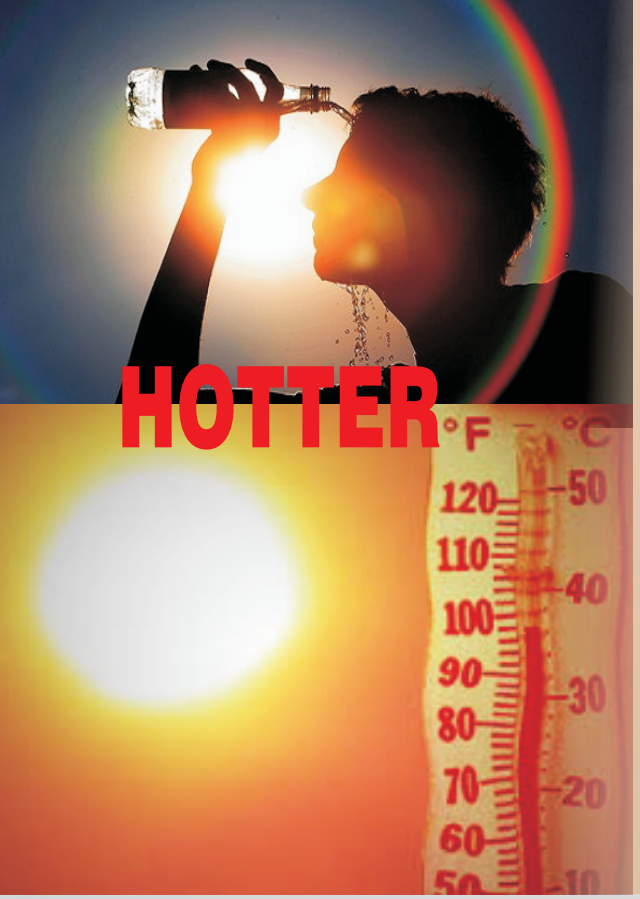


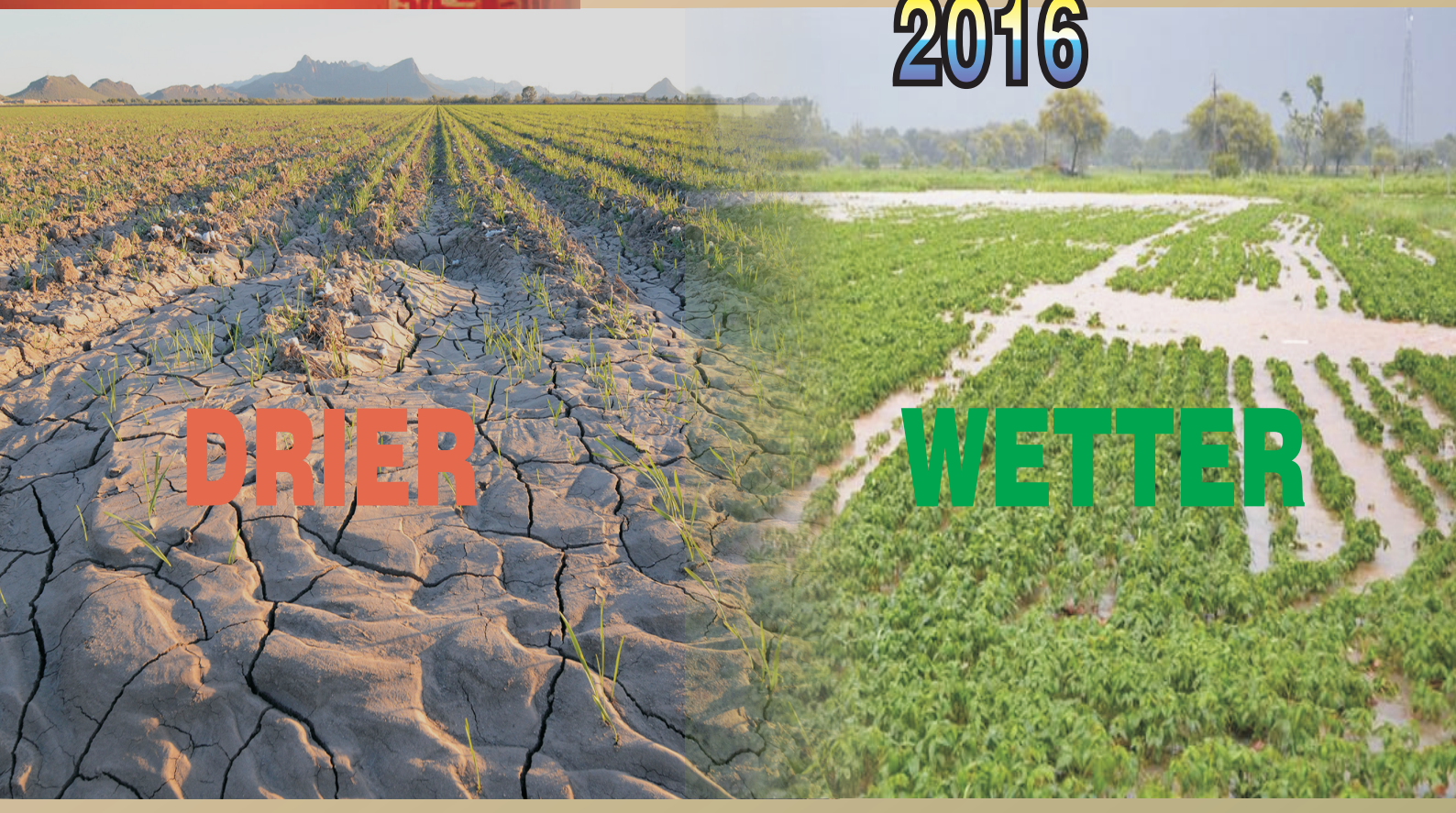
सत्यमेव जयते

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT
आदित्यात् जायते वृष्टिः

वार्षिक प्रतिवेदन

ANNUAL REPORT

2016



भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

पृथ्वी विज्ञान मंत्रालय, भारत सरकार

Ministry of Earth Sciences, Govt. of India

Annual Report 2016

Compiled and Edited

by

Publication Section
India Meteorological Department,
New Delhi – 110 003 (India)
Phone : 91 – 11 – 24651287
Email : mausamps@gmail.com

वार्षिक प्रतिवेदन

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2016

INDIA METEOROLOGICAL DEPARTMENT

(MINISTRY OF EARTH SCIENCES, GOVT. OF INDIA)

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

TELEFAX : 91-11-24623220

Website : www.imd.gov.in

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by

Publication Section
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Phone : 91 – 11 – 24651287
Email : mausamps@gmail.com

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Dialing from outside Delhi : 011 4382XXXX

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

Website : www.mausam.gov.in

www.imd.gov.in

Toll Free Number : 1800-180-1717

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Appointment of Director General of Meteorology

Dr. K. J. Ramesh, DGM

Dr. K. J. Ramesh an eminent Scientist has taken over the charge of DGM from 1st August, 2016 after superannuation of Dr. L. S. Rathore on 31st July, 2016. Dr. Ramesh has got his Ph. D. in Monsoon Dynamics from Indian Institute of Technology, Delhi. His areas of specialization include Numerical Weather Prediction, Weather Forecasting, Hazard and Climate Risk Assessment and Early Warning. Prior to assuming the charge of DGM, Dr. Ramesh was working as an Adviser in Ministry of Earth Sciences since 2007. Dr. Ramesh has also worked as Group Head in NCMRWF (Department of Science and Technology) and as Technical Head, Disaster Management Unit, Government of Andhra Pradesh. Dr. Ramesh has wide experience in Meteorological Research and has more than fifty reviewed research publications in national and international scientific journals. His scientific visions, leadership qualities and administrative abilities will take the department to new heights.

FOREWORD

It gives me immense pleasure to bring out the Annual Report of India Meteorological Department (IMD) for the year 2016. The report highlights significant activities of the department during the year. The department has been playing a leading role in the field of Earth and Atmospheric Sciences by providing efficient services in meteorology and contributing to safety of life and property. By all means this contribution is a major towards the cause of national development.

The celebration of IMD's Foundation Day on 15th January, has provided ample opportunity to commemorate past glory and a reflection of the future vision. The Department's progressive strides towards modernization of scientific infrastructure in the fields of meteorological observations and information systems has helped to render better services in areas of agriculture, aviation, shipping, fisheries, energy and transport. Numerical Weather Predictions has established its credibility in giving medium and short range forecasting of severe weather phenomenon like cyclones, heavy rains, thundershower, cold and heat waves.

During 2016, IMD achieved some significant milestones like operational implementation of coupled modelling system for the extended range forecast and also the implementation of very high resolution global model for short to medium range weather forecasts. In addition, the creation of Climate Research and Services in Pune by combing different offices in Pune is another significant achievement of the department to enhance the quality of climate services to different users.

IMD has continued its efforts for the improvement of observing, warning and dissemination systems all through 2016. Its improved services rendered in respect of very short (up to 6 hrs), short (up to 3-days in advance), medium (up to 7-10 days in advance), extended (up to 15 to 20 days in advance), long (monthly and seasonal) range and severe weather (cyclones, thunderstorms, extreme rainfall) forecasts have been built to meet the demands of the user agencies, disaster managers, emergency response groups and other stakeholders in an organized manner.

Though the mega El-Nino event of 2015 declined gradually from the early summer of 2016, its impact lingered over the Indian region during the first half of the year. The winter turned out to be a mild one, with less cold wave occurrences. However, the global trend of above normal temperatures into the hot weather season of 2016 extends to India also. Severe heat waves occurred over major parts of India during April & May. A number of stations broke their previous records of highest maximum temperatures, which include the temperature reported by Phalodi in western part of Rajasthan as 51.0 °C on 19th May, 2016.

The severity of heat waves remained at par with or even more severe than that in 2015, the death toll as reported had been less (480) than that (2200) in 2015.This could be attributed to the advance warnings issued in the form of summer temperature outlook (a fresh initiative of IMD this year) and both extended and medium range forecasts with timely updates. Location specific heat index forecasts were also introduced during 2016. I take this opportunity to appreciate the scientists of IMD for their efforts to support the endeavour.

It is also important to note that IMD developed Wind Chill Temperature Application and implemented it w.e.f 15th February 2016. The damage from Cyclonic Storms remained to be minimum this year, as 3 out of 4 systems re-curved or weakened over the Sea before landfall and only one cyclone crossed the India coast.

The DWRs are commissioned by MoES-IMD at Goa, Karaikal and Paradeep and through joint efforts with ISRO, Indigenously developed DWRs are also commissioned at Cherrapunjee, Bhuj, Gopalpur and Trivendrum. Augmentation in DWRs network will definitely enhance the accuracy of nowcast of concerned areas.

It is noteworthy that IMD has set up a countrywide network of 25 nos. GPS stations for measurement of integrated precipitable water vapor (IPWV) which will enhance the capability for now- casting and assimilation of these data in NWP models and will improve the weather forecasting.

In 2016, instruments of Dust Storm and Fog Monitoring system has been straightened at airports of north India when, IMD has commissioned three more Drishti RVR at IGIA Delhi, one each at Amritsar, Jolly Grant Airport Dehradun and Varanasi, while Lucknow and Jaipur have three new each such new Indigenous Dristhi RVR commissioned in this year.

A film entitled "Glorious Decade (2006-16) of IMD" highlighting the achievement of IMD during last 10 years was produced by Pulse Media Pvt. Ltd. for IMD

Dissemination of agromet advisories to the farmers through different multi-channel system of All India Radio (AIR) and Doordarshan, private TV and radio channels, newspaper and internet, SMS and IVR (Interactive Voice Response Technology) etc. is being made on wider scale. In addition to above Crop Specific Weather based Agromet Advisories' for the country on daily basis are being telecasted through DD Kisan Channel, on real time in programs like 'Kisan Samachar' and 'Mausam Khabar' in Hindi and in regional languages of Gujarati, Marathi, Malayalam and Tamil.

A large number of Workshops, Symposia and Conferences were organized this year by covering such diverse themes as Sustainable Development, Aviation Meteorology, Heat Wave, Tropical Storm and Local Severe Storm Forecasting, Agriculture meteorology etc. The user community was engaged in dialogue by conducting user's seminars during the year. The Annual Report makes an interesting reading on the plethora of activities pursued in this Department in this vibrant area of science.

In conclusion, I am availing this opportunity to thank all the members of IMD for their true dedication and strive to further enhance the reputation of the department with strong national and international credibility. My special thanks to Dr. D. R. Pattanaik and his team of publication unit for their sincere efforts in compilation, editing and publication of this annual report.

Dr. K. J. Ramesh

Director General of Meteorology

IMD ORGANIZATION CHART

INDIA METEOROLOGICAL DEPARTMENT

MINISTRY OF EARTH SCIENCES

GOVT. OF INDIA

Dr. Harsh Vardhan
Hon'ble Union Minister
of Science & Technology
and Earth Sciences

Shri Y. S. Chowdary
Hon'ble Minister of State of
Science & Technology
and Earth Sciences

Dr. Madhavan Nair Rajeevan
Secretary,
Ministry of Earth Sciences,
Chairman, ESSO and Chairman,
Earth Commission

Dr. K. J. Ramesh
Director General of Meteorology
India Meteorological Department

Divisional Heads

Dr. M. Mohapatra, Scientist 'G' / Head
(Services)

Dr. S. K. Peshin, Scientist 'G'
(Satmet)

Dr. S. K. Roy Bhowmik, Scientist 'F'
(Administration & Store and NWP)

Shri S. L. Singh, Scientist 'F'
(Information System & Services Division)

Dr. (Smt.) Surinder Kaur, Scientist 'F'
(Hydrology)

Shri K. C. Saikrishnan, Scientist 'F'
(UAI)

Dr. K. K. Singh, Scientist 'F / HEAD
(Agromet Services)

Dr. R. Suresh, Scientist 'F'
(Central Aviation Meteorology Division)

Shri R. K. Giri, Scientist 'F'
(Organisation)

Dr. D. R. Pattanaik, Scientist 'E' / Head
(HRD & Publication)

Shri Manik Chandra, Scientist 'E'
(Procurement)

Dr. V. K. Soni, Scientist 'E' / Head
(Environment Monitoring & Research Centre)

Regional Administrative & Technical Heads

Dr. Devendra Pradhan, Scientist 'G'
(RMC, New Delhi)

Shri S. B. Thampi, Scientist 'F'
(RMC, Chennai)

Shri K. S. Hosalikar, Scientist 'F'
RMC, Mumbai)

Dr. S. Bandyopadhyay, Scientist 'E'
(RMC, Kolkata)

Shri J. Rajendra Prasad, Scientist 'E'
(RMC, Nagpur)

Dr. Sanjay Oneill Shaw, Scientist 'E'
(RMC, Guwahati)

CRS, Pune office - Dr. A. K. Sahai,
Scientist 'G'

CHAPTER 1

INDIA METEOROLOGICAL DEPARTMENT-OVERVIEW

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

It's mandate is:

- To take meteorological observations and to provide current and forecast meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc.

- To warn against severe weather phenomena like tropical cyclones, norwesters, duststorms, heavy rains and snow, cold and heat waves, etc., which cause destruction of life and property.

- To provide meteorological statistics required for agriculture, water resource management, industries, oil exploration and other nation-building activities.

- To conduct and promote research in meteorology and allied disciplines.

- To detect and locate earthquakes and to evaluate seismicity in different parts of the country for development projects.

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

From a modest beginning in 1875, IMD has progressively expanded its infrastructure for meteorological observations, communications, forecasting and weather services and it has achieved a parallel scientific growth. IMD has always used contemporary technology. In the telegraph age, it made extensive use of weather telegrams for collecting observational data and sending warnings. Later IMD became the first organization in India to have a message switching computer for supporting its global data exchange. One of the first few electronic computers introduced in the country was provided to IMD for scientific applications in meteorology. India was the first developing country in the world to have its own geostationary satellite, INSAT, for continuous weather monitoring of this part of the globe and particularly for cyclone warning. IMD has continuously ventured into new areas of application and service, and steadily built upon its infra-structure in its history of 142 years. It has simultaneously nurtured the growth of meteorology and atmospheric science in India. Today, meteorology in India is poised at the threshold of an exciting future.

India had some of the oldest meteorological observatories of the world and the first astronomical and meteorological unit started at Madras in 1793. Thus, meteorological observation in India was taken even prior to the establishment of the department in 1875. Since then IMD has achieved many milestones during the period from 1793 to 2016.

INDIA METEOROLOGICAL DEPARTMENT

Milestones (1793-2016)

1793 — India has some of the oldest Meteorological Observatories of the world.

First Astronomical and Meteorological Unit started at Madras in 1793.

1875 — All meteorological work in the country was brought under a central authority with the establishment of IMD.

First Headquarters-The Alipore Office at Calcutta, started in 1875.

1878 — Advent of telegraphy enabled centralised data reception and publication of the Indian Daily Weather Report (IDWR) since 1878.

The first weather charts were printed in the IDWR in 1887.

1882 — Seismological activity started in India with the establishment of the first observatory at Alipore, Calcutta.

Seismogram of the disastrous Quetta Earthquake, 1935.

1886 — First Long Range Forecast of Monsoon was issued

1905 — Upper air measurements of winds started in 1905 by the method of tracking balloons with theodolites.

The launching of the Pilot Balloon.

1932 — A separate division was created in 1932 for research activities in the field of Agricultural Meteorology.

The first field unit at Pune.

1954 — Radars were pressed into aviation weather service as early as 1954.

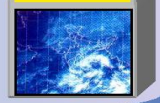
First Cyclone Detection Radar was installed at Vishakhapatnam in 1970.

1957 — Environmental Meteorology took shape in India with the first Ozone measurements at Kodaikanal in 1957.

The Kodaikanal observatory.

1964 — IMD started receiving satellite images from US Satellites in 1964.

Image received from India's own satellite INSAT.



1969 — Meteorological training facilities were created in 1942 and in 1969 upgraded to a Directorate.

A training class at the Central Training Institute in Pune.

1970 — Directorate of Telecommunication was set up in 1970 to rapidly exchange information amongst various centres.

The maze of current communication network.

1973 — The Telecom age ushered in the prospects of global data assimilation and numerical weather forecasting.

View of the Northern Hemispheric Analysis Centre, New Delhi

1977 — The National Data Centre at Pune was created in 1977 for scrutinising and archiving all meteorological data in computerised form.

The control room of NDC, Pune.

1982 — INSAT provided a Geo-stationary platform for remote sensing of the atmosphere and automatic data collection.

An unmanned Data Collection Platform.

2002 — Doppler Weather Radars (DWR) inducted in the cyclone detection network which enable precise estimate of intensity of cyclone.

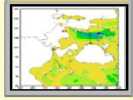
The first DWR was commissioned at Chennai.

2003 — Launch of Meteorological Data and INSAT Imagery through World Space Digital Data Broadcast System.

2006 — The Department took a major initiative to modernize its observational and forecasting infrastructure to deliver a whole range of new services.

Moderization of observing system

2008 — New forecast services were introduced in the country addressing specific needs of individual Districts. It has been specifically designed for providing Agricultural advisories.



2010

2012

- Integrated Forecasting & Communication System (IFCS)
- Setting up of National Weather Forecasting Centre (NWFC) at Delhi
- Operational global model
- Operational extended range forecast
- Nowcasting

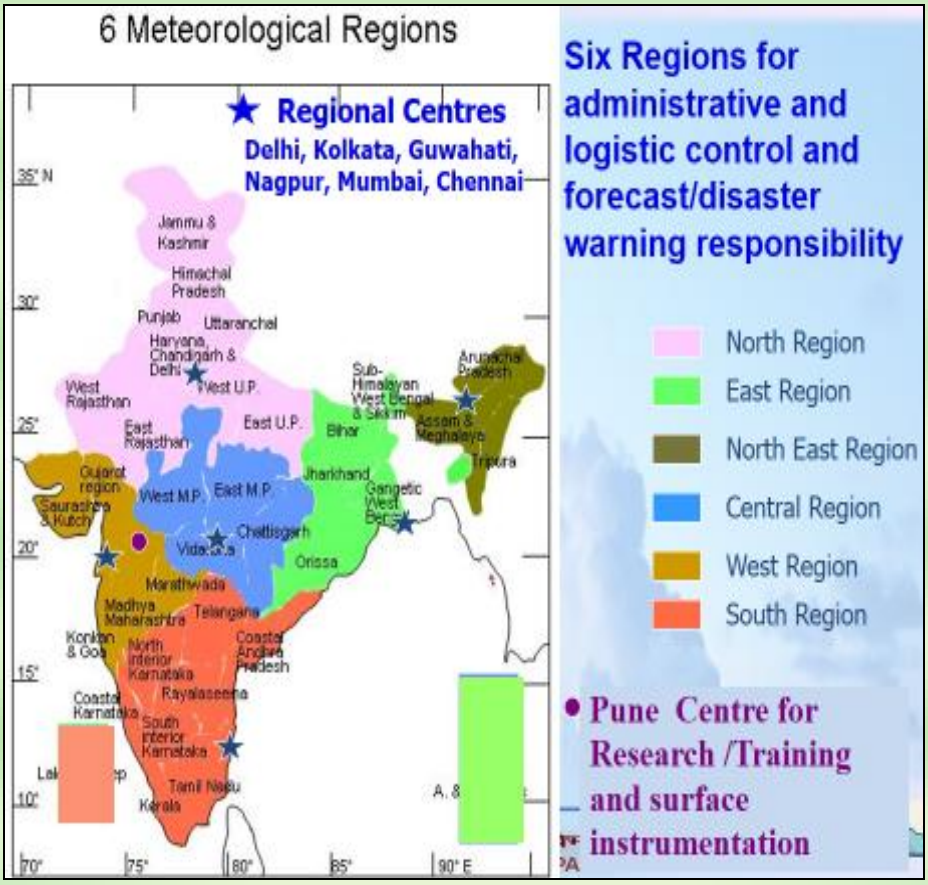
2016

- Agromet advisories through SMS to 3.3 million farmers.
- Nowcasting of Thunder-storms over 117 cities
- ISO 9001-2008 certification to (i) Met. services of IGI airport (ii) Met. centre Hyderabad , (iii) DWR Palam, (iv) RS/RW Aaya Nagar and (v) Synoptic station at Safdarjung, New Delhi

Operationalization of Coupled modeling system for extended range forecast. High resolution global model (≈ 12 km) for medium range forecast.
Creation of Climate Research and Services (CRS) by combining different IMD offices at Pune.

In service of the Nation since 1875

The Director General of Meteorology is the Head of the India Meteorological Department, with headquarters at New Delhi. For the convenience of administrative and technical control, there are 6 Regional Meteorological Centres, each under a Deputy Director General with headquarters at Mumbai, Chennai, New Delhi, Kolkata, Nagpur and Guwahati. Under the administrative control of Deputy Director General, there are different types of operational units such as Meteorological Centres, Forecasting Offices, Agrimet. Advisory Centres, Flood Meteorological Offices and Cyclone Detection Radar Stations.



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

India Meteorological Department has continued its efforts for the improvement of observing, warning and dissemination mechanism/systems all through 2016. Its improved services rendered in respect of very short (up to 6 hrs), short (up to 3-days in advance), medium (up to 7-10 days in advance), extended (up to 15 to 20 days in advance), long (monthly and seasonal) range and severe weather (cyclones, thunderstorms, extreme rainfall) forecasts have been built to meet the demands of the user agencies, disaster managers, emergency response groups and other stakeholders in an organized manner in 2016. Its short, medium and long range and cyclone forecasts were appreciated all over the world.

Recently, the World Meteorological Organisation (WMO), in its provisional statement on the status of Global Climate in 2016, stated that this is very likely to be the hottest year on record, globally, with the average temperatures even higher than the record breaking value in 2015. Like over the globe warmer than normal conditions prevailed over India as well. Though the mega El-Nino event of 2015 declined gradually from the early summer of 2016, its impact lingered over

the Indian region during the first half of the year. The winter turned out to be a mild one, with less cold wave occurrences. Continuing this trend of above normal temperatures into the hot weather season, severe heat waves occur over major parts of India during April & May. A number of stations broke their previous records of highest maximum temperatures, which include the temperature reported by Phalodi in western part of Rajasthan as 51.0 °C on 19th May, 2016. A rather sluggish advance of southwest monsoon led the severity of heat waves to extend into June as well. The drought affected regions of past 2 deficient monsoon years continued to be under water stress during June. However, the above normal rainfall activity in the rainiest month of July turned this year's southwest monsoon to be a beneficial one. Arid regions of Maharashtra, over the north and central parts of peninsular India, which had been undergoing drought situation for the past consecutive 3 years, witnessed flood situations during the withdrawal phase of southwest monsoon during October, causing loss of human lives, live stokes and damage to Khariff crops. Northeastern states, especially Assam had been another region which suffered losses due to floods. Northeast monsoon rainfall activity remained highly subdued in October & November; with the southern states which are its major beneficiaries receiving lowest rainfall ever since 1901. End of November and beginning of December also saw that parts of northwest India, including the national capital, getting covered under a blanket of smog, largely due to stubble burning which was aggravated by the prevailing wind pattern and stable atmospheric conditions. The damage from Cyclonic Storms remained to be minimum this year, as 3 out of 4 systems re-curved or weakened over the Sea before landfall and only one cyclone crossed the India coast. Though the severity of heat waves remained at par with or ever more severe than that in 2015, the death toll as reported had been less (480) than that (2200) in 2015.This could be attributed to the advance warnings issued in the form of summer temperature outlook (a fresh initiative of this year) and both extended and medium range forecasts with timely updates. Location specific heat index forecasts also were introduced from this year onwards.

SUMMARY OF MAJOR ACHIEVEMENTS IN 2016

- The DWRs are commissioned by MoES-IMD at Goa, Karaikal and Paradeep and through joint efforts with ISRO, Indigenously developed DWRs are also commissioned at Cherrapunjee, Bhuj, Gopalpur and Trivendrum and it is under process at Cochi.

- In 2016, instruments of Dust Storm and Fog Monitoring system has been straightened at airports of north India when, IMD has commissioned twelve indigenously developed three more Drishti RVR at IGI Airport Delhi, one each at Amritsar, Jolly Grant Airport Dehradun and Varanasi while Lucknow and Jaipur have three new each such new Indigenous Dristhi RVR commissioned in this year.

- Four GPS based Solar Trackers at Chennai, Thiruvananthapuram, Visakhapatnam and Shillong installed.

- IMD has 47 snow gauge stations over Jammu & Kashmir, Himachal Pradesh and Uttaranchal. Hydromet Division, Pune is keying, processing and archiving these snowfall data. Snowfall data from Himachal Pradesh, Uttarakhand and Jammu & Kashmir (2011 to 2015) has been received and processed during 2016.

- Installation of UV-B Radiometer at Lakshdweep Island stations (Amini & Minicoy).

- Installation of GPRS modem at Anand, Minicoy and Amini.
- Installation of Diffuse shading ring assembly at Anand, Amini, Port Blair and Jaisalmer.
- New acrylic protection box for Radiation receiving system at Jaisalmer, Jaipur and Jodhpur.
- Installation of Fiber door for control Unit of Solar Tracker at RS/RW Jodhpur.
- Calibration of Radiation sensors at Anand, Jaisalmer, Jodhpur and Port Blair.
- High Wind Speed Recorder (HWSR) station installed at Machilipatnam in January, 2016 at Naliya (Gujarat) & Safdarjung (New Delhi) in March 2016. HWSR stations installed at Balasore, Puri, Digha and Paradeep have been revived during March 2016.
- Two new Current Weather Instrument System (CWIS) installed and commissioned at Runway 12 and Runway 30 at Chennai airport in March 2016.
- Total 138 nos. of Digital Station Barometers installed at observatories.
- IMD has installed 682 Automatic Weather Stations (AWS) and other agencies have installed about 1200 AWS all over the country.
- IMD has also installed 58 Automatic Rain Gauge (ARG) Stations.
- IMD has evaluated 51 Thermal Power, 609 Industrial, 81 Coal Mine and 488 Mining projects referred to IMD by Ministry of Environment and Forests during 2016.
- Black Carbon Monitoring Network of 16 stations (New Delhi, Ranichauri, Varanasi, Nagpur, Pune, Port Blair, Visakhapatnam, Guwahati, Kolkatta, Jodhpur, Bhuj, Trivandrum, Ranchi, Amini, Chandigarh and Srinagar) for measurement of Spectral Aerosol Absorption Coefficient and Equivalent Black Carbon Concentration has been established during 2016.
- Operational implementation of coupled modeling system at IMD HQ based on a suite of models from CFSv2 coupled model at different resolutions (CFSv2_T382; CFSv2_T126; GFSbc_T382; GFSbc_T126) for the extended range forecast.
- Operational implementation of Global Forecasting System (GFS Version 13.0.3) at T1534L64 resolution and 06 hourly cycle of Global Data Assimilation System (GDAS) in AADITYA HPCS at IITM Pune for day-to-day operational run.
- Creation of Climate Research and Services (CRS) in Pune by combining its offices.
- A film entitled “Glorious Decade (2006-16) of IMD” highlighting the achievement of IMD during last 10 years was produced by Pulse Media Pvt. Ltd. for IMD.
- 25 ground-based Global Navigation Satellite System (GNSS) receivers collocated with Meteorological sensors all over India for real-time monitoring of total water vapour content in the atmosphere at 10 min intervals.
- 71 Research Papers/books/Met. monographs published.

Chapter 2

Weather Summary during 2016

1. Winter Season (January & February)

Cold Wave conditions

Cold wave conditions were rather moderate during the January. Severe cold wave/cold day conditions prevailed over parts of north, central and adjoining parts of peninsular India only during fourth week (21-27 January) of the January. Moderate or dense to very dense fog prevailed at isolated, few or many places over the plains of northern India almost throughout the month. Dense/moderate foggy conditions prevailed at isolated places over northern and eastern parts of the country almost throughout February. During 2nd week of February, dense to very dense fog occurred at isolated placed of north Rajasthan, Punjab, Delhi and West Uttar Pradesh. During 4th week, very dense fog occurred at isolated places over Haryana, north Rajasthan and Punjab.

Rainfall Features

Rainfall activity over the country as a whole was below normal during the season. It was below normal during both the months of the season (41% of Long Period Average (LPA) during January and 46% of LPA during February). Adjoining subdivisions of South Interior Karnataka and Rayalaseema, subdivisions of Gangetic West Bengal, NMMT (Nagaland, Manipur, Mizoram, Tripura) and the islands of the country in general received excess/normal rainfall, while rest parts of the country received deficient/scanty rainfall. During the season, out of 36 meteorological subdivisions, 3 received excess rainfall, 3 received normal rainfall, 11 received deficient rainfall, 16 sub-divisions received scanty rainfall and remaining 3 sub-divisions received no rain (Fig. 1).

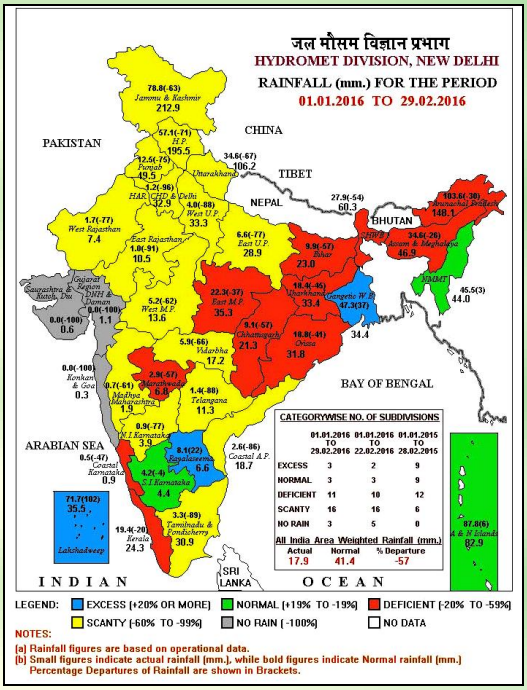


Fig. 1. Meteorological sub-division wise rainfall (mm) during winter season

Northern, central and eastern/northeastern parts of the country in general received more than 20 mm of rainfall. Parts of Jammu and Kashmir, Gangetic West Bengal, Arunachal Pradesh and Assam & Meghalaya received more than 40 mm of rainfall. The rainfall anomaly was negative over most parts of the country. Magnitude of negative rainfall anomaly over parts of South Kerala, Coastal Tamil Nadu and most parts of northern region exceeded 20 mm. Quantitatively, for the winter season 2016, rainfall for the country as a whole was 44% of its LPA value. The rainfall for the season was below normal for all the four homogeneous regions. It was (51.1% of its LPA) over Central India, (32% of its LPA) over

the Northwest India, (74.6% of LPA) over the East & North East India and (33.7% of LPA) over the south peninsula.

Standardized Precipitation Index (SPI)

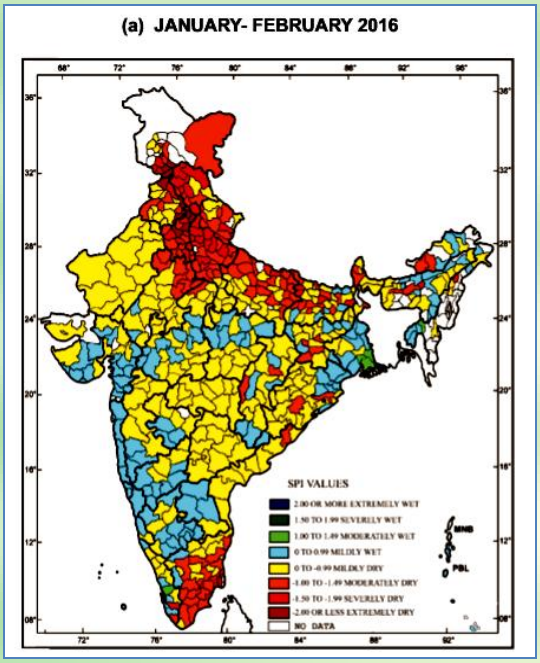
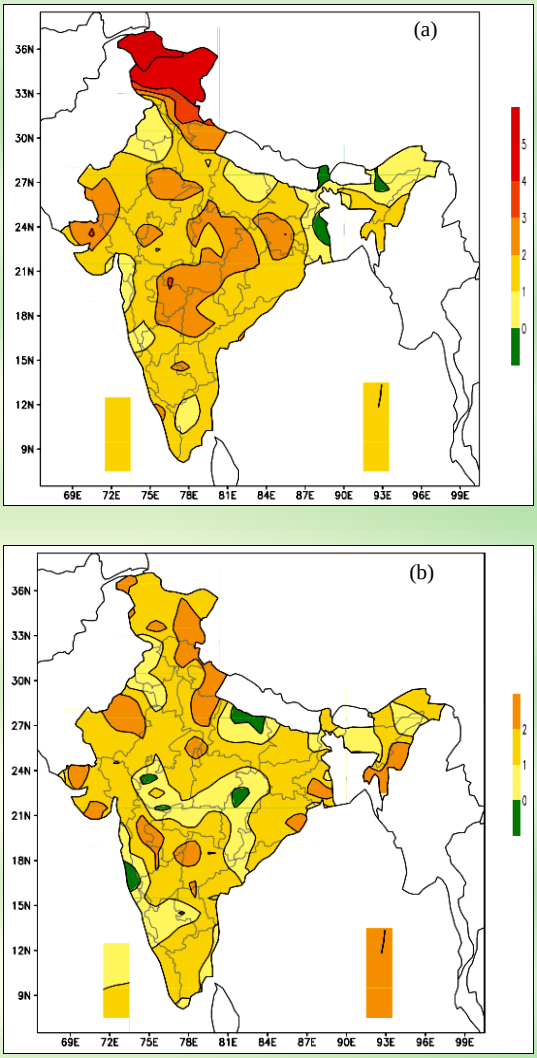


Fig. 2. Standardized precipitation index (SPI) for winter season

The Standardized Precipitation Index (SPI) is an index used for monitoring drought and is based on only precipitation. This index is negative for dry, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. Cumulative SPI values of the two months (January and February) indicate that no part of the country observed extremely wet/severely wet conditions while extremely dry/severely dry conditions were observed over Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Bihar, East Uttar Pradesh, West Uttar Pradesh, Uttarakhand, Haryana, Chandigarh & Delhi, Punjab, Himachal Pradesh, Jammu & Kashmir, Tamil Nadu and Kerala (Fig. 2).

