important social, economic and environmental needs And accurate weather predictions start from the best possible knowledge of the initial state of the Earth's atmosphere, which is built using frequent, global observations of the upper air atmosphere and the underlying surfaces. The observations from satellites are a prominent source, and have become indispensable for forecasting the weather at all ranges, contributing to the downstream production of warnings and other information that support our continued social and economic wellbeing.

6.1. Satellite & upper air Observations

Satellite Meteorology Division of India Meteorological Department receives and processes meteorological data from the meteorological payloads of INSAT satellites namely Kalpana-1, INSAT-3A and INSAT-3D. Kalpana-1 was launched on 12th September, 2002 and is located at 74°E .and INSAT-3A was launched on 10th April, 2003 and is located at 93.5°E. Kalpana-1 and INSAT-3A both have three channel. In addition the INSAT-3A has a three channel Charge Coupled Device (CCD) payload for imaging the earth in Visible (0.62-0.69µm), Near Infra Red (0.77-0.86µm) and Short Wave Infra Red (1.55-1.77µm) bands of Spectrum. The Resolution of CCD payload in all the three channels is 1 km × 1 km.

A new satellite INSAT-3D 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 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. Data of all the three Satellites being received and processed through INSAT-3D Meteorological data Processing system which was dedicated to the nation on 15.1.2014 by then Hon'ble Minister of Science & Technology and Ministry of Earth Sciences on the occasion of IMD foundation day. At Present 48 nos of Satellite images are taken daily from INSAT-3D imager and KALPANA-1 VHRR which are 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. Twenty scans of

Indian land region and four scans of Indian ocean region of INSAT-3D Sounder are taken daily to derive Humidity and temperature profile. In total 28 meteorological products are being generated by Kalpana-1 and INSAT-3A presently.

INSAT-3D carries six channel imager, nineteen channel sounder, DRT & satellite aided search and rescue payloads with several advanced features such as higher spatial resolution in visible, thermal infrared band, yaw flipping on every six month basis and star sensor for achieving better navigation accuracy. 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 channels for achieving better accuracy in estimating sea surface temperature. From sounder data, atmospheric profiles are derived for temp at 40 vertical pressure levels from surface to about 50 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. The salient feature of achievement during the year are as follows:

- A New INSAT-3D Earth Station was installed and has been made operational.

- Assimilation of INSAT-3D Water Vapour radiance data and Atmospheric Motion Vector (AMV) and INSAT-3D Sounder radiances in NWP model.

- The replacement of existing analog and digital Cyclone Warning Dissemination system by DTH based CWDS system through an MOU signed among IMD, ISRO and Doordarshan is in progress and till date 178 nos of DTH based CWDS have been installed successfully. DTH based CWDS system will help in disseminating cyclone warnings to the affected coastal areas during the cyclone.

- Dissemination of Satellite derived Atmospheric Wind Vector Products in BUFR format of INSAT-3D on GTS.

- The generation of specially enhanced cyclone images based on NHC curves and BD curves from INSAT-3D satellite has been started which leads to the improvement in determining the centre and intensity of cyclone.

- Validation of Atmospheric Motion Vector (AMV), Outgoing Long Wave Radiation (OLR), Sea Surface Temperature (SST) of INSAT-3D data for the period of Six Months (July-December-14) has been completed.

6.1.1. Ground receiving and processing systems from Metop/NOAA/MODIS

Three Ground receiving and processing systems for NOAA/ METOP and MODIS Polar orbiting satellites were installed at IMD New Delhi, RMC Chennai and at RMC Guwahati. Metop Satellite data receiving & processing systems has enhanced the capability of weather forecast by direct interpretation of images as well as by giving input to NWP models. Similarly NOAA/MODIS data is also very useful in day to day weather forecasting and input to NWP models as they provide the vertical profile of temperature and

humidity in addition to imagery in various channels**.** The profiles and products are generated and disseminated through website for the use of forecaster on real time basis and validation of various products is in progress In total 30 products are derived from MODIS/NOAA/METOP satellites ground receiving and processing system.

Advanced Tiros Operational Vertical Sounder (ATOVS) data of NOAA Polar Orbiting Satellites received at New Delhi and Chennai is being sent to Regional ATOVS retransmission Service (RARS) group of WMO. This will make India a Member of RARS group. In turn the same data of other global centers is being received at New Delhi and used in NWP models at NCMRWF. NOAA/METOP ground receiving system is upgraded to receive and process the data from recently launched SUOMI-NPP polar orbit Satellite.

6.1.2. National Satellite Data Center

National Satellite Data Center (NSDC) at IMD New Delhi archives and provides processed imagery data from various INSAT satellites and data of derived products in HDF5 format. NSDC is being managed by Satellite Division of India Meteorological Department, Government of India. The vision of the Centre is to archive all types of Satellite data and derived products generated in the Satellite met division and supply the same as per user requirement *vis-à-vis* - time / space / satellite / product / image on line as fast as possible. The Centre started its operations by mid 2005. The data available are satellite imageries and products from Geostationary Indian National Satellites (INSAT) in operation from time to time and having Meteorological payloads. The archival contains new and old data from 1984 onwards and is likely to grow with time with the launch of new satellite like INSAT 3D and archival of satellite data from NOAA/METOPs/ MODIS satellites. Up gradation of NSDC to a state of art New Satellite Data Centre is in progress with new more additional capabilities. The Center has the key capabilitiesfor Archival of processed imagery data of all available satellite and its channels and data of all derived quantitative products from a number of operational satellites.

6.1.3. Global Positioning System (GPS)

Moisture in atmosphere is the main source of all weather related phenomenon. Water content is measured conventionally by upper air soundings and estimated through satellite by Upper Tropospheric Humidity (UTH), Integrated Precipitable Water Vapour measurement which depicts the integrated amount of water vapour vertically over a place is fast being recognized as an important tool for weather forecasting and is being used extensively worldwide. As a pilot project Five no's GPS stations were installed at New Delhi, Mumbai, Chennai, Kolkata, Guwahati & started on 2007. Data are collected at New Delhi from all the five stations at every half hour & processed for integrated preciptible water vapour. The output is made available on IMD website both in graphical as well as in Tabular form. The website gets updated every half hour automatically without any user intervention. Initial response to this measurement technique is good and can be used as important input to forecast thunderstorm activity. Accuracy of IPWV measurement is 5 mm.

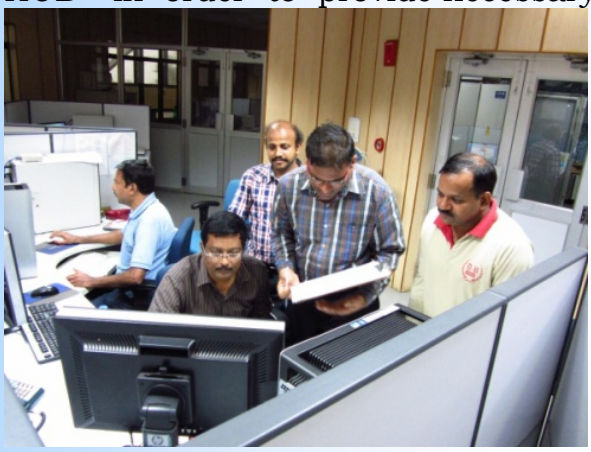
6.2. Radar Observational Network

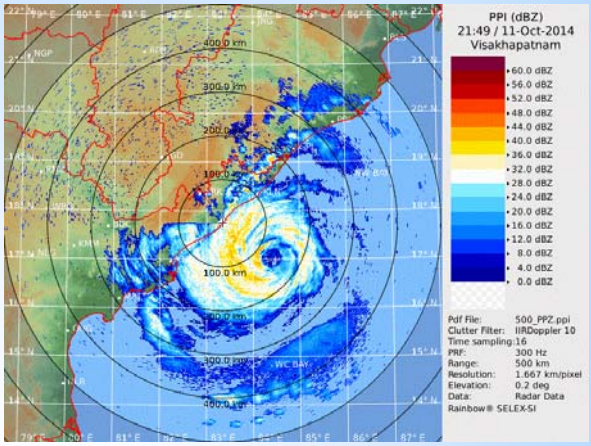
Radar division is involved in implementation of the work of modernization of the Radar Network by replacing old conventional radars with state of art Doppler Weather Radars, procurement of spares for effective maintenance, Networking, Archiving data and coordinating with various user agencies in dissemination of radar data. IMD has a plan to induct more than 55 DWRs in its network in a phased manners to bring the entire country under Doppler Weather Radar coverage. Under modernization phase-I of IMD, 9 Nos. of DWRs (out of 12 nos.) were DWRs commissioned at different location in India. Installation of three DWR's at coastal stations were held up due to security concern. Out of these, one Radar at Karaikal is under installation. Remaining 2 Nos. DWR building's terrace is under modification at Goa and Paradip for installation of DWR. Two Nos. indigenous S-band Doppler Weather Radar have been installed at Mumbai and Bhuj under ongoing radar network scheme, due to non completion of successful SAT, radars are still to be commissioned. Two nos. of DWRs are being installed at Gopalpur and Kochi under ISRO and IMD MoU. DWR Gopalpur building construction is in final stage for installation of this ISRO - BEL DWR. DWR at Bhopal was inaugurated by Secretary, MoES on 30th June,2014 in the presence of DG, IMD.

All the commissioned Doppler Weather Radars have been networked with central server based at HQ to generate DWR secondary products. Storage servers have been installed at two places and functionality initiated for storing DWRs data.

6.2.1. Monitor Cyclone "HUD-HUD"

Expert Scientist from Radar Unit, IMD, H.Q., New Delhi were deputed to Visakhapatnam for serving the DWR and to monitor cyclone "HUD-HUD" in order to provide necessary inputs to forecasters / media on hourly / half hourly basis. The cyclone "HUD-HUD" was monitored during 9th to 16th October 2014. Radar observations were continued during the cyclone till all the outer windows were blow off and a few windows of the radar room also ripped open; observations were continued even when there was seepage of water into the UPS room.





Hudhud cyclone photos fine eye seen after zooming the image

CHAPTER 7

EARTHQUAKE & ENVIRONMENT MONITORING

7.1. Earthquake Monitoring

Center for Seismology (CS) under India Meteorological Department (IMD) / MoES, 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 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 and also posted on IMD's Website (www.imd.gov.in).

7.1.1. Geophysical Observational System

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. All VSAT terminals at 17 field stations and two CRS's of RTSMN have been migrated to the new satellite GSAT-14 during April-May 2014 after the completion of life cycle of INSAT-3E being used earlier. 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 was commissioned in 2013. During the year 2014, a total of 37 seismological observatories of IMD have been provided with new VSAT equipments, of which 15

seismological observatories have been installed with digital seismographs and integrated with VSAT for connectivity with Data centre's at IMD HQ and INCOIS. 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.

7.1.2. Earthquake Monitoring & Services

A total of 2576 earthquake events were detected and auto-located during the period January-November, 2014. These include 1547 events of magnitude 5 and above. A software module for issue of bulk SMS messages has been developed and made functional for dissemination.

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. 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.

The earthquake data and site specific seismicity reports are supplied to industrial units, power houses, river valley projects etc and a revenue worth Rs. 2.0 Lakhs was realized from different parties during January, 2014 to November, 2014. The project 'Archival and vector digitization of seismic analog charts' is completed.

7.1.3. Earthquake Hazard and Risk Assessment

The seismic hazard analysis of NCT Delhi on 1:10,000 scale has been completed based on a state-of-the-art Probabilistic Seismic Hazard Analysis (PSHA) using different source models (Line and Aerial) and attenuation relations. Earthquake sources and parameters have been considered for the area covered under 350 km radius from Delhi, (Latitude 24° – 31.5° N and Longitude 74° – 81.5° E). This area includes part of Himalayan region in which earthquake of maximum magnitude recorded so for is the Chamoli earthquake (M 6.9) of 1999, which is about 300 km from Delhi and produced horizontal PGA of 11cm/s2 at Delhi. To incorporate uncertainty associated with different modeling parameters as well as spatial and temporal uncertainties logic tree approach has been adopted. On the basis of PSHA, Spectral Acceleration maps and site specific Uniform Hazard Response Spectra (UHRS) for different probability of exceedance at engineering bedrock (shear wave velocity 760 m/s) have been derived. These Uniform Hazard Response Spectra (UHRS) for different probability of exceedance have been used for generation of spectrum compatible acceleration time histories.

The PGA for Delhi obtained for PSHA analysis at engineering bedrock varies from 0.18g to 0.31g for MCE and 0.09g to 0.16g for DBE. Site specific Uniform Hazard Response Spectra have been used for

generation of site specific spectrum compatible acceleration time histories at 449 sites after adopting due procedure, applying free surface correction etc and used as input motion for further ground response study. On the basis of time histories free surface corrected Peak Ground Acceleration values at the all 449 sites for different period of exceedance have been evaluated. The Peak Ground Acceleration after free surface correction at engineering bedrock varies from 0. 067g to 0.114g for MCA and from .035g to .058g, for DBE.

At 449 sites geotechnical data have been collected by drilling boreholes, mostly up to 30m depth and DS/UDS soil sampling at each 1.5 m depth. Index properties of soil from all collected soil samples have been evaluated in laboratories. On a few samples special tests such as triaxial /cyclic triaxial and Resonant Column tests have also been performed for evaluation of c, Ø, Shear modulus reduction and damping curves etc. Geophysical investigations such as MASW at 110 sites and CHT/DHT at 25 sites have also been carried out for evaluation of *in-situ* shear wave velocity. On the basis of *in-situ* shear wave velocity and N values collected at a few common sites local empirical relations have been developed for different types of soil, to make use of N value for evaluation of shear wave velocity.

Making use of the above data and input time histories generated based on UHRS, ground response study have been performed at all the 449 sites, using DYNEQ software. Based on ground response study PGA at surface, PGA at different depth, Amplification factor, Peak frequency, Peak amplification, have been evaluated at all the 449 sites. Site specific different types of response spectra have also been generated at all the 449 sites. Based on response spectra spectral acceleration values at different periods have been evaluated for all the 449 sites.

Discrete site specific values of different parameters evaluated at all the 449 sites have been converted in continuous surface using Inverse Distance Weighted (IDW) interpolation technique. Making use of this continuous data different thematic maps have been generated for (i) 2% probability of exceedance in 50 year (based on MCE) and for (i) 10% probability of exceedence in 50 year (based on DBE). Site specific values can be picked up from these GIS base maps and may be used for design of buildings at those particular sites.

The PGA at surface is one of the important parameters used for design of buildings in conjunction with response spectra and other parameters. Zone factors assigned to the different seismic zones in seismic zoning map of the country are equivalence of PGA. PGA at surface obtained from the ground response study for 2% probability of exceedance in 50 years (MCE) for 5% damping varies between 0.168g to 0.479 g. The lower PGA values less than 0.18 are in a very small area of ridge. PGA values at most of the sites are within 0.42g except at two sites, where PGA values are .47g and .44g respectively due to high impedance contrast between first two layers below ground surface. PGA values for 10% probability of exceedance in 50 year (DBE) for 5% damping varies between 0.089g and 0.255 g. PGA values at most of sites is below 0.21g

except at a few site where PGA is between <0.21 to 0.255g.

Uncertainties in evaluation of PGA at surface have also been worked out which are ± 0.06g for MCE and ±0.03g for DBE. PGA map at surface based on MCE indicates that (i) Most of the area of NCT Delhi have PGA values equivalent to the zone factor of zone IV *i.e.* 0.24 (ii) An area of about 500 sq km (33 % of the total area of NCT Delhi), mostly west of NCT Delhi, with small microzones in other parts of NCT Delhi have PGA values equivalent to the zone factor of zone V, *i.e.*, 0.36 (iii) A very small area of about one squire km has even more PGA values, due to very specific local soil conditions (iv) The PGA values in ridge area are not uniformly distributed. PGA values in a very small area near JNU are equivalent to zone factor of zone III and in remaining part of the ridge PGA values are equivalent to zone factor of zone IV.

Peak frequency (Natural frequency) and Peak amplification of soil column above seismic bedrock have been evaluated at 500 sites using Nakamura technique based on noise survey and Peak frequency and Peak amplification of soil column above engineering bedrock have also been evaluated at 449 sites using numerical technique, to be used for deciding sites for construction of buildings of appropriate height to avoid resonance. Liquefaction susceptibility of soil at different depths has also been carried out and site specific factor of safety have been evaluated using a simplified procedure based on empirical correlations with standard penetration tests (SPT).

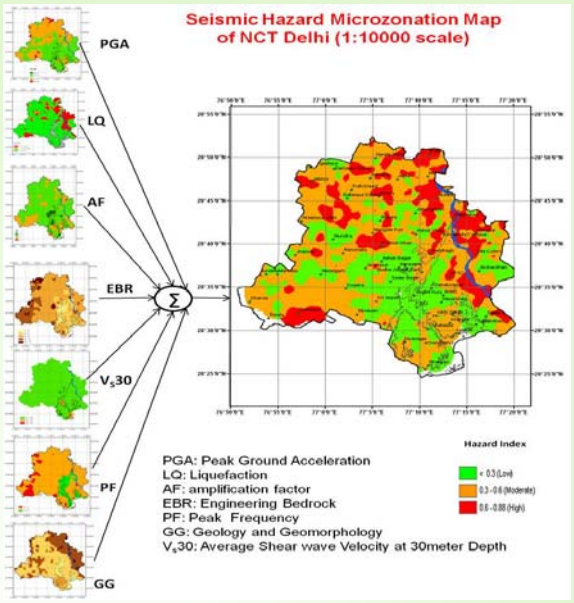


Fig. 1

Seismic hazard microzonation map of Delhi on 1:10,000 scale is prepared (Fig. 1).

7.2. Environment Monitoring

Environment Monitoring Center, India Meteorological Department is maintaining Surface Ozone Monitoring Network by installing Surface UV absorption Ozone Photometer. UV absorption photometer determines O3 concentration by measuring the attenuation of UV light due to O3 in

the absorption cell. One minute average observations are recorded at the stations. Each station is also equipped with the standard Ozone calibrator for onsite calibration.

Environment Monitoring and Research Center, India Meteorological Department has established Aerosol Monitoring Network by installing skyradiometer at twelve locations. Skyradiometer is used to measure optical properties of aerosols such as Aerosol Optical Depth, Single Scattering Albedo, Size Distribution, Phase Function, Asymmetry Parameter etc. Sky radiometers make measurements in eleven narrow wavebands in the ultraviolet, visible and infrared parts of the solar spectrum.

Air Quality Monitoring and Forecasting System: The System for Air Quality Forecasting and Research is operational in Delhi and Pune.

Similar system is under implementation in Mumbai. This is a joint project of IITM and IMD.

EMRC has evaluated 222 Thermal Power, 812 Industrial, 151 Coal Mine and 540 Mining projects referred to IMD by Ministry of Environment & Forests.

CHAPTER 8

INFRASTRUCTURE DEVELOPMENTS

8.1. Inaugurations

Meteorological Data Processing System (IMDPS

INSAT-3D Meteorological Data Processing System (IMDPS) was dedicated to the Nation by Hon'ble Union Minister of Science & Technology and Earth Sciences on 15 January 2014. IMDPS is fully Automated Indigenous Meteorological Data Processing Solution to process multiple INSAT series satellite data. The imaging system of INSAT-3D with significant improvements in spatial resolution, number of spectral channels and functionality is generating Images of Earth disk on half hourly basis help to predict various weather phenomenon such as Cyclone, Western Disturbances, FOG identification, Thunderstorm/ Dust storm, Squall, estimation of Heavy rainfall events with greater accuracy. INSAT-3D adds a new dimension to weather monitoring through atmospheric Sounding System, which provides vertical profiles of temperature and humidity for every 30×30 km resolutions in a cloud free area, integrated ozone from surface to top of the atmosphere, and Total/Layer precipitable water on an hourly basis over the Indian region which helps monitoring the development of mesoscale weather phenomenon. It is also providing valuable weather information for aviation.

Agromet Observatory

An Agrometeorological Observatory was inaugurated on 4th August 2014 at Shreemant Shivajiraje College of Horticulture in the presence of Hon. Shreemant Ramraje Naik Nimbalkar, Executive President, Planning Commission, Government of Maharashtra. Dr. N. Chattopadhyay, DDGM (Agrimet) attended the inaugural function of 'Opening of Agro-Meteorological Observatory' at College of Agriculture, Phaltan on 4th August 2014.

Automatic Weather Observing System

A fully automatic aviation weather observing system, which is a first of its kind in India, was installed and commissioned at Juhu Airport

Hon'ble Minister MoES, inaugurating AWOS

Mumbai and automated software was released on 10th February, 2014. This is a fully automatic system which can collect, assimilate and disseminate meteorological information to helicopter pilots. The system was formally inaugurated by Dr. Shailesh Nayak, Secretary, MoES.

A similar system was installed at Sanjji Chat, Vaishno Devi, for providing weather information to the helicopter pilots. The System was commissioned and formally inaugurated by Dr. Jitendra Singh, Hon'ble Minister of Earth Sciences.

AWOS at Juhu

Shri A. D. Tathe, Scientist 'D' made a presentation on the AWOS with live demonstration, during the inauguration.

RSMC Website

It is adedicated website for Regional Specialised Meteorological Centre-Tropical Cyclone, New Delhi was inaugurated by Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences and Chairman, Earth System Science Organization (ESSO) on 4th April, 2014. The website address is www.rsmcnewdelhi.imd.gov.in.
This website has all the facility for

RSMC Website for tropical cyclone

dynamical uploading of cyclone warning bulletins, advisories and graphical products useful for national and international users especially WMO/ESCAP panel member countries including Bangladesh, Myanmar, Thailand, Sri Lanka, Maldives, Pakistan and Oman. Due to this there was un-interrupted warning service during w.e.f. VSCS Hudhud.

Inauguration of Obsy at Bharati, Antarctica

The summer team members S/Shri V. T. Shinde and Mahender Spakale of IMD participated in summer 34th Indian Scientific Expedition to Antarctica and successfully installed the meteorological observatory at Bharati Station Antarctica, consisting of the instruments such as; Global radiation radiometer, UV-A

Pyrheliometer on Solar Tracker V-SOL-2A2P at, Goa

radiometer, snow gauge, Thermometers Stevenson screen, mast for ultra sonic anemometer. The observatory was inaugurated by the team leader of the expedition.

8.2. Installations

Global Navigation Satellite System

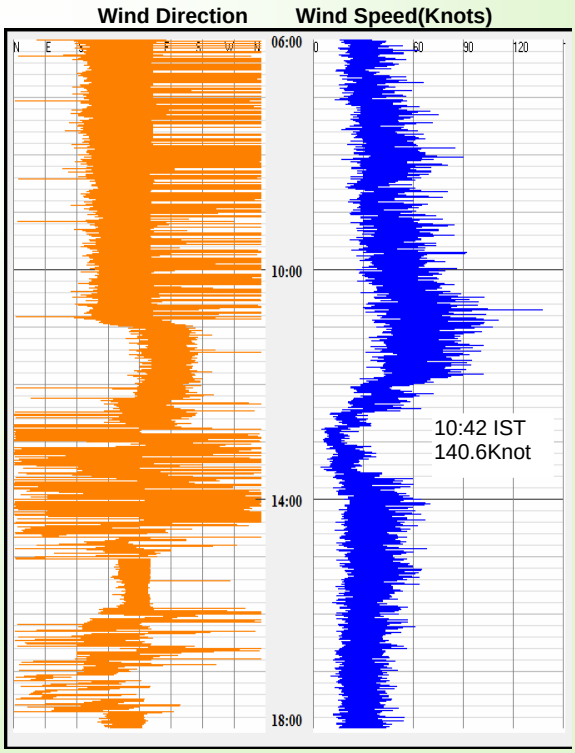
In collaboration with Bhaskaracharya Institute of Space Applications and Geoinformatics (BISAG), Gandhi-nagar, a joint project "Development of a GIS-based decision support system for near real time assessment of earthquake damage scenario" is being developed for Indian region.

The product generated shall be useful in decision support and disaster mitigation. A beta version of the application depicting the intensity of earthquake in and around Indian region in offline mode is installed in one of the system at 24 × 7 Data centre of IMD. The application generates intensity map with different layers of geology, tectonics, cities, roads, railway, dams, airport and rivers. The software will now be used on regular basis at the data centre to generate intensity map of every significant earthquake occurring in and around Indian region. The development of PGA module and its integration with RTSMN system is under progress.

Hand Held Data Loggers (HHDL)

29 observatories under RMC Mumbai have been equipped with HHDL sets. Hand Held Data Loggers is an electronic device which can be used by Conventional Meteorological Observatories to transmit manually collected weather data in near real-time in digital form over GSM Mobile channel to various RMCs and NDC for archival.

Wind direction and Wind speed recorded by HWSR system on 12 October 2014 at Vishakhapattanam during Hudhud cyclone



GPRS based High Wind Speed Recorder installed and made

operational at Kakinada, Kalingapatnam, Puri, Balasore and Digha, Sagar Island Dwarka and Okha Met observatory. Data is available on the website www.imdaws.com. High wind speed recorder giving wind information locally and also automatically uploaded to IMD Web server were installed at and Haldia stations in West Bengal during the month.

Solar Tracker

The state of art Solar Tracker V-SOL-2A2P, an all-weather positioning platform with integrated GPS receiver has been installed at MC Panaji, Goa for sun tracking of Pyrheliometer on 29th October 2014.

Digital Distant Indicating Wind Equipment (DDIWE) installed at Mysore, Tuticorin, Salem and Guwahati airports.

Digital Current Weather Instrument System (DCWIS) installed at Mundra airport. DIWE installed at Naval stations, INS Porbandar and INS Rajali and Aviation Research Centres at Doom Dooma, Assam and Charbhatia, Orissa.

Wireless based DIWE installed at Cochin and HAL Bangalore airports.

Integrated data processing server installed at IGI airport, New Delhi for obtaining data from all the three sites of RWY 28-MID-10 and wireless communication also established.

Ninety eight surface observatories (RMC Mumbai -29, RMC Nagpur -16, RMC Chennai – 53) automated by providing **Hand Held Data Loggers.**

UV-B radiometers

Total Thirty seven nos. of UV B radiometers have been installed and interfaced to data loggers at different network stations. Data loggers at thirty one stations 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.