Temperatures anomaly

Mean seasonal maximum and minimum temperature anomalies are shown in Figs. 3(a&b) respectively. Maximum temperature was above normal over most parts of the country except parts of Gangetic West Bengal, Sub-Himalayan West Bengal and

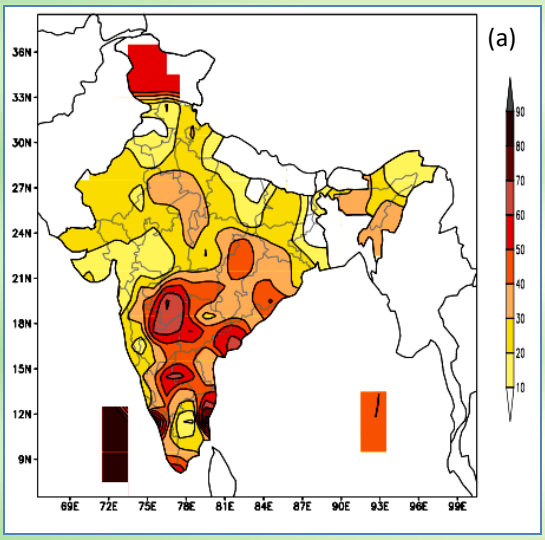


Figs. 3(a&b). Mean seasonal temperature anomaly (°C) (a) Maximum and (b) Minimum for winter season [*Based on 1971-2000 NORMAL(S)*]

Sikkim, Assam and Meghalaya. It was above normal by more than 2 °C over most parts of central India, parts of Gujarat, parts of Rajasthan, parts of Jharkhand and extreme northern India. Minimum temperature was above normal over most parts of the country except some parts of Konkan & Goa, East Uttar Pradesh and Chhattisgarh. Over parts of Jammu and Kashmir, Himachal Pradesh, west Uttar Pradesh, Rajasthan, Gujarat, Madhya Maharashtra and of NMMT (Nagaland, Manipur, Mizoram and Tripura), it was above normal by about 2 °C.

Warm days/cold nights

Figs. 4(a&b) show the percentage of days when maximum (minimum) temperature was more (less) than 90th (10th) percentile. Over parts of Jammu & Kashmir and peninsular India maximum temperature was greater than 90th percentile for more than 50% of the days of the season and over parts of Lakshadweep Islands, it exceeded 80%. For minimum temperature, no significant distribution was observed.



Figs. 4(a&b). Percentage of days when (a) maximum temperature >90th percentile for warm days (b) minimum temperature < 10th percentile for cold nights

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood is shown in Fig. 5. OLR

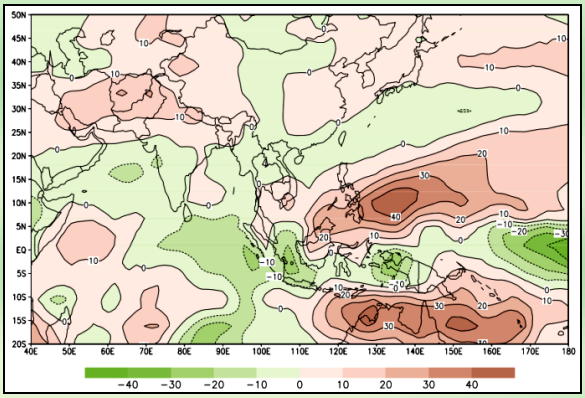


Fig. 5. OLR Anomaly (W/m^2) for the winter season 2016 (*SOURCE : CDC / NOAA, USA*)

anomaly was positive over northern and northeastern parts of the country and was of the order of 10-20 Watts/m^2. However, over central India and south peninsular India negative OLR anomaly of the order of 0 to 10 Watts/m^2 was observed.

2. Pre-Monsoon Season (March-April-May)

Heat wave conditions were initially observed over the central and adjoining western/ northwestern parts of the country from last week of the March to first week of April (24th March to 4th April). These conditions prevailed over most parts of eastern India during the second week of April. As the season progressed, the severity and extent of heating increased during the third week of April resulting in the establishment of severe heat wave conditions over parts of north and eastern India. These conditions continued to prevail over east India and also spread over parts of south India during the next week. During the last few days of April and first fortnight of May, heat wave conditions were observed only at isolated places on some occasions over Parts of Rajasthan, Punjab, Odisha, Bihar, Gangetic West Bengal and Kerala.

Severe heatwave/heatwave conditions again developed and intensified over parts of northwest India since 15th May and spread over parts of central and north peninsular India till 22nd May. Jammu & Kashmir, West &

East Rajasthan, West & East Madhya Pradesh and Vidarbha were especially affected by heat wave during this period. Heat wave conditions gradually abated from most parts of the country after 23rd May and prevailed only at isolated places over parts of Coastal Andhra Pradesh and Telangana during last few days of the season.

Rainfall features

Rainfall activity over the country during the season as a whole was normal (99.8% of LPA value). It was normal during March and May (99% and 107% of LPA respectively) and below normal during April (81% of LPA). Many sub divisions of western India, Odisha and the Islands received deficient/scanty rainfall,

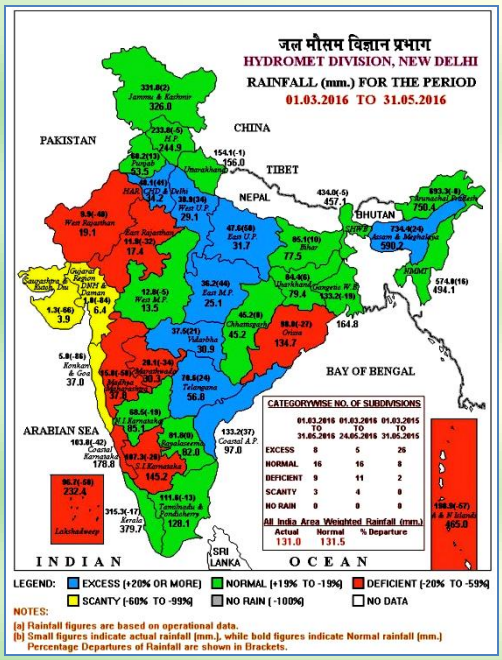


Fig. 6. Meteorological sub-divisionwise rainfall (mm) during pre-monsoon season

while rest of the country received excess/ normal rainfall. Some subdivisions of north, central and peninsular India, *viz*., East & West Uttar Pradesh, Haryana, Chandigarh & Delhi, East Madhya Pradesh and Coastal Andhra Pradesh received about one and half times of their respective normal rainfall. During the season, out of 36 meteorological subdivisions, 8 received excess rainfall, 16 received normal rainfall, 9 received deficient rainfall and 3 received scanty rainfall (Fig. 6).

The spatial pattern of rainfall (mm) received during the season is shown in Fig. 7(a). Except for western and adjoining central region, most parts of the country received rainfall of about 50 to 200 mm. Parts of Jammu & Kashmir, Himachal Pradesh, Bihar, Coastal Andhra Pradesh, Kerala and Andaman & Nicobar Islands received rainfall about 200 to 400 mm. Western parts of Jammu & Kashmir received more than 400 mm of rainfall, while most parts of extreme northeastern region of the country received more than 600 mm of rainfall. Positive rainfall anomaly of about

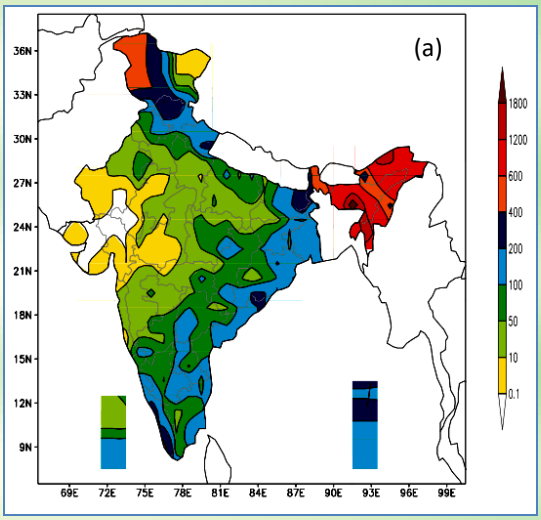


Fig 7 (a). Seasonal rainfall (mm)

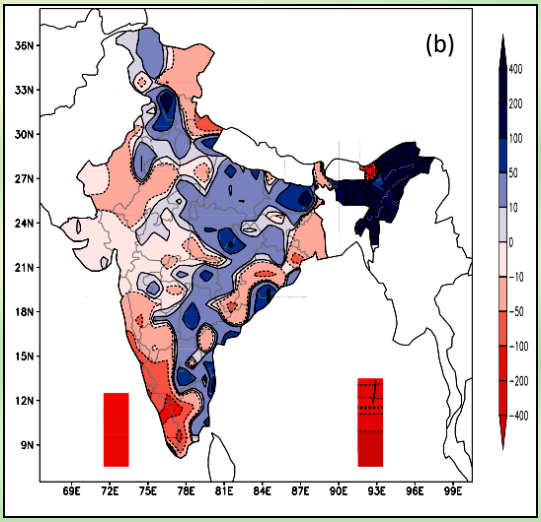


Fig. 7 (b). Seasonal rainfall anomaly (mm) [*Based on 1951-2000 NORMALS*]

50 to 100 mm was observed over parts of Himachal Pradesh, Punjab, Bihar, East Madhya Pradesh and adjoining Chhattisgarh, Telangana, Rayalaseema and parts of east coast. Over most parts of extreme northeastern region, positive rainfall anomaly was more than 200 mm. Negative rainfall anomaly of about 50 to 100 mm was observed over parts of southwest peninsula *viz*. Konkan & Goa, Coastal Karnataka, South Interior Karnataka, Kerala and Tamil Nadu while, that over parts of Kerala, Tamil Nadu and the Islands it exceeded 100 mm [Fig. 7(b)].

Fig. 8 shows the time series of area weighted seasonal rainfall over the four homogeneous

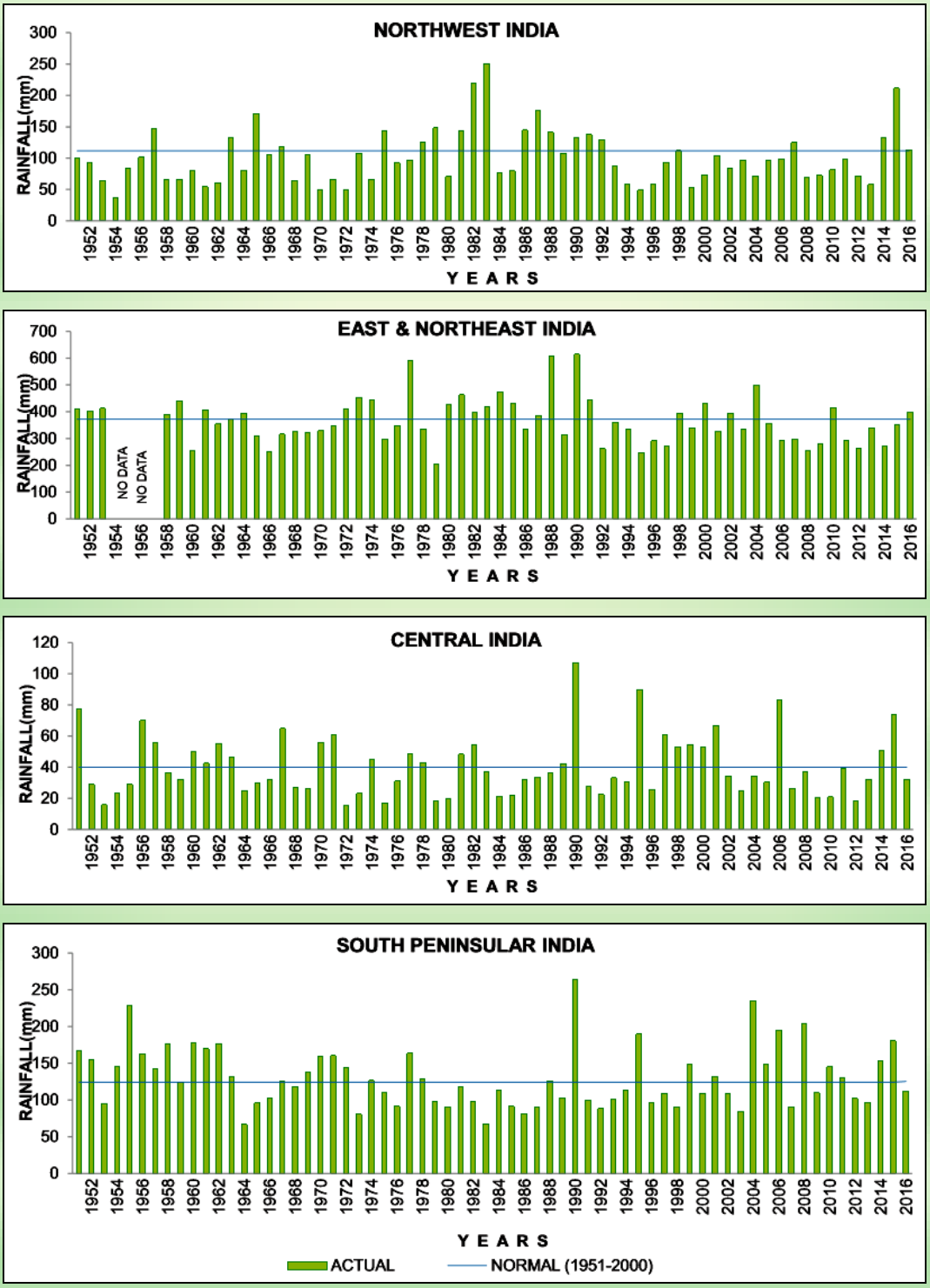
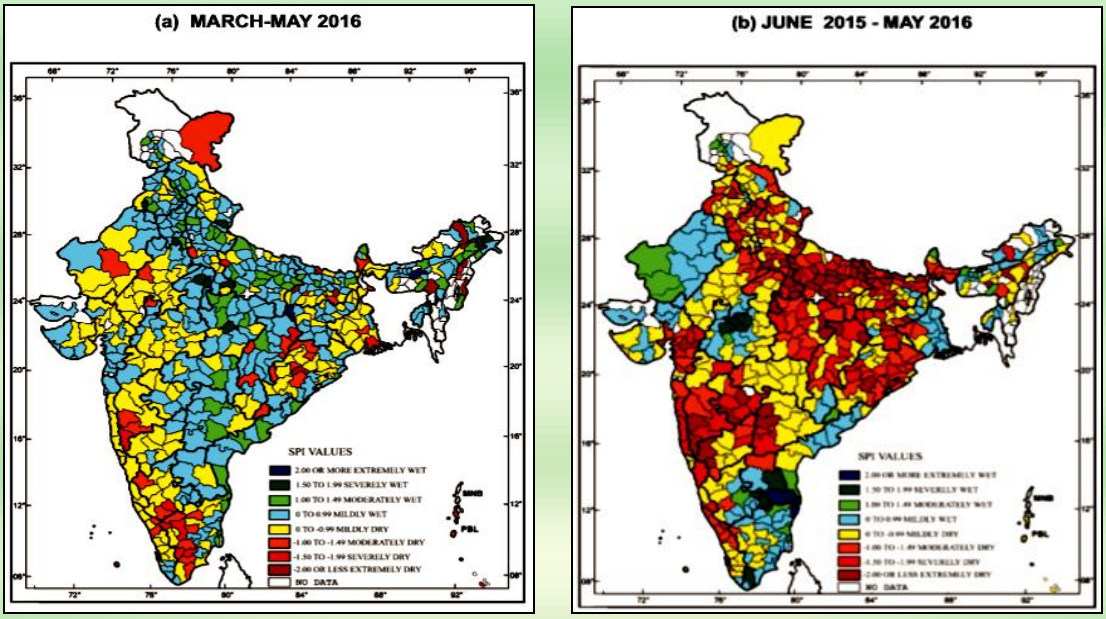


Fig. 8. Time series of area weighted rainfall over the four homogeneous regions (1951 - 2016)



Figs. 9 (a&b). Standardized precipitation index (SPI) for (a) pre-monsoon season (b) since past monsoon season

regions for the period, 1951-2016. During the season this year, East & northeast India, Northwest India and South Peninsular India received normal rainfall (107%, 102% and 90% of their LPA respectively) while, Central India received below normal rainfall (80% of its LPA). The rainfall over East & northeast India (398.3 mm) was the third highest since 2001 [498.4 mm (2004), 414.6 mm (2010)].

Standardized Precipitation Index

Figs. 9(a&b) give the SPI values for the Pre-monsoon season this year and the period from past monsoon season, *i.e.*, June 2015-May 2016 (12 months cumulative) respectively. Cumulative SPI values of the past three months show extremely wet/severely wet conditions over parts of Arunachal Pradesh, Assam & Meghalaya, Tripura, Jharkhand, West Uttar Pradesh, Uttarakhand, Haryana, Chandigarh & Delhi, Punjab, West & East Madhya Pradesh and Tamil Nadu and extremely dry/severely dry conditions over parts of Andaman& Nicober Islands, Arunachal Pradesh, Assam & Meghalaya, Nagaland, Manipur, Gangetic West Bengal, Odisha, Bihar, East Uttar Pradesh, Madhya Maharashtra, Chattisgarh, Tamil Nadu and South Interior Karnataka. Cumulative SPI values of the past twelve months show extremely wet/severely wet conditions over parts of Assam, West Madhya Pradesh, Rayalaseema, Tamil Nadu and South Interior Karnataka and extremely dry/severely dry conditions over parts of Arunachal Pradesh, Assam & Meghalaya, S.H. West Bengal & Sikkim, Odisha, Jharkhand, Bihar, East & West Uttar Pradesh, Haryana, Chandigarh & Delhi, Punjab, Himachal Pradesh, East Madhya Pradesh, Gujarat Region, Konkan & Goa, Madhya Maharashtra, Marathwada, Chhattisgarh, Telangana, Coastal Karnataka, North Interior Karnataka and Kerala.

Temperature anomaly

Mean seasonal maximum and minimum temperature anomalies are shown in Figs. 10(a&b) respectively.

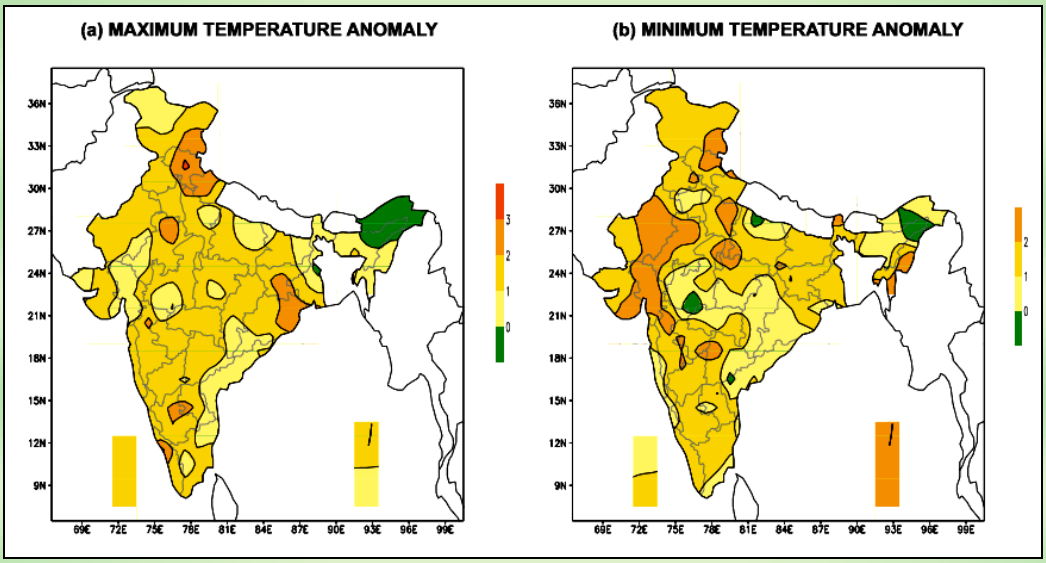
Mean seasonal maximum and minimum temperature anomalies was above normal by about 1 to 2 °C over most parts of the country except for parts of extreme northeastern region and some isolated places. Over parts of Himachal Pradesh, Jammu & Kashmir, Uttarakhand, East Rajasthan, South Interior Karnataka, Kerala, northern parts of Odisha and adjoining Jharkhand, maximum

temperature was above normal by about 2 to 3 °C. Similarly, minimum temperature was above normal by more than 2 °C over parts of Himachal Pradesh, Jammu & Kashmir, West Uttar Pradesh, Rajasthan, Gujarat, north Madhya Maharashtra, Telangana and adjoining areas, Sikkim, Nagaland, Manipur Mizoram & Tripura and Andaman & Nicobar Islands.

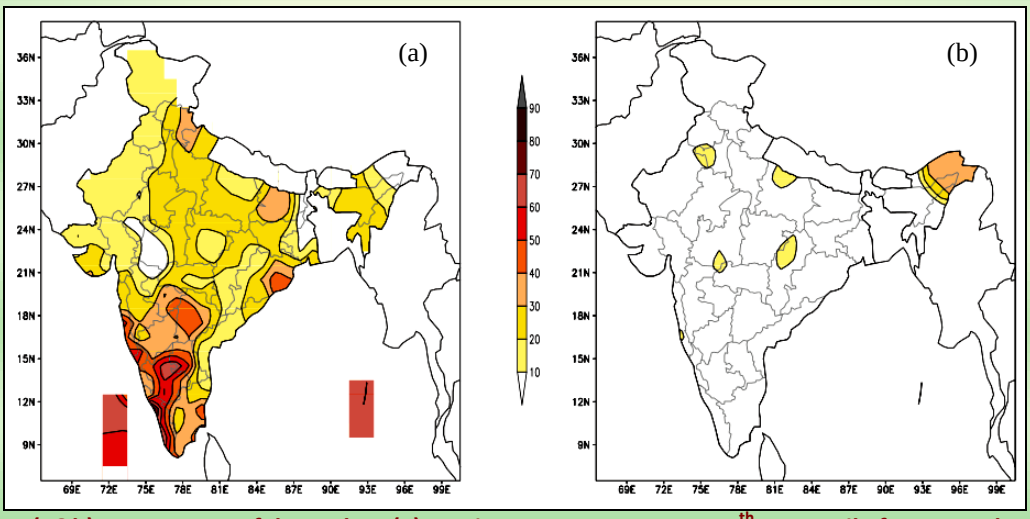
Percentage of Warm days/Cold nights

Figs. 11(a&b) show the percentage of days when maximum (minimum) temperature was more (less) than 90th (10th) percentile. Over parts of peninsula, *viz*., Konkan & Goa, Karnataka, Kerala, Telangana, Rayalaseema, Tamil Nadu, coastal Odisha thand both the islands, maximum temperature was greater than 90 percentile for more than 40 to 70% of the days of the season. Over parts of Arunachal Pradesh and Assam & Meghalaya, minimum temperature was less than 10th percentile for about 30 to 40% of the days of the season.

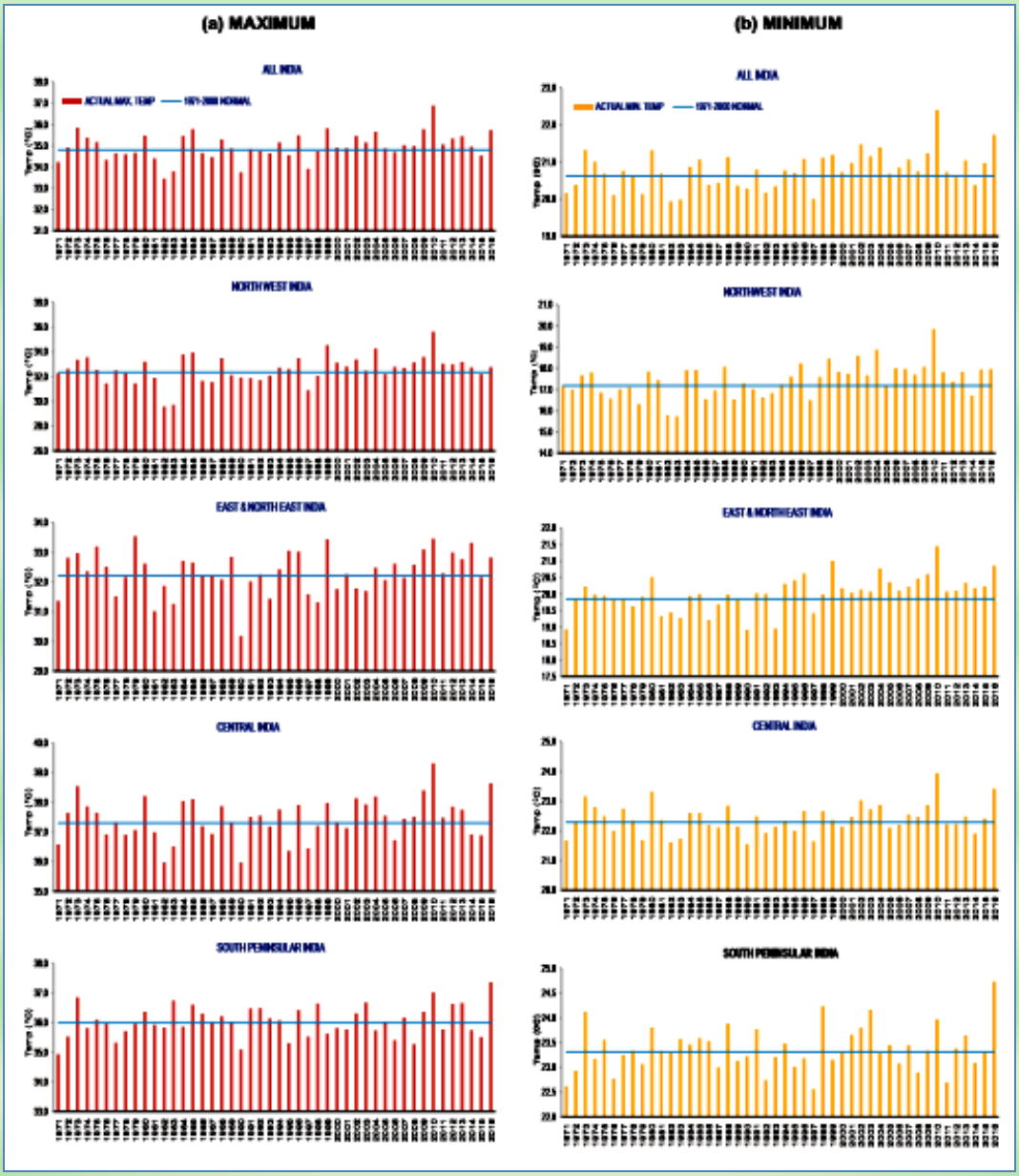
Based on the time series of mean temperature for the country as a whole during the Pre-monsoon season (1971-2016), the mean temperature for the season this year (28.8 °C)



Figs. 10(a&b). Mean temperature anomaly (°C) (a) maximum (b) minimum [*Based on 1971-2000 NORMALS*]



Figs. 11 (a&b). Percentage of days when (a) maximum temperature > 90th Percentile for warm days and (b) minimum temperature < 10th percentile for cold nights



Figs. 12(a&b). Temperature for the country as a whole and the four homogeneous regions (1971-2016)

was above normal by about 1 °C, thus making it the second warmest Pre-monsoon season since 1971. Year 2010 with mean temperature 29.7 °C & anomaly 1.9 °C was the warmest pre-monsoon season since 1971.

Figs. 12(a&b) show the maximum and minimum temperature series respectively for the country as a whole and the four homogeneous regions during the season since 1971. Minimum temperature was above normal by about 1 °C over the all the four homogeneous regions during the season. Maximum temperature was above normal by about 0.5 °C over the homogeneous region of northwest and east & northeast India and by more than 1 °C over the Central and south Peninsular India.

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood is shown in Fig. 13. Negative OLR anomaly exceeding 10 W/m^2 was observed over most parts of Arabian Sea and adjoining Saurashtra & Kutch region, Southern parts of Bay of Bengal and adjoining Tamil Nadu and over parts of Assam &

Meghalaya and Arunachal Pradesh. Over north and south Andaman Sea, positive OLR anomaly exceeding 10-20 W/m^2 was observed.

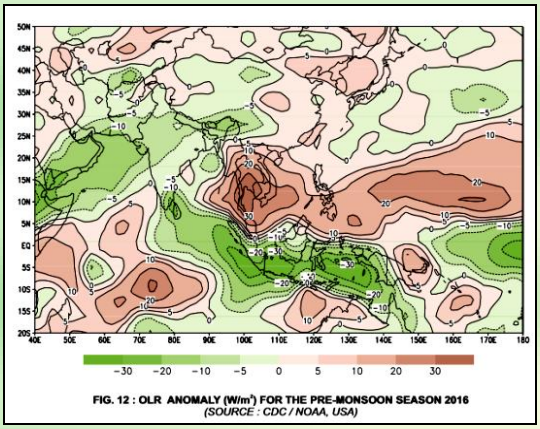


Fig. 13. OLR anomaly (W/m^2) for the pre-monsoon season 2016 [*SOURCE : CDC / NOAA, USA*]

Significant weather events during the season

Snowfall (Avalanche): During the month of March, snowfall claimed 5 lives in Jammu & Kashmir. Affected districts were Kargil, Kupwara and Leh.

Squall: In the month of April & May, Squall claimed 4 lives from Nagaon, Sonitpur and Tinsukia districts of Assam. Several houses & huge amount of standing crop was damaged.

Duststorm: Dust storm claimed total 5 lives from Hardoi, Kanpur, Meerut, Sambhal and Unnao districts of Uttar Pradesh on 23 May. It also caused heavy damage to mango crop, electric poles and other infrastructures.

Heat wave: The most striking feature of the season, *i.e.*, heat wave claimed about 550 lives mostly from central and peninsular parts of the country during the month of April & May. Of these, over 300 deaths were reported from Telangana alone. Over 100 deaths, from Andhra Pradesh, 87 from Gujarat, 43 from Maharashtra, 20 from Odisha and 4 from Kerala.

Lightning: Lightning claimed about 150 lives mostly from central, peninsular and eastern/north-eastern parts of the country. Of these, 49 deaths were reported from Odisha in May, 25 from Madhya Pradesh in March, 21 from Maharashtra, 11 from Karnataka, 9 from Andhra Pradesh, 8 each from Bihar & West Bengal, 6 each from Telangana & Uttar Pradesh, 5 from Rajasthan, 3 from Tamil Nadu, 2 from Tripura and one from Jammu & Kashmir.

Thunderstorm: Thunderstorm activity claimed over 35 lives from central and north-eastern parts of the country during the the season. On 4 May, 7 persons died and 90 others were injured in a Kumbh Mela at Ujjain in Madhya Pradesh. 22 persons died in Assam during the season. Extensive damage to crops & several houses was also reported. Thunderstorm also affected Nagaland claiming 2 lives & damaging more than 1000 houses on 2 May. 2 persons died and 3 others were injured & extensive damage to crops was reported from Bhojpur, Buxar & Purnia districts of Bihar on 14th March.

Hail storm: During the season, 20 persons died due to hailstorm from central and northern parts of the country. Of these, 10 deaths were reported from Bihar on 4 May, 6 from Odisha during May, 3 from Uttar Pradesh on 18 March and the 1 from Madhya Pradesh. Damage to tonnes of grains was reported in New Delhi on 16 March. In Jammu & Kashmir, apple, almond & vegetable crops were extensively damaged during 11-14 May.

Heavy Rain: Rain related incidents claimed over 92 lives from northern, north-eastern and central parts of the country during the season. Total 19 persons died in Assam (Of these, 8 persons died due to heavy rain from Cachar, Charaideo, Dhubri, Dibrugarh, Jorhat, Lakhimpur and Sivsagar districts on 23-24 April. In the same incidence, 86,905 people from 7 districts were affected & damage to cropland over area of 5009 hectares was reported. In another incidence, 11 thpersons died due to land slide from Hailakandi & Karimganj districts of Assam on 17 May). 16 deaths were reported from Chamoli,

Dehradun, Tehri and Uttarkashi districts of Uttarakhand in May, 12 deaths each were reported from Bihar (due to cyclonic circulation) on 18 May and Uttar Pradesh (due to cloud burst) on 29 May. Cloud Burst also thclaimed 5 lives from Shimla (Himachal Pradesh) on 9 May. Landslide due to heavy rains claimed 3 lives in Ramban district of Jammu & Kashmir on 11 May and 3 in Aizwal (Mizoram) on 23 May. Landslide due to heavy rains claimed 17 lives from Tawang district of Arunachal Pradesh 23/24 April.

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

Onset and advance of SW Monsoon

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 monsoon was set in over Kerala on 8th June, 2016 (Fig. 14).

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

Kerala received widespread (>75% of the rain gauge stations) rainfall since 5th June. Out of the 14 rainfall monitoring stations enlisted for declaring the Monsoon onset over Kerala, more than 85% of stations reported 24 hour cumulative rainfall exceeding 2.5 mm for consecutive two days, *i.e.*, on 7th and 8th June (Fig. 14).

The depth of the southwesterlies upto 600 hPa was seen from 2nd June onwards. The wind/Outgoing Long wave Radiation (OLR) criteria and the rainfall criteria were satisfied on 7th and 8th June. The average wind speed at 925 hPa over the area bounded by Latitudes 5-10° N and Longitudes 70-80° E was 23 knots (INSAT derived OLR value in the box confined by Lat. 5-10° N, Long. 70-80° E was 196.18 W/m^2 on 7th June and 172. 10 W/m^2 on 8th June and percentage of rainfall over the rainfall monitoring stations was 93% and 86% on 7th and 8thJune respectively.

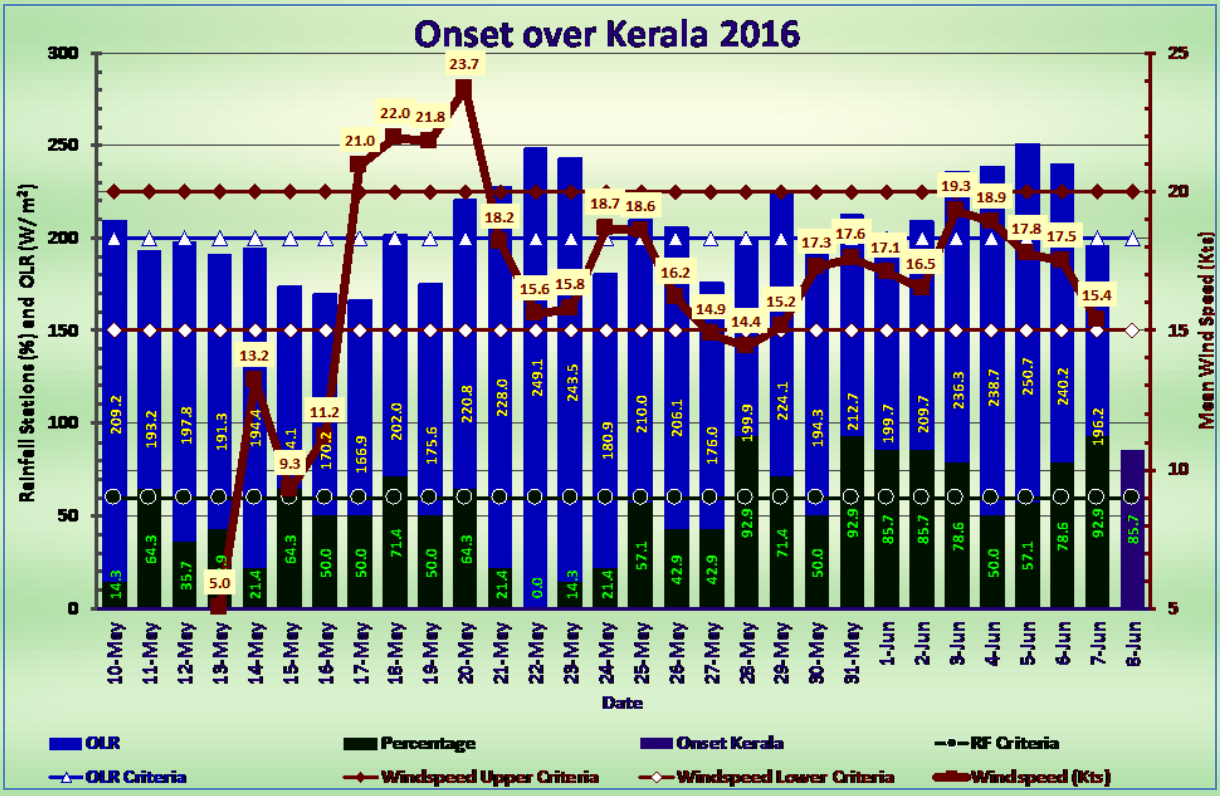


Fig. 14. Time series of meteorological elements monitored along with threshold criteria for declaring the monsoon onset over Kerala this year

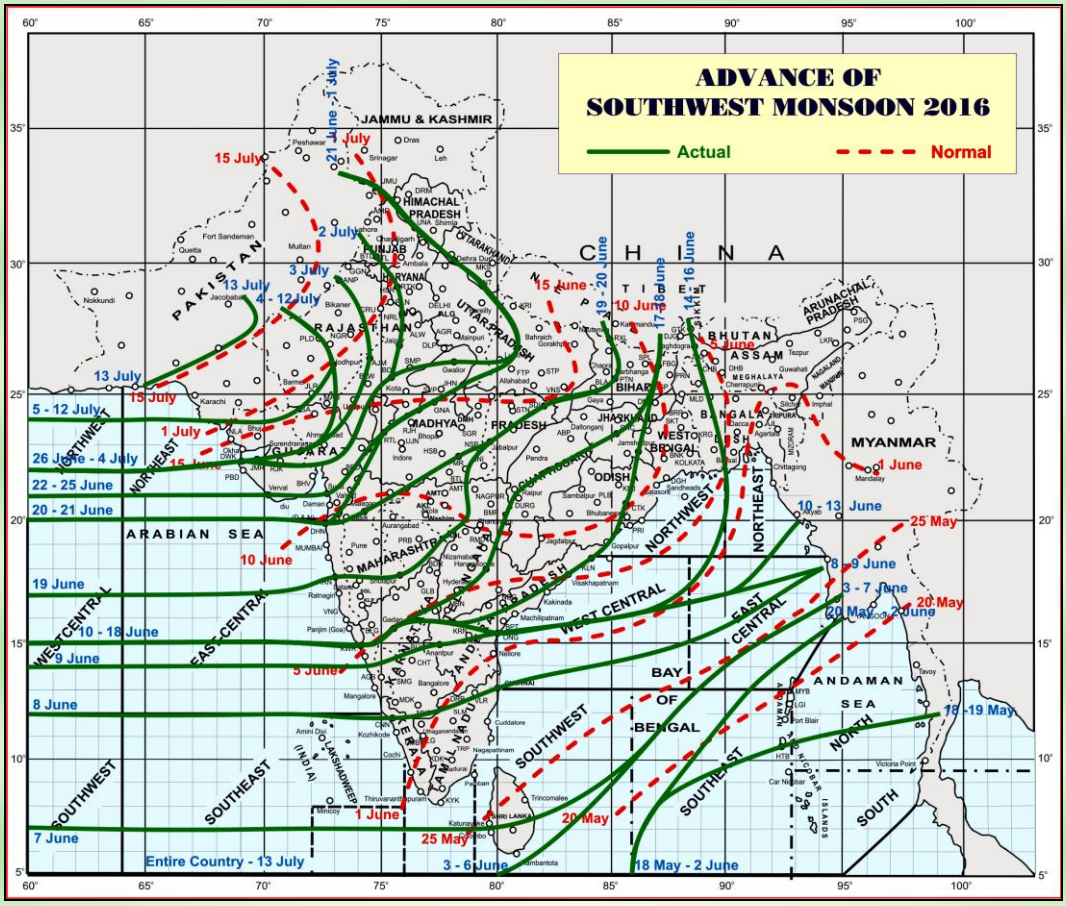


Fig. 15. Advance of southwest monsoon 2016

Genesis phase of the Cyclonic Storm 'Roanu' created the synoptic situation conducive for the advent of southwest monsoon current into parts of south Bay of Bengal, Nicobar Islands and adjoining Andaman Sea on 18th May, 2 days ahead of its normal date. It further advanced into some more parts of southeast Bay of Bengal, remaining parts of Andaman Sea and Andaman Islands on 20th May.

Along with the onset over Kerala, it advanced into south Arabian Sea, Maldives-Comorin areas, most parts of Kerala and Tamil Nadu, some parts of south interior Karnataka, remaining parts of south Bay of Bengal and some more parts of central Bay of Bengal on 8th June (Fig. 15). Then, it rapidly advanced upto Lat. 15°N in the subsequent two days. Thereafter a hiatus occurred on western part due to weakening of the Arabian Sea branch. A comparatively stronger Bay of Bengal branch led to further advance of monsoon into northeastern states by 14th June. In the third week, as the convectively active phase of the Madden Julian Oscillation (MJO) moved eastwards over the Indian Seas, the Bay of Bengal became more convectively active. Triggered by this, the southwest monsoon advanced rapidly further and covered most parts of peninsular India and western Himalayan region, entire central and east India and some parts of north Arabian Sea and northwest India by 22nd June. The last week of June witnessed the formation of a Depression over northeast Arabian Sea and a low pressure area over west central and adjoining northwest Bay of Bengal. Aided with active east-west trough and shear zone embedded with circulations, enhanced the rainfall activity over northern plains and central India. But it did not help much in the further advance of monsoon. Thus, a hiatus re-occurred during the last week of June. With the strengthening of wind in the lower tropospheric levels in the first week of July and the formation of a short-lived Land Depression led to rapid advance of

southwest monsoon to cover most parts of the country, outside some areas of Kutch and west Rajasthan by 5th July. Reduced rainfall activity thereafter in the regions where monsoon was yet to advance resulted once again a hiatus for a week. The formation of an east-west shear zone at mid tropospheric levels and its northward shifting to the north of Lat. 20° N helped the SW monsoon to cover the entire country on 13th July (Fig. 15).

Withdrawal of southwest monsoon

The rainfall activity over the northwestern parts of Rajasthan remained subdued since 5th Sept. A change over in the lower tropospheric circulation pattern over the region from cyclonic to anticyclonic on 15th September indicated the beginning of the withdrawal of southwest monsoon from the region (Fig. 16).

Subsequent to the commencement of withdrawal of southwest monsoon from western parts of Rajasthan on 15th September, moisture incursion due to the low level south-easterlies resulted in isolated convective rainfall events over major parts of northwest India. Though west Rajasthan reported "Dry weather" upto 22nd September, isolated rainfall activity re-commenced over this Met. sub-division from 23rd-28th. Similarly the other three western most sub-divisions over north India *viz*., Jammu & Kashmir, Punjab & Haryana, Chandigarh & Delhi experienced isolated rainfall on most of the days from 16th-28th September. However, on 28th September, the lower tropospheric flow pattern & INSAT-3D derived total perceptible water vapour indicated a further reduction in the humidity levels over these regions, which implied the occurrence of dry weather during the coming 3-4 days over parts of these sub-divisions. These features suggested that the southwest monsoon further withdrew from parts of the above mentioned regions on 28th.

With the southward shift of the sub-tropical westerly Jet stream over to the northern most

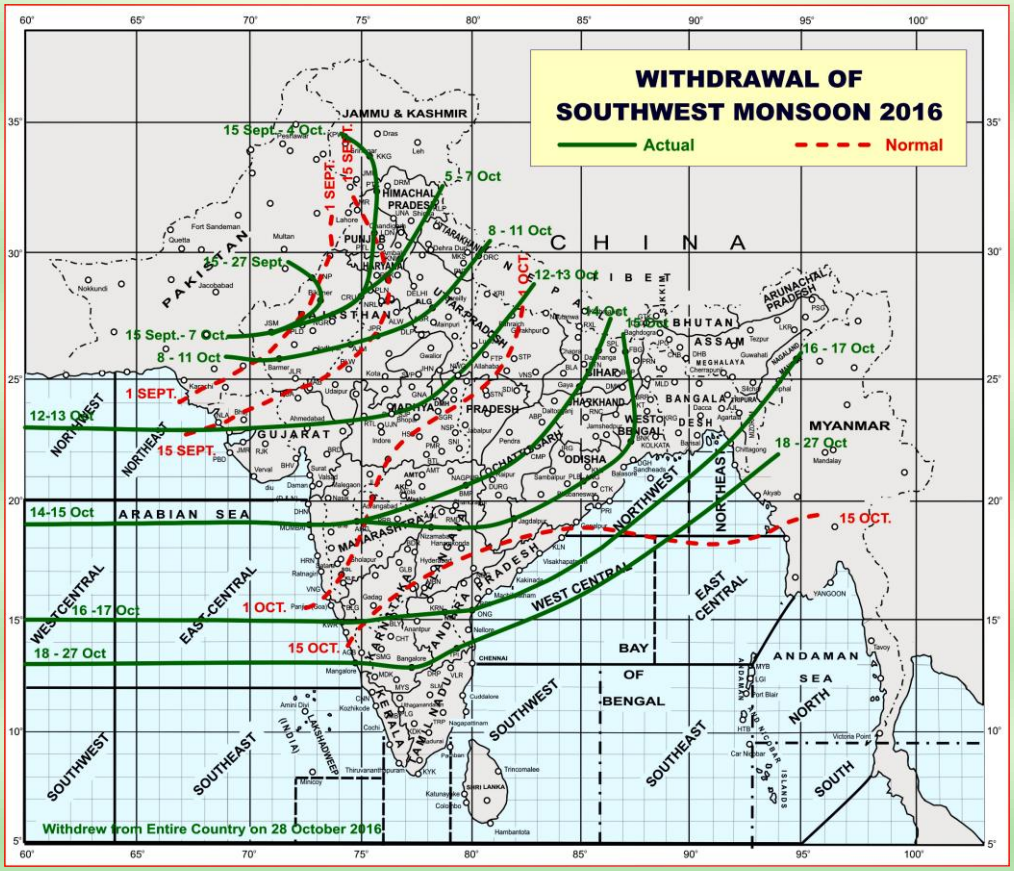
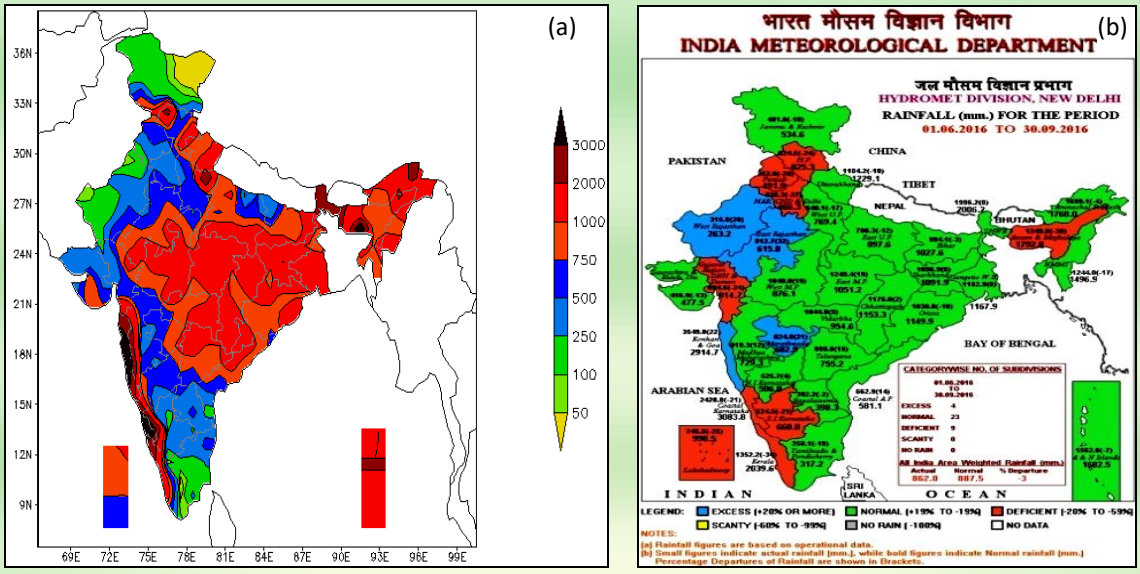


Fig. 16. Isochrones of withdrawal of southwest monsoon 2016



Figs. 17 (a&b). (a) Seasonal rainfall (cm) and (b) All India area weighted rainfall

Indian Latitudes since first week of October led to the cutoff of moisture thereby causing further withdrawal of southwest monsoon from some more parts of northwest India on 5th Oct. The increased dominance of mid-latitude circulation regime over the northern half of India caused reduction in the lower tropospheric moisture and hence the rainfall, which led to further withdrawal of southwest monsoon from most parts of northwest India and some parts of western and central India by 12th October and from major parts of India except parts of south peninsula by 18th Oct. The formation of a low pressure area over east central Bay of Bengal on 19th and its further intensification into Cyclonic Storm 'KYANT' and its movement led to enhancement of southwesterlies over southern most parts of the Indian Seas. This caused delay in further withdrawal of southwest monsoon. As the storm weakened over west central Bay of Bengal off Andhra coast southwest monsoon withdrew from entire country on 28th October 2016 (Fig. 16).

Rainfall Features

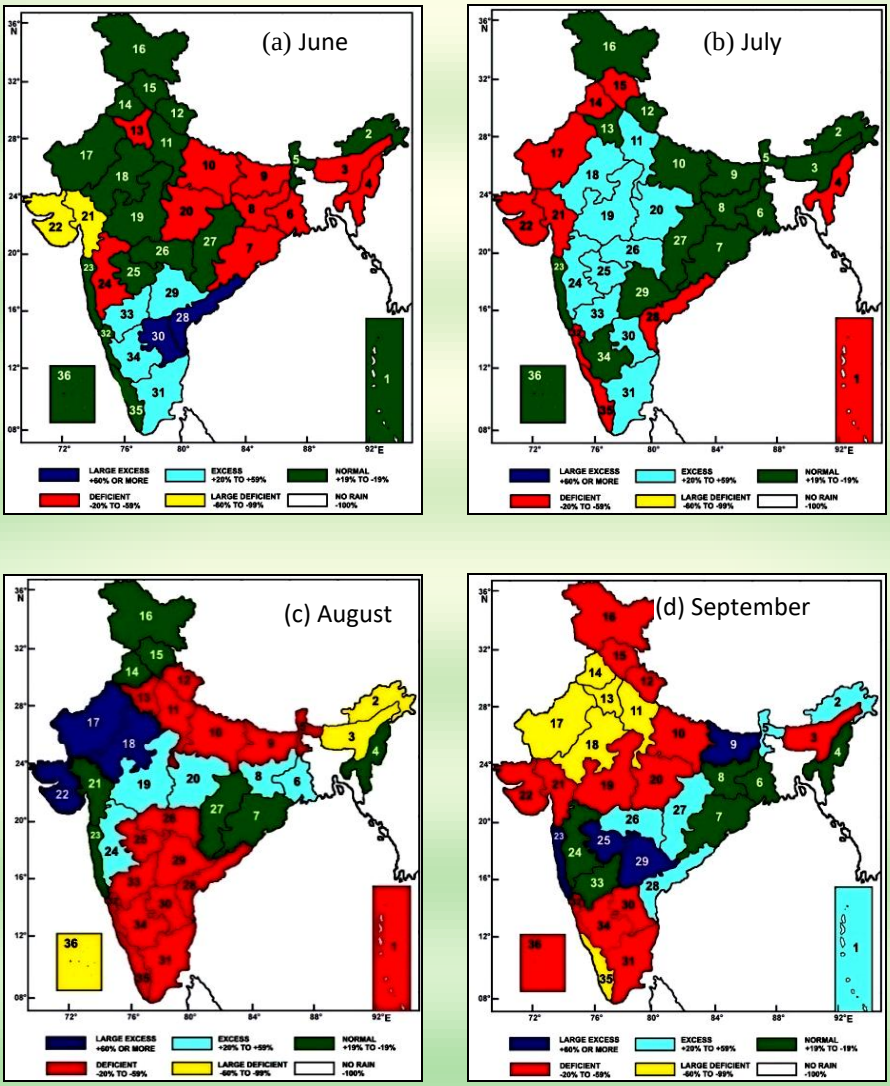
The southwest monsoon season rainfall over the country as a whole was normal [Figs. 17(a&b)]. Many subdivisions of the country received excess/normal rainfall. However, nine sub-divisions received deficient rainfall. Out of the 9 deficient subdivisions, 3 were from Northwest India (Haryana, Chandigarh & Delhi, Punjab and Himachal Pradesh), one subdivision each from East & Northeast and Central India (Assam & Meghalaya and Gujarat region respectively) and 4 sub-divisions from South Peninsular India (Coastal Karnataka, South Interior Karnataka, Kerala and Lakshadweep). During the season, out of 36 meteorological sub-divisions, 4 sub-divisions received excess rainfall, 23 received normal rainfall and the remaining 9 sub-divisions received deficient rainfall [Fig. 17(b)]. The area weighted rainfall for the monsoon season this year was 97% of its LPA value.

As seen from Fig. 17(a) the central, north peninsular, eastern/northeastern and some northern parts of the country, parts of west coast and the Islands received rainfall of the order of 750-2000 mm. Parts of Konkan & Goa, Coastal Karnataka, and Assam & Meghalaya received more than 3000 mm of rainfall. Rainfall anomaly was positive over central and adjoining western, eastern and north peninsular parts of the country and negative over northern, northeastern/extreme northeastern and south peninsular parts of the country. Positive rainfall anomaly over parts of Madhya Pradesh, Rajasthan, Konkan & Goa,

south Madhya Maharashtra, Vidarbha, Telangana, Coastal Andhra Pradesh, south Chattisgarh, Bihar, Jharkhand, West Uttar Pradesh and Andaman & Nicobar Islands was more than 200 mm. Similarly, negative rainfall anomaly over parts of extreme northeastern region, northern part of East Uttar Pradesh and adjoining northern parts of Bihar, South Coastal Karnataka and Kerala was of the order of 400 to 600 mm.

Figs. 18(a-d) shows the sub-divisionwise distribution of monthly rainfall percentage departures for the four months of the monsoon season (June to September) 2016. The figures also represent number of sub-divisions which received excess, normal, deficient or scanty rainfall during the corresponding month in terms of percentage departure of its LPA.

Fig. 19(a) shows the daily area weighted rainfall (in mm) and its long term normal over the country as a whole and the Fig. 19(b) shows the area weighted rainfall (in mm) and its long term normal over the four homogeneous regions during the season. For the country as a whole, rainfall averaged was above or near normal on many days during the season. The rainfall for the season was normal over the Northwest, Central and South peninsular India (95%, 106% and 92% of LPA respectively) and slightly below normal over the East & Northeast India (89% of LPA).



Figs. 18(a-d). Monthly sub-divisions wise distribution of rainfall percentage departures

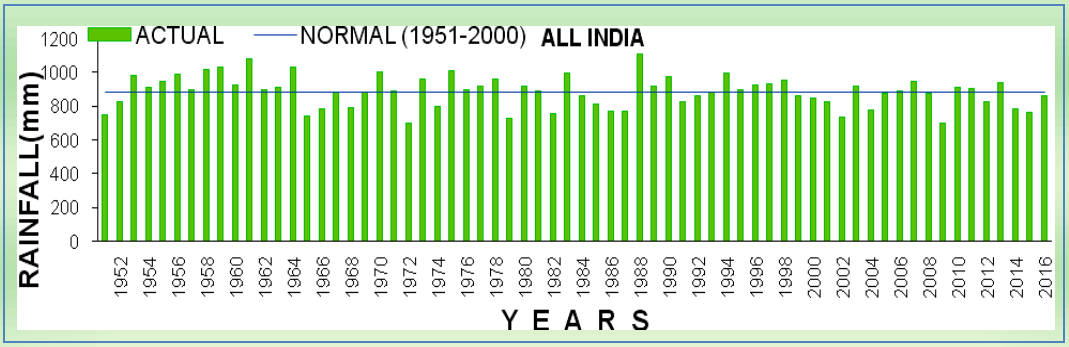
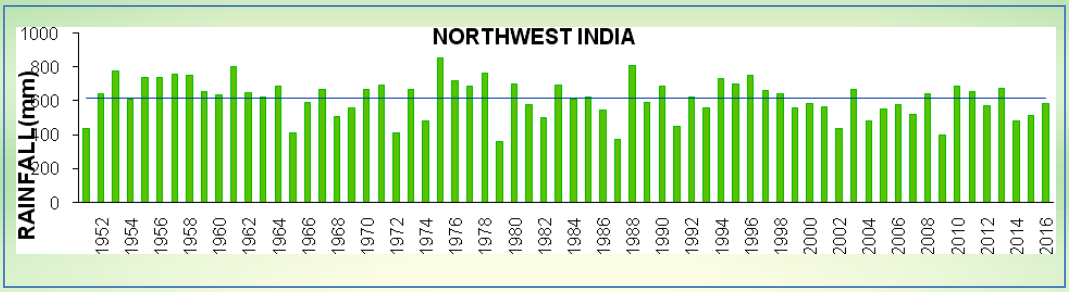
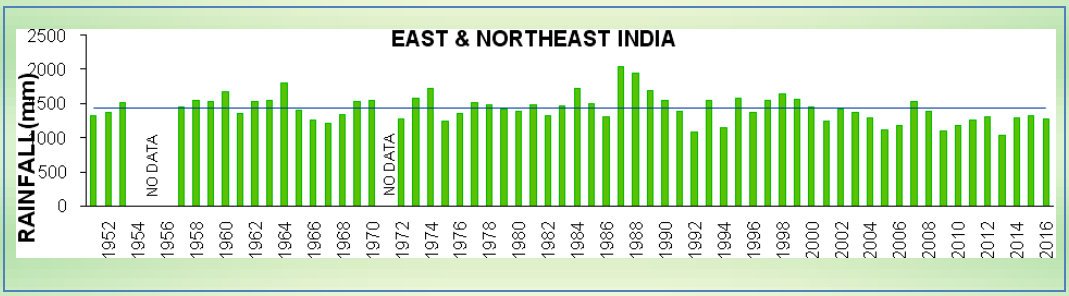
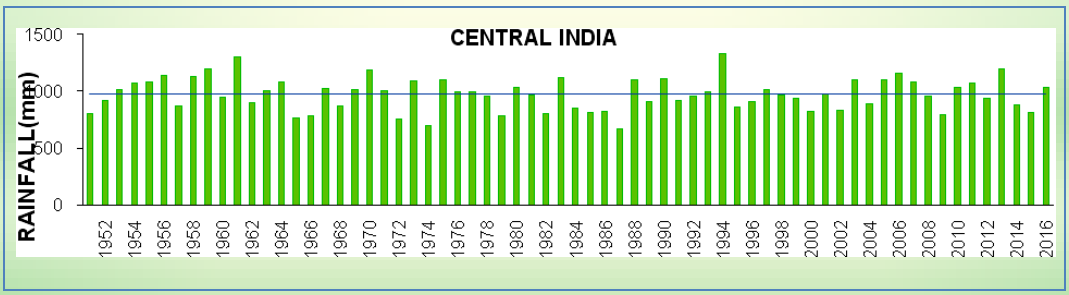


Fig. 19(a). Time series of area weighted rainfall over the country as a whole for the monsoon season (1951-2016)







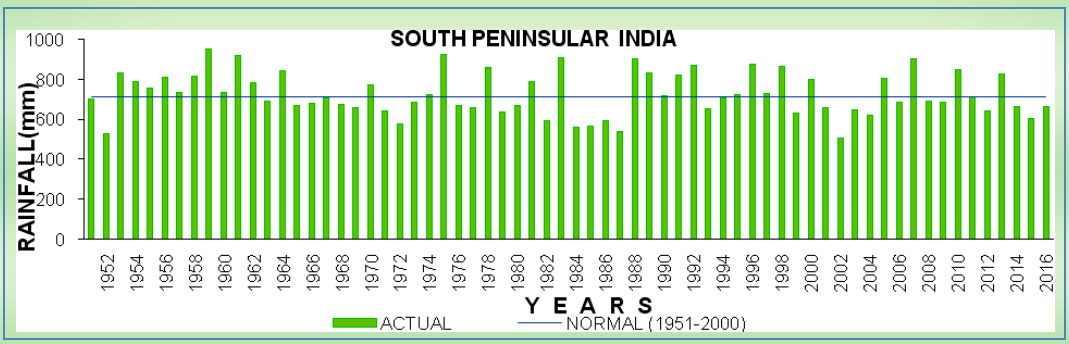


Fig. 19(b). Time series of area weighted rainfall over the four homogeneous regions for the monsoon season (1951-2016)

Temperature anomaly

Mean seasonal maximum and minimum temperature anomaly is shown in Figs. 20(a&b) respectively. Both maximum and minimum temperature anomaly was within ± 1 °C range over most parts of the country during the season. However, maximum temperature was above normal by more than 1 °C over eastern parts of Jammu & Kashmir, parts of Himachal Pradesh, West Rajasthan, Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura and Kerala. Similarly, minimum temperature was also above normal by more than 1 °C over parts of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Chandigarh & Delhi, West Uttar Pradesh, Rajasthan, Sub-Himalayan West Bengal & Sikkim, Nagaland, Manipur, Mizoram & Tripura, Tamil Nadu, and Andaman & Nicobar Islands.

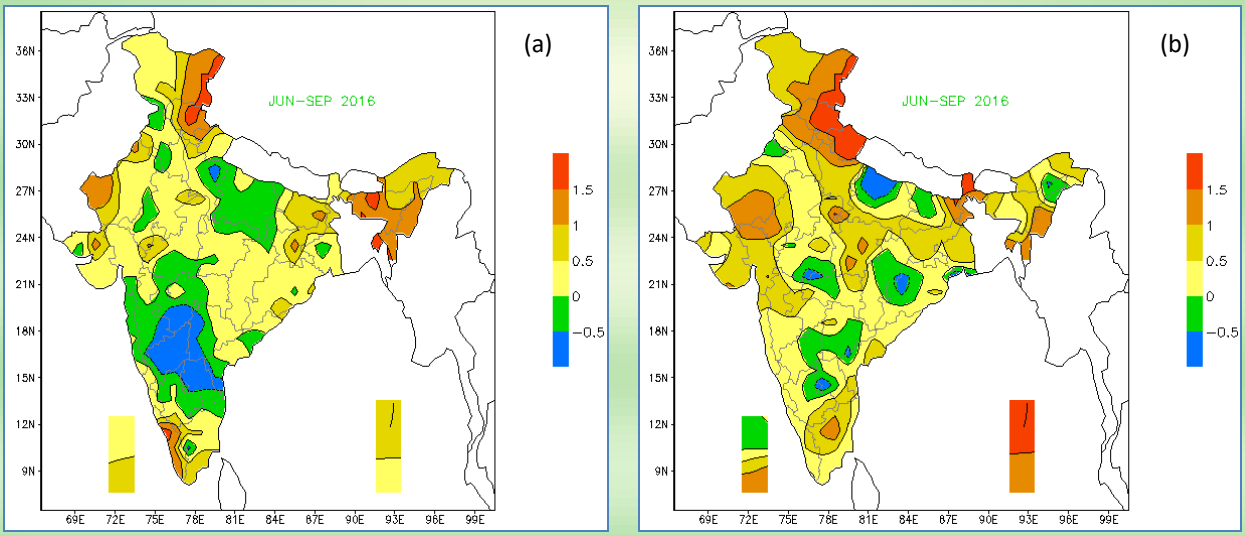
The mean temperature (28.1 °C) for the season during this year since 1971 was near normal by +0.2 °C. Five years running mean centered at 2014 is the highest since 1997.

The maximum and minimum temperature series respectively for the country as a whole and the four homogeneous regions during the season since 1971. Over the homogeneous region of East & Northeast India, both maximum and minimum temperature was above normal by about 0.5 °C whereas, over the country as a whole and the other three homogeneous regions, both maximum and minimum temperature was near normal (anomaly within +0.5 °C).

Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is an index used for and is based only on precipitation. Fig. 21 gives the SPI values for the monsoon season 2016 respectively.

Cumulative four months SPI values for the monsoon season indicate, extremely wet/severely wet conditions over parts of Jharkhand, East Uttar Pradesh, Uttarakhand, West & East Rajasthan, West & East Madhya Pradesh, Konkan & Goa, Coastal Andhra Pradesh, Telangana and North Interior Karnataka , while extremely dry/severely dry



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

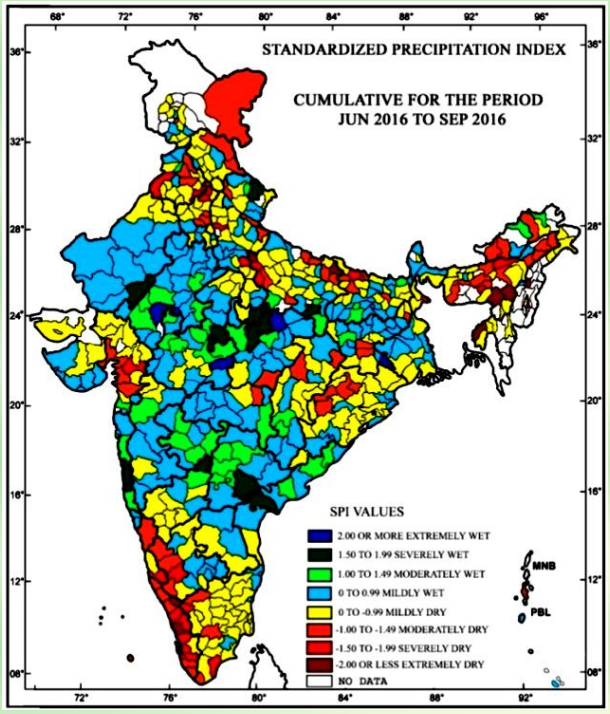


Fig. 21. SPI during June-September, 2016.

conditions were observed over parts of Assam & Meghalaya, Nagaland, Tripura, Sub Himalayan West Bengal & Sikkim, Bihar, East & West Uttar Pradesh, Haryana, Chandigarh & Delhi, Punjab, Gujarat Region, Tamil Nadu, Coastal Karnataka, South Interior Karnataka and Kerala.

Pressure & wind

The pressure anomaly was near normal (within ± 0.5 hPa) over most parts of the country except for the northern/ northeastern region where it was more than 1 to 1.5 hPa.

At 850 hPa level, an anomalous east- west trough extending from south Rajasthan to west central Bay of Bengal across central parts of the country was observed. This anomalous trough was observed at 500 hPa level also. At 250 hPa level, anomalous northeasterlies/easterlies were observed over central and peninsular parts of the country.

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighbourhood was Positive exceeding 5 to 10 W/m^2 over the south peninsula and adjoining seas, over the North Bay of Bengal and adjoining eastern region and also over the western parts of the equatorial Indian Ocean region. Similarly, negative OLR anomaly exceeding 5 to 10 W/m^2 was observed over the northeastern parts of the country and also over the central and eastern equatorial Indian Ocean region.

4. Post Monsoon Season (October-November-December)

Northeast monsoon rains commenced over the south peninsular India on 30th October with a delay of 10 days from its normal date and 2 days after the withdrawal of southwest monsoon from the country on 28th October.

Northeast monsoon activity

Rainfall activity over the core region of south peninsula (comprising of 5 subdivisions *viz*., Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu & Puducherry, South Interior Karnataka and Kerala) during the season as a whole was substantially below normal [35% of Long Period Average (LPA)]. It was subdued during October (67% of LPA), November (25% of LPA) and December (49% of LPA). Post monsoon season 2016 received the record lowest rainfall for the season since 1901. All the five sub-divisions of the northeast monsoon rainfall region received large deficient rainfall during the season.

Rainfall features

Rainfall activity over the country as a whole was subdued during the season. During the season, out of 36 meteorological subdivisions, 3 sub-divisions received large excess rainfall, 1

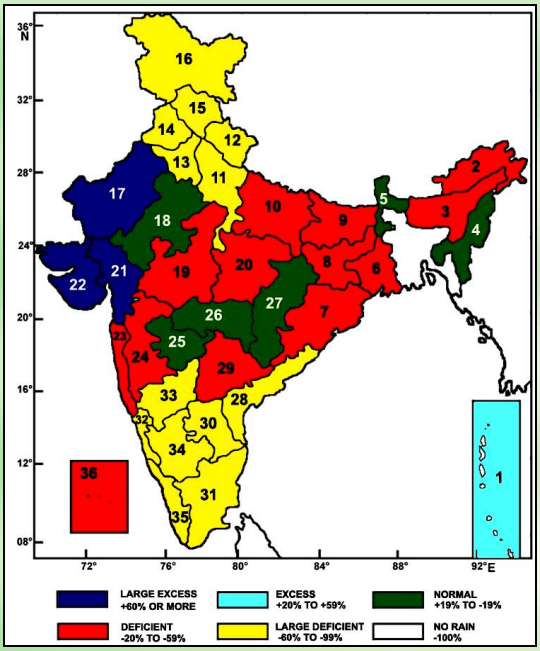
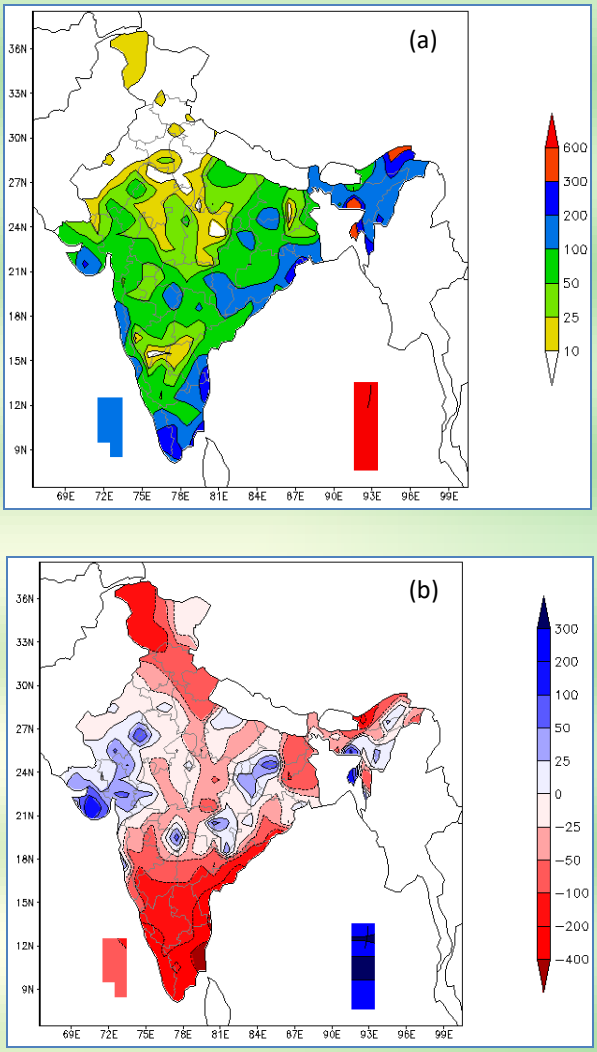


Fig. 22. Sub-division wise rainfall percentage departures for the post monsoon season 2016

received excess rainfall, 6 received normal rainfall, 13 received deficient rainfall and remaining 13 subdivisions received large deficient rainfall (Fig. 22).