Update of Installation

Automatic Weather Station

Target 675 & Installed 675,

Automatic Rain Gauge

Target 1244 & Installed 777

GPS Sonde

Target 16 & Commissioned 16

Doppler Weather Radar

Target 15 & Commissioned 15

Ozone Instrument

Target 17 & Commissioned 15

8.3. ISO Certification


Certificate of Registration

QUALITY MANAGEMENT SYSTEM

INDIA METEOROLOGICAL DEPARTMENT
(SURFACE INSTRUMENT DIVISION)
Shivaji Nagar, Pune, Maharashtra - 411 005.

Scope
Manufacture, Testing, Calibration and Supply of Meteorological Instruments.

This is to certify that the Quality Management System of the above mentioned Organization meets the requirement of
ISO 9001:2008

MS: 13710611-1 — Certificate Number
11 June 2011 — Date of Initial Registration
11 June 2014 — Date of Last Issue
10 June 2017 ♦ — Date of Expiry

♦ Note: - The above validity is subject to the satisfactory Compliance verified through periodic Surveillance.

OSS Certification Services Pvt. Ltd.

CERTIFICATE

An ISO certification ISO9001:2008 for Meteorological Watch Office, Minambakkam, Chennai was awarded. Renewal of ISO9001 certification for MC Hyderabad was done.The Surface Instruments division of the IMD acquired ISO 9001:2008 certification for the process of manufacturing, testing, calibration and supply of meteorological Instruments. Six offices of IMD have received ISO certification during the year.

CHAPTER 9

PUBLIC AWARENESS & OUTREACH PROGRAMME

9.1. Workshop & Conferences

Sixth Fog Workshop

IMD and DIAL have jointly organized Sixth one day annual Fog Workshop for the winter 2013-2014 with theme as "Fog Monitoring and Forecasting Services" on 16 January, 2014 at IGI Airport, Auditorium Udan Bhavan, IGI Airport, New Delhi. Objective of this Workshop was to further improve fog services of IGI Airport and other airports through intensive discussion between forecaster, observer and researcher and promote its effective use through a close co-ordination and discussion with various stake holders and users' communities and fog researcher. There were detail interact on various new technology/tools available in India for better monitoring and forecasting of Fog.

INTROMET-2014

The Indian Meteorological Society (IMS) has organizing an International Symposium on Tropical Meteorology, INTROMET – 2014, on Monsoons – Observations, Prediction and Sustainability (MOPS) during 21-24 February, 2014 to assimilate the present as well as the evolving concepts related to Indian and other monsoons of the world. Dr. Shailesh

Nayak, Secretary, MoES inaugurated the symposium at SRM University, Kattankulathur on 21st February, 2014. It has provided a unique opportunity for the operational meteorologists, researchers, planners, hydrologists, agriculturists, disaster managers and instrumentation scientists to exchange their views on the Indian monsoons and their related aspects with monsoons elsewhere. The symposium focused on the following sub - themes of monsoons viz. Observing systems and techniques, Monsoon prediction, and Teleconnections, Aerosols, Clouds and Regional climate forcing, Ocean - Land - atmosphere coupling extreme events Climate, Agriculture and Water resources etc. Many scientists of IMD participated in this Seminar and presented their papers. Exhibits of IMD activities were displayed and explained to the international participants.

Agromet Field Unit Meet

Agro met Field Unit Meeting at Chennai

Agromet Field Unit Meet was held on 22 February, 2014 at RMC Chennai. The meet was chaired by DGM, Dr. L. S. Rathore, Co-chaired by DDGM, RMC Chennai, Dr. Y. E. A. Raj and Head, Agromet, IMD, Dr. K. K. Singh. It was attended by delegates from nine AFMUs of Tamil Nadu and Puducherry besides a few NGOs, Service providers and farmers. Special Address was given by Dr. V. Geethalakshmi, Principal Nodal Officer, GKMS Tamilnadu & Puducherry.

User's conference

User's conference on "Services Rendered by Meteorological Centre, Thiruvananthapuram for the users of Kerala and Lakshadweep" was held at, Thycaud, Thiruvananthapuram on 24th March, 2014 was participated by 58 participants from various user agencies.

Satellite Information for GKMS

Agrimet Division, IMD, Pune organised workshop on "Applications of satellite information in Gramin Krishi Mausam Sewa" at Meteorological Training Institute, IMD, Pashan, Pune on 27th March, 2014. High level dignitaries namely Dr. L. S. Rathore, DGM, IMD, New Delhi, Dr. V. K. Dadhwal, Director,

Participants in Gramin Krishi Mausam Seva

NRSC, Hyderabad, Dr. B. N. Goswami, Director, IITM and Scientists from different organisations participated in the workshop. The basic purpose of this workshop was to build mechanism of use of satellite information in operational Agromet Advisory Services not only from the Indian satellites but also the other satellites available from other parts of the world.

Communication of Agromet Advisories

Agrimet Division, IMD, Pune organised National Level Media Workshop on "Communication of Agromet Advisories to the User Communities" at Meteorological Training Institute, IMD, Pashan, Pune on 28th March, 2014. High level dignitaries namely Dr. L. S. Rathore, DGM, IMD, New Delhi, Shri Ashish Bhatnagar, Deputy Director General (Engg.), All India Radio,

Pune, Dr. Swati Sardesai, NIC, Pune, Prof. M.C. Varshneya, Ex-Vice chancellor, AAU, Anand and Scientists from different organisations participated in the workshop. Media is a powerful channel for dissemination of sensible weather information and Agromet advisories to the farming community through multimedia including mobile technology. Under GKMS project, linkages are being established with different medias The basic purpose of this workshop was to make media personnel aware about weather processes and usefulness of weather information for the purpose of agriculture, educate them about various terminologies, concepts and definitions.

Workshop on Verification Methods

The 6th International Verification Methods Workshop was held in New Delhi, India, from 13-19 March, 2014 and was jointly organized by WMO, NCMRWF and IMD. This International Workshop was attended by about 120 experts from 25 countries and leading Institutes from India. The Workshop was inaugurated by Dr. Shailesh Nayak, Secretary, MoES with address from Dr. L. S. Rathore, DGM, IMD, Dr. Swati Basu, Director (NCMRWF), E. Ebert, Chair- Scientific Programme Committee and welcome by Dr. S.D. Attri, DDGM (O). The goal of the workshop was to promote recent advances in the theory and practice of verification of weather and climate forecasts worldwide. The participants were from operational, research and forecast user communities to discuss methods for more effectively measuring and conveying the accuracy and utility of forecasts and warnings. The workshop was divided in two sessions a tutorial session (March 13-15) and scientific program (March 17-19). The scientific program covered keynote addresses as well as contributed talks and posters on new verification techniques and issues related to the practice of forecast verification.

Capacity Building Workshop

IMD organized a Capacity Building Training Workshop on "Operational Climate Prediction of summer monsoon rainfall over South Asia" at Pune during 14-21 April, just prior to SASCOF-5. Participants from eight South Asian countries, *viz.*, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Sri Lanka, Dhaka and UKMO London attended this workshop. Experts from the IMD, IITM- Pune, United Kingdom Meteorological Office-U.K, APCC-Korea, NOAA-U.S. and World Meteorological Organization-Geneva participated in the training workshop as the resource persons.

Workshop for Operational Climate Prediction

A Capacity Building Training Workshop on "Operational Climate Prediction for South Asia" was conducted at the India Meteorological Department (IMD), Pune for participants from the South Asian countries. The training workshop was attended by representatives from eight South Asian countries, *viz.*, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Sri Lanka, Dhaka and UKMO London. Experts from the IMD and IITM, Pune and international experts from United Kingdom Meteorological Office, U.K, APCC, Korea, NOAA, U.S. and World Meteorological Organization, Geneva participated in the training workshop as the resource persons. Two days SASCOF-5 meeting co-hosted by IMD was held at IITM, Pune during 22-23 April, 2014.

Training Workshop on INSAT-3D

Satellite Meteorology Division, India Meteorological Department, New Delhi- 110003 organized a Training Workshop on INSAT-3D Satellite Data Products from 30th April, 2014 to 1st May, 2014 at MoES, New Delhi. Number of Scientist/Officers from the department participated in Training Workshop on INSAT-3D Satellite Data Products during the period.

Weather Forecasting System

One day training workshop on "IMD Weather Forecasting System" was conducted on 10th June, 2014 at RMC Kolkata Alipore. Twenty Officers of Irrigation Department and twelve from Damodar Valley Corporation attended the training workshop. Dr. D. Pradhan, DDGM, inaugurated the workshop and delivered the lecture on "Application of DWR in Hydrology and Prediction of Quantitative Estimates of Rainfall". Dr. S. Bandopadhyay, Scientist 'E', Dr. G. C. Debnath, Scientist 'E' and Shri Animesh Chanda, Scientist 'D' also delivered lectures on various topic related to QPF, forecasting system and AWS/ARG respectively.

Dr. L. S. Rathore, DGM inaugrated "Summer Training" of 6-8 weeks during June-July, 2104, wherein 106 MSc / B. Tech students of different Colleges, Universities, IITs etc pursued projects in different division of IMD, New Delhi.

Hindi Sangoshthi

Hindi Sangoshthi' was organized in AMO Mohanbari on 18th June, 2014. Shri M. K. Gupta, DDGM, RMC Guwahati was the Chief Guest. On this occasion Hindi dictation competition was organized for the officers and members of staff of AMO Mohanbari. Hindi Essay competition was organized for school children.

Scientific lectures in Hindi were delivered- on Chai Baagaan aur Mausam Vigyan, Mohanbari hawai adda ke Mausam upkarno ka aadhunikaran, Mohanbari ka Mausam, Aasam ki baar, Assam ke chai baagaan, Brahamputra and RSR W mark IV aur G RSRW aadi.

Understanding weather and forecasting

An interactive session was conducted on 27th June, 2014 at RMC Kolkata with Electronic and Print media on "Understanding weather and forecasting". Dr. D. Pradhan, DDGM inaugurated the session and presented a presentation on "Forecasting techniques of IMD and usefulness of DWR and Satellite in weather prediction. About 25 media personnels attended the session and provided their feedback.

Workshop on Severe Weather Events

A workshop on users' meet related to severe weather events was organized on 8 July, 2014 at Pantha Nivas, Bhubaneswar. Shri jugal Kishore Mohapatra, IAS, Chief Secretary, Govt. of Odisha was the Chief Guest and Dr. L. S. Rathore, DGM, IMD, New Delhi, presided over the meeting. Shri P. K. Mohapatra, IAS, SRC, Dr. D. Pradhan, DDGM, RMC Kolkata, Dr. A. K. Sharma, DDGM (A & S), New Delhi, and other scientist of the department, attended the meeting.

Dr. M. Mohapatra delivered a lecture on severe weather monitoring and forecasting in this workshop.

Enhanced and Unique Cyclonic Activities

A two day workshop on 'Enhanced and Unique Cyclonic Activity during 2013' was orgaqnised by Cyclone warning Division, India Meteorological Department, New Delhi on 24 & 25 July, 2014 at New Delhi. It was participated by 80 delegates from various institutes of the country including the renowned scientists in the field. 54 papers were presented in the workshop on various themes. A book of abstract and a book on Climatology of Jammu and Kashmir were released by Prof. S.K. Dube, Vice Chancellor, Amity University, Rajsthan, who was the chief guest during the inaugural session. Number of recommendations has been adopted for future action so as to improve further the cyclone forecast and warning services of IMD.

Farmers' Awareness on contingent planning

Farmers' Awareness Programme on "contingent planning" were conducted at DRS Building, IGKV on 6th August under Gramin Krishi Mausam Sewa Project. About 60 farmers in and around Raipur participated in the seminar. Shri M. L. Sahu Scientist 'E', M. C. Raipur delivered a lecture on latest technology in weather forecasting. Professor ASRAS Sastri talked about date palm crop which is a desert crop is now grown by villagers of Durg district. This type of desert crop could not be even thought of a few years ago. Dr. Sanjay Sharma (Scientist Entomology), made presentation on insect-pests of rice crop in detail. He cautioned the farmers not to mix the different kinds of insecticides which will end up with dangerous situation. Dr. C. P. Khare (Scientist pathology) focused on symptoms and control measures of common fungal and bacterial diseases of vegetable crops and he cleared the doubts of farmers on management of diseases. Dr. S. R. Patel, HOD Dept. of Agrometeorology, IGKV Raipur), focused on climate change which occurred in the Chhattisgarh state and focused on weather based crop insurance scheme and encouraged the farmers to go for weather insurance policy to tackle unprecedented weather aberrations. The programme achieved its objectives.

Workshop on Crop Simulation Modelling

IMD in collaboration with Rajasthan Agricultural Research Institute, Durgapura, Jaipur (KNAU, Jobner) organized a working group meeting cum workshop on use of crop simulation model for decision making and yield forecasting at Jaipur during 15-19 Sep, 2014. Sixteen Technical officers from AMFUs participated in this workshop.

Flood Met. Officer's Meet

Two days Workshop on 'Annual Flood Met. Officer's Meet-2014 and interaction with user agencies' was held during 20 & 21 November, 2014

at MC Ahmedabad. This workshop was inaugurated by Dr. P. K. Pal, SAC, ISRO, Ahmedabad in the August presence of Dr. L. S. Rathore, DGM, IMD. Dr. (Mrs) Surinder Kaur, DDGM (H) & Dr. A. K. Das, Sc. 'D' from Hydromet Division, New Delhi has also participated in the Annual Flood Meet 2014.