Figs. 23(a&b) show the spatial pattern of rainfall (mm) received during the season and its anomaly respectively. Parts of Tamil Nadu, Kerala, South Coastal Andhra Pradesh, Rayalaseema, Odisha, Gangetic West Bengal, Chhattisgarh, Marathwada, Konkan & Goa, Coastal Karnataka, Saurashtra & Kutch, south Bihar and adjoining north Jharkhand, Lakshadweep Islands and most parts of extreme northeastern region of the country in general received more than 100 mm of rainfall. Parts of Arunachal Pradesh, Assam & Meghalaya and Nagaland, Manipur, Mizoram & Tripura received more than 300 mm of rainfall. Rainfall over parts of Andaman & Nicobar Islands exceeded 600 mm. Rainfall anomaly was negative over most parts of the country except for parts of western region and some isolated parts of central and eastern/ northeastern region. Positive rainfall anomaly over parts of Saurashtra & Kutch and Tripura exceeded 100 mm and that over parts of Andaman & Nicobar Islands it exceeded 300 mm. Negative rainfall anomaly exceeded



Figs. 23(a&b). (a) Seasonal rainfall (mm) and (b) Seasonal rainfall anomaly (mm) [*Based on 1951-2000 NORMAL(S)*]

100 mm over most parts of south Peninsula, western parts of Jammu & Kashmir and parts of Arunachal Pradesh. Over parts of south Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu, Kerala and coastal Karnataka, negative rainfall anomaly was more than 200 mm.

Fig. 24(a) shows the all India area weighted rainfall series for the season since 1951.

Similarly, Fig. 24(b) shows the area weighted rainfall series for the season since 1951 over the northeast monsoon region of south peninsula. Rainfall over the core region of south peninsula this year (117.7 mm) was the lowest since 1901.

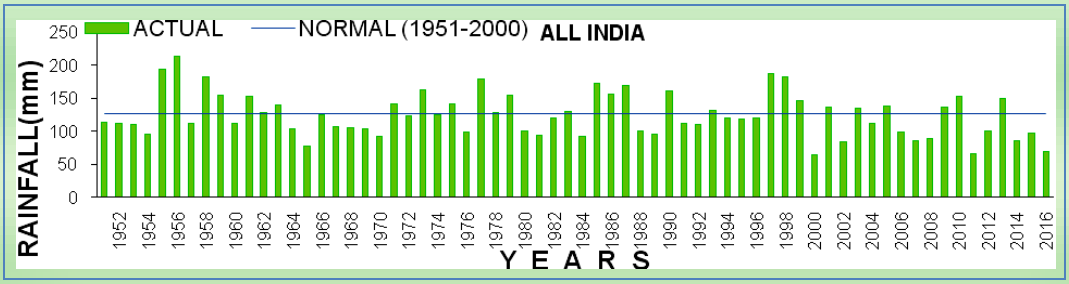


Fig. 24(a). Time series of area weighted rainfall over the country as a whole (1951-2016)

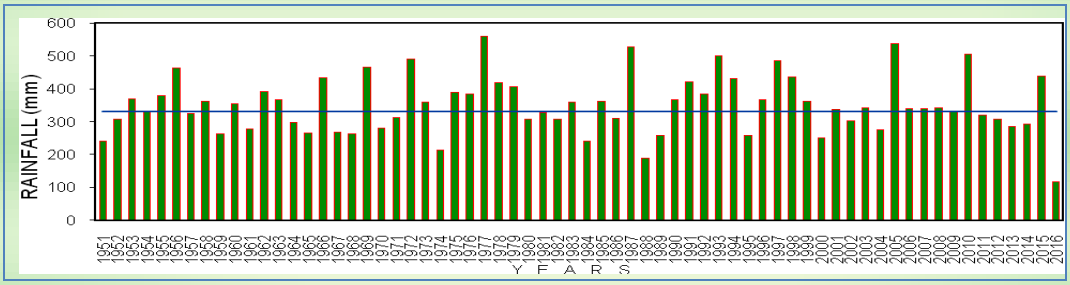


Fig. 24(b). Time series of area weighted rainfall over the south peninsula (1951 - 2016)

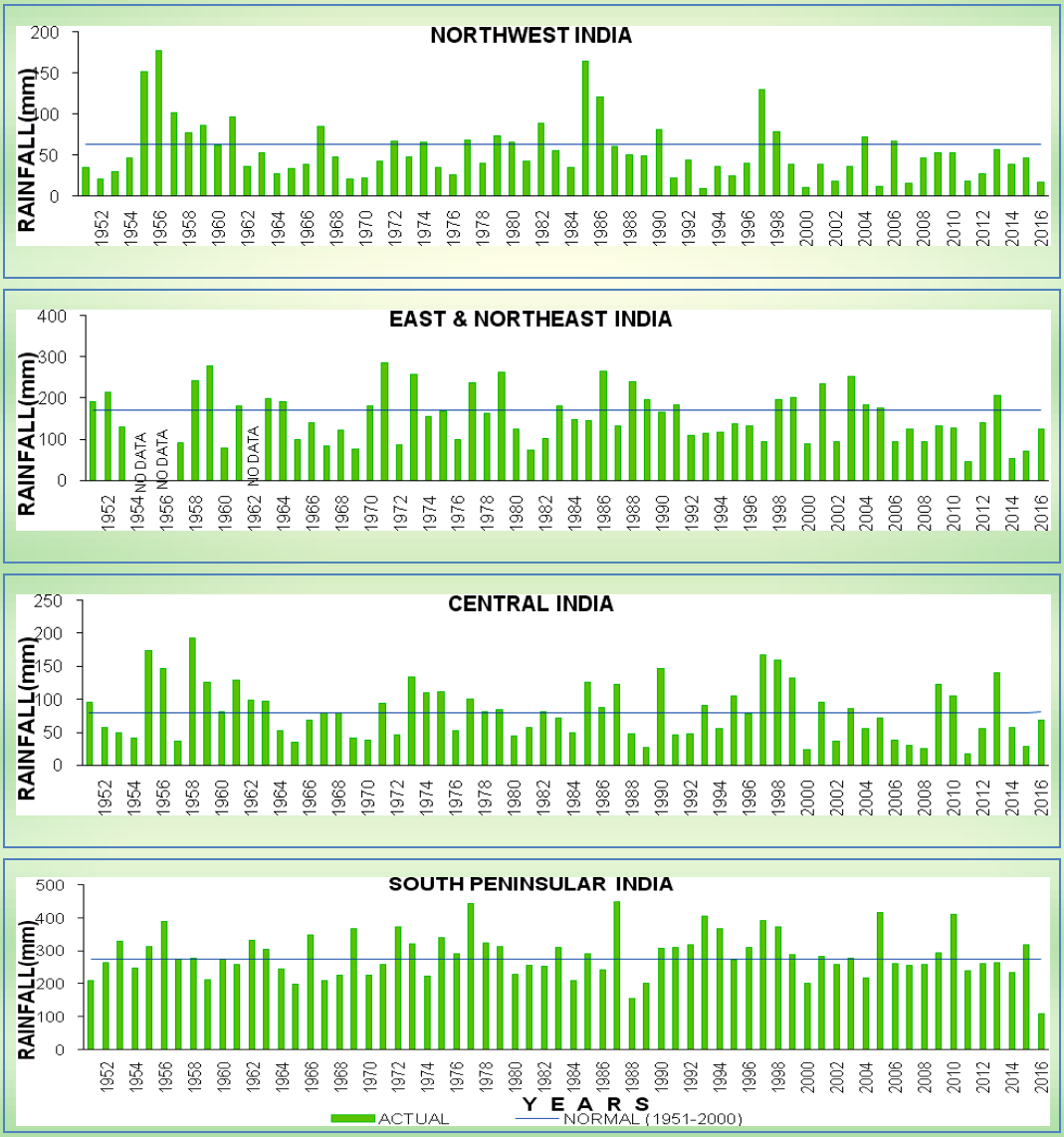


Fig. 25. Time series of area weighted seasonal rainfall over the four homogeneous regions for the period, 1951-2016

Fig. 25 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 all the homogeneous regions. It was (40% of LPA) over the south peninsular India (lowest since 1901), 86% of LPA over the central India, 73% of LPA over the East & Northeast India and 27 % of LPA over the northwest India.

Standardized Precipitation Index

Fig. 26 gives the SPI values for the post monsoon season 2015. Cumulative SPI values

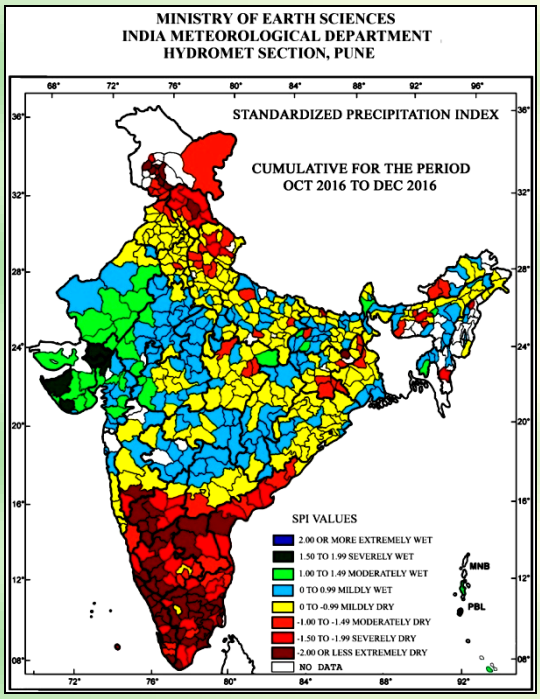


Fig. 26. SPI for post-monsoon season 2016

for the northeast monsoon season indicate, extremely wet/severely wet conditions over parts of A & N Islands, Gujarat Region and Saurashtra & Kutch, while extremely dry/severely dry conditions were observed over parts of Assam & Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Jharkhand, Bihar, Uttarakhand, Himachal Pradesh, Jammu & Kashmir, Madhya Maharashtra, Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu, Coastal Karnataka, North Interior Karnataka, South Interior Karnataka, Kerala and Lakshadweep.

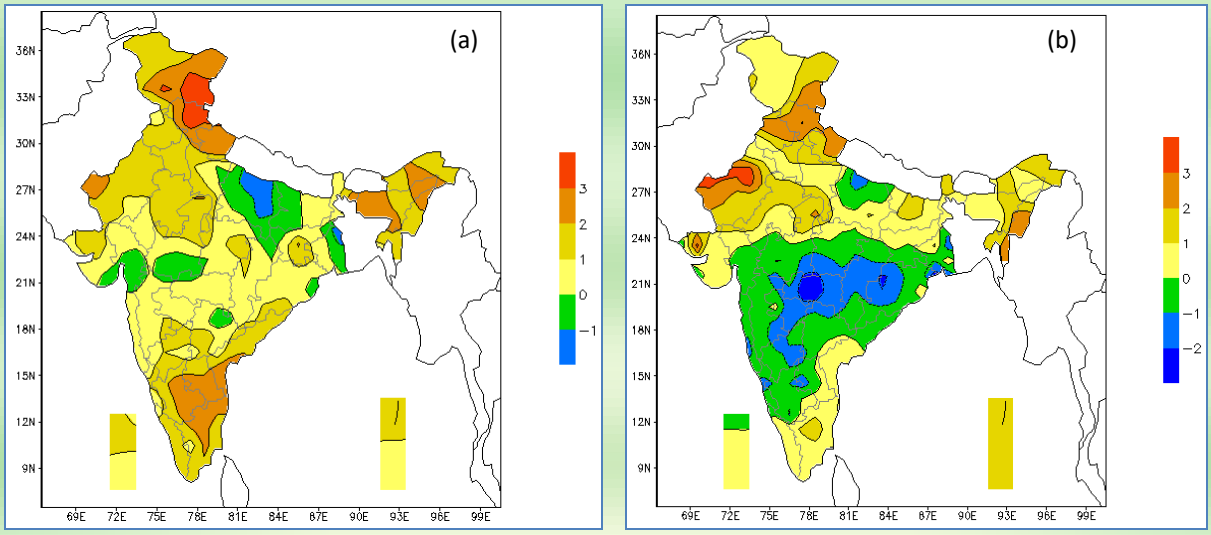
Temperature anomaly

Mean seasonal maximum and minimum temperature anomaly is shown in Figs. 27(a&b) respectively. Maximum temperature was above normal over most parts of the country except for parts of East Uttar Pradesh and adjoining Bihar, Gangetic West Bengal, Gujarat and West Madhya Pradesh. Over most parts of northern/northwestern and extreme northeastern region and parts of south peninsula, it was above normal by more 1 °C. Over parts of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, West Rajasthan, Coastal Andhra Pradesh, Rayalaseema, South Interior Karnataka, Tamil Nadu, Assam & Meghalaya, Arunachal Pradesh and Nagaland, Manipur, Mizoram & Tripura, it was above normal by more than 2 °C. Over parts of East Uttar Pradesh and Gangetic West Bengal, maximum temperature was below normal by more than 1 °C.

Minimum temperature was below normal over central and adjoining north peninsular and eastern parts of the country and also over parts of East Uttar Pradesh, and was above normal over rest of the country. It was above normal by more than 2 °C over parts of Jammu & Kashmir, Himachal Pradesh, Punjab, Uttarakhand, West Rajasthan, Saurashtra & Kutch and Nagaland, Manipur, Mizoram & Tripura. Minimum temperature was below normal by more than 1 °C over parts of East Uttar Pradesh, Gangetic West Bengal, Odisha, Chhattisgarh, south Madhya Pradesh, Vidarbha, Marathwada, Telangana, south Madhya Maharashtra and North Interior Karnataka and by more than 2 °C over western parts of Vidarbha.

Fig. 28 shows 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 for the season this year was above normal by about 0.38 °C.

Figs. 29(a&b) show the maximum and minimum temperature series respectively for



Figs. 27(a&b). Mean seasonal temperature anomaly (°C) (a) Maximum and (b) Minimum [*Based on 1971-2000 NORMAL(S)*]

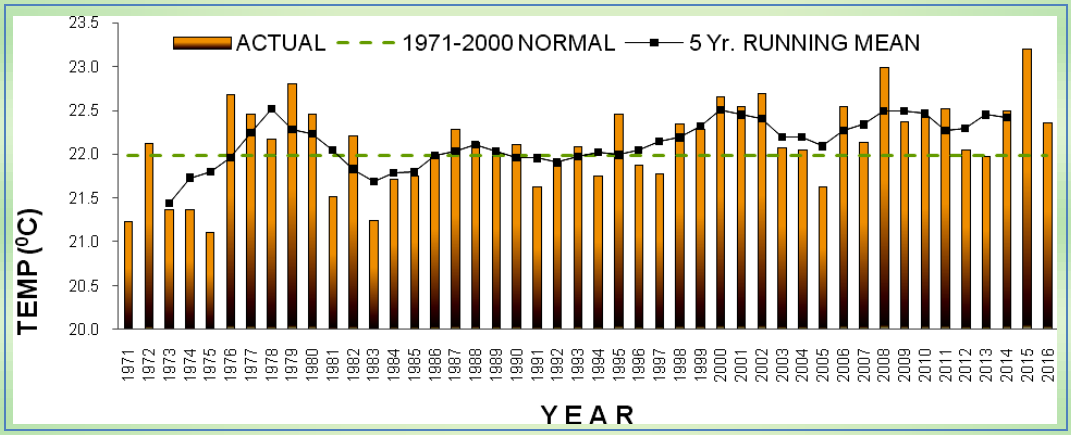


Fig. 28. Time series of mean temperature averaged over India (vertical bars) & five year running mean (continuous line) for the monsoon season (1971-2016)

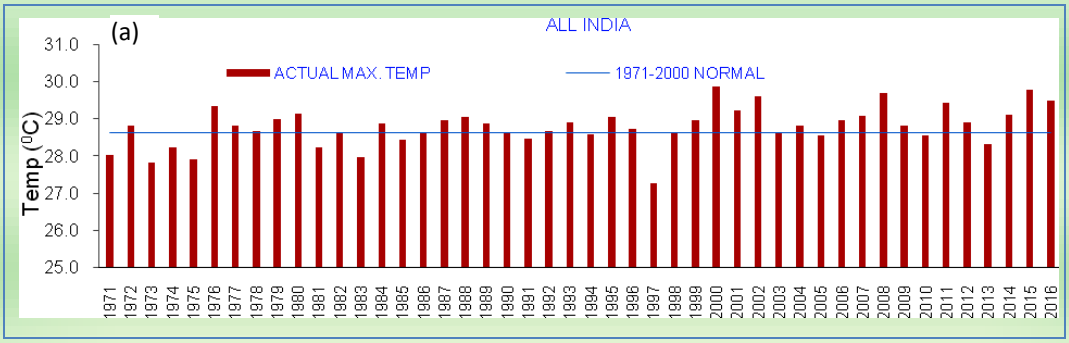
the country as a whole and the four homogeneous regions during the season since 1971. Maximum temperature for all the homogeneous regions was above normal and for south peninsular India and Northeast India it was the highest since 1971. Minimum temperature for all the homogeneous regions was near normal.

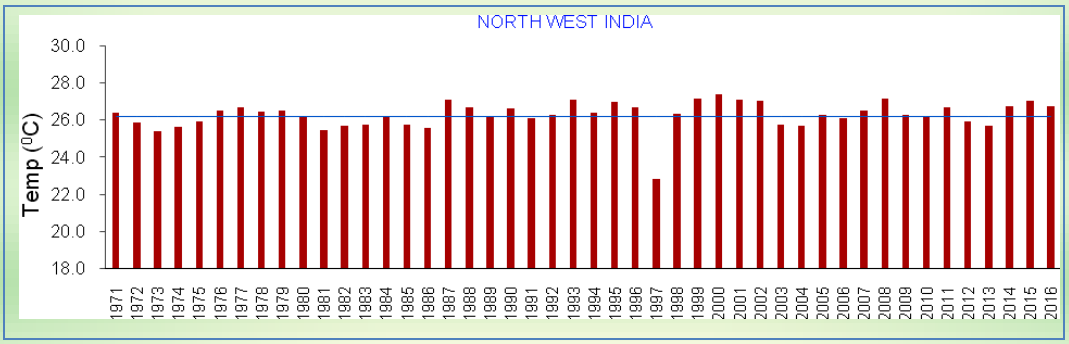
Percentage of Warm days/Cold nights

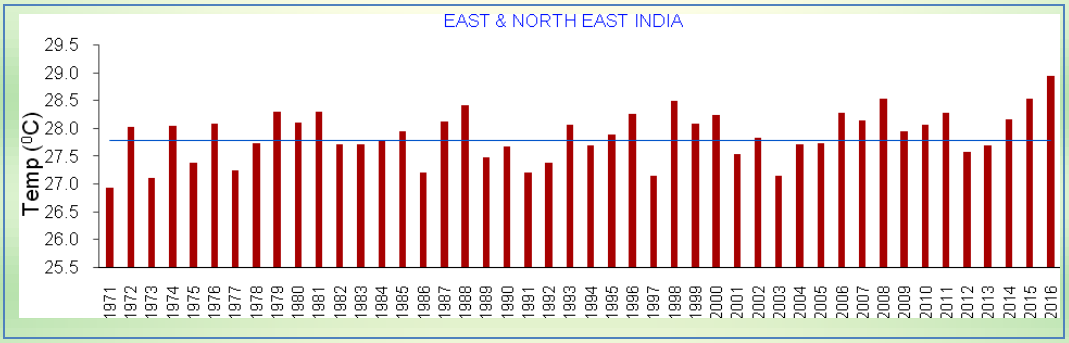
Figs. 30(a&b) show the percentage of days when maximum (minimum) temperature was more (less) than 90th (10th) percentile. Over parts of Arunachal Pradesh, Assam and Meghalaya, Nagaland, Manipur, Mizoram & Tripura, Himachal Pradesh, Uttarakhand Coastal Andhra Pradesh, Rayalaseema, South Interior Karnataka, Tamil Nadu, Kerala and Andaman & Nicobar Islands, the maximum temperature was greater than 90th percentile for more than 60% of the days of the season. However, for minimum temperature, no significant distribution was observed.

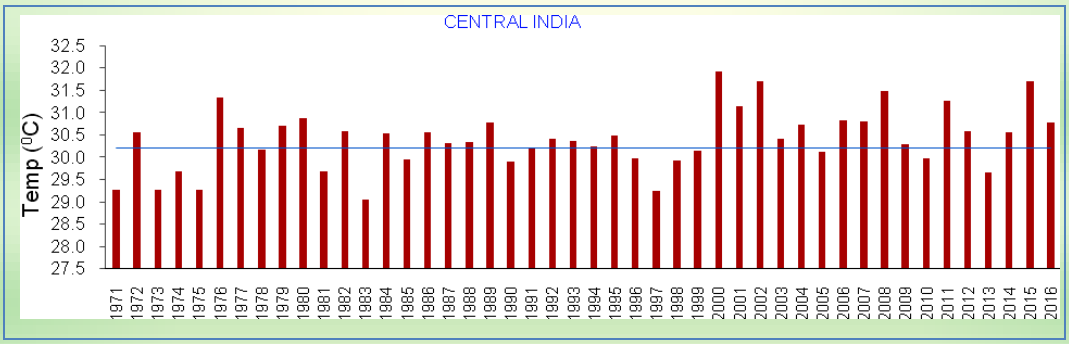
Low Pressure systems

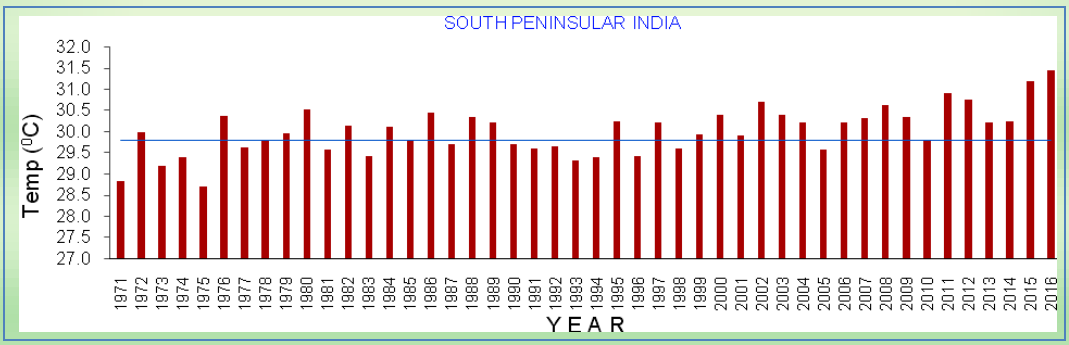
Post-monsoon season was cyclogenically active with the formations of one Very Severe Cyclonic Storm (VSCS) "VARDAH" over Bay of Bengal in December, two Cyclonic Storms (CS) "KYANT and NADA" over Bay of Bengal (one each in October & November) and two Depressions each over the central Andaman Sea in November and the Arabian Sea in December.

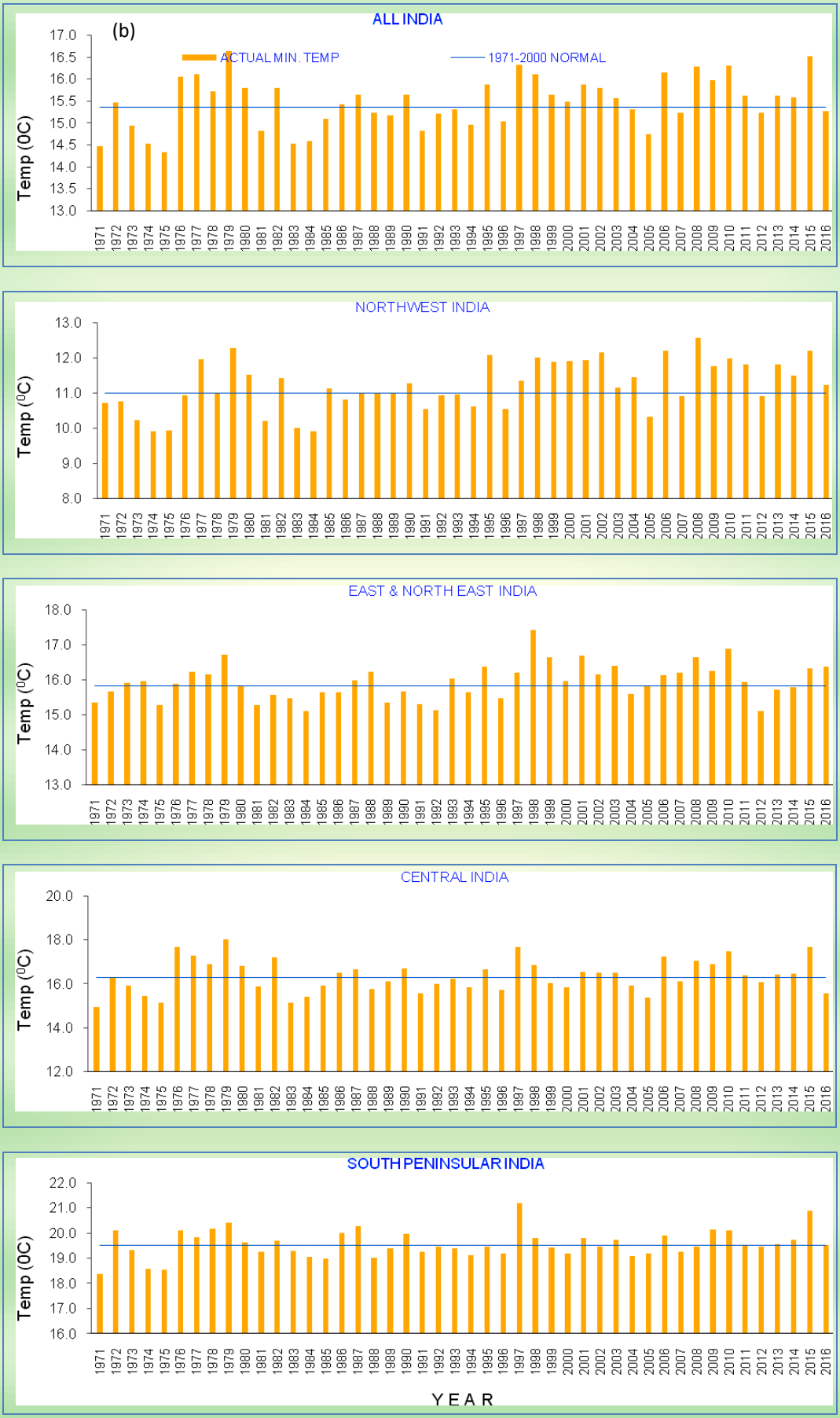

(a)
ALL INDIA
ACTUAL MAX. TEMP
1971-2000 NORMAL
Temp (⁰C)


NORTH WEST INDIA
Temp (⁰C)

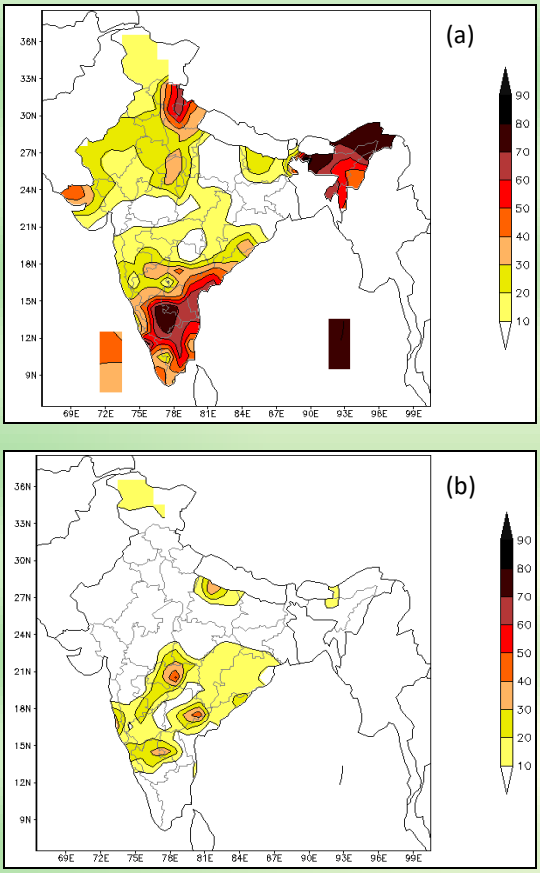

EAST & NORTH EAST INDIA
Temp (⁰C)


CENTRAL INDIA
Temp (⁰C)


SOUTH PENINSULAR INDIA
Temp (⁰C)
YEAR



Figs. 29(a&b). Time series of temperature for the country as a whole and for four homogeneous regions (1971-2016) (a) Maximum (b) Minimum



Figs. 30(a&b). Percentage of days when (a) maximum temperature more than 90th Percentile (b) minimum temperature less than 10th Percentile

The first intense low pressure system of the northeast monsoon season formed over the Bay of Bengal as **cyclonic storm 'KYANT'** (21st - 27th Oct.). Initially it moved in an east-northeast direction under the influence of low level westerly winds. Subsequent to its further intensification it re-curved anti-clockwise in a west-northwest direction. However, after recurving it came under the influence of an anti-cyclone over the north Arabian Sea and weakened *in situ* over west central Bay of Bengal off Andhra coast without causing adverse weather over land.

The second intense system of the post monsoon season was the **Depression** (2nd - 6th Nov.) formed over southeast Bay of Bengal and neighbourhood. It moved initially northwestwards and then recurving in a clockwise direction moved faster northeastward. However, under the influence of high vertical wind shear and influx of dry air from northwest, it dissipated near the Bangladesh coast. It caused heavy rainfall at many places with isolated heavy rainfall over north coastal Andhra Pradesh, coastal Odisha, coastal West Bengal, south Assam, Tripura and Mizoram. But the rainfall over other core region of northeast monsoon continued to remain deficient.

The second **Cyclonic Storm 'NADA'** (29th November - 2nd December) of the season formed over south Bay of Bengal. It moved in northwest direction and weakened *in-situ* into a Depression over the Sea before crossing north Tamil Nadu due to large vertical wind shear and less ocean thermal energy. However, the crossing phase of this system caused active northeast monsoon conditions over Tamil Nadu for the first time during this season on 1st & 2nd December.

The third Cyclonic Storm, **'VARDAH'** (6th - 13th December) of the season formed over the southeast Bay of Bengal. As a **depression** it moved initially in a west-northwest direction and then moving northwards it intensified into a **Deep Depression** over southeast Bay of Bengal on 7th. It further moved northwards and intensified into **cyclonic Storm** and as a **Severe Cyclonic Storm** over southeast Bay of Bengal on 8th and 9th respectively. It moved initially north and then west-northwestwards and intensified into **Very Severe Cyclonic Storm** over west central and adjoining south Bay of Bengal on 10th. It crossed north Tamil Nadu on 12th afternoon and became the first land falling system of severe intensity during this year. It further weakened into Depression over the north interior Tamil Nadu itself and emerged as a low pressure area over southeast Arabian Sea on 14th. This storm created havoc over Chennai and adjoining districts of north Tamil Nadu and also copious rainfall over the large rainfall deficient region for couple of days.

The remnant of VSCS 'Vardah' moving westwards emerged into the Arabian Sea and

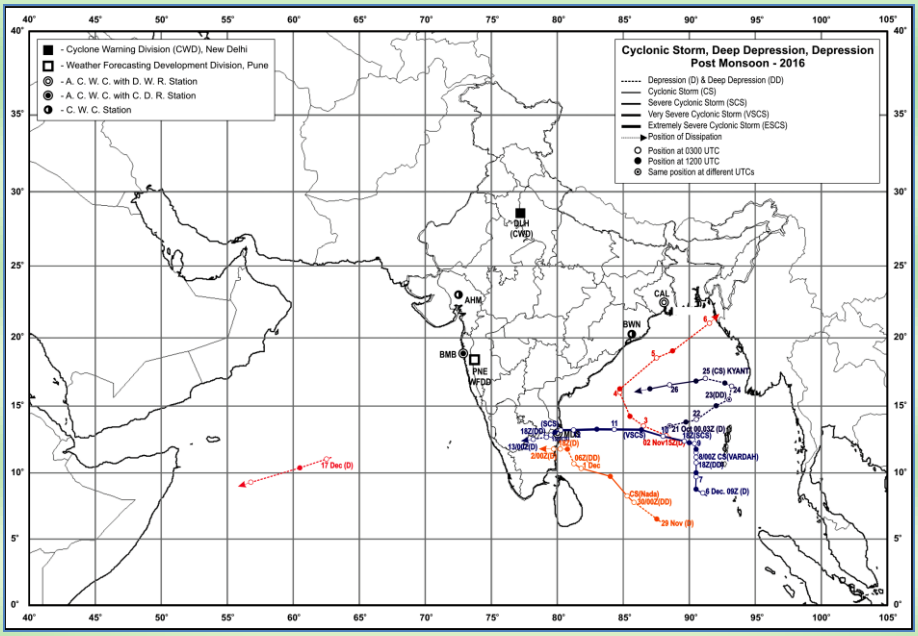


Fig. 31. Tracks of intense low pressure systems formed during the post-monsoon season 2016

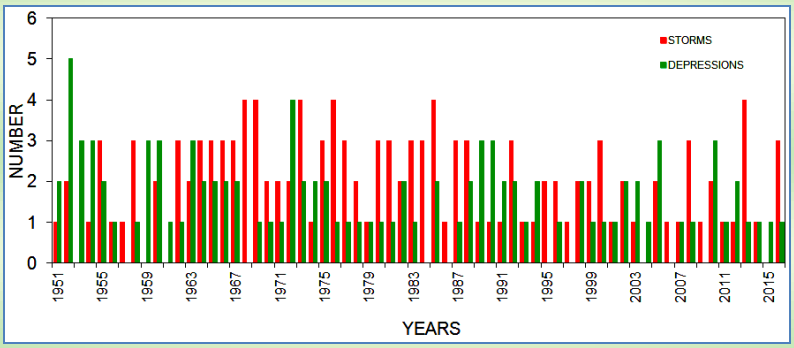


Fig. 32. Frequency of depressions / cyclonic storms formed over the Bay of Bengal during the post-monsoon season (1951 - 2016)

concentrated into a **Depression** over southwest Arabian Sea during 17th - 18th December. Moving west-southwestwards it weakened in-situ as it approached Somalia coast, encountering colder Sea Surface temperatures and dry desert air. The Fig. 31 shows the tracks of these systems and Fig. 32 shows the number of Depressions formed over Bay of Bengal during the post monsoon season (1951-2015).

Outgoing Longwave Radiation (OLR)

OLR anomaly (W/m^2) over the Indian region and neighborhood is shown in Fig. 33. Positive OLR anomaly (W/m^2) over the Indian region OLR anomaly (W/m^2) over the Indian region and neighborhood is shown in Fig. 33. Positive

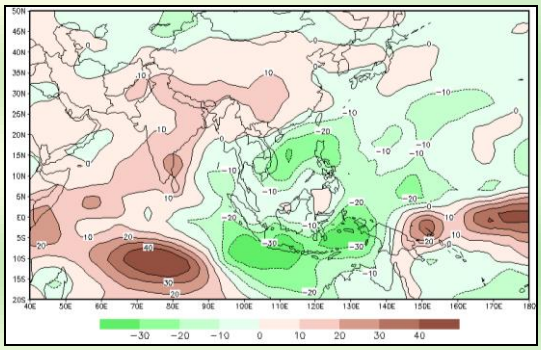


Fig. 33. OLR anomaly (W/m^2) for the post monsoon season 2016 (*Source : CDC / NOAA, USA*) (based on 1981 - 2010 climatology)

OLR anomaly exceeding 10 W/m^2 was observed over most parts of the country and over northern parts of Tamil Nadu, it exceeded 20 W/m^2. Over eastern parts of Bay of Bengal and the Andaman seas, negative OLR anomaly exceeding 10 W/m^2 was observed.

CHAPTER 3

NUMERICAL WEATHER PREDICTION

MAJOR ACHIEVEMENTS DURING 2016

- Operational implementation of Global Forecasting System (GFS Version 13.0.3) at T1534L64 resolution and 06 hourly cycle of Global Data Assimilation System (GDAS) in AADITYA HPCS at IITM Pune for day-to-day operational run.

- Operational implementation of coupled model with a suite of models from CFSv2 coupled model at different resolutions (CFSv2_T382; CFSv2_T126; GFSbc_T382; GFSbc_T126) for the operational extended range forecast.

- The double nested (9 and 3 km) WRF-ARW model with improved physical parameterization schemes in version 3.6.1 has been operational from monsoon 2016 and various diagnostic products have been developed during the cyclone and fog FDP projects for operational forecast generation.

- The triple nested (18, 6 and 2 km) version (v3.7.1) of Hurricane WRF (HWRF) model with its various diagnostic products has been run operationally established with 6 hourly intervals for the cyclones over North Indian Ocean during the year 2016.

- Both the WRF and HWRF models have been operationally tested over HPCS Bhaskara at NCMRWF, Noida as a standby option to achieve uninterrupted operational forecast products.

- Development of All India Nowcasting system for Thunderstorms that facilitates the forecaster at MC/RMC's to generate forecast in Nowcast mode and display on the public portal on real time basis.

- The demonstration webpage for Severe Weather Forecast Demonstration Project-Bay of Bengal (SWFDP-BoB) created for providing NWP guidance products from different modeling centres to the member countries is operationalised during May 2016 with model products available from different modelling centres from India (IMD, NCMRWF, INCOIS) and abroad (ECMWF, NCEP and UKMO).

OPERATIONAL IMPLEMENTATION OF NEW NWP MODELS AT IMD IN CO-ORDINATION WITH MoES INSTITUTIONS

High resolution GFS model for medium range weather forecasting

- The GFS (*GSM.V13.0.3*) model at T1534L64 (~12 km) in horizontal resolution and 64 hybrid sigma - pressure layers with

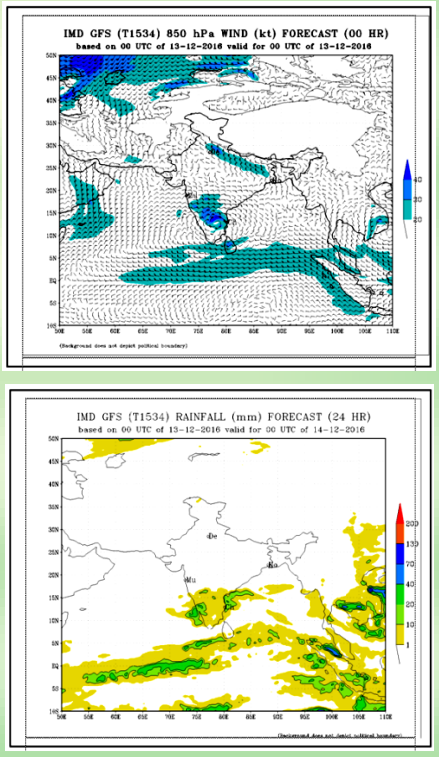


Fig. 1. 850 analysis wind and 24 hr rainfall forecast plot of GFS T1534L64 based on 13th December, 2016

the top layer centered around 0.27 hPa (approximately 55 km) runs operationally on ADITYA High Performance Computing Systems (HPCS) at IITM Pune twice in a day (0000 & 1200 UTC) since 1st December, 2016 to give deterministic forecast in the short to medium range (Fig. 1).

The initial conditions are generated from the NCEP based Ensemble Kalman Filter (EnKF) component of hybrid Global Data Assimilation System (GDAS) run on BHASKARA HPCS at NCMRWF. For the operationalisation of this model in IMD Delhi, NCMRWF Noida has provided the real-time implementation support and support for Data assimilation, whereas, the pre-operation testing and validation supports were provided by MoES-IITM, Pune.

Suite of CFSv2 model for extended range weather forecasting

- Operational implementation of coupled model with a suite of models from CFSv2 coupled model has been implemented in IMD, Delhi during September, 2016. This dynamical prediction system developed at IITM, Pune has been transferred to IMD and the same has been implemented by IMD for generating operational Extended Range Forecast products to different users. This suite of models at different resolutions with atmospheric and oceanic Initial conditions obtained from GDAS cycle run at NCMRWF, Noida and GODAS cycle run at INCOIS, Hyderabad respectively are (*i*) CFSv2 at T382 (≈ 38 km) (*ii*) CFSv2 at T126 (≈ 100 km) (*iii*) GFSbc (bias corrected SST from CFSv2) at T382 and (*iv*) GFSbc at T126. The operational suite is ported in ADITYA HPCS at IITM Pune for day-to-day operational run by IMD. The Multi-model ensemble (MME) out of the above 4 suite of models are run operationally for 32 days based on every Wednesday initial condition with 4 ensemble members (one control and 3 perturbed) each for CFSv2T382, CFSv2T126, GFSbcT382 and GFSbcT126. The same suites of model are also run on hindcast mode for 13 years (2003-2015) alongwith the every week operational run as shown in Fig. 2. The average ensemble forecast anomaly of all the 4 set of model runs of 4 members each is calculated by subtracting corresponding 13-year model hindcast climatology. For the preparation of mean and anomaly forecast on every Thursday, which is valid for 4 weeks for days 2-8 (week1; Friday to Thursday), days 09-15 (week2; Friday to Thursday), days 16-22 (week3; Friday to Thursday) and days 23-29 (week4; Friday to Thursday) as shown in Fig. 2.

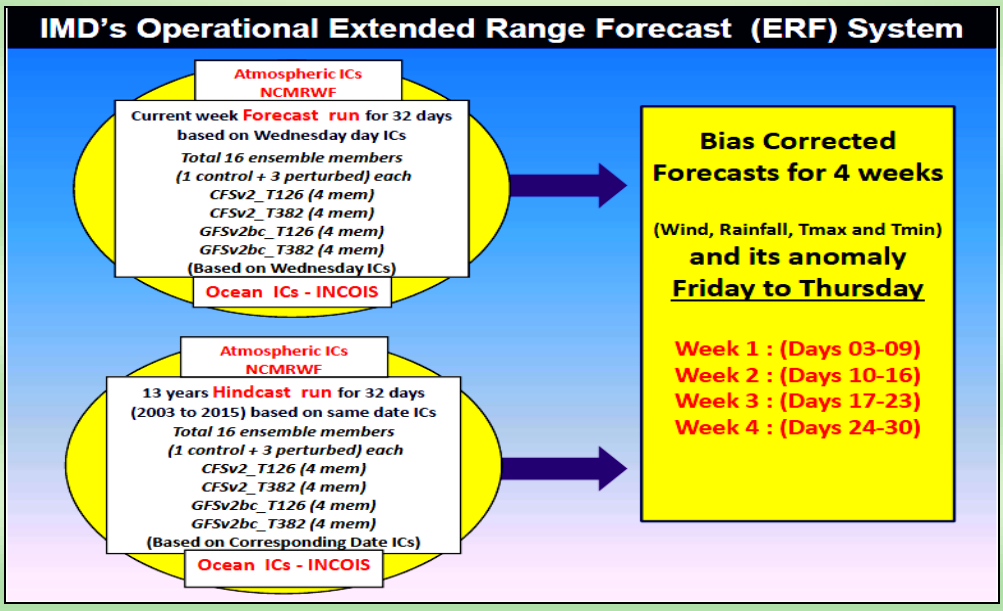


Fig. 2. IMD's operational extended range forecast (ERF) system

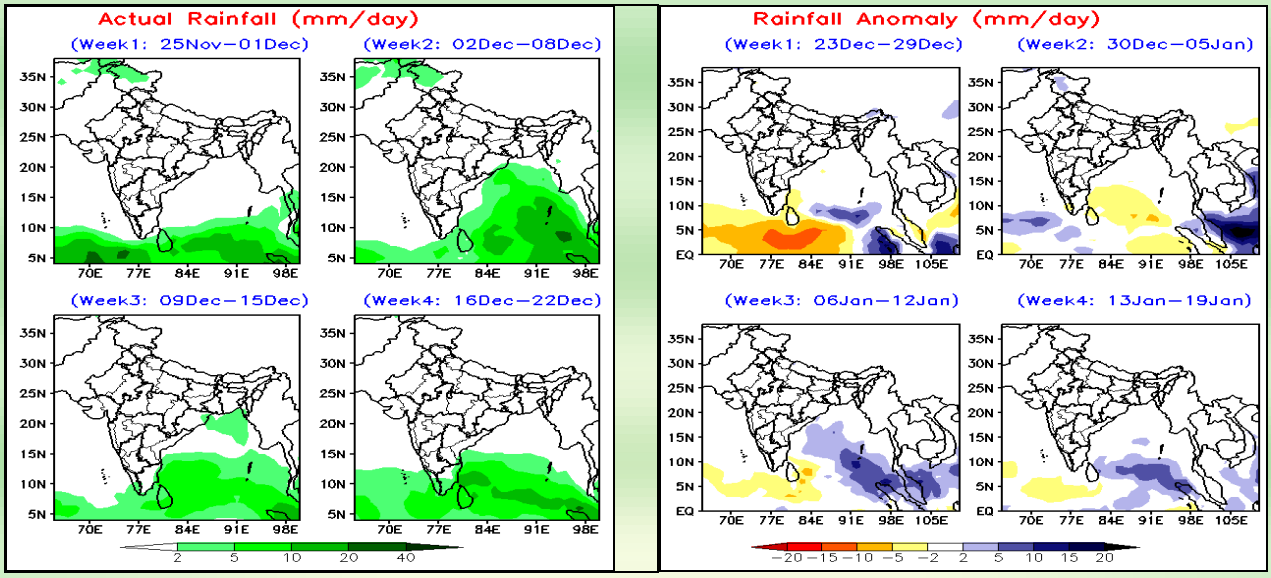
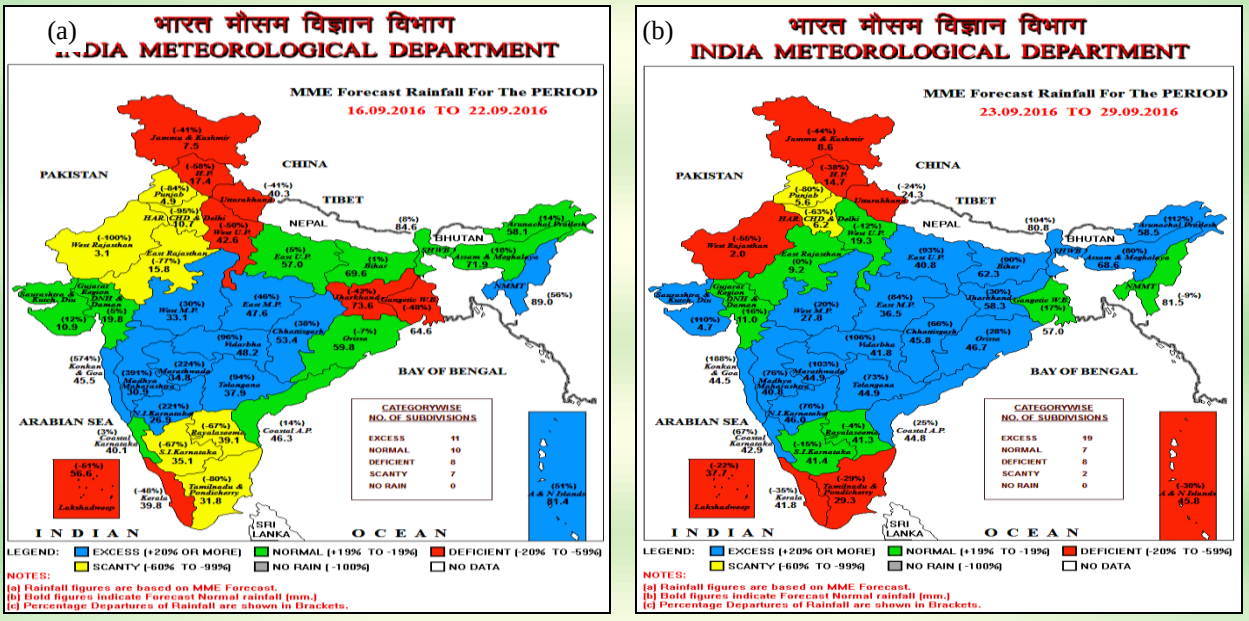


Fig. 3. The MME based extended range forecast of mean and rainfall anomaly for 4 weeks based on the initial condition of 23 November, 2016 and valid for 25 November to 22 December, 2016



Figs. 4 (a&b). MME based met-subdivision wise forecasts rainfall departure for 2 weeks based on 14 September and valid for (a) 16-22 September and (b) 23-29 September, 2016

The forecast of mean and rainfall anomaly for 4 weeks based on the initial condition of 23rd November, 2016 and valid for the period from 25 November to 22 December, 2016 is shown in Fig. 3.

The MME forecast is also prepared on smaller spatial scales (4 homogeneous regions of India and 36 Met. sub-divisions). During the southwest monsoon season from June to September the meteorological subdivision wise forecasts for two weeks are being used for providing agromet advisory to farmers. The met-subdivision wise MME forecast for two weeks based on 14th September, 2016 and valid for 16-29 September, 2016 indicating revival of monsoon during the withdrawal of monsoon is shown in Figs. 4(a&b). The quantitative forecast rainfall departure on all India and 4 homogeneous regions also indicate above normal monsoon during the withdrawal phase.

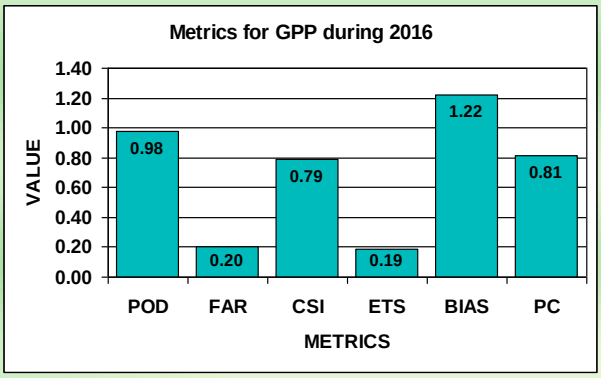


Fig. 5. POD, FAR, CSI, ETS, BIAS and PC for all genesis forecasts of GPP during 2016

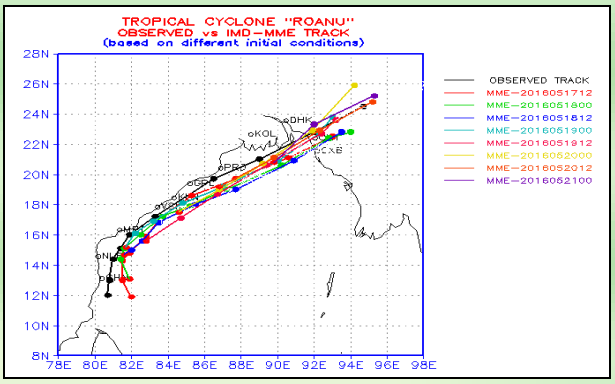


Fig. 6. Cluster of Track prediction of cyclone ROANU by MME (17-21 May 2016)

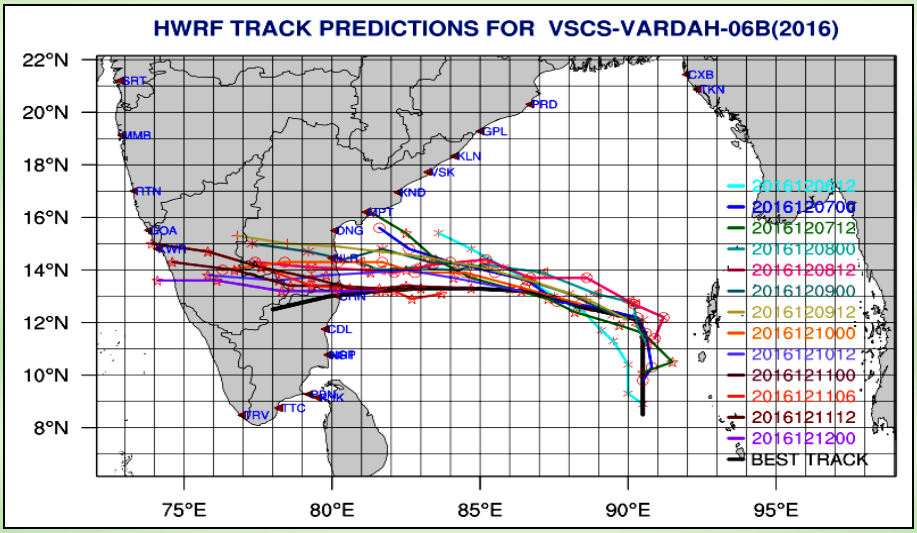


Fig. 7. Cluster of Track prediction of cyclone VARDAH by HWRF model (7-12 December, 2016)

CYCLONE GENESIS POTENTIAL PARAMETER (GPP) AND TRACK FORECAST

Since all low pressure systems do not intensify into cyclones, it is important to identify the potential of intensification (into cyclone) of a low pressure system at the early stages (T. No. 1.0, 2.0) of development. Analysis and forecasts of GPP shows that GPP ≥ 8.0 (threshold value for intensification into cyclone) indicated its potential for intensification into a cyclone at early stages of development (T. No. 1.0 to 2.0).

Six metrics, such as the probability of detection (POD), the false alarm rate (FAR), critical success index (CSI), equitable threat score (ETS), frequency bias (BIAS) and percentage correct (PC) have been computed to evaluate the skill of the GPP for genesis forecasts issued during 2016. It can be seen from the Fig. 5 that the POD of the GPP was 0.98, the FAR was 0.20, CSI was 0.79, ETS was 0.19, BIAS was 1.22 and PC was 0.81 for 154 forecast events during 2016. The results show that POD was much higher than FAR and near desirable value for BIAS and also high CSI and PC indicate that the GPP was skillful for cyclogenesis prediction.

The MME based cyclone track is also prepared for each cyclone. Track forecasts of cyclone VARDAH and ROANU by MME and HWRF model are shown in Figs. 6 and 7 respectively. The average track forecast errors (in km) during 2016 is shown in Fig. 8. It shows that under wide variation of track forecasts of different NWP models MME track provided very useful guidance during 2016.

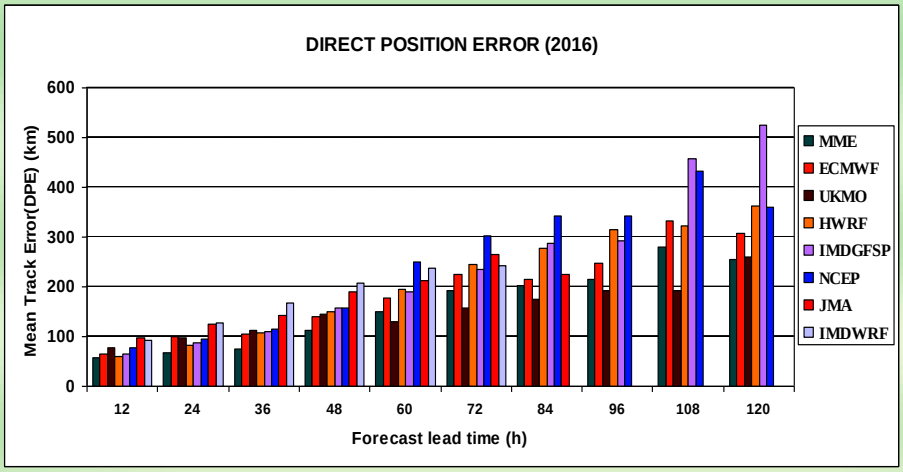
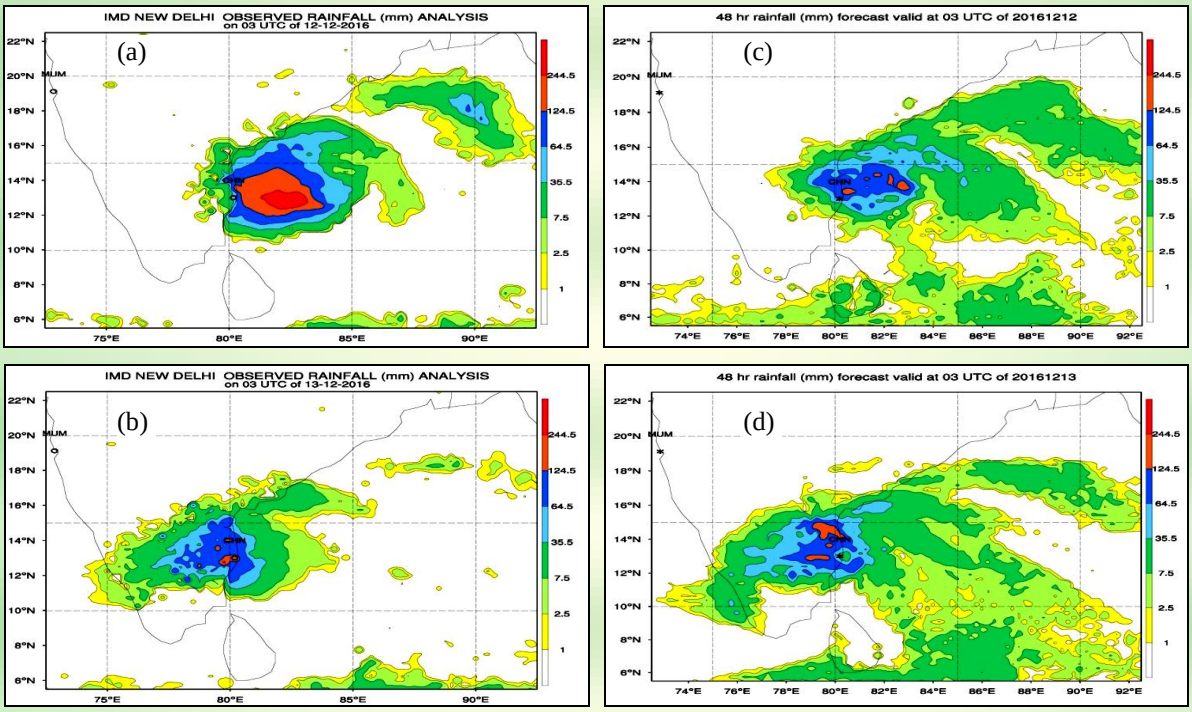


Fig. 8. Average track forecast errors (in km) during 2016



Figs. 9(a-d). Comparison between observed rainfall analyses and WRF model rainfall forecasts during 12 and 13 December 2016 due to cyclone Vardah. Observed Rainfall valid at 0300 UTC (a) 12 December (b) 13 December and 48 hr forecast valid at 0300 UTC (c) 12 December and (d) 13 December

SHORT RANGE FORECASTING BASED ON MESO-SCALE MODEL WRF

Figs. 9(a-d) shows heavy rainfall scenarios occurring over Tamilnadu during 12 and 13 December 2016 as that has been observed and forecasted by the model when the tropical cyclone "Vardah" made landfall. The observed rainfall distribution has been captured well by the 48 hours forecasts of WRF model although the highest intensity of rainfall is under-predicted by the model. The specific coverage of rainfall over north Tamilnadu within the period as noticed in the observation has also been brought out by the model forecast.

CHAPTER 4

OBSERVATIONAL NETWORK

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

4.1. UPPER AIR OBSERVATIONAL NETWORK

Radiosounding Radiowind (RS/RW) network

For measuring the vertical profile of the Atmosphere *viz*., Temperature, Pressure, humidity, Wind Speed and Direction, the upper air observations are taken by using balloon borne soundings. Under the global observing system (GOS) network of WMO, India Meteorological Department (IMD) has 43 operational Radiosonde radiowind stations in their upper air network. These stations are engaged in taking the radiosounding observations twice a day at 0000 UTC and 1200 UTC hours.

As a subset of GOS network, World Meteorological Organization (WMO) in collaboration with the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU) established Global Climate Observing system (GCOS) network in 1992, as an outcome of 2nd World Climate Conference. In the upper air domain of GCOS, aiming on further improvement of upper air data quality, IMD established GUAN standard radiosounding observations at its 6 Regional Meteorological Centres (RMCs). These stations have been equipped with high quality (M/s GRAW radiosondes, Germany make) radiosounding system, GS-E along with DFM-09 radiosondes. The ground system GS-E and radiosondes DFM-09 are compatible to be used at a standard GUAN upper air observatory for radiosounding. The existing "Global climate observation system upper air network (GUAN) standard -compatible network of India Meteorological Department (IMD)" is shown in Fig. 1.

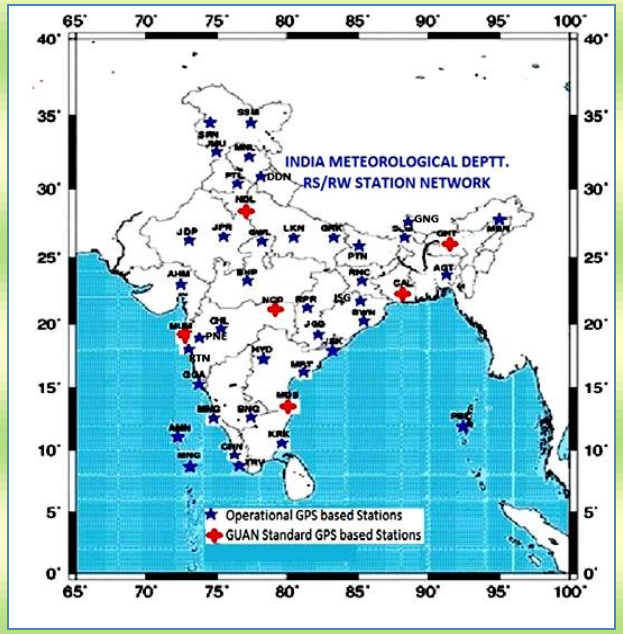


Fig. 1. RS/RW station network

Pilot Balloon (PB) network

62 stations in the upper air network of IMD having pilot balloon observations (Fig. 2). Pilot Balloon Observations are used to measure the upper air wind speed and direction. The balloon is tracked using Optical Theodolite. These observations are made every synoptic hour.

Fig. 2. Upper air network of IMD

Accomplishments during the year 2016

(i) Total network of upper air radiosounding (RS/RW) of 43 stations has been upgraded with GPS based radiosounding systems and all the stations are working at present.

(ii) GPS based high quality radiosounding systems (make M/s GRAW Germany) continued operation as per WMO GCOS Network (GUAN) standard installed at 6 Regional Meteorological Centres (New Delhi, Kolkata, Chennai, Guwahati, Mumbai, Nagpur).

WMO-GCOS secretariat has been approached to include these 6 stations into WMO-GUAN standard network. A formal request has been sent the Secretary General of WMO from DGM.

(iii) Pilot Balloon (PB) observatories of Jharsuguda, Pune, Ratnagiri and Gangtok have been up-graded to RS/RW. The details of new installations during the year are given below:

GPS Stations Dates of commissioning

S. No.	Name of Station	Installation Date
1	Gangtok	06/05/2016
2	Pune	18/06/2016
3	Ratnagiri	22/06/2016
4	Jharsuguda	08/07/2016

GPS Radiosounding System at Jharsuguda is shown in Fig. 3.

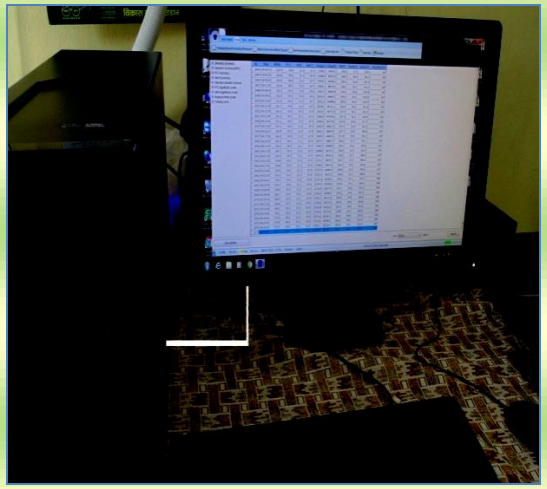


Fig. 3. GPS Radiosounding System-Jharsuguda

Fig. 4. Field Testing of radiosonde at RMO, Ayanagar

(iv) Indigenous GPS based radiosonde is in final stage of production. Procurement of different components is completed. Sensor package is awaited to start the production (Fig. 4).

Future Projects

- Induction of Indigenous GPS based radiosounding system in IMD's upper air network, and production of GPS based radiosondes in IMD workshop.
- Fully Automatic Surface Mounting Technology (SMT) based machine.
- Induction of 5 portable GPS based upper air stations under proposed modernization of IMD phase-II program.

- Under Atmospheric Observation System Network scheme - Up-gradation of 5 pilot balloon (PB) stations using GPS pilot-sonde. Up-gradation of remaining 57 pilot balloon (PB) stations using GPS pilot-sonde under proposed modernization of IMD phase-II.

Items proposed under Himalayan Meteorology Programme;

- GPS upper air systems -7 Nos.
- Radiometers - 3 Nos.

Following items are to be introduced in IMD upper air network under Development of High Impact Severe Weather Warning System:

- Mobile GPS upper air systems-2 Nos.
- Raman LIDAR - 1 No.
- Wind Profilers - 2 Nos.
- Polarized LIDAR - 1 No.
- Microwave radiometer - Set of 4 Nos.
- Phased array SODAR - 1 No.

4.2. SURFACE OBSERVATIONAL NETWORKS

India Meteorological Department augmented its surface observational structure during 2016 and established following major instrument/ networks.

Installation of Digital Current Weather Instrument System (DCWIS)

Digital Current weather Instrument System has been installed in runway 12 and 30 of Chennai Airport during 8-15 March, 2016.

Installation of Met Report Display System

Current weather observations in the airports are disseminated to local users, *viz.*, ATC tower and Area control units in plain language and to the global users as METAR in coded form. The Met Reports are delivered by hand to the local users except in Chennai, Mumbai, Kolkatta and Palam where there is Met Report Display System attached to the AMSS (automatic Message Switching System). The system developed in AMO Chennai is an intranet web-based display system. The current weather observation input in a web page is converted into Met Report and METAR by the software and Met Report is displayed in ATC tower and Area control units and METAR in AFTN (Aeronautical Fixed Telecommunication Network) room. This system has been installed in CIAL Kochi and AMO Thiruvananthapuram during the year 2016.

Computerization of Aviation Forecast Verification

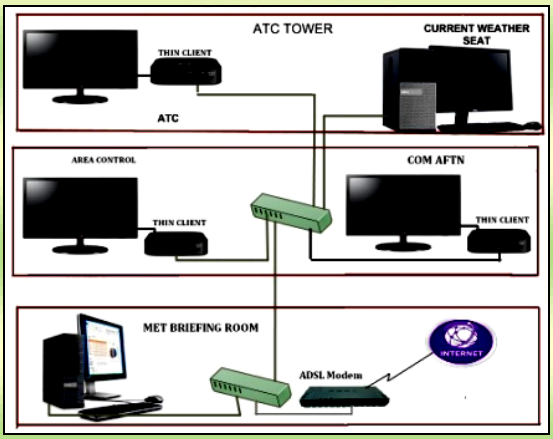


Fig. 5. Met report display system

Software for verifying aviation forecasts is being developed at AMO Chennai (Fig. 5). On input of the station name, month and year the system shall retrieve relevant data *viz.*, METARs, TAFs, Take-Off Data and TREND forecasts from AMSS and generate monthly verification report as per the standards laid in ICAO Annex-3, 16th edition for operational desirable accuracy of forecasts.

Automatic Rain Gauge (ARG) Stations

Automatic Rain Gauge stations are used to take rainfall observations and transmit

automatically at locations where the regular manned observatories are not possible to maintain. During 2016, 58 such Automatic Rain Gauge (ARG) Stations were installed by IMD.

Digital Standard Barometer

• As per WMO guidelines Mercury Barometers are to be phased out by 2020. Initiative has been taken to replace the Mercury Barometer by Digital Standard Barometer at all observatories of IMD (Fig. 6). In 2016, 93 nos. of Digital Station Barometers at different observatories are installed.

Fig. 6. Digital Standard Barometers

Fig. 7. GNSS - Global Navigation Satellite System

• GNSS is used to determine the Latitude/ Longitude and Altitude of a place (Fig. 7). GNSS measures Altitude with an accuracy of ±10 cms. As on date total 537 AWS sites are surveyed using GNSS for determining accurate Latitude/Longitude and Altitude. This has improved the accuracy of pressure measurement significantly at all these sites.

Radiation measuring Instruments

Pyranometer

Four Pyranometers are installed and made operational at Port Blair, Jaisalmer, Jaipur and Coimbatore for measurement of continuous Global radiation. Pyranometer are also used as Diffuse Radiation measurements.

Fig. 8. Different types of Pyranometers

Six pyranometers with shading ring assembly are installed & made operational at Anand, Port Blair, Jaisalmer, Tadong, Coimbatore and Shimla (Fig. 8).

UV-B Radiometers

Fig. 9. UV-B Radiometers

• UV-B ranges are physiologically important because it includes erythemal wavelengths which have destructive actions on organisms and which destroys the skin tissues (Fig. 9). UV-B Radiometer has been installed at 5 centres, *viz.*, Amini, Minicoy, Anand, Shimla and Coimbatore.

Sun Shine Recorder

Fig. 10. Sun Shine Recorder

Sunshine Recorder has been installed at 9 centers, *viz.*, New Delhi, Chennai, Kodaikanal, Shillong, Thiruvananthapuram, Nagpur, Goa, Ahmedabad and Jodhpur (Fig. 10).

Airport meteorological Instruments

Dhristhi

Twelve indigenously developed new Dristhi RVR systems at the Indira Gandhi International Airport Delhi, Lucknow, Jaipur, Amritsar, Dehradun and Varanasi. These RVR systems are developed indigenously by CSIR-NAL. It measures Wind speed, Wind direction, Pressure, Temperature, Humidity, Dew Point and Visibility (Fig. 11).

Fig. 11. Dristhi weather monitoring system

Current Weather Instruments System (CWIS)

IMD make Current Weather Instruments System (CWIS) installed at Chennai airport. CWIS along with Data Logger and Display Unit is shown in Fig. 12.

Fig. 12. CWIS, CWIS System Data Logger and CWIS Display Unit

Distant Indicating Wind Equipment (DIWE)

Distant indicating wind equipment is used for the continuous monitoring of wind direction and wind speed at the touchdown zone of runway in an airport. The DIWE provides instantaneous, 2 minute and 10 minute averaged wind data. Normally, DIWE is installed at airports where air traffic is less. Monitoring of atmospheric pressure, air temperature and relative humidity is not done in DIWE. These observations are provided from conventional observatory data. DIWE System on field, DIWE Data Logger and DIWE display units are installed at different airports (Fig.13).

Fig. 13. DIWE System on touchdown zone of runway, DIWE Data Logger and DIWE Display Unit

HWSR - High Wind Speed Recorder System

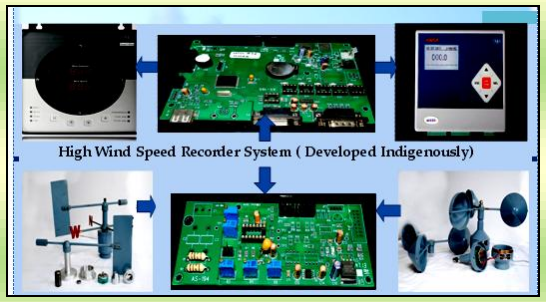


Fig. 14. HWSR - High Wind Speed Recorder System

High Wind Speed Recorder System is used for minute to minute graph of wind direction and wind speed *vs* time (Fig. 14). During 2016, High wind speed recorder (HWSR) installed at the following stations:

West Bengal	:	Digha, Haldia, Sagar Island
Orissa	:	Balasore, Gopalpur, Paradeep, Puri
Andhra Pradesh	:	Kakinada, Visakhapatnam, Machilipatnam, Nellore, Ongole, Kalingapatnam
Goa	:	Panjim
Tamil Nadu	:	Chennai
Puducherry	:	Karaikal
Gujarat	:	Veraval, Dwarka, Bhuj, Naliya
Andaman & Nicobar	:	Port Blair

4.3. SATELLITE OBSERVATIONS

The meteorological satellite data of INSAT is processed and disseminated by INSAT Meteorological Data Processing System (IMDPS) of India Meteorological Department (IMD) which was installed by M/s Antrix Corporation through an MOU with India Meteorological Department. At present, Kalpana-1(VHRR, DRT), and INSAT-3D (Imager, Sounder, DRT) satellites carrying meteorological payloads are supporting weather forecasting services. INSAT-3D Meteorological Data Processing System (IMDPS) was dedicated to the nation by the Hon'ble Minister of Science and Technology, Ministry of Earth Sciences on 15 January 2014. The system is capable to receive and process the data of all two-existing geostationary meteorological satellites. The performance of the system during the current year has been maintained to the level of 98% operation efficiency (24 × 365 bases). The output generated by the system is used for efficient and successful forecasting the major weather events particularly major cyclones (Roanu in May, 2016), Kyant October 2016, Nada Nov 2016 and Vardah December 2016.