Satellite information in operational Agromet Advisory Service

Agricultural Meteorology Division, India Meteorological Department, Pune organized a two day workshop on use of "Application of Satellite information in operational Agromet Advisory Service" at Meteorological Training Institute, Pune during 16-17 December, 2014 inviting the members, co-ordinators of Working Groups already been constituted by the Honourable Director General of Meteorology. The objective of the workshop was to prepare the terms of reference along with the time bound implementation plan amongst the members of the working groups.

Workshop on Now casting

Nowcast Training Workshop was organised on 22 and 23 December, 2014. Around 50 delegates including Incharges of Meteorological centres and senior forecasters from Regional Meteorological centres participated in

the workshop. The Objectives of the training was building of human resource at outstations. This was a training of Trainers. The operational forecasters keep on changing in outstations and therefore this training capacitated the In charges for training the forecasters in their region. To meet the increase in demand of Nowcast by various stakeholders, the improvement in skill score was discussed. Skills to be improved using WDSS-II and TITAN softwares. Nowcast should have higher accuracy as compared to other forecasts therefore FAR to be reduced to less than 0.2 and POD more than 0.8. Dr. Ashok Kr. Das, Sc-D attended the 'Nowcast Training Workshop' at ARNAV Hall, MoES, New Delhi arranged by NWFC, IMD, New Delhi during December, 22-23, 2014.

9.2. Events

IMD Foundation day

The 139th Foundation day of India Meteorological Department was

celebrated on 15th January, 2014 at H. Q., New Delhi. On this occasion Dr. Shailesh Nayak, Secretary, MoES welcomed the Hon'ble Minister Shri S. Jaipal Reddy, who dedicated the "INSAT 3D Meteorological Data Processing System to the Nation". The Minister felicitated Eminent Scientist Dr. Ajit Tyagi, former Director General of IMD and gave awards to best employees, best officers of IMD and to School Children for various competitions organized on this occasion.

A website, India weather was also launched on this occasion. Shri Reddy complemented the accurate forecast for southwest monsoon 2013 and the Phailin Cyclone which helped in saving of several lives in the coastal regions. Many publications were also released by the Hon'ble Minister on this occasion Dr. L. S. Rathore, Director General, IMD told that in the last few years, IMD has received worldwide appreciation from various stake holders.

World Meteorological Day

World Meteorological Day is celebrated every year on 23rd March to commemorate the entry into force in 1950 of the convention that created the World Meteorological Organization. This year's World Meteorological Day 2014 the theme is "Weather and climate: engaging youth". The theme of this year is more appropriate in Indian context

School children at Ahmedabad, Meteorological Office

Ministry of Earth Sciences, especially. The weather forecast and information to public in service and youth in particular are being disseminated through social media at facebook. There is a subpage, entitled, youth pertex in the IMD website to educate and aware the youth about the weather and climate. World Meteorological Day 2014 was celebrated at HQ New Delhi as well as all other offices of IMD. Exhibitions were organized in various offices, sub-offices of IMD. Observatories were kept open for general public, Media & school children. On the occasion of auspicious, World Meteorological day 2014, IMS, Delhi Chapter is organizing an invited lecture on, "Advances in Prediction of High Impact Weather" by Dr. Elizabeth Ebert, Research Program Leader, Weather & Climate Research, Bureau of Meteorology, Australia on 24th March at Mahika Hall, MoES.

National Science Day

National Science Day is celebrated all over India with great enthusiasm on 28th of February every year in order to commemorate the invention of the Raman Effect in India by the Indian

physicist, Sir Chandrasekhara Venkata Raman on the same day in the year 1928. The National Science Day was celebrated at H.Q. New Delhi and other offices of on 28th February, 2014. Many visitors visited at these offices to aware with functioning of the department. The functioning of DWR Chennai was explained to the visitors on that day.

Earth Day

The April 22 Earth Day, founded by Senator Gaylord Nelson, was first organized in 1970 to promote ecology and respect for life on the planet as well as to encourage awareness of the growing problems of air, water and soil pollution. Earth Day was celebrated on 22nd April, 2014 at most of the sub-offices spread all over India. Many scientists participated in discussion/ interviewed in print/electronic media.

Vigilance Awareness week

The Vigilance Awareness Week was observed this year from October 27, 2014 to November 01, 2014 and this years theme is Combating Corruption Technology as an enabler. It is believed that efficiency and objectivity in governance hold the key to eradication of corruption from public life and for this purpose it has to be ensured that transparent and fool proof systems and procedures are put in place which provide for appropriate accountability at every level of hierarchy in public administration. Pledge in connection with observing "Vigilance Awareness week" on 27 October, and an Essay Competition was organized in Hindi/ English on the topic "Combating Corruption Technology as an Enabler" on 30 October, 2014.

9.3. Sports & Cultural Programme

13th All India Annual Sports

The 13th All India Annual Sports Meet 2013-14 was organized under the chairmanship of Dr. L. R. Meena, Sc. 'F' & President IMD Recreation Club, New Delhi to promote the spirit of competition, harmony and brotherhood among the participants. It was hosted by Recreation Club, Pune at Shivchhatrapati Sports Complex, Balewadi, Pune during 21-24 March, 2014. The officer & 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 21st March in the presence of Chief Guest Mr. Mc. Mary Kom, the five time world Boxing champion and only Indian boxer who has won Bronze Medal in summer Olympic, 2012. Shri R. R. Mali, Scientist 'E' and President, Recreation Club, Pune presented the prizes to the winners and runners-up of different sports events including team trophies during closing ceremony held at office Compound Shivaji Nagar, Pune.

Inter Ministerial Cultural Programme

Cultural wing of IMD has participated in Inter Ministry Music, Dance and short play competition 2013-14 held from 18-21 February, 2014 at CSOI Vinay Marg, New Delhi. During this Inter Ministrial Cultural Programme. The IMD cultural team on achieved total 7 prizes for direction, script writing, best acting, folk and solo dance etc. 21 officials of IMD who participated in this inter ministry cultural programme.

9.4. Distinguished visitors

Visits of Secretary, MoES

The Secretary, MoES visited RMC, Mumbai and released a documents pertaining to Automatic Weather Operating System and automated software in the presence of DGM and ADGM (R) on 10th February, 2014. Shri B. Mukhopadhyay, Scientist 'F', DDGM (C) and Dr. G. Krishnakumar, Scientist 'E' also participated in this programme.

Visit of N Chandra Babu Naidu, Chief Minister of Andhra Pradesh

On 16th October 2014 Shri N Chandrababu Naidu, Chief Minister of Andhra Pradesh visited Kailasagiri, Doppler Weather Radar Station, Visakhapatnam and witnessed the

destruction that took place. Shri S. Venkateswarlu, Sc. E and Shri K. Ramachandra Rao, Director briefed him about direction of wind before and after the eye, 3-D View of the cyclone and various terms used in describing cyclone in weather reports.

Visits at Central Hydromet Observatory

A Central Hydromet Observatory is situated at IMD, New Delhi for taking observations and for demonstration as a Model Observatory to visitors. During 2014-15, 2546 students, teachers, Scientists and Administrators from various schools/Govt./Private Institutions, *viz.*, IIT, NIDM, Agriculture University, BSF and many more visited the Central Hydromet Observatory to get familiarization of India Meteorological Department and working of C.H.O.

Foreign Visitors

Prof. Franziska Steinbruch, Indo-German Centre for Sustainability

(IGCS), Indian Institute of Technology, Madras (IITM), visited RMC Chennai on 13th August, 2014 and had discussions with Shri S. B. Thampi, DDGM, RMC Chennai for engaging students in project works related to a course on sustainable development conducted at IIT Madras.

Dr. Murty of IM Systems Group (IMSG), a contracting company for NOAA satellite research and applications (STAR) center in Maryland, USA, visited AMO Chennai on 20th October, 2014 and had discussions with Dr. R. Suresh, Director-in-charge on possibility of collaboration to improve aviation weather services especially utilizing.

Dr. Yinka R. Adebaya, Chief, Education & Fellowships Division, Development & Regional Activities Department, World Meteorological Organisation, Geneva, Switzerland visited Surface Instruments Division during 24th to 28th November 2014 for supervision and inspection of facilities provided by IMD during the WMO Training held between 3rd and 28th November 2014.

Dr. John Colvin, Senior Adaptation Practitioner, Oxford Center for Innovation, U.K. and Shri Dimka Stantchev Skeie, Federal Department of Foreign Affairs, Swiss Agency for Development and Cooperation, (SDC), Switzerland visited Agrimet Division, Pune on 5th March, 2014 in connection with the evaluation of the collaborative project of Watershed Organization Trust (WOTR), Pune and India Meteorological Department.

Delegation from UCAR, USA

Delegation from UCAR, USA visited IMD on 22nd September, 2014 and held discussion with Senior Officers of IMD regarding collaboration in Atmospheric sciences.

CHAPTER 10

AWARDS, HONOURS AND ACHIEVEMENTS

Best Employee Award

Sri K. Srivastav Receiving the award

During IMD foundation day 14 Officers and Staff were awarded IMD Best Employee Award. These are S/Shri Kuldeep Srivastav, Sunit Das, Ujjawal Das, Monica Sharma, N. Ramdoss, M. K. Majumdar, Kewal Singh, Utpal Kalita, Anthony Nongrum, G. M. Pala, Ajay Bhat, Ramesh Kumar Manjhi, S. K. Mohanty and Umesh Chandra.

Dr. Y.E.A. Raj receiving best RMC Award

Best Regional Meteorological Centre, Best Meteorological Centre and best Meteorological Observatory Award conferred to RMC Chennai, M.C. Bhubaneswar and MO Kanyakumari respectively. Dr. Y. E. A. Raj, DDGM RMC Chennai. Dr. S. C. Sahu, Scientist 'E', M. C. Bhubaneswar, received the award from Shri. Jaipal Reddy, Hon'ble Minister of MoES on this occasion

Cyclone Warning Division received 'Achievers Award' for accuracy of prediction cyclone Phailin on the occasion of IMD Foundation Day held on 15th January, 2014.

Rajbhasha Award

The article '**Safalta Ka Mull Mantra Samay Ka Sadupyog'** authored by Shri M. R. Kalve was adjudged as second prize by Rajbhasha. On the occasion of Hindi diwas 14th September Shri M.R. Kalve received the prized from the Hon'ble President

Shri M. R. Kalve Receiving Award from the Hon'ble President

of India which consist of a Citation and cash prize of Rs. 20,000/- which is not only honour for hm but it is the honour for IMD also.

26th Biennial MAUSAM Award

Shri A. K. Jaswal, Scientist 'E' is conferred upon 26th Biennial MAUSAM Award on the occasion the IMD foundation day for his research paper entitled 'Changes in Total Cloud Cover over India based upon 1961-2007 Surface Observations' published in quarterly journal of MAUSAM , **61**, No. 4.

IMS Award

Dr. D. S. Pai, Scientist 'E' was awarded Indian Meteorological Society award on Weather and Climate Services for the paper entitled, 'District-wise Drought Climatology of the Southwest Monsoon Season over India based on Standardized Precipitation Index (SPI)'.

Dr Somenath Dutta, DDGM (Training) was felicitated by IMS bi-ennial award for best published paper on monsoon studies (formerly Dr B. N. Desai award) for the paper entitled "A dynamical comparison between two recent drought south-

west monsoon season 2002 and 2009 over India" by Dr. Somenath Dutta et al. in INTROMET 2014 held at SRM University Chennai. The study also shows that in both years, the Seasonal total (June-September) of conversion of zonal available potential energy to eddy available potential energy $[C(A_z, A_E)]$ was positive, but in 2009 its order of magnitude was 10^{-4} J/kg/cm^2/sec where as in 2002 it was 10^{-6} J/kg/cm^2/sec, indicating that the influence of mid-latitude westerly was much more in 2009, which may have attributed towards weaker mean monsoon circulation in 2009.

Best Employee Award from MoES

Shri D. P. Nayak, A.M.-I Receiving the Award

The Ministry of Earth Science celebrated its Foundation Day on 27th July 2014 at Vigyan Bhawan, New Delhi. It was chaired by which witnessed Dr. Jitendra Singh,

Minister of State (Independent Charge) for Earth Sciences as Chief Guest and Prof. Govardhan Mehta, National Research Professor & Jubilant-Bhartia Chair, University of Hyderabad, Hyderabad, as the Guest of Honour. On this occasion a galaxy of Scientists and budding talents from institutions across the country were awarded and given certificates of merit. Shri Subhash Chander Bhan, Scientist 'E' and Shri Narendra Nigam, Scientist 'E' IMD – They have made outstanding contributions in Group 'A' Officers. The awards were also given to the best employee Group B, C and D employee of the department. Shri D. P. Nayak, Assistant Meteorologist Gr. I of Cyclone Warning Division was conferred Best Employee Award on this occasion.

Appreciation for Weather Prediction

a. **Dr. David Rogers and Dr. Vladimir V.** Tsikunov members of world bank team who had earlier visited, Meteorological Centre, Dehra Dun, mentioned in their report that the weather forecasts for heavy rainfall during Kedarnath disaster in June, 2013 were "accurate and timely" which helped in limiting the exposure of tourists beginning their pilgrimage. It is a great recognition from World Bank Team for India Meteorological Department.

b. Consequent upon the success in monitoring, prediction and early warning services in case of VSCS Hudhud, IMD received applause from various sectors.The Hon'ble Prime Minister of India in his speech categorically praised IMD for accurate prediction with sufficient lead time.