INSAT-3DR has been launched successfully 8th September, 2016 by GSLV -F05 and placed at 74 degree east in place of Kalpna-1 which has been shifted at 73.2-degree East. INSAT-3DR similar to INSAT-3D, is an advanced meteorological satellite of India configured with an imaging System and an Atmospheric Sounder. INSAT-3DR carries a multi spectral Imager, 19 channel Sounder, Data Relay Transponder and Search and Rescue Transponder payloads. IMD is in action to establish Multi-Mission Meteorological Data Receiving and Processing System (MMDRPS) for INSAT-3D, INSAT-3DR and INSAT-3DS in collaboration with M/s Antrix Corporation Ltd, ISRO for which a MOU will be signed soon between IMD and ISRO. The project is being monitored closely for implementation. At present the processed data of INSAT-3DR Imager and Sounder is being obtained from SAC, Ahmedabad through dedicated NKN connectivity and images generated at IMDPS and are disseminated on IMD website on real time basis.

The products derived from the satellite data include: Cloud images in the Visible, Short wave Infra-red, Mid Infra-red, Thermal Infra-red, Water Vapour Channels and special enhanced images, Atmospheric Motion Vectors (IR Wind, Water Vapour Winds, MIR and Visible Winds), Sea Surface temperature, Outgoing Long-wave radiation, Land Surface Temperature (LST), Insolation, Quantitative Precipitation Estimates, Night time Fog, Smoke, Fire, Snow Cover, Aerosol Optical Depth, Upper Tropospheric Humidity, Temperature & Humidity profiles, Total ozone, Total/Layer Precipitable Water Vapour,

Stability Indices .In addition to these, IMD has also started generation of Wind derived products such as Vorticity(at 850 hPa, 700 hPa, 500 hPa, 200 hPa levels), Wind Shear, Mid-level Wind Shear , Shear Tendency, Low level Convergence and Upper Level Divergence using Imager Wind product and NCEP forecast file and T-phi gram at all district locations using Sounder data. All these images and products are disseminated in a real time basis through dedicated IMD website. Satellite observed radiances and winds are now being assimilated in NWP models to improve their forecast ability. Satellite images are used in monitoring Cyclones. Intensity and position of cyclones is given to forecasters in real time using Dvorak technique. Satellite data and images are also used in monitoring various other significant weather phenomena such as Fog and thunderstorms.

The validation of atmospheric Motion Vector (wind products), sea surface temperature, outgoing long wave radiations (OLR) vertical Profile of temperature and humidity has been carried out and the feedbacks are used for fine tuning of algorithm of these products and calibration coefficients.

A joint calibration/validation (Cal/Val) campaign (19th April, 2016 to 23rd April, 2016) was carried out successfully at Runn of Kutch, Gujarat by IMD and SAC (ISRO). A joint report of Cal/Val campaign results has been prepared and site has been accepted for conducting regular Cal/Val campaign for INSAT-3D/3DR Cal/Val.

IMD has installed 682 Automatic Weather Stations (AWS) and other agencies have installed about 1200 AWS all over the country. IMD has also installed 1350 Automatic Rain Gauge (ARG) Stations. AWS and ARG services are operational by using the Data Relay Transponders (DRT) of INSAT-3D having global receive coverage with a 400 MHz uplink and 4504 MHz downlink frequencies with a data rate of 4.8 kbps for relay of Meteorological, Hydrological, Agro-Meteorological and Oceanographic data from unattended stations. The data collection is mostly carried out in Time Division Multiple Access (TDMA) mode to enhance the output. IMD is in process to upgrade its network using dual communication (GPRS & DRT) mode which will ensure frequent data availability in all type weather.

IMD's Area Cyclone Warning Centres generate special warning bulletins and transmit them every hour in local languages to the affected areas. During Recent past, in cases of Roanu in May, 2016, Kyant October, 2016, Nada November 2016 and Vardah December, 2016 Cyclones warnings were disseminated to all stake holders which resulted in minimum loss to human life. Advanced Dwork Technique (ADT) software has been customized for INSAT-3D and implemented to determine the intensity of Tropical Cyclones.

To improve navigation accuracy, Fixed Grid Navigation and Automatic Template Based Registration package for INSAT-3D Imager was developed and operationalized at Space Application Centre, Ahmedabad and IMD, New Delhi. The Ancillary Data Products Generation Software (ADPS) capability enhanced to include HRIT/LRIT products, AWS (Automatic Weather Station) Data Decoding, archival and report generation. Generation of Day Time Microphysics using Visible, SWIR and TIR1 spectral band and Night time Microphysics using MIR, TIR1 and TIR2 RGB composite Images have been started which are being used for cloud classification, operationally.

Space Application Centre, Ahmedabad has developed the Real Time Analysis Product & Information Dissemination (RAPID) which is a web based quick visualization and analysis tool for satellite data on a real-time basis and IMD has hosted it operationally since January 2015. This introduces Next Generation Weather Data Access & Advanced Visualization Application that touch the life of common man in one or other way ranging from weather events to atmospheric phenomenon. This has capability to visualize the Fog presence over railway

track and highways & a pilot can see the position of clouds and fog of the entire route in real time basis interactively. This also have capability to generate, time series plot of different products derived from satellites along with measuring capability of distance, area of any cloud system and to display the digital value of different parameters over different types of maps. The following additional features have been added in RAPID such as Taluk boundaries, India Sub-Basins and FMO Basin and the following enhancement (Aviation colour enhancement (AVN), Funktop enhancement-to highlight intense areas of precipitation, Rainbow ie Colourful enhancement for a pretty image, New variation on the Rainbow enhancement curve - Colourful enhancement (RBtop) are integrated in RAPID.

IMD has set up a countrywide network of 25 nos. Global Navigation Satellite System (GNSS) stations for "Earth and Atmospheric studies" have been Installed and commissioned to drive integrated precipitable water vapor (IPWV). The IPWV data is being used for now casting and assimilated in NWP models to improve the weather forecasting. A dedicated website has been developed to access IPWV data of 25 GNSS site in real time. Graphical user Interface was also provided to visualise 15 min, hourly, daily, weekly and monthly IPW data along with Meteorological data and minimum and Maximum value of IPW etc.

Software for forecasting and tracking of evaluation of cloud cluster acquired from National Institute for Space Research / Centre for Weather Forecast and Climate Studies (INPE//CPTEC), Brazil has been customized for INSAT-3D and operationalized.

It is stated that satellite technology is of great use in meteorology and plays a very significant role in the improvement of weather forecasting and dissemination. In fact the improvement in weather forecasting is mainly attributed to increasing use of satellite data.

4.4. ENVIRONMENT MONITORING AND RESEARCH CENTER (EMRC)

Black Carbon Monitoring Network of 16 stations for measurement of Spectral Aerosol Absorption Coefficient and Equivalent Black Carbon Concentration has been established during 2016. The names of the stations are New Delhi, Ranichauri, Varanasi, Nagpur, Pune, Port Blair, Visakhapatnam, Guwahati, Kolkatta, Jodhpur, Bhuj, Trivandrum, Ranchi, Amini, Chandigarh and Srinagar (Fig. 15).

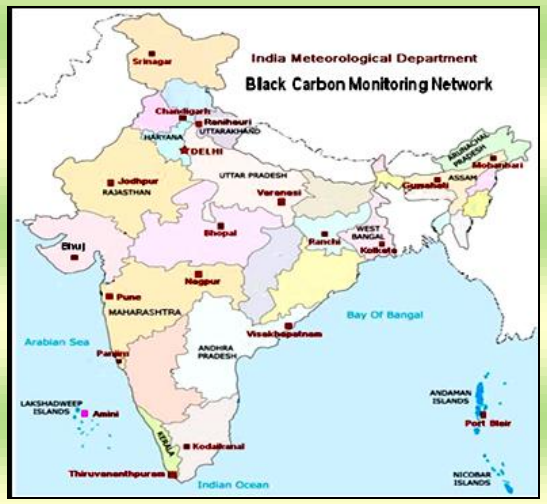


Fig. 15. Black Carbon Monitoring Network

High Volume Samplers for collecting PM10, PM2.5 and Total Suspended Particulate Matter have been installed at Delhi, Ranichauri, Pune and Varanasi. The filter papers will be analyzed for chemical characterization of aerosols.

Fig. 16. Ion-chromatograph, UV-VIS Spectrophotometer and Semi-micro Balance installed in Air Pollution Laboratory, Pune

Ion-chromatograph, UV-VIS Spectrophoto-meter and Semi-micro Balance have been installed in Air Pollution Laboratory, O/o ADGM(R), IMD, Pune for chemical analysis of precipitation samples and particulate matter (Fig. 16).

EMRC has evaluated 51 Thermal Power, 609 Industrial, 81 Coal Mine and 488 Mining projects referred to IMD by Ministry of Environment & Forests during 2016.

GPS based Ozonesonde system has been installed at Bharati Meteorological Observatory in Antarctica for measurement of vertical profile of Ozone (Fig. 17).

Fig. 17. Ozonesonde ascent at Bharati, Antarctica

Infrastructure Development & Installation

4.5. RADAR OBSERVATIONS

IMD has the network of Radar observations both at coastal and inland stations. Radar transmitter transmits electro-magnetic waves through a directional antenna in any given direction in a focused manner. A part of transmitted energy is absorbed by the atmosphere. Some of the energy travels further through the atmosphere and a fraction of it scattered backward by the targets and received by the radar receiver. The amount of return power provides information about the intensity of weather systems, whereas, the azimuth and elevation of the antenna gives the location and height of the cloud systems.

It is stated that Radar technology is of great use in meteorology and plays a very significant role in the improvement of weather forecasting and dissemination. In fact the improvement in Nowcasting of weather is mainly attributed to increasing use of Radar data.

IMD is continuously modernizing it's Radar networks by replacing the convectional radars located at different locations by Doppler Weather Radars (DWRs) along with installations of DWRs at fresh locations. During 2016, DWRs at Goa, Karaikal and Paradeep were commissioned. Through the joint efforts with ISRO Indigenously developed DWRs at Cherrapunjee (Fig. 18), Bhuj, Gopalpur and Thiruvananthapuram.

Fig. 18. Doppler Weather Radar at Cherrapunjee

ISO Certification

ISO 9001:2008 Certification has been awarded to Central Aviation Meteorological Division (CAMD) on 27thFebruary, 2016.

ISO Certification of Meteorological Centre Bhubaneswar, Area Cyclone Warning Centre and Doppler Weather Radar Kolkata is under process and expected to be completed shortly. The RFPs from the offices/units are being uplinked in Regional Meteorological Centre Kolkata's website for inviting bids from interested parties according certification.

Approval for QMS certified external audit bodies for obtaining ISO 9001:2008 certificate is under process at M. C. Ahmedabad.

4.6. SAARC STORM PROJECT – 2016

The SAARC 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 for highly damaging severe thunder storms over various parts of India. The Program Implementation Committee (PIC) of the SAARC STORM Project was reconstituted by MoES in 2008. During the pilot-phase of 2009, the domain was extended to include the neighbouring countries Nepal, Bhutan and Bangladesh through a newly established lead partnership with the SAARC Meteorological Research Centre (SMRC), Dhaka. In the SAARC STORM Project so far, four STORM Field Experiments have been conducted in Phase-I focusing on Norwesters in pre-monsoon seasons during 2009-2012. In Phase-II of SAARC STORM Programme since 2013 and accordingly STORM Reports were prepared. This year also Storm field experiments covered whole India. A Weather Advisory Group, established at the India Meteorological Department (IMD), New Delhi was set up, whose main task was to watch the development of daily weather situation over the STORM campaign area during March-June-2016, advice the various participating offices on the nature and frequency of observations required to be taken by them on day to day basis and to issue a bulletin every Monday, Wednesday and Friday.

Nowcasting of Thunderstorms, squalls and Hailstorms

This year also, Nowcast Unit prepared a storm report document that contains information on daily weather situation, important weather which started in 2012, STORM Field Experiments were also carried out jointly in Afghanistan, northwest India and Pakistan focusing on deep convective moist and dry storms during pre-monsoon season, 2012. In Phase-III of SAARC STORM Programme which started in 2013, STORM Field Experiments were also executed in southern peninsular

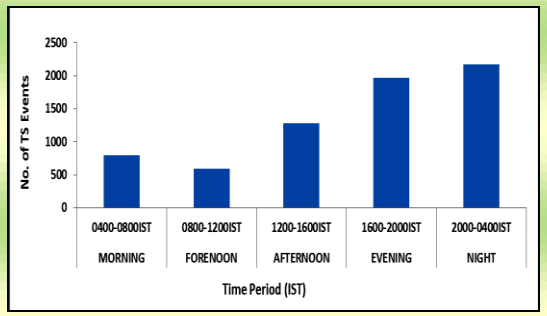


Fig. 19. Diurnal distribution of thunderstorm events over the country during Storm Period-2016

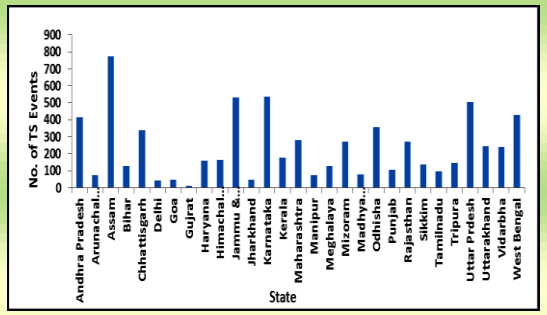


Fig. 20. Statewise distribution of thunderstorm events over the country during Storm Period-2016

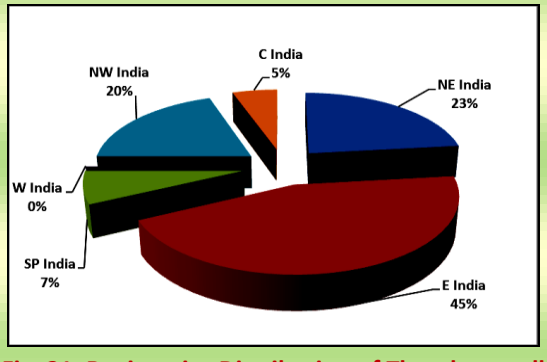


Fig. 21. Regionwise Distribution of Thundersquall events over the country during entire Storm Period-2016

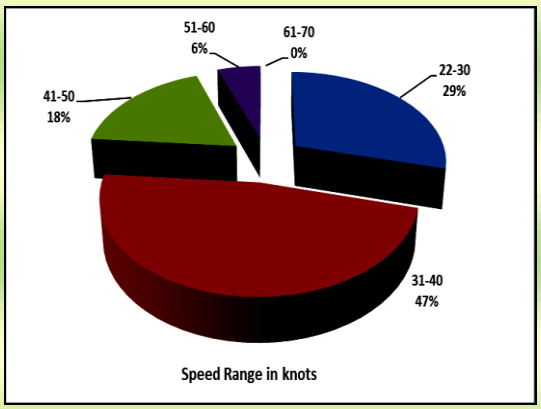


Fig. 22. Distribution of thunder squalls over the country based upon max wind speed (Kt) - Storm Period-2016

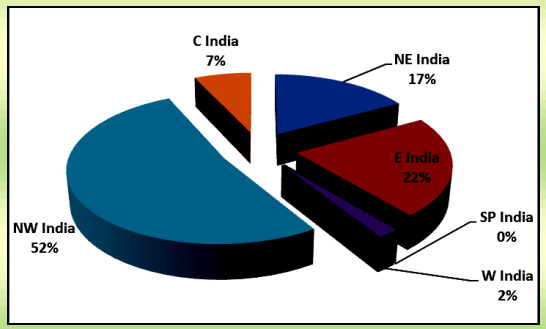


Fig. 23. Regionwise Distribution of Hailstorm Events over the Country during entire Storm Period-2016

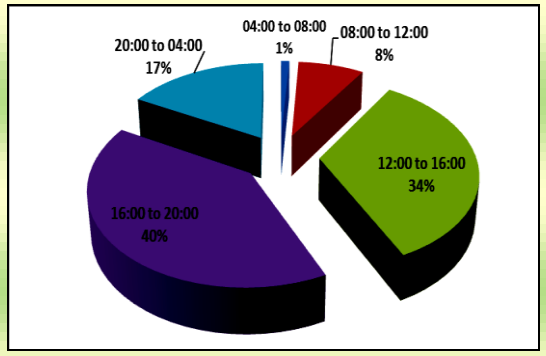


Fig. 24. Diurnal Distribution of Hailstorm Events over the Country during entire Storm Period-2016

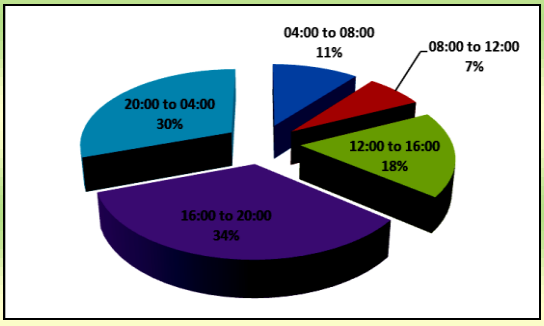


Fig. 25. Diurnal Distribution of Thundersquall Events over the Country during entire Storm Period-2016

India, Maldives and Sri Lanka to study maritime and continental convective storms during pre-monsoon season of 2013, 2014 & 2015, thus covering whole India charts, severe weather events all through the campaign period, case studies and the bulletins issued during the period. The report is expected to be released soon. Figs. 19 to 25 represent some of the important results of the Storm Report-2016 and Table 1 gives the verification of Intensive Observation Period (IOP) issued during the storm period.

Nowcasting is based on the ability of the forecaster to assimilate great quantities of weather data, conceptualize a model that encompasses the structure and evolution of the phenomenon and extrapolate this in time. Nowcasts require high resolution of spatial and temporal meteorological data to detect and predict the occurrence of an event. Lack of data of the mesoscale imposes limit on ability to diagnose and predict an event. Nowcasting in India has benefited from major developments in observational meteorology and computer - based interactive data processing and display systems in IMD. In view of the recent improvement in monitoring and forecasting, due to introduction of (*i*) digital and image information at 10 mins interval from a network of 18 Doppler Weather Radars, (*ii*) dense automatic weather station (AWS) network, (*iii*) half hourly satellite

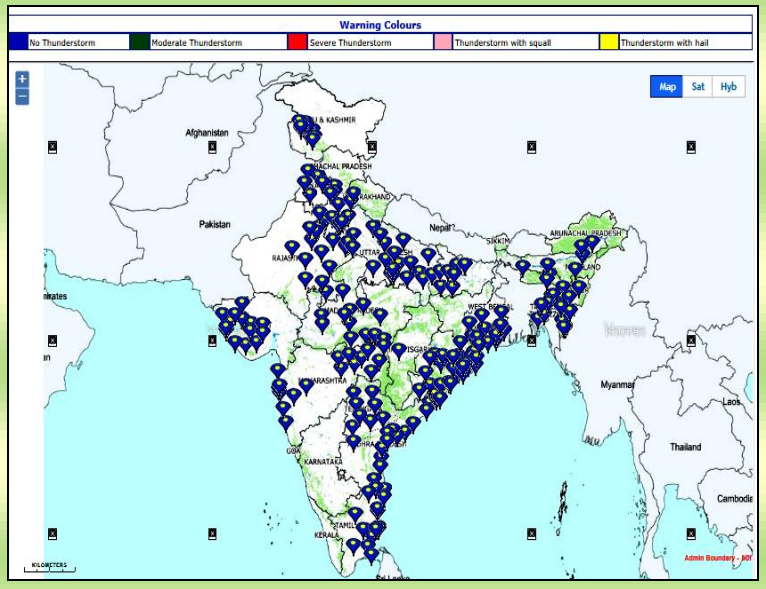


Fig. 26. All India Nowcast

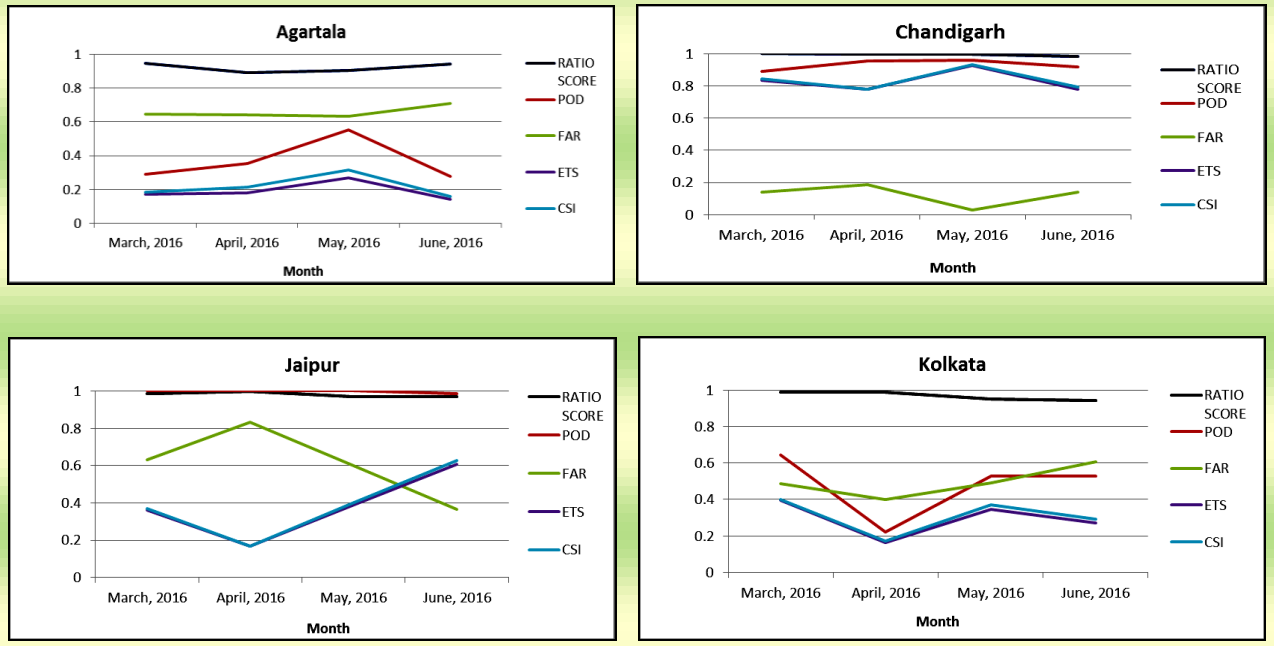


Fig. 27. Skill scores of thunderstorm nowcast verification for STORM Period-2016 for Agartala, Chandigarh, Jaipur & Kolkata

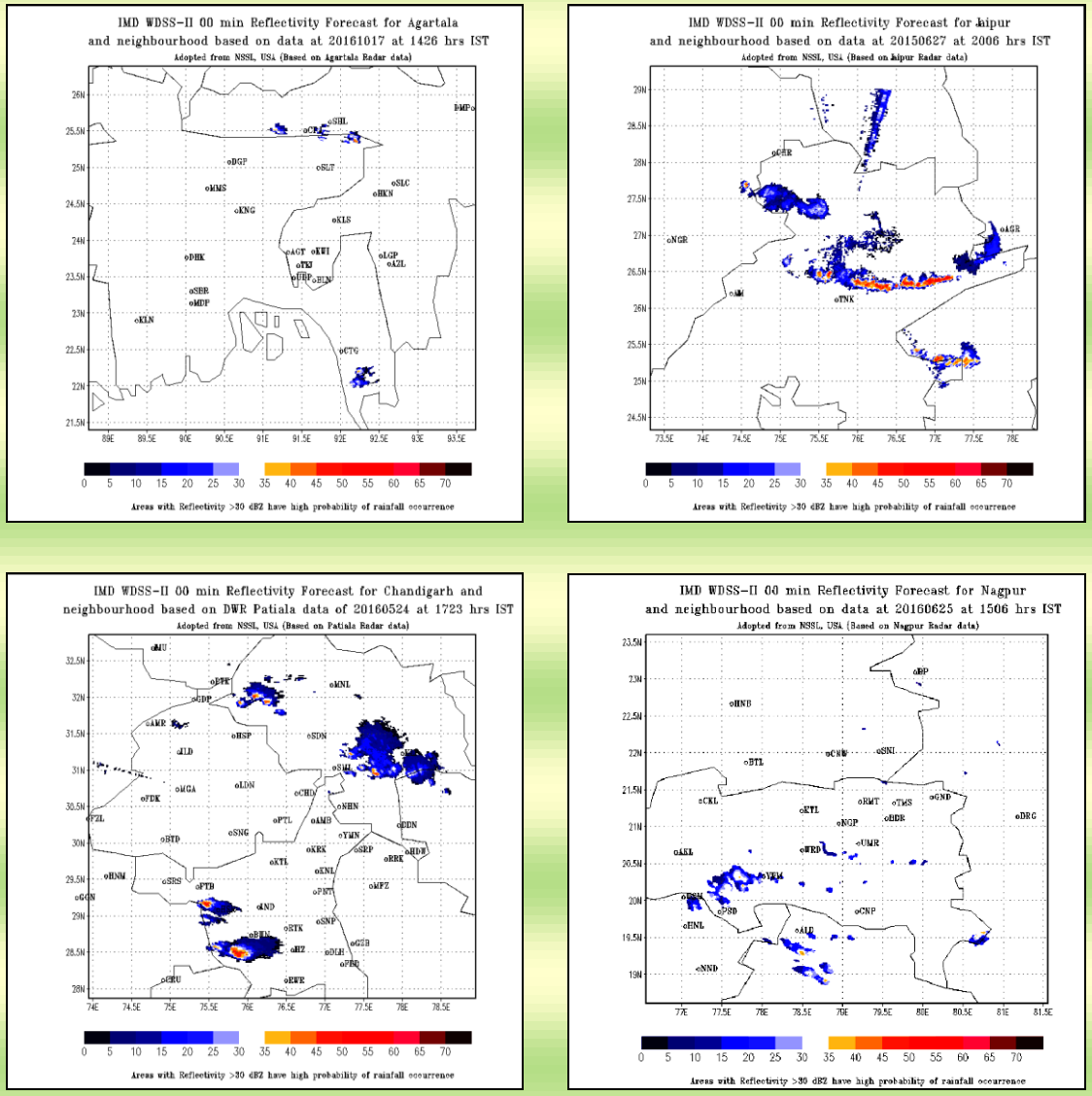


Fig. 28. IMD WDSS-II reflectivity forecast for Agartala, Jaipur, Chandigarh and Nagpur

TABLE 1

Verification of Intensive Observation Period Issued during STORM Period-2016

Region	IOP Period	Total number of days	Total no. of IOP issued	No. of times Significant Weather (TS/HS/SQ) Occurred	% age Correct
Northwest India	1-03-16 to 15-06-16	105	30	27	90
Central India	1-03-16 to 15-06-16	105	19	18	95
West India	1-03-16 to 15-06-16	105	8	3	38
South Peninsular India	1-03-16 to 15-06-16	105	32	29	91
East India	1-03-16 to 15-06-16	105	47	36	77
Northeast India	1-03-16 to 15-06-16	105	41	33	80

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 (Fig. 26).

This year, with the operationalization of DWR Karaikal, Gopalpur, Bhuj & Paradeep and installation of WDSS-II at Agartala, 72 new stations were added, thereby, increasing the total number of nowcast stations to 228 within 200 km radius of various Doppler Weather Radars. TS nowcast of these stations is uploaded every 3 hourly interval utilizing Synoptic Data, Model outputs, Satellite products and finally various Radar outputs. The forecast was operational from December 2012.

Skill Scores of Thunderstorm Nowcast Verification - 2016 for Agartala, Chandigarh, Jaipur & Kolkata for the STORM Period is shown in Fig. 27.

Warning Decision Support System Integrated Information (WDSSII)

WDSSII (Warning Decision Support System Integrated Information) for automated nowcasting of thunderstorms for upto 120 minutes ahead at 30 minute intervals, was additionally installed at MC Chandigarh, MC Patna, MC Jaipur, RMC Nagpur, RMC Kolkata, MC Agartala for nowcasting purpose. With this a total of nine stations (including the above and RMC Chennai, RMC Delhi and MC Hyderabad) have automatic nowcasting of Thunderstorm occurrence and movement for a 250 km domain around the respective Doppler radar location. This information is uploaded at ten minute intervals at the various MC Websites on real time basis. Fig. 28 shows IMD WDSS-II reflectivity forecast for Agartala, Jaipur, Chandigarh & Nagpur.

CHAPTER 5

WEATHER AND CLIMATE SERVICES OF IMD

5.1. HYDROMET SERVICES

The Hydro-meteorological Division is providing the necessary technical and operational support to various Central/State Govt. organization and other agencies in the field of hydro met design, flood forecasting, rainfall monitoring for water management and agricultural planning purposes etc. The number of districts upgraded from 641 to 660 for the preparation of daily/weekly rainfall Statistics w. e. f. 31st August, 2016. Hydromet Division, New Delhi is computing Sub-basin wise QPF using operational NWP models and uploaded on ESSO-IMD website for 146 flood prone sub-basins of India to be used as Guidance for forecasters for issuance of operational QPF for river basins. Design storm study in respect of sixteen (16) Hydraulic projects have been completed during the period January - December, 2016. The revenue of Rs.31,11,653/- has been deposited in IMD A/c for providing the design storm estimates to various project. The state wise list of the projects completed during the period January-December 2016 are given in Table 1.

Major Services

Design storm Estimates

Design Storm is the estimation of rainfall amount and its distribution over a given drainage basin which is adopted as the basis for the derivation of the design flood. It consists of Standard project storm (SPS), PMP and temporal distribution. It involves the work of storm analysis, calculate Probable Maximum Precipitation (PMP) and and its time distribution are used as main input by design engineers in estimating design flood for hydraulic structures, irrigation projects etc. This is required for safe and optimum design of storage and spillway capacity. During 2016, the following projects have been completed.

TABLE 1

The state wise list of the projects completed during the period January - December 2016

S. No.	State	No. of Projects	Name of the Project
1.	Uttarakhand	1	Sirkaribhyol Rupsiabagar Hydroelectric Project,
2.	Meghalaya	1	Mawblei Hydroelectric Project
3.	Karnataka	3	Malaprabha Dam, Mallaghatta Dam, Amarja Reservoir Project
4.	Arunachal Pradesh	2	Kurung HEP, Doimukh Hydro Electric Project
5.	Rajasthan	1	Brahmani to Banas river
6.	Himachal Pradesh	2	Pong Dam, Pandoh Dam
7.	Andhra Pradesh	1	Vottigedda Dam
8.	Maharashtra	3	Bandra Nalla Subsidiary Storage Dam, Bhandora Nalla Subsidiary Storage Dam, Pale Parmar Nalla Subsidiary Storage Dam
9.	Nagaland	2	Tizu Project, Zunki Project

The PMP values are provided to State Govts., Central Water Commission, NHPC, Uttrakhand Jal Vidyut Nigam Ltd. (UJVNL), WAPCOS, Project authorities etc.

Besides these work DSU is preparing PMP Atlases for the Krishna river basin which will be useful for design estimates for small and

medium projects and also reviewing the PMP values of existing hydraulic projects.

Rainfall Monitoring

Hydromet Division brings out real-time rainfall summary every week from Thursday to Wednesday and also for months. During Monsoon season, the same is prepared on daily basis for 660 Districts, 36 Met. Sub Divisions, 36 States including UTs, 4 Regions and for the country as a whole. Besides this, rainfall statistics is also prepared for **61 selected River basins** of India and the maps are uploaded on IMD website. The Unit also brings out updated monthly, seasonal and annual rainfall statistics after incorporating the late receipt data. Rainfall Monitoring Unit also publishes Annual Rainfall Report.

The rainfall summary is used by various stake holders for multiple purposes like Agricultural planning and advisories, Crop yield forecast, Agricultural pricing, Estimation of irrigation requirements, Relief measures, Hydro-power Planning and many other economical and research activities.

Recipients of rainfall statistics includes higher authorities like Office of Hon. Prime minister, Secretary MoES etc.

The annual Rainfall statistics for the year 2016 (January to December) for the country as a whole was 1083.1 mm, 91% of its Long Period Average (LPA) of 1187.6 mm. Out of 36 Met. Sub-divisions, 1 Met. Sub-division remained in Excess Rainfall category, 23 in Normal rainfall category and 12 remained in Deficient category of rainfall. None of the Met subdivisions remained in Large Excess, Large Deficient or No Rain category. Subdivision-wise rainfall map of India during 2016 is shown in Fig. 1.