> इस **Cyclone** में **Technology** का बहुत ही **Perfect** उपयोग हुआ, पहले दिन से ही। इस **Cyclone** में मौसम विभाग ने **Technology** का बखूबी उपयोग किया और **6** तारीख से ही ये संकेत दिए गए थे। जो अनुमान थे, उतनी ही **Velocity** रही। जो दिशा थी अनुमाननत, वही दिशा रही। जो अनुमाननत **Time** था, वही **Time** रहा और एक प्रकार से इस संकट से बचने में ये **Technology** का उपयोग भी काफी काम आया।"
>
> ***Prime Minister of India***

c. The dedicated website for Cyclone Warning Services, launched on 4th April 2014, by IMD has been appreciated by various National and International agencies including WMO, WMO/ESCAP Panel countries, Researchers, MoES, and sister organisations like NIOT, INCOIS and NCMRWF.

d. The WMO training on 'Dvorak's technique and Cyclone Forecast' organised at Muscat, Oman, by RSMC New Delhi has been appreciated by WMO.

Achievements

Dr. D. R. Pattanaik, Scientist 'E' received the Certificate from the Secretary General of WMO in appreciation of services to the World Meteorological Organization and particularly to the WMO Technical Commission for Climatology for his contributions as Co-Lead of the Task Team on Definitions of Extreme

Weather and Climate Events (TT-DEWCE) during the fifteen inter-seasonal period (2010-2014).

Dr. R. Suresh, Scientist 'E' AMO, Chennai adjudicated a Ph.D Thesis for the Department of Physics, University of Kerala, Thiruvananthapuram.

Dr. N. Chattopadhyay, DDGM (Agrimet) has been nominated as Chairman under the theme of OPCAME World Meteorological Organisation, Geneva.

Dr. M. Mohapatra, Scientist 'E' RSMC has been nominated as a member of the committee constituted by MHA to publish a blue book on lessons learnt from Cyclone, Hudhud, by Ministry of Home Affairs, Govt. of India per directive of Prime Minister. He has been nominated as a member of expert team on climate impact on tropical cyclones of WMO Tropical Cyclone Panel also.

Leadership for 34th ISEA, programme

NCAOR, Goa organized a meeting National Coordination Commettee for Polar Research (NCPP) under the Chairmanship of Dr. Shailesh Nayak, Secretary, MoES, New Delhi on 28th July, 2014 at MoES, New Delhi. Shri K. C. Bhindwar, A. M.-I for participation in the meeting and discussed the programme. It is honour for the department that Shri K. C. Bhindwar, A.M.-I given the Leadership responsibility for 34th ISEA Bharti team.

Shri Anand Sharma, Scientist-E, MC Dehradun was felicitated by Governor of Uttarakhand Shri Aziz Qureshi, at the Northern India International Trade Fair for participating as a representative of Ministry of Earth Sciences and for providing accurate prediction of rainfall and advice to cover the exposed materials for 14 October.

CHAPTER 11

NATIONAL & INTERNATIONAL COLLABORATIONS

11.1. National collaborations

MoU for Met Services for Aviation

A milestone has been achieved in the field of aviation safety when National Aerospace Laboratories, Bangalore and India Meteorological Department signed a partnership agreement on 20th May, 2014 for joint production of Drishti system; a sophisticated instrument for assessment of Runway visual range. The agreement which was signed by Dr. Shyam Chetty, Director - NAL and Dr. L. S. Rathore, Director General of Meteorology, IMD; encompasses a wide range of research & development activities for further development of various meteorological sensors. The agreement paves the way for operational deployment of Drishti system at different airports where IMD provides aeronautical meteorological services. A mega project for installing nearly 70 such systems at various Airports of the country is being jointly undertaken by the two organisations. Drishti Transmissometer, a visibility measuring system is an innovative, indigenous product first of its kind, designed and developed by CSIR-NAL to cover the wide span of lowest to highest visibility. Drishti Transmissometer, a visibility measuring system is an innovative, indigenous product first of its kind, designed and developed by CSIR-NAL to cover the wide span of lowest to highest visibility (< 25 to > 2000 meters) aiding pilots for safe landing and take-off. This cost effective product is a mandatory system required at all airports as per International Civil Aviation Organisation (ICAO) and World Meteorological Organisation (WMO).

Memorandum of Understanding (MoU) was also signed with the following agencies for the provision Aviation meteorological Services at the airports which are under development:

a) M/S Kannur International Airport Limited (KIAL), Kerala.

b) Bengal Aerotropolis Projects Limited (BAPL), Durgapur, West Bengal.

Collaboration with Sathyabama University

Meeting for Colloborative Project with Satyabama University

A collaborative project titled "Research on Organization of Atmospheric Convection (RONAC)" is undertaken with Space Physics Laboratory, ISRO, Thiruvananthapuram. Doppler weather radar data archived at all DWR stations of IMD will be used in this project. Sathyabama University proposed to collaborate with RMC Chennai jointly for R & D Project.

An interactive session was convened by DDGM RMC chennai on 7th August, 2014 with senior scientists of RMC Chennai and Dr. B. Sheela Rani, Vice Chancellor and Scientists from Centre for Remote Sensing and Geoinformatics / Earth and Atmospheric Sciences, Sathyabama University on possible research work. About 31.3 GB of raw data of DWR Chennai was provided to Space Physics Laboratory, VSSC, Trivandrum in connections with RONAC on 20th August, 2014.

Collaboration with Space Application Centre (SAC)

IMD in collaboration with Space Application Centre (SAC), Ahmedabad is generating the Normalised Difference Vegetation Index (NDVI) maps, derived from INSAT 3A CCD data, for agromet advisories for different states. Besides, Division in collaboration with International Centre for Radio Science (ICRS), Jodhpur is preparing maps for soil moisture estimation for Gujarat, Madhya Pradesh and Uttar Pradesh states. These maps are being generated on experimental mode in near real time using satellite data *viz.* soil moisture, NDVI and brightness temperature data from SMOS, MODIS and LST values from SSMIS sensors.

Visit of DGM at SHAR, Sriharikota

Dr. L. S. Rathore, Director General of Meteorology and Dr. Y. E. A. Raj visited Satish Dhawan space centre, SHAR, Sriharikota, Andhra Pradesh on 24th January, 2014 and had meeting with Dr. M. Y. S. Prasad, Director Satish Dhawan, Space Centre. Dr. L. S. Rathore visited rocket launch site at SHAR and inspected DWR Sriharikota satellite remote sensing data and products.

Committee for a Green field airport

A Steering Committee is constituted under the Chairmanship of Secretary, Ministry of Civil Aviation to coordinate and monitor the various clearances required for setting up of a Greenfeild airport. DGM, IMD is a member of this committee and the committee meets as and when

matters related to the Greenfeild airport arises. An apex level Standing Committee with DGM, IMD and Chairman, AAI, as Co-Chairpersons exist to sort out the issues related to the service provider and user.

11.2. International collaboration

DG, IMD at 66th WMO Executive Council Meet

The 66th Session of the World Meteorological Organization Executive Council (EC-66) was held at Geneva. During the meeting inter alia, the Global Framework for Climate Services (GFCS), Aeronautical meteorology, Public weather services, the Tropical Cyclone Programme, Marine meteorology and Oceanography, Agricultural meteorology, Water management, disaster risk reduction (DRR), data processing and forecasting, WMO Integrated Global Observing System (WIGOS) and WMO Information System (WIS), strengthening good governance and capacity-building, partnerships and research under the implementation of the WMO Strategic Plan 2012-2015; resource management and communication and public affairs were discussed.

Dr. L. S. Rathore, DGM and PR of India with PRs of BRICS countries and Advisers at WMO Geneva

Dr. Shailesh Nayak, Secretary, MoES, Dr. L. S. Rathore, DGM & Member Executive Council of WMO, Shri A. S. Khati, Joint Secretary, MoES, Shri B. N. Reddy, DPR, PMI Geneva and Dr. S. D. Attri, DDGM (O) attended 66th Executive Council Meeting of WMO held during 18-27 June, 2014 at Geneva.

Excellency Shri Dilip Sinha, PR of India with UN at Geneva, Dr Shailesh Nayak, Secretary, MoES, Dr L S Rathore, DGM & Member Exccutive Council of WMO, Sh A S Khati, Joint Secretary, MoES and Dr S D Attri, DDGM (O) at 66th Executive Council Meeting of WMO, Geneva

41st Session of the WMO/ESCAP Panel on Tropical Cyclones (PTC)

The forty-first session of the WMO/ESCAP Panel on Tropical Cyclones (PTC) hosted by Bangladesh was held in Dhaka, Bangladesh from 2 to 6 March 2014. The session was attended by 38 participants from the eight Members of the PTC, namely, Bangladesh, India, Maldives, Myanmar, Oman, Pakistan, Sri Lanka and Thailand. It was also attended by representatives of WMO, UN-ESCAP and observers from UNESCO, Intergovernmental Oceanographic Commission, ICAO and China.

The summary report on the 2013 cyclone season provided by the RSMC including the tracks of the cyclonic disturbances formed over the north Indian Ocean was discussed during the panel discussion.

The Panel expressed its appreciation to the RSMC New Delhi for its continued valuable support to the Members. It also expressed its hope that existing cooperation and collaboration between the Members and the RSMC New Delhi will be further strengthened though those activities.

Smt. Suman Goyal, Scientist 'E', Shri R. B.Verma, Director and Shri Rizwan Ahmed, SA imparted lecture on CWDS to Tropical cyclone forecasters from WMO/ESCAP panel member countries (Myanmar, Srilanka and Thailand) on 27th February, 2014.

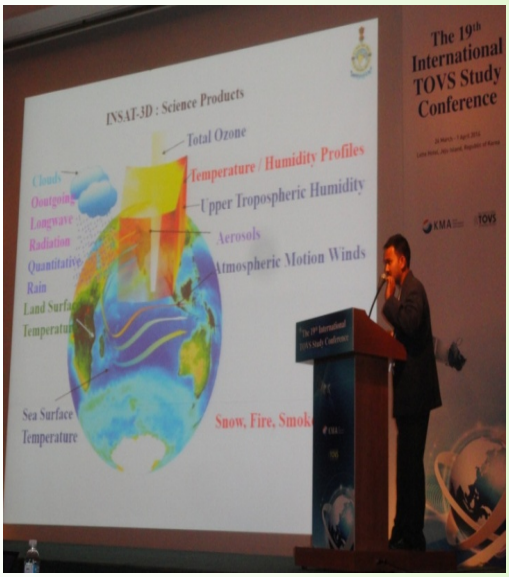
Dr. M. Mohapatra, Scientist 'E' was on foreign deputation to Dhaka, Bangladesh to attend the 41st Session of WMO/ESCAP Panel on Tropical Cyclones during the period 2- 6 March, 2014.

Shri B. Mukhopadhyay, ADGM (R) was on ex-India deputation to Korea Meteorological Administration, Seoul, South Korea to attend the 26th Session of WMO EC Panel on Education and Training, from 24-28 March, 2014.

Smt. Neetha K. Gopal, Scientist 'D' was on foreign deputation to Beijing, China, during 17-19 March, 2014 represented India in the 12th Meeting of Asia/Pacific ROBEX Working Group (ROBEX WG/12) organized by International Civil Aviation Organization, Asia Pacific Regional Office held at Asia and Pacific Regional Sub-Office.

Shri A. K. Sharma, Scientist 'F' participated in the 2014 Annual meeting of Global Space Based Inter Calibration System (GSICS) Research and Data working Group from 24-28 March, 2014 at Darmstadt, Germany.

Shri A. K. Mitra, Scientist 'D', was on foreign deputation to Jeju, Island, Republic of Korea to attend 19th International TOVS Study Conference (ITSC-19) during the period 26th March to 1st April, 2014.



Dr. N. Chattopadhyay, DDGM (Agrimet) participated in the International Conference on "Promoting Weather and Climate Information for Agriculture and Food Security" held at Antalya, Turkey during 7-9 April, 2014 and presented on "Overview and case studies for Agro meteorological Services".

Dr. L. S. Rathore, Director General of Meteorology was on foreign deputation to Antalya, Turkey to attend 16th Session of Commission for Agriculture Meteorology of WMO during the period 10-15 April, 2014.

Dr. S. D. Attri, DDGM (O) was on foreign deputation to Geneva, Switzerland to attend the 9th meeting of Management Group of Commission for Atmospheric Science during the period 23-25 April, 2014.

Smt. Suman Goyal, Scientist 'E' participated in the eighth Session of Expert team on Satellite Utilization and products (ET-SUP-8) during 14-17 April, 2014 at Geneva, Switzerland.

Shri Virendra Singh, Scientist 'E' participated in the 42nd plenary Session of the Coordination Group for Meteorological Satellites (CGMS-42) at Guangzhou, China during 19-23 May, 2014.

Participants of SSOP at China

Dr. Y. V. Rama Rao, Scientist 'E' was on foreign deputation to Taipei, Taiwan to attend the Workshop on Numerical Prediction of Tropical Cyclones during the period 20-22 May, 2014.

Dr. D. S. Pai, Scientist 'E' and Shri S. D. Raskar, S.A. participated as a resource person and as a trainee during 1-5 June in a two weeks training course on "Seasonal Weather Prediction" which was organized by SAARC Meteorological Research Centre (SMRC) at Dhaka, Bangladesh during the period 1-12 June, 2014.

Dr. S. D. Attri, DDGM (O) delivered Key Note Address on "CLIMATE

CHANGE PERSPECTIVE" on the occasion of World Environment Day on 5th June, 2014 at BHEL Haridwar.

Shri G. K. Das, Scientist 'D' was on foreign deputation to Nanjing, China during 9-11 June, 2014 for the training workshop on "Synergized Standard Operating Procedures (SSOP) for Coastal Multi-Hazards Early Warning System.

Ms. Maduri M Musale, S.A. was on foreign deputation to Trieste, Italy to participate ICTP IITM COLA Targeted Training Activity TTA Challenges in Monsoon Prediction during the period 23rd June to 4th July, 2014.

Shri B. Mukhopadhyay, LACD, ADGM (R) Pune attended the WMO Conference on Climate Services-Building CLIPS Legacy during 30 June to 2 July 2014 followed by 16th Session of WMO Commission for Climatology (CCL) Heidelberg, Germany during the period 3 - 8 July, 2014.

Shri D. K. Malik, Scientist 'E' was on deputation to St. Petersburg , Russia, to present a paper on GPS based Radiosonde, in TECO - 2014 (a WMO sponsored International Conference on Meteorological Instrument & Methods of Observation) from 7-9 July, 2014.

Dr. S. K. Roy Bhowmik, Scientist. 'E', IMD, New Delhi deputed as Head Theoretical Division for a period of three years w.e.f. 13 July, 2014 in SAARC Meteorological Research Centre, Dhaka, Bangladesh.

Shri J. K. S. Yadav, Scientist 'E' IMD, Pune participate International Training Course on WMO Indian System (WIS) and Tehran GISC WMO Tehran, Islamic Republic of Iran during the period 4-6 August, 2014.

Shri R. R. Mali, DDGM (SI) participated in the extraordinary session of the Commission for Basic Systems of WMO held at Asuncion, Paraguay during 8-12 September, 2014.

Shri G. Suresh, Scientist 'E', was on deputation to Taipei, Taiwan for participation in the International Training Program on "Seismic design of Structures" organized by NCREE, Taiwan during 13 - 18 September, 2014.

Dr. M. Mohapatra, Scientist 'E', Dr. Kamaljit Ray, Sc. 'E', New Delhi, Shri C. S. Tomar, Sc. 'D', participated in International Wrokshop on Dvorak Technique and Tropical Cyclone Forecasting, Muscat, Oman during the period 28 September to 2 October, 2014.

Dr. N. Chattopadhyay, Scientist 'E', IMD, Pune to participated in first CAgM MG Meeting at WMO & 2nd Co-ordination meeting on implement-tation of Global framework of Climate services, Geneva, during 29 September- October, 2014.

Dr. Someshwar Das, Scientist 'G' was on foreign deputation to Thimpu (Bhutan) to attend the 7th Meeting of International Programme Committee (IPC) during October 27-30, 2014.

Dr. Kamaljit Ray, Scientist 'E' attended a WMO/Oman International workshop on 'Dvorak Technique & Tropical Cyclone Forecasting' held at Oman during 28 September to 2 October, 2014.

Smt. Suman Goyal, Scientist 'E' (was deputed to Chiang Mai, Thailand to participate in coastal multi-hazard EW information Sharing and technical transferring mechanism meeting held from 9-10 Oct., 2014.

Dr. L. S. Rathore, DGM, attended Second Session of the Intergovernmental Board on Climate Services at WMO, Geneva during November 10-14, 2014.

Dr. Sunil Peshin, Scientist 'F', was on foreign deputation to Moscow, Russia for participating in joint collaboration work on Ozone Theme during 12-18 November, 2014.

Shri Anand Sharma, Scientist 'E', participated in International Workshop on "Mountain People Adapting to Change" during 9-12 Nov 2014 at Kathmandu, Nepal.

Dr. M. Mohapatra, Sc-E RSMC, New Delhi participated in 8th International Workshop on Tropical Cyclones and third International Workshop on Tropical Cyclone Landfall Process (during 2-10 December 2014 organised by WMO and KMA at Jeju, Korea.

Dr. L. S. Rathore, DGM chairing IBCS 2 proceedings of WMO

Dr. Shailesh Nayak, Secretary, MoES, Dr. L. S. Rathore, DGM & Co-Vice Chair of IBCS of WMO attended IBCS-2 at Geneva during 10-14 November, 2014.

Dr. Shailesh Nayak, Secretary, MoES, Dr. L. S. Rathore, DGM & PR of India with WMO, Dr S D Attri, DDGM (O) and Dr N Chattopadhyay, DDGM(Agrimet) attended RECO-6 of RA II of WMO held during 2-4 December, 2014 at Doha, Qatar.

Dr. A. K. Srivastava, Scientist 'E' participated in UNESCAP neeting on the theme, "Increasing economic co-operation to address shared vulnerabilities, risks and challenges" at Bangkok during 10-11 December 2014.

CHAPTER 12

RESEARCH PUBLICATIONS

MAUSAM (Formely Indian Journal of Meteorology, Hydrology & Geophysics), established in January 1950, is the quarterly research journal brought out by the department. It is a medium. MAUSAM is a premier scientific research journal in the field of Meteorology, hydrology & Geophysics for publication of original scientific research work. MAUSAM is being indexed and abstracted by Thomson Reuter U.S.A. MAUSAM" has an IMPACT FACTOR (IF): 0.152 and 5-year Impact factor 0.188 calculated by Thomson Reuter U.S.A. The rating score is 6.14 given by National Academy of Agricultural Sciences for the year 2013.

12.1. Departmental journals, 'MAUSAM'

D. S. Pai, Latha Sridhar, M. Rajeevan, O. P. Sreejith, N. S. Satbha and B. Mukhopadhyay, **"Development of a new high spatial resolution (0.25° × 0.25°) long period (1901-2010) daily gridded rainfall data set over India and its comparison with existing data sets over the region"**, *Mausam*, **65**,1, 1-18.

G. K. Sawaisarje, P. Khare, C. Y. Shirke, S. Deepakumar and N. M. Narkhede, "**Study of winter fog over Indian subcontinent: Climatological perspectives**", *Mausam*, **65**, 1, 19-28.

G. K. Sharma and J. L. Chaudhary, **"Time trends in temperature of Bastar plateau agro-climatic zone of Chhattisgarh"**, *Mausam*, **65**, 1, 29-36.

Sunitha Devi S., Somenath Dutta and K. Prasad, **"Energetics of super cyclone 'GONU' and very severe cyclonic storm 'SIDR"**, *Mausam*, **65**, 1, 37-48.

S. Josephine Vanaja, B. V. Mudgal and S. B. Thampi, "**Rainfall-runoff modeling using Doppler weather radar data for Adyar Watershed, India",** *Mausam*, **65**, 1, 49-56.

Fei Ge, Zaheer Ahmad Babar, Sheng-li Guo, Xie-Fei Zhi, Yun Chen and Wei-Wei Tang, "**Heavy rainfall in Pakistan during 27-29 July 2010: Role of atmospheric energy conversion characteristics**", *Mausam*, **65**, 1, 57-66.

Pragyan Kumari, Rajan Kumar Ojha, A. Wadood and Ramesh Kumar, **"Rainfall and drought characteristics for crop planning in Palamau region of Jharkhand",** *Mausam*, **65**, 1, 67-72.

K. Ghosh, M. Rajavel, R. P. Samui, G. P. Singh and C. Karmakar, "**Forewarning incidence of American boll worm (*Heliothis armigera* H.) of cotton at Akola in Vidarbha region of Maharashtra**", *Mausam*, **65**, 1, 73-82.

M. M. Abd El-Wahab, Khaled S. M. Essa, H. M. Elsman, A. Sh. Soliman,

S. M. Elgmmal and A. A. Wheida, **"Derivation of the Gaussian plume model in three dimensions",** *Mausam*, **65**, 1, 83-92.

B. N. Vishnoi, "**Sector wise echoes study and climatology around Jaisalmer**", *Mausam*, **65**, 193-98.

Sunit Das, C. S. Tomar, R. K. Giri, K. Bhattacharjee and *B. Barman,* "**The severe thunderstorm of 5th April, 2010 at Guwahati airport : An observational study",** *Mausam*, **65**, 1, 99-102.

D. P. Dubey and *G. Krishnakumar,* "**Trends in precipitation extremes over Central India",** *Mausam*, **65**, 1, 103-108.

Neeraj Kumar, Suman Kumar and A. S. Nain, **"Response of CERES-wheat and CROPGRO-urd model (DSSAT model v 4.5) for tarai region of Uttarakhand**", *Mausam*, **65**, 1, 109-114.

B. Geetha and *S. Balachandran,* "**Decadal variations in translational speed of cyclonic disturbances over north Indian ocea**n", *Mausam*, **65**, 1, 115-117.

Kamaljit Ray, B. N. Joshi, I. M. Vasoya and *J. R. Chicholikar,* "**Quantitative precipitation forecast for Mahi basin based on synoptic analogue method**", *Mausam*, **65**, 1, 118-123.

O. P. N. Calla, Kishan Lal Gadri, Gaurav Rathore, Rahul Sharma, Sunil Kumar Agrahari and Abhishek Kalla, **"Evaluation of SMOS soil moisture based on rainfall variability over semi-arid tract of India",** *Mausam*, **65**, 1, 124-127.

Ashok Kumar, D. K. Shukla, Arun Kumar, S. K. Sarkar and B. C. Arya, **"Effects of the solar eclipse of 15 January 2010 on direct solar irradiances, surface ozone, NO_x, total ozone column and water vapour observed at Thiruvanathapuram, India",** *Mausam*, **65**, 1, 127-136.

O. P. N. Calla, Rahul Sharma, Kishan Lal Gadri, Sunil Kumar Agrahari, Abhishek Kalla and Gaurav Rathore, **"Microwave remote sensing application for monitoring of floods",** *Mausam*, **65**, 2, 147-152.

Ranbir Singh Rana, Sharda Singh, Navell Chander, Ruchi Sood, Rohit Sharma and Aditya, **"Impacts of changes in climate on mountain water resources of Himachal Pradesh",** *Mausam*, **65**, 2, 153-160.

Amrender Kumar, C. Chattopadhyay, K. N. Singh, S. Vennila and Vum, Rao, **"Trend analysis of climatic variables in Pigeonpea growing regions in India**", *Mausam*, **65**, 2, 161-170.

R. B. Sonar, "**Observed trends and variations in rainfall events over Ratnagiri (Maharashtra) during southwest monsoon season",** *Mausam*, **65**, 2, 171-178.

G. N. Raha, K. Bhattacharjee, M. Das, M. Dutta and *S. Bandyopadhyay,* **"Statistical study *of surface temperature and rainfall over four stations in north Bengal*",** *Mausam*, ***65**, 2, 179*-184.

B. Geetha and *Y. E. A. Raj,* "**Spatial patterns of northeast monsoon rainfall over sub-regions of southern peninsular India and Sri Lanka as revealed through**

empirical orthogonal function analysis", *Mausam*, **65**, 2, 185-204.

Geeta Agnihotri, **"Objective forecast of thundery and non-thundery days using conventional indices over Bangalore during pre-monsoon season",** *Mausam*, **65**, 2, 205-214.

Neeraj Kumar, Suman Kumar, A. S. Nain and *Sumana Roy,* **"Thermal indices in relation to crop phenology of wheat (*Triticum aestivum* L.) and urd (*Vigna mungo* L. Hepper) at Tarai region of Uttrakhand",** *Mausam*, **65**, 2, 215-218.

Rajasri Sen Jaiswal, V. S. Neela, Sonia R. Fredrick, M. Rasheed, Leena Zaveri and *V. Sowmya,* **"Identification of convective/ stratiform dominance over surface rainfall",** *Mausam*, **65**, 2, 219-232.

P. W. Chan, **"Observation and numerical simulation of terrain-disrupted wavy motion in the boundary layer with minor temperature inversion/ isothermal at the Hong Kong international airport",** *Mausam*, **65**, 2, 233-244.

Bhim Singh, Jitendra Singh, Prerak Bhatnagar and *V. K. Upadhyay,* **"Impact of rainfall variability on fruit production in Jhalawar district of Rajasthan",** *Mausam*, **65**, 2, 245-252.

M. Abdel-Wahab, Khaled S. M. Essa, M. Embaby and *Sawsan E. M. Elsaid,* "**Derivation the schemes of lateral and vertical dispersion parameters: Application in Gaussian plume model",** *Mausam*, **65**, 2, 253-260.

V. Vizaya Bhaskar, **"Aerosol optical thickness over Indian Antarctica station Maitri",** *Mausam*, **65**, 2, 261-263.

Arnab Hazra, Sabyasachi Bhattacharya and *Pabitra Banik,* **"Modelling Nakshatra-wise rainfall data of the eastern plateau region of India",** *Mausam*, **65**, 2, 264-269.

Balambal Usha and *B.V. Mudgal,* **"Rainfall variability over smaller spatial scale",** *Mausam*, **65**, 2, 270-276.

RM. A. N. Ramanathan and *Y. E. A. Raj,* "**Statistical prediction of movement of cyclonic storms and depressions over Bay of Bengal through LOESS Technique**", *Mausam*, **65**, 3,319-332.