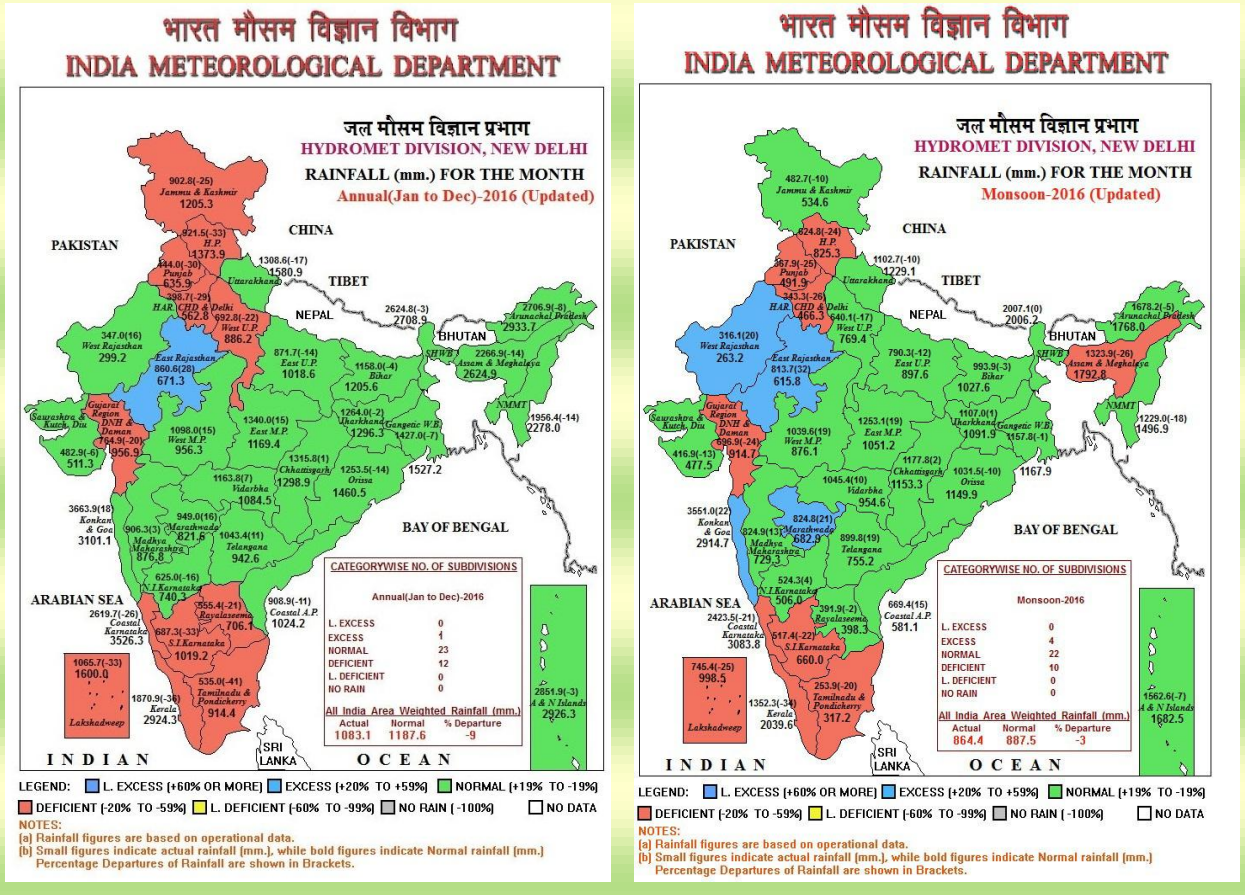


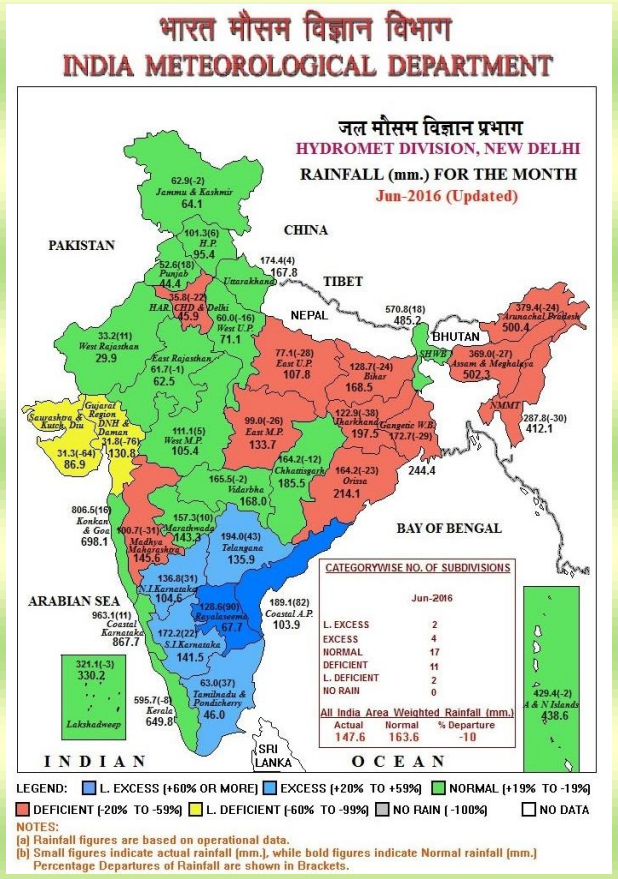
Fig. 1. Subdivision-wise rainfall map of India during 2016

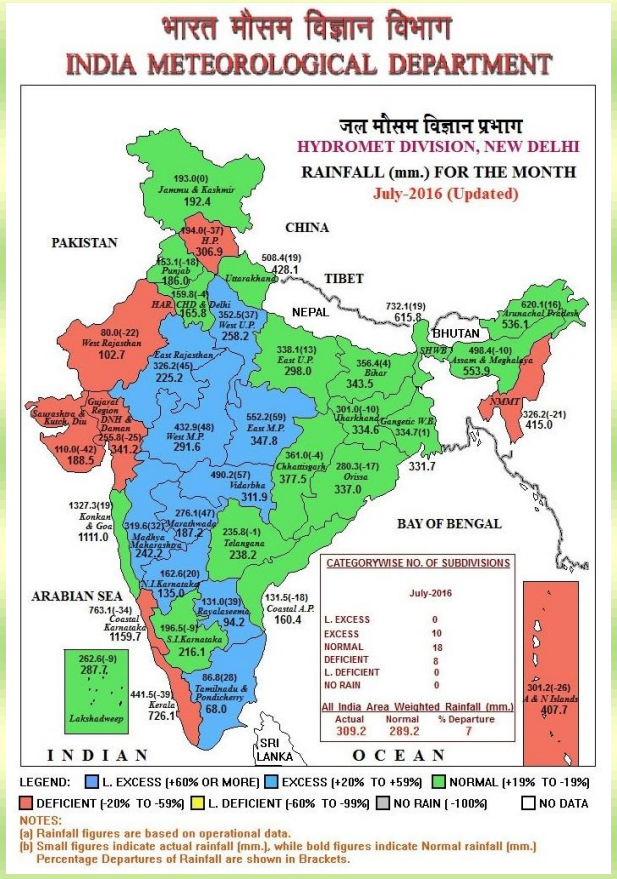
TABLE 2

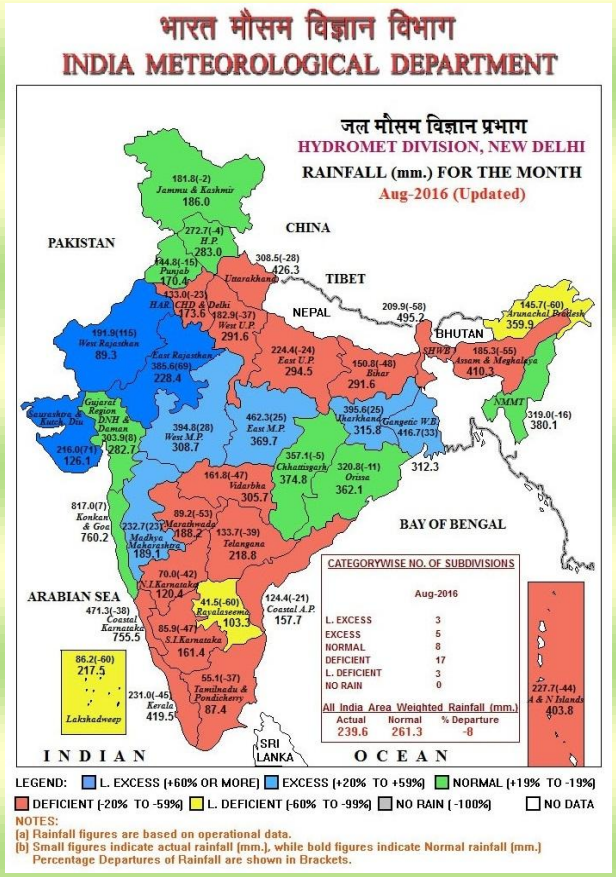
Subdivision-wise rainfall (mm) distribution

S. NO.	METEOROLOGICAL SUBDIVISIONS	ANNUAL	JAN-DEC, 2016		
		ACTUAL	NORMAL	% DEP.	CAT.
EAST & NORTH EAST INDIA		1857.1	2037.8	-9%	
1.	ARUNACHAL PRADESH	2706.9	2933.7	-8%	N
2.	ASSAM & MEGHALAYA	2266.9	2624.9	-14%	N
3.	N M M T	1956.4	2278.0	-14%	N
4.	SHWB & SIKKIM	2624.8	2708.9	-3%	N
5.	GANGETIC WEST BENGAL	1427.0	1527.2	-7%	N
6.	JHARKHAND	1264.0	1296.3	-2%	N
7.	BIHAR	1158.0	1205.6	-4%	N
NORTH WEST INDIA		740.6	866.9	-15%	
1.	EAST U.P.	871.7	1018.6	-14%	N
2.	WEST U.P.	692.8	886.2	-22%	D
3.	UTTARAKHAND	1308.6	1580.9	-17%	N
4.	HAR. CHD & DELHI	398.7	562.8	-29%	D
5.	PUNJAB	444.0	635.9	-30%	D
6.	HIMACHAL PRADESH	921.5	1373.9	-33%	D
7.	JAMMU & KASHMIR	902.8	1205.3	-25%	D
8.	WEST RAJASTHAN	347.0	299.2	16%	N
9.	EAST RAJASTHAN	860.6	671.3	28%	E
CENTRAL INDIA		1145.0	1111.0	3%	
1.	ODISHA	1253.5	1460.5	-14%	N
2.	WEST MADHYA PRADESH	1098.0	956.3	15%	N
3.	EAST MADHYA PRADESH	1340.0	1169.4	15%	N
4.	GUJARAT REGION	764.9	956.9	-20%	D
5.	SAURASHTRA & KUTCH	482.9	511.3	-6%	N
6.	KONKAN & GOA	3663.9	3101.1	18%	N
7.	MADHYA MAHARASHTRA	906.3	876.8	3%	N
8.	MARATHWADA	949.0	821.6	16%	N
9.	VIDARBHA	1163.8	1084.5	7%	N
10.	CHHATTISGARH	1315.8	1298.9	1%	N
SOUTH PENINSULA		884.9	1128.3	-22%	
1.	A & N ISLAND	2851.9	2926.3	-3%	N
2.	COASTAL ANDHRA PRADESH	908.9	1024.2	-11%	N
3.	TELANGANA	1043.4	942.6	11%	N
4.	RAYALASEEMA	555.4	706.1	-21%	D
5.	TAMILNADU & PUDUCHERRY	535.0	914.4	-41%	D
6.	COASTAL KARNATAKA	2619.7	3526.3	-26%	D
7.	N. I. KARNATAKA	625.0	740.3	-16%	N
8.	S. I. KARNATAKA	687.3	1019.2	-33%	D
9.	KERALA	1870.9	2924.3	-36%	D
10.	LAKSHADWEEP	1065.7	1600.0	-33%	D
COUNTRY AS A WHOLE		1083.1	1187.6	-9%	

Sub-division wise rainfall maps for monsoon months of 2016







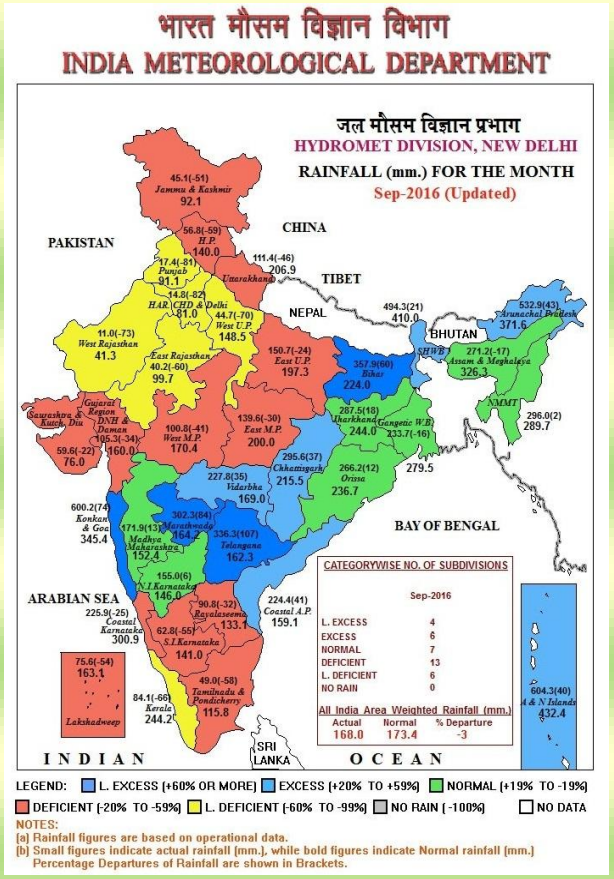


Fig. 2. Sub-division wise rainfall maps for monsoon months of 2016

River Basin rainfall map for monsoon 2016

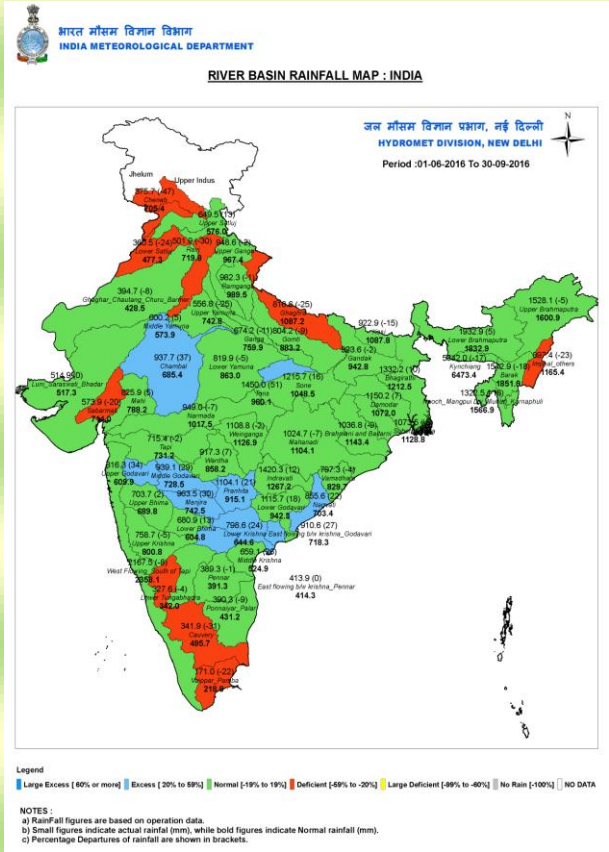


Fig. 3. R/F Map of India-Monsoon 2016 (river basins)

Rainfall Monitoring Unit also published "Rainfall Statistics of India 2016" that includes important information like spatial distribution of Monsoon rainfall, spatial analysis of heavy rainfall events, Station Name and date of heaviest one day rainfall in each sub-division, rainfall intensity map etc. besides the usual statistics for the country, regions, Met. Sub divisions, states and districts of India.

Rainfall Monitoring Unit of Hydromet Division organised a training programme on "Revised mkRAIN software for processing of rainfall data to prepare rainfall statistics for the districts, Met. sub-divisions and states of India" during 26-27 May, 2016 at New Delhi.

Flood Meteorological Service

There were 10 Flood met Offices (FMO) & DVC Met till 2014, FMO Srinagar was started in 2015 and two FMOs at Bangaluru and Chennai started in 2016 and supplied Hydromet services to Central Water Commission (CWC) which is the main inputs for flood forecasting (Fig. 4). During flood season 2016, FMO Chennai issued QPF for lower Cauvery, Pennar, Periyar, Vaigai, Korttalaiyar; FMO Bengaluru for Cauvery and Krishna and FMO Srinagar for Jhelum basin. The total Nos. of QPFs issued till 31st December 2016 is 24196 each for Day-1, Day-2 and Day-3.

List of Basins/Sub-basins for which QPF is issued

S. No.	FMO	Area (Km^2)	Name of Main River Basins	No of Sub-basins for which QPF are Issued
1.	Patna	171698	Ganga	**8**
2.	Asansol	23669	Kangsabati, Ajoy, Mayurakshi	**3**
3.	New Delhi	36670	Yamuna, Sahibi	**3**
4.	Agra	292492	Banganga, Chambal, Betwa, Ken, Agra	**8**
5.	DVC Met	21013	Barakar, Damodar, Lower Valley	**6**
6.	Lucknow	220465	Ganga, Bhagirathi, Alkananda, Ramganga, Ghaghra, Sharda, Rapti	**14**
7.	Jalpaiguri	16714	Brahmaputra	**5**
8.	Bhubaneswar	244670	Subarnrekha, Burhabalang, Baitarni, Brahmani, Mahanadi, Rushikuliya, Vamsadhara, Nagavali	**9**
9.	Guwahati	194355	Brahmaputra, Barak, Gumti	**20**
10.	Ahmedabad	220946	Narmada, Tapi, Mahi, Sabarmati, Banas, Damanganga	**19**
11.	Hyderabad	363678	Godavari, Krishna	**16**
12.	Srinagar	37352	Indus, Jhelum	**8**
13.	Chennai	79214	Pennar, East Flowing River	**15**
14.	Bengaluru	278761	Cauvery, Krishna, East Flowing River, West Flowing River	**15**
		2201696		**149**

Hydromet Division, New Delhi is computing sub-basin wise QPF using operational NWP model *viz*., WRF, MME and GFS and uploaded on IMD website for 146 flood prone sub-basins of India to be used as Guidance to forecasters for issuance of operational QPF for river basins.

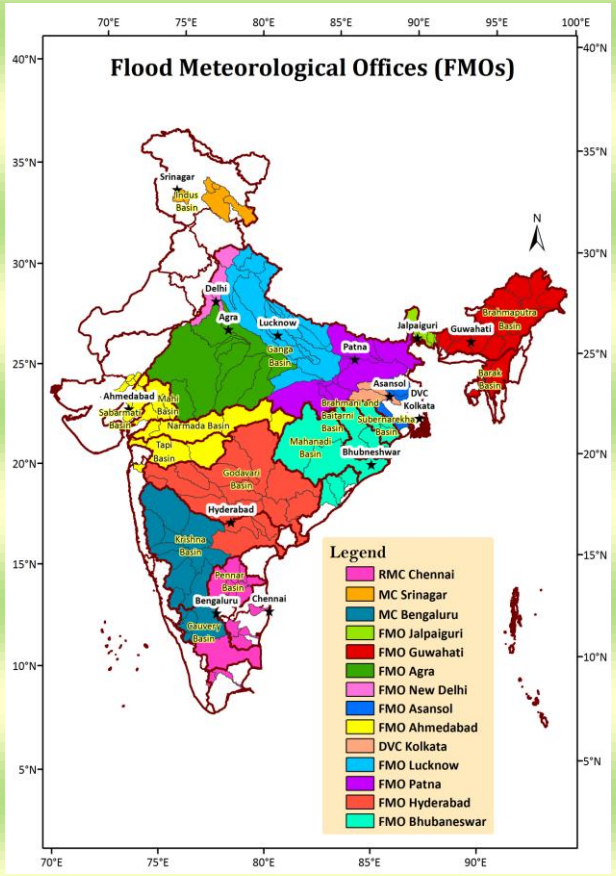


Fig. 4. Map of 14 FMOs

Sub basin wise Quantitative Precipitation Estimate for Day-1, Day-2, Day-3, using WRF ARW (9 km × 9 km) based on 0000 UTC and 1200 UTC, MME (0.25° × 0.25°) based on 0000 UTC and Day-1 to Day-7 using GFS (12 km × 12 km) based on 0000 UTC run by IMD are computed and uploaded on IMD website operationally for all sub-divisions.

Central Hydromet Observatory (CHO)

Central Hydromet Observatory (CHO) is taking observations and for demonstration as a model observatory to visitors. In 2016, 3425 numbers of visitors *i.e*., students, teachers from different schools and colleges, engineers, scientists from different Govt. agencies and general public visited CHO for general awareness in meteorology. Lectures on basics of weather elements and how the observations are taken are delivered. Services of India Meteorological Department's rendered to the nation are also explained. Daily weather observations are taken four times a day and the data is transferred to RWFC and NWP for further application in forecasting activities. Many PG/M. Tech students from IIT, Delhi; Engineering colleges, PG Residents from AIIMS, Management Institutes & different Universities have visited the CHO during 2016.

5.2. AGRO ADVISORIES SERVICES

Dissemination of agromet advisories

Dissemination of agromet advisories to the farmers through different multi-channel system of All India Radio (AIR) and Doordarshan, private TV and radio channels, newspaper and internet, SMS and IVR (Interactive Voice Response Technology) etc. is being made on wider scale. Under PPP mode, Reuter Market Light, IFFCO Kisan Sanchar Limited (IKSL), NOKIA, Handygo, Reliance Foundation Information Services (RFIS), National Bank for Agricultural and Rural Development (NABARD) are disseminating agromet advisories in SMS and IVR format to the farming community. In addition to that number of AMFUs are sending agromet advisories through SMS in collaboration with National Informatics Centre (NIC)/Agricultural Technology Management Agency (ATMA)/ KVK/ NABARD/ Internet etc. Agromet Advisories are also being disseminated in both Regional and English languages through "Kisan SMS", a portal of Ministry of Agriculture, Government of India. At present 19.5 million agriculture dependent households are benefitted by this service. Weather forecast and advisories under alerts and warnings through SMS now enable farmers in planning farming operations effectively to minimise/

control damage of crops under adverse weather conditions.

In addition to above Crop Specific Weather based Agromet Advisories' for the country on daily basis are being telecasted through DD Kisan Channel, on real time in programs like 'Kisan Samachar' and 'Mausam Khabar' in Hindi and in regional languages of Gujarati, Marathi, Malayalam and Tamil.

Agrometeorological Observatories & Data Management

Agrimet Division maintains a network of agrometeorological observatories, evapo-transpiration observatories, evaporation observatories, dewfall recording observatories and soil moisture observatories. The data received from these observatories are scrutinized, archived and supplied to scientists, planners etc. through NDC, Pune. To use the agromet data for operational purpose, Agricultural Meteorology Division, IMD, Pune has developed web (php) based software in collaboration with NIC, Pune for online transmission of agromet data, which is experimentally hosted in the website of Agrimet Division. Around 90 AMFU and 60 CWS Agromet observatories have started uploading agromet data daily on web portal of Agrimet Division.

Weather Services – Agrometeorology

Preparation of Agromet Advisory Service (AAS) bulletins

AAS bulletins have been prepared and issued at district, state and national levels to cater to the needs of users at various levels. The district level bulletins are prepared and issued by Agromet Field Units (AMFUs) located in State Agricultural Universities, ICAR institutes, IITs etc. The bulletins include past weather, medium range weather forecast for next 5 days and specific advisories on field crops, horticultural crops, livestock etc. At present these bulletins are issued for 636 districts in the country.

Bulletins are also generated through e-Agromet portal of Ministry of Agriculture. 100 Agromet Field Units and State Meteorological centres are utilizing the portal to moderate the district level weather forecast and generate district level agromet advisory services bulletin on every Tuesday and Friday.

IMD in collaboration with CRIDA, Hyderabad issued Operational Agromet advisory Service Bulletin based on Extended Range Weather Forecast during monsoon was prepared to help farmers to cope with climate risks and uncertainties and effectively use seasonal to inter-annual climate forecasts.

Research & Development Project on AAS

Following R & D projects have been undertaken for use in AAS.

(*i*) Downscaling of surface soil moisture using SMOS satellite data at 1 km resolution.

(*ii*) NDVI maps are generated using the NDVI data from NOOA/AVHRR.

(*iii*) Gridded soil moisture index (SMI) maps are generated using gridded rainfall (0.25 × 0.25 km) & potential evapo-transpiration data by book keeping method.

(*iv*) SMI is being generated on experimental mode using the Five day medium range district level weather forecast data by book keeping method.

(*v*) Sowing suitability maps for kharif season has been developed using NDVI and Soil moisture Data

Proposed Future Plan

1. NDVI Maps will be generated from the weekly composite of AWiFS data provided by NRSC.

2. Development of standardized precipitation evapotranspiration index (SPEI) using gridded rainfall and temperature (0.25 × 0.25 km).

3. The station wise rainfall, temperature real time and 5 day forecast data will be displayed on the all India map.

4. Block level location mapping of surface observatories, AWS, AMS; updating under process.

New Initiative under "Gramin Krishi Mausam Sewa"

Agrimet Division has taken special initiative under the project "Graim Krishi Mausam Sewa" during 12th Five Year Plan to make agromet advisories more precise and accurate and reach 1 in 9 agriculture dependent farming household like.

1. Farmer's Registration for SMS advisory through Agrimet portal.

2. Advertisement through Print Media and TV.

3. Pilot project has been initiated with Postal Department in five states to collect the farming household information at village level.

Forecasting Agricultural output using Space, Agrometeorology and Land based observations (FASAL)

Developed crop yield forecast for the following crops for communication to Mahalanobis National Crop Forecast Centre (MNCFC), Department of Agriculture & Cooperation (DAC), Ministry of Agriculture, New Delhi.

Rabi Sorghum for the states of Maharashtra and Karnataka.

Rapeseed & Mustard for the states of Gujarat, Madhya Pradesh, Uttar Pradesh, Haryana, Rajasthan and West Bengal.

Wheat for the states Bihar, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Punjab, Rajasthan, Uttarakhand and Uttar Pradesh.

Winter Potato for the states of Gujarat, Punjab, Uttar Pradesh and West Bengal.

Rabi rice for the states of Andhra Pradesh, Telangana, Karnataka, Odisha & West Bengal.

Rabi onion for the states of Gujarat and Karnataka and Jute for Assam, Bihar, West Bengal.

Sugarcane for Gujarat, Haryana, Maharashtra, Karnataka and Uttar Pradesh.

Rice yield forecast for Andhra Pradesh, Assam, Bihar, Chhattisgarh, Haryana, Jharkhand, Karnataka, Madhya Pradesh, Odisha, Punjab, Telangana, Uttar Pradesh and West Bengal. Cotton crop at F1 stage for Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Punjab, Rajasthan and Telangana.

Awareness and Outreach Programmes; Vessel Management

Farmers' Awareness Programme: Farmers' awareness programmes were organised at 7 Agromet Field Units (AFUs) across the country. Besides, the Nodal Officers / Technical Officers participated in number of awareness programme and taken active initiatives in popularising the GKMS. AMFUs also arranged field visits, field demonstration, farmers' interaction & also participated in Kisan Mela.

Outreach programs

(*i*) IMD officials participated in 44th 'Joint Agresco Meet 2016' which is annually organized by all four Agricultural Universities of Maharashtra State and gave presentation on "Activities and Services to farmers of Maharashtra by IMD" held at Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola during 28-30 May, 2016.

(*ii*) IMD officials participated in "Climate change, weather forecasting and risk

management in Agriculture" on 2nd May, 2016 at AMFU, Parbhani.

(*iii*) IMD officials participating in the 7th Agrovision-2016 from 11-14 November, 2016 conducted at Reshim Bagh Ground in Nagpur.

5.3. ENVIRONMENTAL MONITORING

IMD continued to provide environmental monitering services to the Ministry of Environment, Forests and Climate Change and carried out environmental impact assessment of 1229 development projects (Thermal Power: 51, Industries: 609, Mining: 488 and Coal mining: 81) in 2016 in the country. Dr. V. K. Soni, Sc. 'E' & Head, EMRC, Shri Sanjay Bist, Scientist 'D' and Dr. Siddhartha Singh, Scientist 'D', IMD participated in monthly expert appraisal committee meetings as representative of India Meteorological Department.

IMD also provided air quality forecast services to public under the project SAFAR with IITM, Pune.

5.4. POSITIONAL ASTRONOMY DATA PREPARATION

With a view to developing astronomical and astrophysical studies in India as envisaged by the planning committee constituted by the Govt. of India in 1945, a small unit, known as Nautical Almanac Unit, was set up under CSIR at Calcutta. Although the Govt. of India used Gregorian calendar for official use, divergent practices of calendar keeping were in vogue during the period of post independence of the country. A need was felt by the then Prime Minister, Late Pt. Jawaharlal Nehru to develop a unified National Calendar on the basis of the most accurate modern astronomical data in the interest of national integrity. Keeping these in view, a Calendar Reform Committee was formed in 1952 under the CSIR with Late Prof. Meghnad Saha as the Chairman. The Committee recommended preparation of the Indian Ephemeris and Nautical almanac (renamed as Indian Astronomical Ephemeris from 1979 issue) incorporating therein usual astronomical data calculated with most modern astronomical formula, to publish the National Calendar of India (using Saka era) in the form of Rashtriya Panchang with Solar Calendar system for civil use and Luni solar Calendar system for religious use. It was decided that these works should be done by the Nautical Almanac Unit. This Unit was taken over by the India Meteorological Department from CSIR on 1st December, 1955 and put under Regional Meteorological Centre, Calcutta. On 1st December, 1979, following the recommendations of Dr. Ramanna Committee, the centre was made an independent centre and renamed as Positional Astronomy Centre. It was then brought under the direct administrative control of DGM. A standing advisory committee consisting of eminent experts in the field of astronomy advices DGM on technical matters and future scientific programs of the centre.

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 Govt.

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.

This centre also provides five years advance accurate calendric data to many leading panchang makers of the country for preparation of their own Panchangs.

The centre also contributes to a great extent in popularizing astronomy through publication of monthly astronomical bulletin and star charts (presently star charts are being prepared on computer), issuing press release on different astronomical events through various print media, attending live discussions on various electronic media etc.

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

Activities during the year 2016

1. The Indian Astronomical Ephemeris for the year 2017, an annual publication of Positional Astronomy Centre, which mainly contains positional data of the Sun, Moon and planets, basic data on yearly positions of fundamental stars, diary of celestial events, calendric data, eclipse data, explanatory text and other useful information on astronomy has been published both in hard copy and soft copy format.

2. Fourteen language editions of Rashtriya Panchang of 1938 SE (2016-17 AD) and Sunrise-Sunset and Moonrise-Moonset Tables for 2017 have been published during the year 2016. These are important regular publications of the centre catering to daily need of users of almanac, Panchang makers and other users.

3. Web based service has been started by the centre by creation of electronic versions of 14 language editions of Rashtriya Panchang which can be accessed by the users through a newly developed website.

4. A pocket-type, card-size calendar containing brief information on important celestial events during the year 2016 has been published in for benefit of users.

5. The centre has prepared monthly star charts and astronomical bulletins for 12 months during the year 2016 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.

Awareness and Outreach Programme

An awareness and observational programme was conducted on Transit of Mercury over the disc of the Sun on 9 May 2016 afternoon in the PAC Office building. A large number of students, teachers and general public gathered on the occasion and the event was arranged to show by projection method through telescope. A large number of electronic and print media were present for telecast/ reporting the show.

5.5. WEATHER FORECAST SERVICES

Weather Forecasting and Warning Through Social Media

IMD introduced Weather forecast & warnings dissemination service through YouTube in September 2016 and through Facebook & Twitter in June, 2016 (Fig. 5).

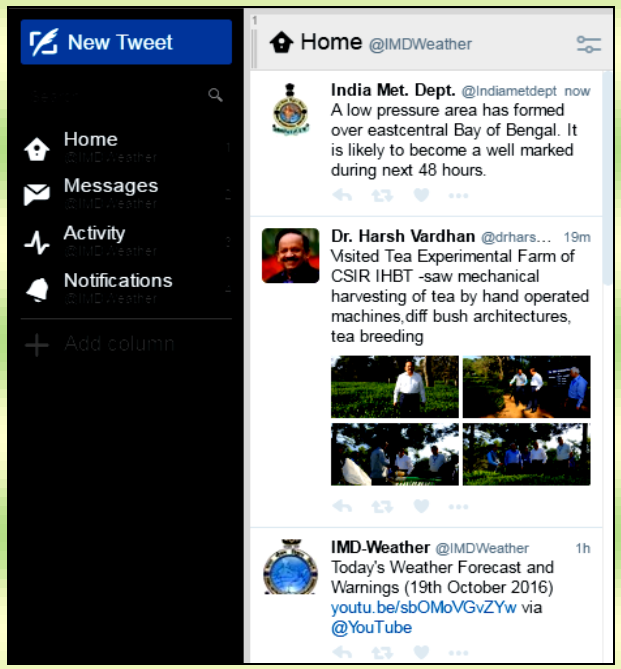


Fig. 5. Weather forecast and warnings dissemination services through YouTube, Facebook & Twitter

Severe Weather Forecast Demonstration Project (SWFDP)

It is an ambitious project taken up with the joint initiative of IMD and WMO. The objective of the project is to monitor, predict and warn the public and the Disaster Managers against the Severe Weather namely heavy rain, strong wind, storm surge and high waves. RSMC New Delhi is the regional centre to provide daily Regional Severe Weather Guidance to the member countries including Bangladesh, India, Bhutan, Nepal, Pakistan, Afghanistan, Sri Lanka and Maldives. It is a 3-tier cascading process involving various Numerical Weather Prediction (NWP) centres at global levels, RSMC New Delhi at regional levels and the National Meteorological centres of the member countries. The project also stresses upon the Public Weather Services and liaison with Disaster Managers, Media and others for effective management of severe weather over the region. Every day regional guidance is being provided to member countries on dedicated webpage http://nwp.imd.gov.in/mme/fdp-bob since 2nd May, 2016.

Heavy Rainfall Forecast Performance

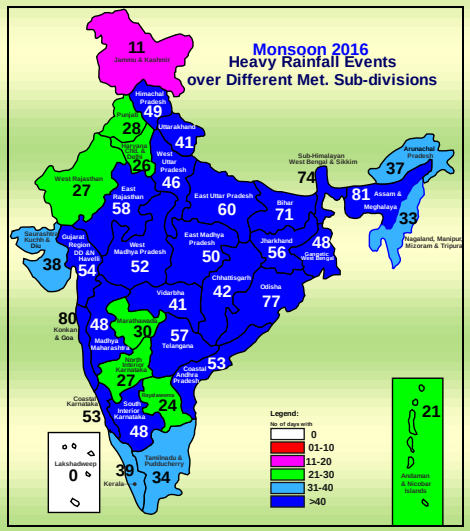
The verification skill scores for the heavy rainfall warning issued by NWFC during monsoon season, 2016 is presented in Table 1.

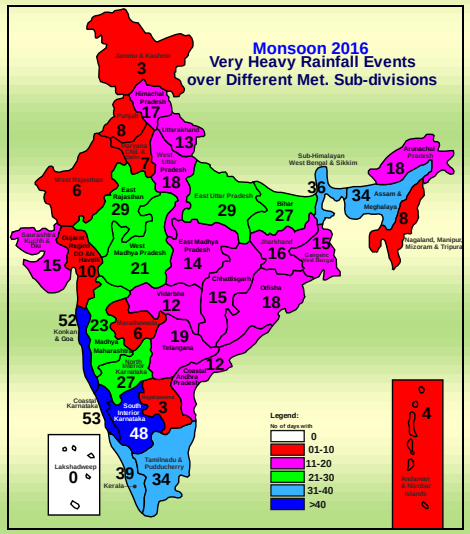
TABLE 1

All India skill scores of Heavy rainfall during monsoon season, 2016

Heavy Rainfall (Between 64.4 and 115.5 mm)						
	POD	MR	FAR	CSI	HSS	PC
Day 1	0.34	0.66	0.38	0.28	0.25	0.68
Day 2	0.27	0.73	0.41	0.23	0.18	0.66
Day 3	0.29	0.71	0.38	0.25	0.21	0.61
Very Heavy Rainfall (>115.5 mm)						
	POD	MR	FAR	CSI	HSS	PC
Day 1	0.35	0.65	0.45	0.28	0.37	0.88
Day 2	0.30	0.70	0.54	0.22	0.29	0.86
Day 3	0.20	0.80	0.55	0.16	0.21	0.86
Heavy, very heavy and extremely heavy rainfall (>64.4 mm)						
	POD	MR	FAR	CSI	HSS	PC
Day 1	0.54	0.46	0.14	0.44	0.42	0.74
Day 2	0.45	0.55	0.13	0.37	0.33	0.71
Day 3	0.54	0.46	0.14	0.44	0.42	0.74

No. of heavy rainfall, very heavy rainfall and extremely heavy rainfall events over different meteorological sub-divisions are shown in Fig. 6.





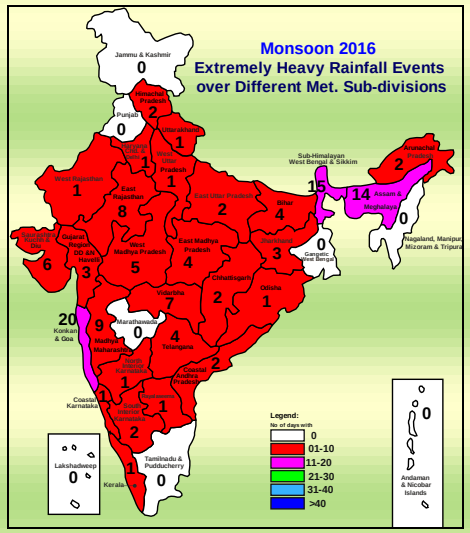


Fig. 6. Number of heavy, very heavy and extremely heavy rainfall events over different meteorological sub-divisions

The interannual variation in the skill scores during 2002 to 2016 are shown in Fig. 7.