Suman Goyal, D. R. Sikka and *Ajit Tyagi,* **"Morphology of Long Lasting Mesoscale Convective System under weak synoptic forcing over the Gangetic Plain in May 2010 during the STORM-2010 campaign",** *Mausam*, **65**, 3, 333-352.

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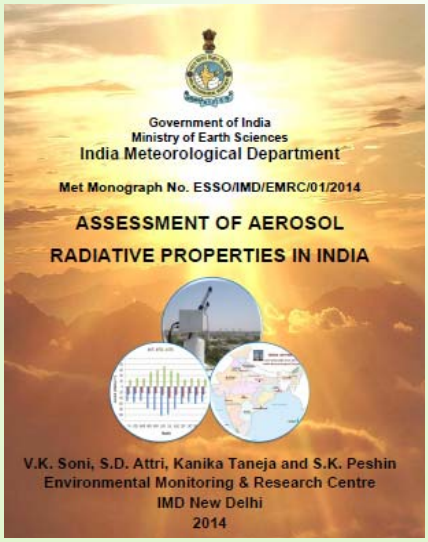
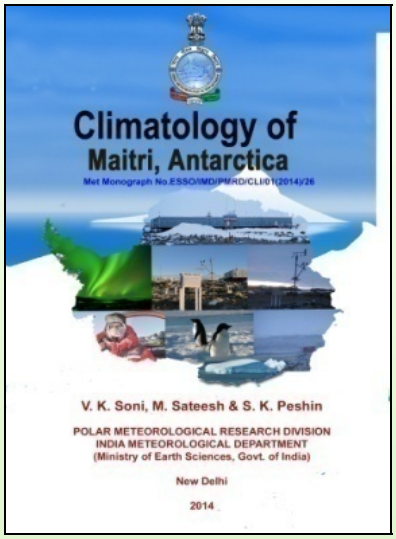
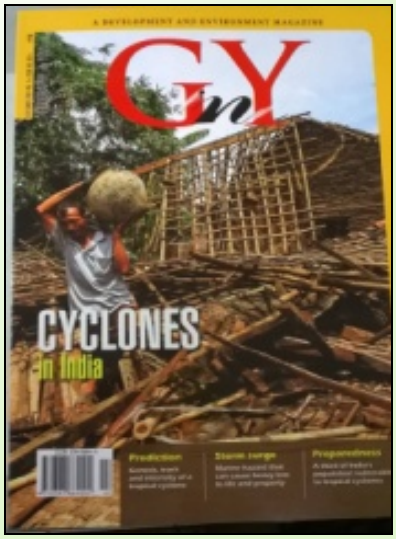






CHAPTER 13

RESOURCES MANAGEMENTS

Resources management creats an enabling environment for the development and management of human and financial 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.

13.1. Financial Resources Management

Budget Estimates

Budget provisions for the department during the financial year 2014-15 were as follows:

Budget Estimates (Plan)

B.E. (Revenue) Rs.75 Crores

B.E. (Capital) Rs.115 Crores

Plan Schemes

To further upgrade the weather & forecasting capabilities, various plan schemes were approved during 2014-15 as follows:

The new scheme **"Integrated Himalayan Meteorology Programme for Western & Central Himalayas"** approved for Rs. 117.17 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.

New scheme **"Development of High Impact Weather Forecasting System (DSWFS)"** approved at Rs 88 Crores for development of state-of-art high resolution modeling framework for predictions of high-impact weather systems including Thunderstorms, Cyclone, Fog, Cloudburst & Heavy Rainfall.

The new 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.

Plan Scheme Monitoring

A new package was designed, developed & introduced for the online monitoring of the progress of Plan schemes, status of procurements, expenditure status and online submission of quarterly progress report.

Revenue generated

IMD received Rs.39.38/- Crore from Airport Authority of India towards reimbursement of cost of Aviation Met. Services rendered by IMD.

13.2. 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 for 2014-15 was prepared and submitted to Performance Management Division, Cabinet Secretariat to Government of India for the performance monitoring and evaluation of the department. Final achievement against the targets of the RFD (2013-14) was 70.

13.3. Citizen's/Client's Charter

Citizen's/Client's Charter was finalized and displayed at all offices upto the level of AMOs highlighting the standards of service delivery that it subscribes to, availability of choice for public and avenues for grievance redress and other related information. The total composite score on performance of the service standards of the Citizen's/Client's Charter of the India Meteorological Department for the year 2013-2014 was 92.52.

13.4. Innovation Action Plan

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

13.5. Human Resources Managements

An organized training centre started functioning at IMD Pune by 1943-1944. Facilities for meteorological training at Pune and New Delhi have been recognized by the World Meteorological Organisation (WMO) as the Regional Meteorological Training Centre (RMTC) in all the four main disciplines namely, General Meteorology, Radiometeorology, Telecomm and Agrometeorology. Candidates nominated by the Meteorological Services of other countries have been trained here from time to time.

The XII FYP scheme, "Training in operational Meteorology" has been approved by MoES. This is first time in IMD; a plan scheme exclusively for IMD's training activities has been approved 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 Telecommuni-cation keeping in view the changed requirements of the office This cources are conducted at all the four training centres *viz.*, New Delhi, Pune, Chennai and Kolkata. Training curriculum of Intermediate Course in Instrumentation / Telecommuni-cation 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.

13.5a During 2014 following training program were conducted for departmental officials

25, 05 and 46 number of IMD Officials in different cadre were trained for cources Integrated Met. Trg., LA Modular Trg. and Intermediate Met. Trg. Course respectively at RMC New Delhi Training centre

A training on "Preparation of PMP Atlas using GIS tools", organized by CWC and M/S RMSI, Noida during 10-14 March, 2014.

Limited departmental competitive examination for Scientific Assts. was conducted at MTI Pune during 19- 21 June, 2014.

A training programme was organized on Surface Observations through HHDL by SAMEER Mumbai

Training work shop on "Early warning Services in disaster" held at MC Thiruvananthapuram

Seven departmental nominees for 34th ISEA for Maitri and Bharti station Antarctica have undergone Pre Antarctica training at IMD office Pune during 21st July to 8th August,.

NWFC organized an Operational Forecaster's Training workshop at New Delhi during 1-6 September, 2014.

Training for Hand held data logger was held at RMC Chennai

13.5b. For non departmental candidates

A workshop for imparting training to the personnel posted at PTOs was conducted from 7-9 January, 2014 at M.C. Ahmedabad.

Training course on 'Application of Weather Based Agrometeorological Advisories' for Telefarm Advisors of Kisan Call Centre, Pune was organised during 12-15 March, 2014

3-days training programme on "INSAT-3D Data Utilization" during 26-28 March, 2014

Training work shop on "Co-ordination of different agencies on weather forcasting services for farmers" held at MC Thiruvananthapuram on 7th May, 2014.

Agrimet Division, IMD, Pune in association with GIZ (German International Cooperation) organized 5 days customized training programme on 'Agrometeorology towards better advisories for serving end users' requirement' from 25-29 August, 2014. Total 39 participants attended the training

International Training Program

An international training program, WMO group training on "Maintenance and Calibration of instruments", held during 3-28 November, 2014 at Meteorological Training Institute and at Surface instruments division, Pune. Total 24 foreign participants from 21 different countries participated in this training program. The training was

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

Forecasters Training Programme

A two week training programme on Tropical Cyclone Monitoring, Forecasting and Warning Services was conducted during 17-28 February, 2014 at RSMC, New Delhi. The cyclone forecasters from Myanmar, Thailand, Srilanka and also from ACWC & CWC of India Meteorological Department participated in the training. Dr. L.S. Rathore, DGM, IMD inaugurated the training programme on 17th February, 2014.

Tropical Cyclone Forecasters Trainees

One foreign trainee from Mauritius Met Services, Advanced Met Training Course Batch No. 175.

13.6. Departmental Promotions

Following promotions were made during the year.

Name of the Post	No. of official
Scientist 'E' to Scientist 'F'	03
Scientist 'D' to Scientist 'E'	11
Scientist 'C' to Scientist 'D'	14
Asstt. Meteorologist Gr.II to Asst. Met. Gr.I	105
Scientific Assistant to Assistant Meteorologist Gr. II	128
Admin. Officer Gr. III to Admin. Officer Gr.II	3
Assistant to Admin. Officer Gr. II	16
Private Secretary to Senior P.S.	01
Steno Gr. I to P.S.	02
Hindi Translator Gr. I to Hindi Officer	-
UDC to Assistant	18
Steno Gr. II to Steno Gr.I	01
Staff Car Driver Gr.I to Car Driver Special Grade	02
Mech. Gr. II (Ind) to Mech Gr. I (Ind)	-
Mech Gr. I (Ind) to Mechanical Asstt (Ind)	10
Mech. Gr.I (Non.Ind) to Mechanical Asstt. (Non.Ind.)	01
LDC to UDC	07
Group D (MTS) to LDC	07
M.O. III to M.O. II	-
Staff Car Driver Gr. II to Staff Car Driver Gr. I	01
Staff Car Ordinary Grade to Staff Car Driver Gr. II	-
MTS to M.O. III	62

CHAPTER 14

राजभाषा नीति का कार्यान्वयन-2014

1. राजभाषा हिंदी के प्रगामी प्रयोग के संवर्धन के लिए भारत मौसम विज्ञान विभाग का हिंदी अनुभाग राजभाषा नीति के कार्यान्वयन के साथ-साथ प्रमुख रूप से अनुवाद का कार्य करता है। अनुवादकों द्वारा अनुवाद के सभी प्रमुख नेमी कार्यो के अलावा विभागीय शोध पत्रिका 'मौसम' के लिए 80 शोध पत्रों के सारों, विश्व मौसम विज्ञान दिवस 2014 की प्रेस विज्ञप्ति, दक्षिणी पश्चिमी मानसून वर्षा 2014 के दीर्घावधि पूर्वानुमान की प्रेस विज्ञप्ति, नागरिक/ग्राहक चार्टर, मौसम प्रेक्षक श्रेणी 1–, 11, और 111 के भर्ती नियमों का हिंदी अनुवाद, राज्यसभा तारांकित/अतारांकित प्राथमिकता प्रश्न डायरी सं S436-09 जुलाई 2014 को उत्तर दिए जाने के लिए, भारत के राष्ट्रपति को सम्बोधित याचिका, सूचना प्रणाली एवं सेवाएँ प्रभाग से प्राप्त हुए कार्मिक एवं प्रशिक्षण विभाग के कार्यालय आदेश सं.ए.बी 2009/6/1417-.स्था. (भर्ती नियम) अनुलग्नक-।।, स्थापना अनुभाग के नेमी प्रकार के चार आदेशों, अक्तूबर 2014 को महानिदेशक महोदय द्वारा स्वच्छता दिवस के अवसर पर पढ़े जाने वाले प्रधानमंत्रीजी के संदेश, कतर नागरिक उड्डयन प्राधिकरण, दोहा, कतर और पृथ्वी प्रणाली विज्ञान संगठन, पृथ्वी विज्ञान मंत्रालय, भारत गणराज्य, नई दिल्ली के मध्य वैज्ञानिक और तकनीकी सहयोग हेतु समझौता ज्ञापन, मौसम विज्ञान के उपमहानिदेशक (उवाउ) नई दिल्ली से प्राप्त फार्म और मानक मसौदा का हिंदी अनुवाद सम्बंधित अनुभागों को उपलब्ध कराया गया। भारत मौसम विज्ञान विभाग की वार्षिक रिपोर्ट 2013-के लगभग 100पृष्ठों का टंकित अनुवाद प्रकाशन अनुभाग को भेजा गया। विभागीय वेबसाइट imd.gov.in के 18 स्टैटिक पृष्ठों का हिंदी अनुवाद आई एस एस डी को अपलोड करने के लिए ईमेल से उपलब्ध कराया। प्रादेशिक मौसम केंद्र,गुवाहाटी की वेबसाइट के मुख्य पृष्ठ और 03 अन्य पृष्ठों का हिंदी अनुवाद उक्त केंद्र को उपलब्ध कराया गया।

2. 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 20.03.2014, 03.06.2014, 06.08.2014 और 05.11.2014 को आयोजित की गईं ।

पृथ्वी विज्ञान मंत्रालय की दिनांक 12.06.2014 को आयोजित राजभाषा कार्यान्वयन समिति की तिमाही बैठक में सुश्री रेवा शर्मा, वरिष्ठ हिंदी अधिकारी और श्रीमती एम.अनुराधा, वरिष्ठ अनुवादक और दिनांक 25.09.2014को आयोजित राजभाषा कार्यान्वयन समिति की तिमाही बैठक में सुश्री रेवा शर्मा, वरिष्ठ हिंदी अधिकारी और श्रीमती सरिता जोशी हिंदीअधिकारी ने भाग लिया।

3. क. केंद्रीय हिंदी प्रशिक्षण संस्थान की गहन हिंदी टंकण की पूर्णकालिक परीक्षा उतीर्ण करने पर मुख्यालय के 02 अवर श्रेणी लिपिकों को हिंदी टंकण का परीक्षा परिणाम और प्रमाण पत्र भेजे गए। मुख्यालय के 02 आशुलिपिकों को गहन आशुलिपि की पूर्णकालिक पाठ्यक्रम के लिए नामित किया गया।

ख. राजभाषा विभाग,गृह मंत्रालय, केंद्रीय हिंदी प्रशिक्षण संस्थान द्वारा कम्प्यूटर पर हिंदी में कार्य करने के लिए आयोजित 05दिवसीय बेसिक प्रशिक्षण कार्यक्रम में मुख्यालय के 02 कार्मिकों ने प्रशिक्षण प्राप्त किया।

ग. नराकास सचिव,प्रसार भारती, नई दिल्ली द्वारा दिनांक 31.05.2014 को आयोजित 01 दिवसीय राजभाषा प्रशिक्षण शिविर में वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा और हिंदी अधिकारी श्रीमती सरिता जोशी ने भाग लिया।

4. कार्यालयों में राजभाषा हिंदी की प्रगति का जायज़ा लेने के लिए वरिष्ठ हिंदी अधिकारी ने दिनांक 27.06.2014 को प्रादेशिक मौसम केंद्र, गुवाहाटी, विमानन मौसम कार्यालय,गुवाहाटी और दिनाक 01.08.2014 और 04.08.2014 को पुणे स्थित सभी कार्यालयों का राजभाषायी निरीक्षण किया और राजभाषा नीति के अनुपालन हेतु उपयोगी सुझाव दिए ।

5. प्रादेशिक मौसम केंद्र, नई दिल्ली के एक कार्मिक को हिंदी शिक्षण योजना के अंतर्गत हिंदी टंकण परीक्षा उत्तीर्ण करने पर प्रोत्साहन स्वरूप 1600/-रू. की राशि की स्वीकृति प्रदान की गई। प्रादेशिक मौसम केंद्र, चेन्नै में कार्यरत तीन कार्मिकों को हिंदी शिक्षण योजना के अंतर्गत हिंदी प्रवीण परीक्षा उत्तीर्ण करने पर प्रोत्साहन स्वरूप 6000/-रू. की राशि की स्वीकृति प्रदान की गई। प्रादेशिक मौसम केंद्र, नागपुर के एक तथा प्रादेशिक मौसम केंद्र चेन्नै के एक कार्मिक को हिंदी प्राज्ञ परीक्षा उत्तीर्ण करने पर कुल 4,800/-रू. की राशि की स्वीकृति नकद पुरस्कार के रूप में प्रदान की गई। प्रादेशिक मौसम केंद्र नई दिल्ली में कार्यरत दो कार्मिकों को हिंदी शिक्षण योजना के अंतर्गत हिंदी टंकण परीक्षा अच्छे अंक लेकर उत्तीर्ण करने पर 4000/-रू. की राशि नकद पुरस्कार के रूप में स्वीकृत की गई ।

6. पृथ्वी विज्ञान मंत्रालय एवं विज्ञान और प्रौद्योगिकी मंत्रालय के माननीय मंत्री महोदय श्री एस .जयपाल रेड्डी ने दिनांक 15.01.2014 को भारत मौसम विज्ञान विभाग के 139वें स्थापना दिवस के अवसर पर निबंध सागर 2014-के अंक 2 का विमोचन किया। और महानिदेशक महोदय द्वारा दिनांक 16.09.2014 को हिंदी दिवस समारोह के अवसर पर हिंदी गृह पत्रिका 'मौसम मंजूषा' के 19 वें संस्करण का विमोचन किया गया।

'मौसम मंजूषा' का विमोचन

7. वर्ष 2014-2013में हिंदी में सबसे अधिक पत्राचार करने के लिए दिनांक 16.09.2014

को हिंदी दिवस के अवसर पर डॉ लक्ष्मण सिंह राठौड़ ने राजभाषा चलशील्ड श्री राम प्रसाद लाल, वैज्ञानिक 'ई' को प्रदान की। भारत मौसम विज्ञान विभाग की अखिल भारतीय विभागीय हिंदी निबंध लेखन प्रतियोगिता-2014 योजना के अन्तर्गत प्रथम, द्वितीय, तृतीय तीन पुरस्कार और 3 प्रोत्साहन पुरस्कार प्रदान किए गए।

8. मुख्यालय के हिंदी अनुभाग द्वारा दिनांक 19.05.2014 से 21.05.2014 तक तीन दिवसीय हिंदी कार्यशाला आयोजित की गई जिसमें 11 कार्मिकों ने भाग लिया।

मौसम कार्यालय सफदरजंग द्वारा दिनांक 28.03.2014 को आयोजित हिंदी कार्यशाला में वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा, हिंदी अधिकारी श्रीमती सरिता जोशी और कनिष्ठ अनुवादक श्री बीरेन्द्र कुमार ने व्याख्यान दिए।

9. मुख्यालय में दिनांक 01.09.2014 से 16.09.2014 तक हिंदी पखवाड़ा मनाया गया।

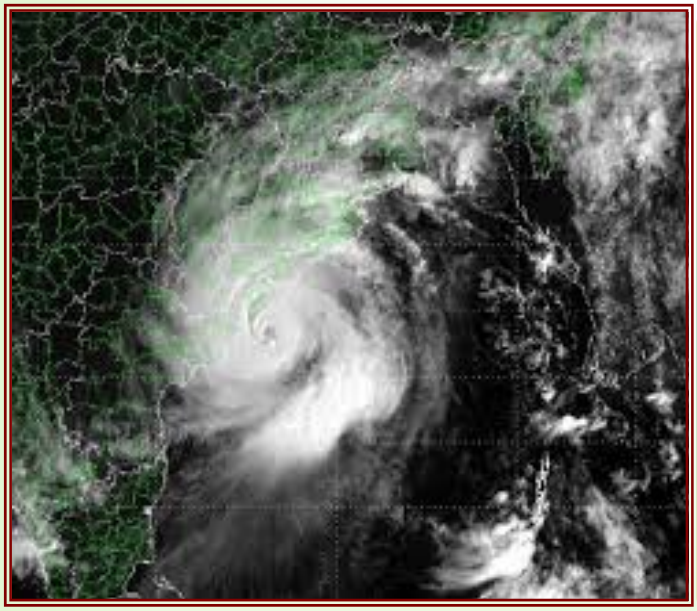
इस दौरान विभिन्न हिंदी प्रतियोगिताओं जैसे हिंदी निबंध, हिंदी रूपांतरण, हिंदी टंकण, हिंदी श्रुतलेखन, हिंदी आशुभाषण, एवं हिंदी वाद विवाद प्रतियोगिता का आयोजन किया गया एवं हिंदी दिवस समारोह 16 सितम्बर 2014 को वृष्टि सभागार में आयोजित किया गया। समारोह की अध्यक्षता मौसम विज्ञान के महानिदेशक डॉ. लक्ष्मण सिंह राठौड़ ने की। समारोह का शुभारम्भ महानिदेशक महोदय डॉ लक्ष्मणड़सिंह राठौ , डॉ. एल. आर. मीणा, वैज्ञानिक 'एफ', श्री ए. के. शर्मा, वैज्ञानिक 'एफ' द्वारा संयुक्त रुप से दीप प्रज्ज्वलित करके किया गया ।मौसम विज्ञान के महानिदेशक ने अपने अध्यक्षीय भाषण में कहा कि हिंदी पखवाड़ा/हिंदी दिवस के आयोजन का मुख्य उद्देश्य सरकारी कार्य में हिंदी को बढ़ावा देना है। अध्यक्ष महोदय ने विभाग के सभी कार्मिकों को कार्यालय का कार्य अधिक से अधिक हिंदी में करने की सलाह दी तथा राजभाषा विभाग द्वारा निर्धारित किए गए लक्ष्यों को प्राप्त करने के लिए और अधिक प्रयास करने का अनुरोध किया एवं राजभाषा के प्रचार-प्रसार में अपना अमूल्य योगदान देने पर भी जोर दिया ।

इस समारोह में हिंदी प्रतियोगिताओं के विजेताओं को नकद पुरस्कार और प्रमाण पत्र प्रदान किए गए। अखिल हिंदी दिवस के अवसर पर माननीय गृह मंत्री श्री राजनाथ सिंह द्वारा भेजे गए संदेश को सुश्री रेवा शर्मा ने सभागार में पढ़कर सुनाया और हिंदी दिवस की शुभकामनाएँ दी। इसके बाद विभागीय हिंदी गृह पत्रिका 'मौसम-मंजूषा' के 19 वें अंक का महानिदेशक महोदय द्वारा विमोचन किया गया। की गई।इस समारोह में बाल कलाकरों और विभाग के कार्मिकों द्वारा मनोहर नृत्य, रोचक एवं ज्ञानवर्द्धक सांस्कृतिक कार्यक्रम भी प्रस्तुत किया गया।

Appreciation for accurate

Prediction of VSCS, 'Hudhud'

Hon'ble Prime Minister of India Shri Narendra Modi, getting briefing about IMD preparedness for Cyclone Hudhud by DG, IMD, Dr. L. S. Rathore (Photo: PTI)



Advances in cyclone forecasting and warning is appreciated by Prime Minister of India The text of Hon'ble Prime Minister Shri Narendra Modi's address at the 102nd Indian Science Congress on 3rd January, 2015 is as follows.

"Our scientists put Mangalyaan in the Mars orbit in the first attempt – I must congratulate Radhakrishnan`s team – and their accurate prediction of Cyclone Hudhud saved thousands of lives ……."

Top Ten Most Searched

Hudhud is one of
the top ten most searched news events in 2014
According to Google Search. Cyclone Hudhud stands in 9 position
in Top Searched New Events in 2014
(Source : TOI: 17 Dec 2014)

APPENDIX

IMPORTANT TELEPHONE LINKS

NAME	DESIGNATION/OFFICE	EPABX New Delhi	OFFICE TELEPHONE NO. / FAX
Dr. L. S. Rathore	DGM	4201	011-24611842
Shri J. P. Sharma	Senior PS to DGM	4253	011-24611842
Shri A. K. Sharma	DDGM (A&S and Sat. Met.), New Delhi	4210	011-24621472
Smt. Mamta Negi	PA to DDGM(A&S), New Delhi	4302	011-24621472
Shri L. R. Meena	Scientist 'F' (ISSD), New Delhi	4314	011-24616051
Shri B. Mukhopadhyay	Scientist 'F', ADGM (R), Pune		020-25535411
Dr. S. K. Roy Bhowmik	Scientist 'F', (NWP), New Delhi		
Shri B. K. Bandyopadhyay	Scientist 'F', (Services), New Delhi	4334	011-24635664
Dr. (Smt.) S. Kaur	Scientist 'F' (Hydrology), New Delhi	4223	011-24619167
Shri M. K. Bhatnagar	Scientist 'F', (CAMD), New Delhi	4301	011-24615371
Shri S. K. Kundu	Scientist 'F', (UI), New Delhi	4245	011-24611451
Dr. S. K. Peshin	Scientist 'F' (EMRC/PMRD/Seismo), ND	4405	011-24611305
Shri Satish Bhatia	Scientist 'F', (UAI), New Delhi	4513	011-24611710
Shri Surya Bali Jaiswar	Scientist 'F', (CPU), New Delhi	4227	011-24624486
Dr. S. D. Attri	DDGM (Organisation), New Delhi	4309	011-24640701
Dr. Mrs. Suman Goyal	Scientist 'E', (Sat. Met.), New Delhi	4408	011-24626019
Shri S. L. Singh	Scientist 'E', (ISSD), New Delhi	4314	
Shri B. P. Yadav	Scientist 'E', (NWFC), New Delhi	4398	011-24629798
Dr. M. Mohpatara	Scientist 'E', (CWD), New Delhi	4385	011-24652484
Dr. R. K. Datta	Scientist 'E', (Radar Lab.), New Delhi	4224	011-24632234
Dr. G. Krishna Kumar	Scientist 'E', (NDC), Pune		020-25530992
Dr. J. Rajendra Kumar	Scientist 'E', (AMO), Palam, New Delhi		011-25654335
Shri S. C. Bhan	Scientist 'E', (DGM Sectt.), New Delhi	4513	011-24611710
Shri Suresh Chand	Scientist 'E', (CPU), New Delhi	4236	011-24698247
Dr. Hari Singh	Scientist 'E', (Finance), New Delhi	4487	011-24697640

Shri Shiv Ganesh	Scientist 'E' (IT), New Delhi	4549	
Shri Vivek Sinha	Scientist 'E' (CAMD), New Delhi	4442	011-24625547
Shri S. B. Tyagi	Scientist 'E' (Vigilance), New Delhi	4254	011-24652318
Shri R. P. Lal	Scientist 'E', F. O. & Planning, N. Delhi	4502	011-24623210
Shri U. P. Singh	Director (Publication), New Delhi	4262	011-24651287
Shri Sanjay Bist	Director (Admn.), New Delhi	4204	011-24602480
Caretaker, Mausam Bhawan	-	4372	
Guest House (H.Q.)	-	4472	

New Exchange – Airtel Telephone

Dialing from Delhi : 4382XXXX

Dialing from outside Delhi : 011 4382XXXX

Where XXXX stands for 4 digit EPABX number

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

Website : www.mausam.gov.in

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इस cyclone में Technology का बहुत ही Perfect उपयोग हुआ, पहले दिन से ही। इस cyclone में मौसम विभाग ने Technology का बखूबी उपयोग किया और 6 तारीख से ही ये संकेत दे दिए गए थे। जो अनुमान थे, उतनी ही Velocity रही। जो दिशा थी अनुमानित, वही दिशा रही। जो अनुमानित Time था, वही Time रहा और एक प्रकार से इस संकट से बचने में ये Technology का उपयोग भी काफी काम आया।

"Prime Minister of India"
(PMO website - 2014)

भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

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