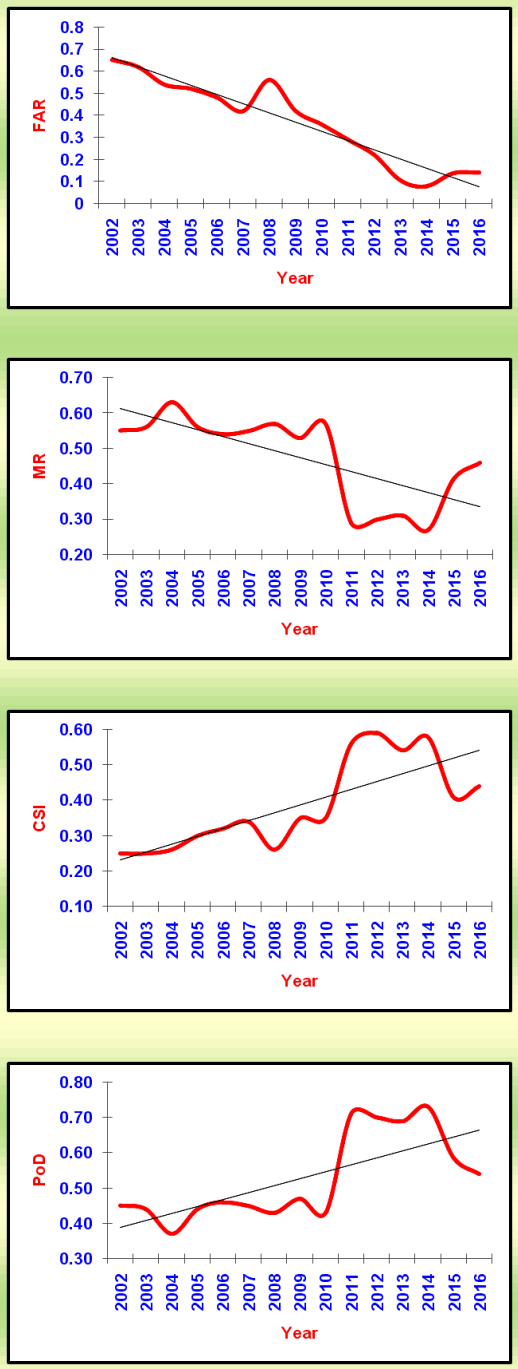


Fig. 7. Interannual variation in the skill scores during 2002 to 2016

Special Forecast Issued by IMD during 2016

Wind Chill Temperature Application was developed and implemented w.e.f. 15th February, 2016.

Weather forecast for Independence Day in Delhi was provided daily commencing from 1st August. Hourly forecast update was issued from the forenoon of 14th August, 2016 on the weather situation over Red Fort area of Delhi. India Meteorological Department (IMD)

earned accolades from Prime Minister's Office for its accurate predictions in this regard.

On the request of UPSC, Special Rainfall Intensity Forecast for 72 Centers across the country for 6 & 7 August, 2016 was provided by NWFC.

A special bulletin was commenced by NWFC, IMD w.e.f. 1st August, 2016 on observed and heavy rainfall warnings for next 5 days and sent to all concerned authorities including NDMA, MHA etc.

5.6. FOG FORECASTING SERVICES

Winter Fog Field Campaign at New Delhi (December 2015 - February 2016)

A successful joint IITM-IMD (MoES) fog campaign completed in December-January 2015-16 at IGIA Delhi- IITM-IMD under Ministry of Earth Sciences, have jointly conducted a special scientific observational Fog campaign at Delhi in this winter 2015-16 during 17 December till 10 February, 2016. A total of thirty-one new instruments were in use at 24×7 to monitor and to measure these various fog characteristics including fog Micro-Physics. In the 1st phase of the campaign, it was completed as a surprise to all participated scientists, as there was almost not a single case of dense fog formation till 6 January 2016, though there were enough formation of shallow and moderate fog events almost in all dates and in fact it was higher than 2014-15 for the same period. Thereafter in the 2nd phase, when, 7-8 January had brought a very longer duration of dense fog of zero visibility first time in the season followed with dense fog events formed at regular intervals till the end of the campaign. In total, January, 1-31 had fifteen and February, 1-10 had four interesting cases of very interesting dense fog events at IGIA in together with a major low clouds and dense fog spell case affecting it for 11 days in a row during 13-24 January. All the thirty-one instruments deployed at inside the airport worked satisfactorily. Some of the instruments deployed to capture fog related data, are for first time in India for any meteorological experiments. Tether Sonde Baloon Observations upto 1000 m were taken during 3 to 23 January, 2016 (Fig. 8).

Fig. 8. Tether Sonde Baloon Observations

Winter Fog Experiment (WIFEX) 2016-17

Recognizing the importance of fog forecasting for Aviation sector, an observational campaign was launched to understand different physical features of fog and factors responsible for its genesis, intensity and duration. For the first time, an observational campaign was conducted at the Indira Gandhi International Airport (IGIA) and at ICAR Institute at Pusa during this winter season (2015-16) in pilot mode. WIFEX was conducted in a pilot mode at IGIA during last winter, and will be continued during December 2016 till February 2017. The main scientific objective of this project is to study the characteristics and variability of fog events and associated dynamics, thermodynamics and fog microphysics, with the aim to achieve better understanding of fog life cycle and ultimately improve capability in fog prediction. A total of thirty-one new instruments were in use at 24 × 7 to monitor and to measure these various fog characteristics including fog Micro-Physics. In 2016, instruments of Dust Storm and Fog Monitoring system has been straightened at airports of north India when, IDM has commissioned three more Drishti RVR at IGIA Delhi, one each at Amritsar, Dehradun and Varanasi while Lucknow and Jaipur have three new each such new Indigenous Dristhi RVR commissioned in this year.

The Airport Authority of India and GMR, Indira Gandhi International Airport Have extended full cooperation and support. In addition to Indian Institute of Tropical Meteorology (IITM), Pune, India Meteorological Department (IMD), National Center for Medium Range Weather Forecast (NCMRWF) and Indian Institute of Science Education and Research (IISER) Mohali are also participating in this observational campaign. For modeling efforts, IITM Pune and NCMRWF are also involved.

5.7. CYCLONE MONITORING & PREDICTION

Cyclonic disturbances during 2016

There were 10 cyclonic disturbances (depressions and cyclones) over the north Indian Ocean (NIO) and adjoining land regions during 2016 against the long period average (LPA) of 11.5 disturbances per year based on data of 1961-2015. Out of 10 CDs, 4 intensified into tropical cyclones against the normal frequency of 4.5 cyclones per year over north Indian Ocean (NIO) based on LPA. It included including 3 cyclonic storms (CS) and one very severe cyclonic storm (VSCS). These cyclones are :

- ***Cyclonic storm, Roanu over Bay of Bengal (17-21 May)***

- ***Cyclonic storm, Kyant over Bay of Bengal (21-28 October)***

- ***Cyclonic storm, Nada over the Bay of Bengal (29 November-02 December)***

- ***Very severe cyclonic storm, Vardah (06-13 December)***

- The cyclonic activity over the NIO was near normal during 2016. The activity during post-monsoon and pre-monsoon seasons were also near normal with the formation of 3 and 1 cyclones during these seasons respectively.

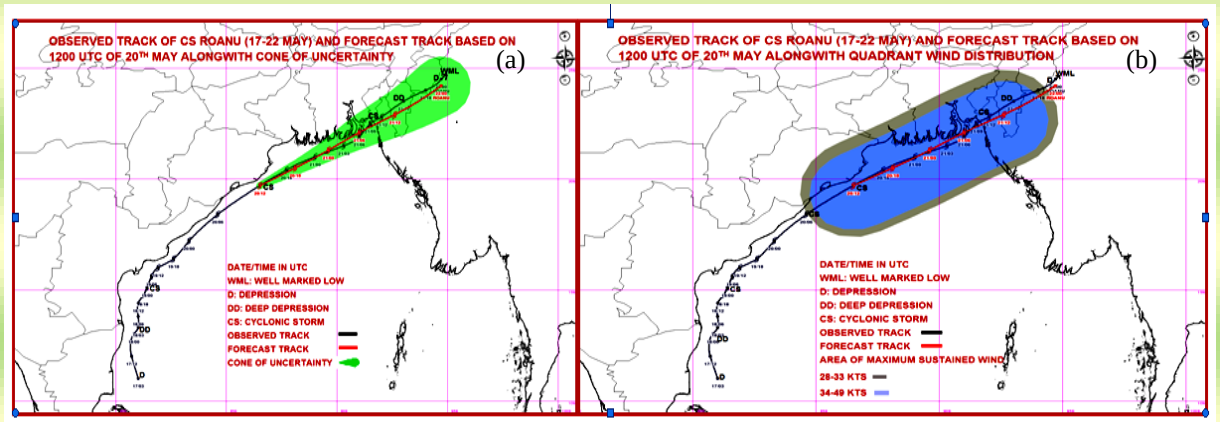
- There was one severe cyclonic storm or higher intensity storm (Maximum sustained wind speed (MSW) ≥ 48 kts & above) over NIO including BOB & AS in 2016 against the average of 2-3 such storms.

- All the cyclones during 2016 had recurving tracks. While cyclone Roanu had anticyclonic recurvature, cyclone Kyant, Nada and Vardah had cyclonic recurvatures.

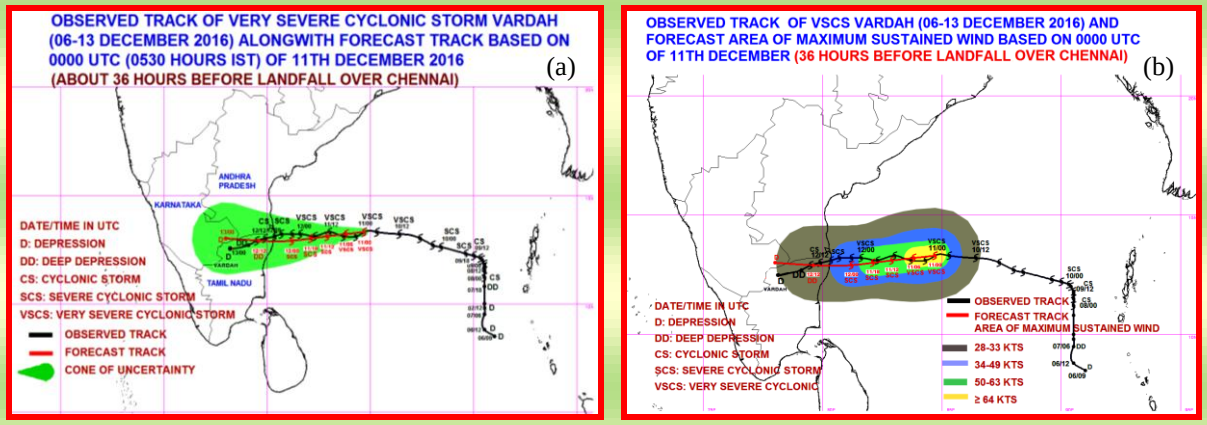
- Cyclone, Roanu developed over southwest BoB off Sri Lanka coast on 17th May. It moved initially northwards and then north-northeastwards skirting Indian coast and crossed Bangladesh coast near latitude 22.6° N and longitude 91.6° E, to the north of Chittagong around 1530 hours IST of 21st May with MSW of 45 kts [Figs. 9(a&b)].

- The Cyclonic Storm (CS) Kyant developed on 21st October with the formation of a depression (D) over eastcentral Bay of Bengal (BOB). Initially, it moved east-northeastwards towards Myanmar coast and steadily intensified into a deep depression (DD) on 23rd morning. Thereafter, it changed its direction of movement and recurved west-northwestwards. It intensified into a CS in the morning of 25th over eastcentral BOB. Thereafter, it again changed its direction of movement and moved west-southwestwards towards west-central BOB off Andhra Pradesh coast. It maintained its intensity till midnight of 26th and thereafter weakened gradually becoming DD in the early hours 27th and D in the same evening. It weakened into a well marked low pressure area over westcentral BOB off Andhra Pradesh coast in the morning of 28th.

- Cyclone Nada formed from a depression formed over southeast BOB in the evening of 29th November. It moved initially northwest-wards and intensified gradually into cyclonic storm (CS) "Nada" over southeast Bay of Bengal (BoB) in the



Figs. 9(a&b). Observed track of CS Roanu (17-22 May, 2016) and forecast track based on 1200 UTC of 20th May along with (a) Cone of uncertainty and (b) Quadrant wind distribution



Figs. 10(a&b). Observed track of VSCS Vardah (6-13 December, 2016) and forecast track based on 0000 UTC of 11th December along with (a) Cone of uncertainty and (b) Quadrant wind distribution

morning of 30th. It maintained its intensity till the evening of 1st December while moving west-northwestwards. It weakened into a deep depression (DD) in the noon of 1st December and further into a depression in the same midnight. Continuing to move west-northwestwards, it crossed north Tamil Nadu coast near Nagapattinam (about 20 km south of Karaikal) during 0400-0500 hours IST of 2nd December. Continuing to move westwards, it further weakened into a well marked low pressure area over interior Tamil Nadu in the forenoon of 2nd December, 2016.

- The last cyclone, Vardah developed from a depression (D) developed over southeast Bay of Bengal (BOB) in the afternoon of 6th December. Moving northwestwards initially and northwards thereafter, it intensified into a deep depression (DD) in the midnight of 7th December, into a cyclonic storm (CS) "VARDAH" in the morning of 8th and into a severe cyclonic storm (SCS) in the midnight of 9th. It then moved west-northwestwards and intensified further into a very severe cyclonic storm (VSCS) over westcentral and adjoining south BOB in the evening of 10th December. It then moved nearly westwards and reached its peak intensity of about 130 kmph on 11th December evening and maintained the same intensity till noon of 12th December. It weakened into an SCS and crossed north Tamil Nadu coast near Chennai during 1500-1700 hrs IST of 12th December 2016 with a wind speed of 100-110 kmph gusting to 120 kmph. After the landfall, the SCS moved west-southwestwards and weakened into a CS in the evening, into a DD in the midnight of 12th and into D in the early morning of 13th. Continuing its west-southwestwards movement, it weakened into a well marked low pressure area in the forenoon of 13th December [Figs. 10(a&b)].

- Thus there were only two landfalling cyclones over the north Indian Ocean in 2016 against normal of 4 such cyclones per year based on long period average based on 1961-2015.

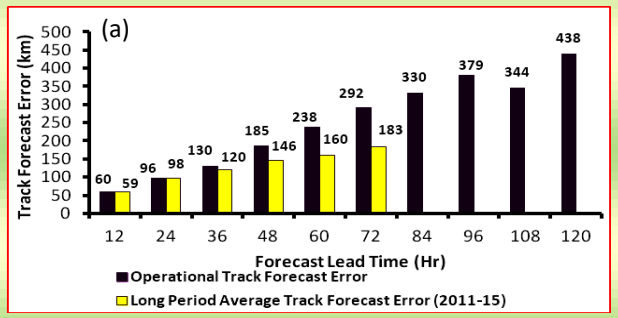
- Only one cyclone (Vardah) crossed India coast against the normal of about 2 such cyclones per year.

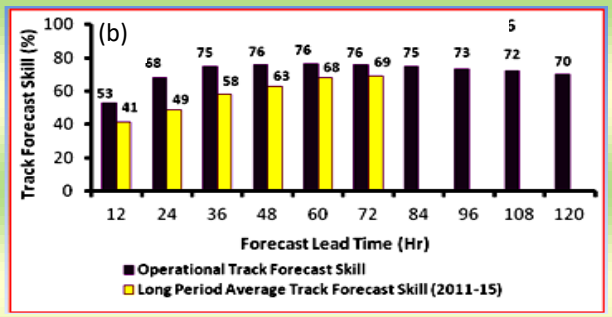
Cyclone Forecast Verification

The annual average track forecast error [Fig. 11(a)] has been 96 km, 185 km and 292 km, respectively for 24, 48 and 72hrs against the past five year average error of 97.5, 146 and 183 km based on data of 2011-2015. The error has been higher during this year, as all the four cyclones during the year had recurving track. However comparing the average error of recurving tracks (Mohapatra *et al*., 2013), the error during 2016 has been significantly less. It is reflected in the assessment of track forecast skill during 2016 [Fig. 11(b)]. The track forest skills compared to climatology and persistence forecast [Fig. 11(b)] are 68%, 76% and 76% respectively for the 24, 48 and 72 hrs lead period which is much higher than long period average of 2011-2015 (49%,63% & 69% respectively).

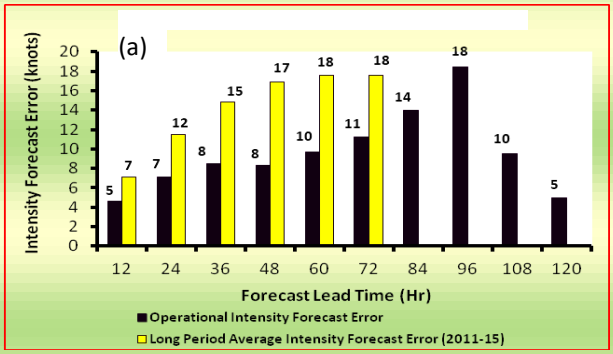
The landfall forecast error is 14 km, 127 km and 180 km for 24, 48 and 72 hrs lead period during 2016 against the average of past five years of 56 km, 93 km and 106 km during 2011-2015. The landfall time forecast error has been 3, 9 and 6.8 hrs for 24, 48 and 72 hrs lead period during 2016 against the average of past five years of 4.2, 4.7, 1.8 hrs during 2011-2015. Due to recurving nature of the track, the landfall error like the track error has been relatively higher in 2016.

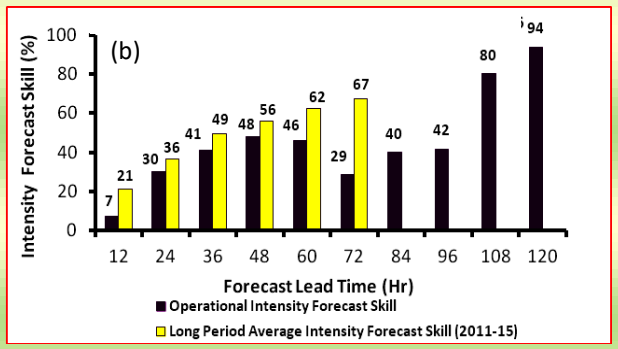
The annual average absolute error (AE) in intensity forecast error [Fig. 12(a)] has been 7 nautical miles per hour (knots), 8 knots and 11 knots respectively for 24, 48 and 72 hrs lead period of forecast against the past five year average of 12, 17 and 18 knots. The skill in terms of AE compared to persistence forecast [Fig. 12(b)] was 30%, 48% and 29%.





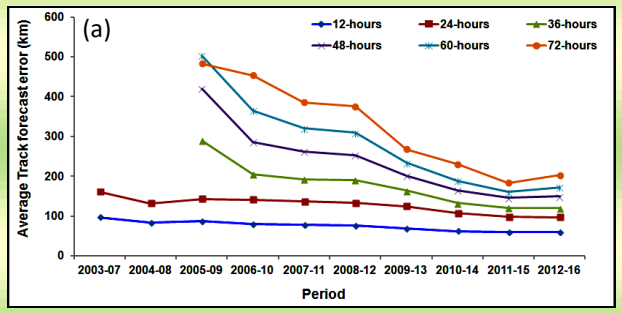
Figs. 11 (a&b). Annual Average track forecast (a) error (b) skill-2016

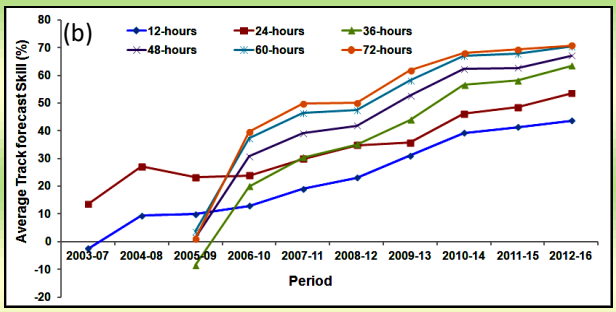




Figs. 12 (a&b). Annual (a) average AE in intensity forecast intensity (b) forecast skill based on AE-2016

It can be seen from Figs. 13 (a&b) that there has been continuous improvement in forecast accuracy with decrease in landfall and track forecast errors and increase in skill over the years. However, due to modernization programme of IMD and other initiatives of MoES, the improvement has been more significant since 2009.





Figs. 13(a&b). Five year moving average track forecast (a) error (km) (b) skill (%)

Forecast of VSCS "VARDAH"

The unique feature of very severe cyclonic storm (VSCS) "VARDAH" over the Bay of Bengal during 2016 monsoon season is that it was the only cyclone crossed Indian coast during the entire year. Initially a depression (D) developed over southeast Bay of Bengal (BOB) in the afternoon of 6th December. Moving northwestwards initially and northwards thereafter, it intensified into a deep depression (DD) in the midnight of 7th December, into a cyclonic storm (CS) "VARDAH" in the morning of 8th and into a severe cyclonic storm (SCS) in the midnight of 9th. It then moved west-northwestwards and intensified further into a very severe cyclonic storm (VSCS) over westcentral and adjoining south BOB in the evening of 10th December. It then moved nearly westwards and reached its peak intensity of about 130 kmph on 11th December evening and maintained the same intensity till noon of 12th December. It weakened into an SCS and crossed north Tamil Nadu coast near Chennai during 1500-1700 hrs IST of 12th December, 2016 with a wind speed of 100-110 kmph gusting to 120 kmph. After the landfall, the SCS moved west-southwestwards and weakened into a CS in the evening, into a DD in the midnight of 12th and into D in the early morning of 13th. Continuing its west-southwestwards movement, it weakened into a well marked low pressure area in the forenoon of 13th December.

The observed track of the system during 6-13 December is presented in Fig. 14. Typical satellite imagery and radar imagery during the time of landfall are presented in Fig. 15.

Heavy rainfall occurred at many places with very heavy falls at few places and isolated extremely heavy rainfall over Chennai, Kancheepuram, Tiruvallur, and Villupraum districts of Tamil Nadu. Heavy to very heavy rainfall occurred at a few places over Vellore, Krishnagiri, Tiruvannamalai districts of Tamil Nadu, Nellore district of coastal Andhra Pradesh and Chittor, Anantapuram and Cuddapah districts of Rayalaseema on 12th December. Isolated heavy rainfall occurred over coastal Andhra Pradesh on 13th. During

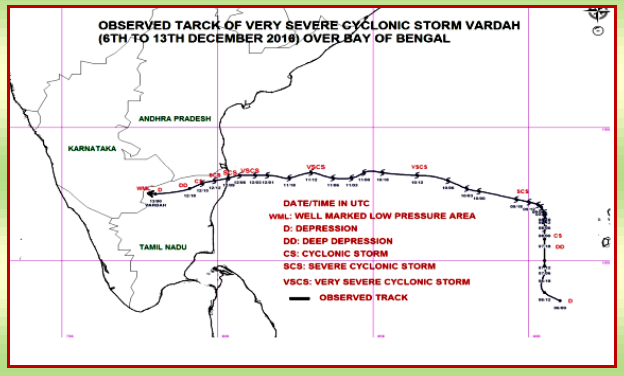


Fig. 14. Observed Track of VSCS Vardah during 6-13 December, 2016

genesis stage, cyclone Vardah caused heavy to very heavy rainfall at a few places over Andaman and Nicobar Islands on 7-10 December with isolated extremely heavy rainfall on 8th December. The spatial distribution of rainfall based on satellite and raingauge merged data set is shown in Fig. 16.

With respect to the forecast performance of "VARDAH" first information regarding genesis of depression over southeast BOB on 6th December was issued by RSMC New Delhi on 3rd December with probability of 51-75%. First

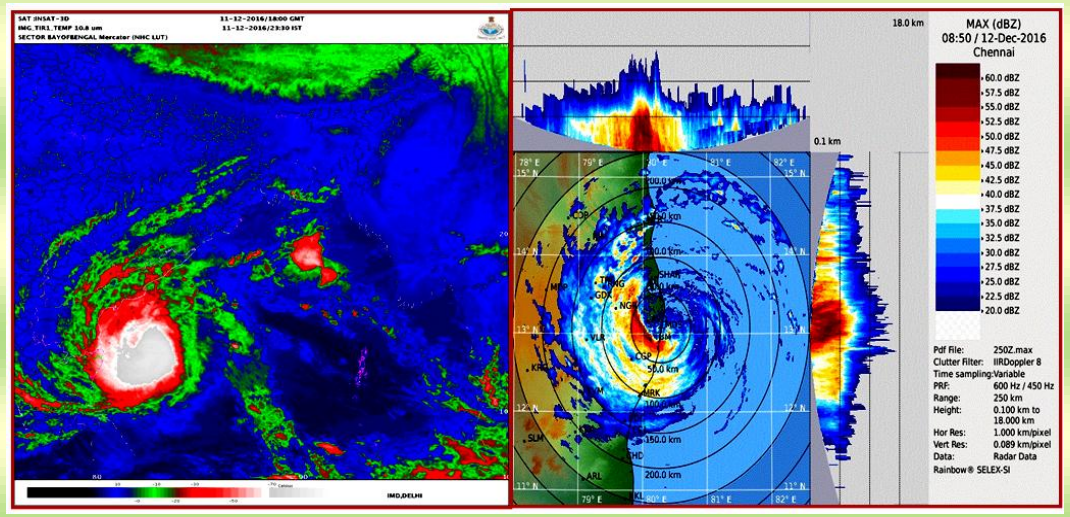


Fig. 15. Typical Satellite and DWR Chennai Radar imagery of VSCS Vardah during landfall

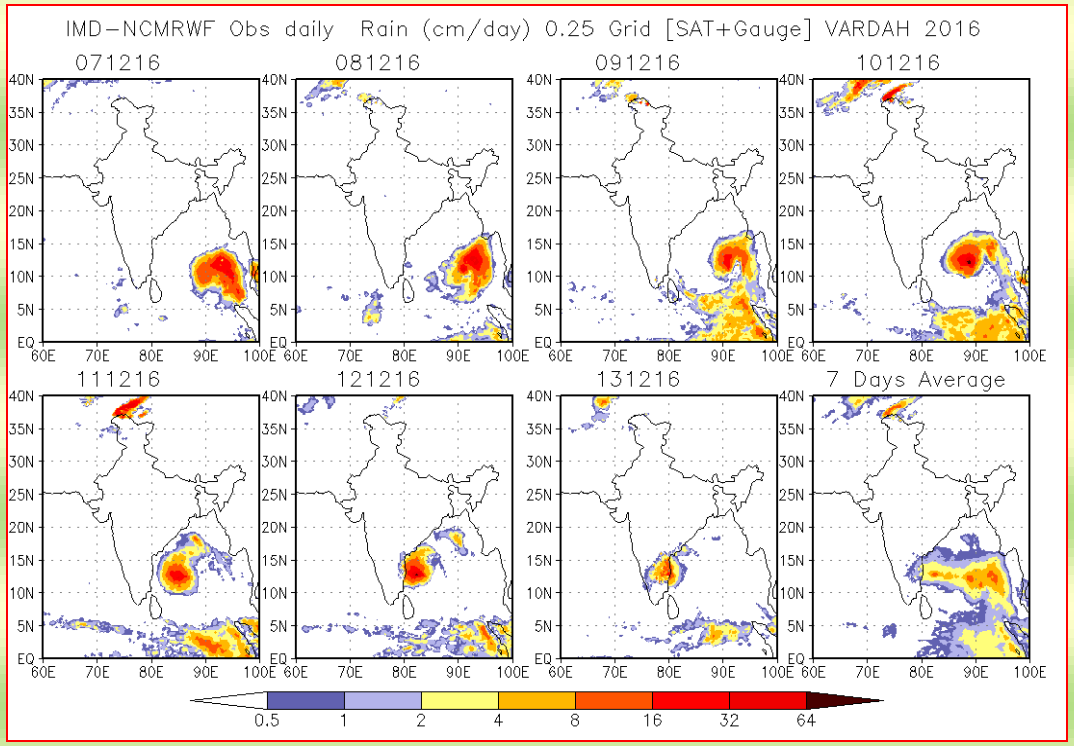


Fig. 16. Spatial distribution of rainfall based on satellite and raingauge merged data set

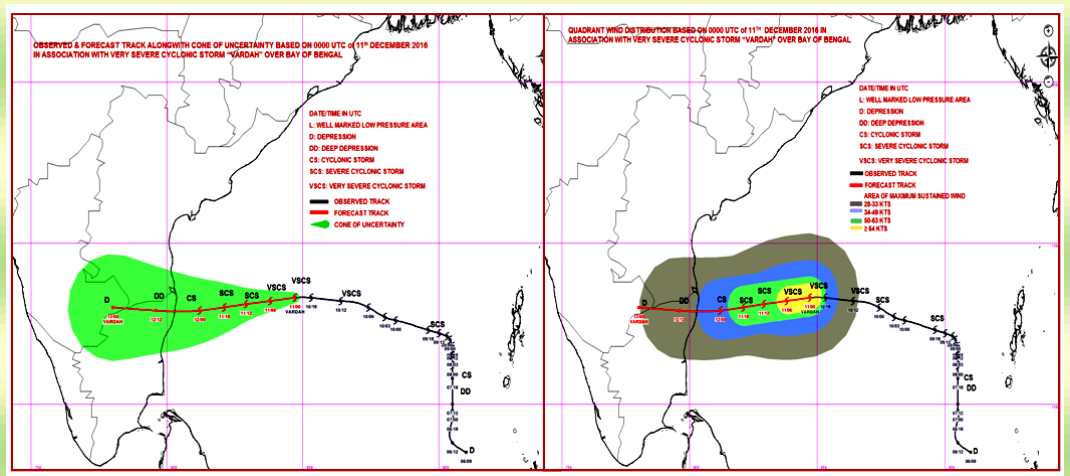


Fig. 17. Forecast track with cone of uncertainty and wind distribution based on 0530 IST of 11th December, 2016

bulletin indicating the landfall of cyclone between Ongole and Chennai by afternoon/evening of 12th December was issued based on 1730 hours IST observations of 10th (48 hours prior to landfall). Bulletin indicating landfall of cyclone close to Chennai around afternoon of 12th December was issued based on 0530 hours IST observations of 11th (36 hours prior to landfall). There was almost zero error in landfall forecast issued 24 hrs before landfall and about 66 km in the forecast issued 36 hrs before landfall. The forecast track with cone of uncertainty and wind distribution based on 0530 IST of 11th December, 2016 is shown in Fig. 17. The track forecast error for 24, 48 and 72 hrs lead period were 93, 147 and 193 km respectively, which is significantly less than the average track forecast errors of re-curving cyclones in last five years. The track forecast skill is about 62%, 74% and 77% for 24, 48 and 72 hrs lead period respectively, which are higher than the long period average (LPA) during 2011-15. The absolute intensity (wind) forecast error for 24, 48 and 72 hrs lead period are 09, 11 and 13 knots against the LPA of 12, 15 and 18 knots respectively. The adverse weather like heavy rain, strong wind and storm surge were also predicted accurately for Andaman & Nicobar Islandsm Tamil Nadu, Puducherry, south coastal Andhra Pradesh and Rayalaseema. The track, intensity and landfall forecast of VSCS "VARDAH" near Chennai has been appreciated by disaster managers authorities, press, electronic media and general public.

Other activities of RSMC During the year 2016

- Country report on tropical cyclone genesis, intensity, track, landfall process and warning communication was sent to WMO IWTX-2016.

- Cyclone bulletins sent to Control Room MHA, Cabinet Secretariat, Minister of Science & Technology, Secretary and Earth Sciences, DST, HQ Integrated Defence Staff, DG Doordarshan, All India Radio, DG-NDRF, Dir. Indian Railways, Indian Navy, IAF, Chief Secretary - Kerala, Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal, Odisha, Mizoram, Arunachal Pradesh, Assam, Manipur and Tripura.

- On the day of landfall of cyclone Vardah, hourly updates of cyclone position, landfall point & time and associated MSW at the time of landfall was issued by email and SMS to disaster managers, press and electronic media and registered general public.

- RSMC, New Delhi provided input for development of WMO's synergized standard operation procedure (SSOP) for multi hazard early warning system and the cyclone bulletins sent to All WMO/ESCAP member countries.

- SMS to registered general public were issued during cyclonic disturbances affecting India As a whole 1,70,703 SMS were disseminated to public during 2016 which included 1,47,188 SMSs during the cyclone, Vardah. In addition the SMS were also issued to farmers through Kissan Portal, Govt. of India and to the fishermen through the SMS service of INCOIS, Hyderabad. IMD also issued the SMS to national and state level disaster managers during the cyclonic disturbances.

- Tropical Cyclone Advisory Centre bulletins were issued by RSMC to Met Watch offices in Asia Pacific regions though GTS to issue Significant Meteorological information for International Civil Aviation, WMO's Aviation Disaster Risk Reduction (ADRR), Hong Kong through ftp.

Synergized fishermen warnings were issued every three hourly by IMD and INCOIS.

5.8. CLIMATE RESEARCH and SERVICES

The Climate Centre at IMD Pune has been now recognized as the Regional Climate Centre for providing regional climate services. In 2016, Climate Research and Services (CRS) division is

created by by combining different IMD offices at Pune. The major services provided by this division are given below :

(i) Operational Long Range Forecast and its Verification

Operational LRF System

The present operational Long Range Forecasting (LRF) system for generating the rainfall/precipitation forecast is essentially based on the statistical methods and that for generating temperature forecasts is based on the coupled forecasting system (CFS). The operational LRF system based on statistical models was developed through in house research activities and regular review. India Meteorological Department (IMD) issues operational long range forecasts for rainfall/ precipitation during winter (January-March), southwest monsoon (June to September) and northeast monsoon (October-December) seasons. Among these, forecast for monsoon season is most important as the rainfall received during this season accounts for 70-90% of the annual rainfall over most parts of the country and due strong positive ssociation of monsoon season rainfall with both Kharif and rabi crop production in the country. Table 2 summarises various operational long range forecasts currently issued by IMD.

Since 2012, as additional forecast guidance, IMD started to use the experimental forecasts for the monsoon rainfall generated by the dynamical model approach developed by Indian Institute of Tropical Meteorology

TABLE 2

Various operational forecasts issued by IMD

S. No.	Forecast for	Region for which forecast issued	Issued in	Method / Model
1	Winter Season (Jan- March) Precipitation	Northwest India	December	Statistical
2	Hot Weather Season (April-June) Temperature	Subdivision wise	March	Dynamical
3	SW Monsoon Season (June to September) Rainfall	Country as a whole	April	Statistical
4	SW Monsoon Season (June to September) Rainfall	Country as a whole	June	Statistical
5	South-West Monsoon Onset	Kerala	May	Statistical
6	SW Monsoon Season (June to September) Rainfall	Four broad geographical regions: Northwest India, Northeast India, Central India and South Peninsula	June	Statistical
7	SW Monsoon Monthly Rainfall for July and August	Country as a whole	June	Statistical
8	SW Monsoon Second half of the Season (August-September) Rainfall	Country as a whole	July	Statistical
9	September Rainfall	Country as a whole	August	Statistical
10	NE Monsoon Season (October to December) Rainfall	South Peninsula	September	Statistical
11	Cold Weather Season (December - February) Temperature	Subdivision wise	November	Dynamical

(IITM), Pune. The present dynamical model forecasting system is based on the global climate forecasting system CFS) version 2. The CFS is a fully coupled general circulation model (CGCM) implemented by IITM under Monsoon Mission project launched by the Ministry of Earth Sciences (MoES). The global monthly and season forecasts for rainfall and temperature prepared using Monsoon Mission CFS (MMCFS) is updated 15th of every month is now available through IMD, Pune (www.imdpune.gov.in) website. In 2016, CFS was used for issuing an outlook for seasonal temperatures over India during the hot weather season (April to June) and 2017 cold weather season (December to February).

Details of the various long range forecasts issued by IMD for 2016 and their verification are discussed in this report.

Verification of Operational Long Range Forecasts

(i) Winter Season (January to March, 2016) Precipitation over North India

The LRF for the 2016 winter season (January to March) rainfall over north India was issued in the last week of December 2015. North India consisting of seven subdivisions (East U.P., West U.P. Uttaranchal, Haryana, Punjab, Himachal Pradesh, Jammu & Kashmir) receives about 17% of its annual rainfall during the winter season (January to March). The Jammu & Kashmir in particular receives about 30% of its annual rainfall during this period. This year, for preparing the quantitative and probabilistic forecasts for winter season rainfall over the North India, a 4-parameter Principle Component Regression (PCR) has been used.

The long range forecast for 2016 winter season (Jan to March) rainfall over north India was indicated to be normal (85% - 115% of the Long Period Average (LPA). The LPA of the winter rainfall over North India for the period 1951-2000 is 183.1 mm). However, the corresponding observed rainfall was found to be below normal (< 85% of LPA).

(ii) Hot Weather Season (April – June, 2016) Temperatures

The country experiences hot weather season primarily during April to June. During this season, many parts of the country experience heat wave conditions (days with abnormally warmer temperatures) with many adverse consequences. Abnormally above normal temperatures can have devastating effects on human health, water resources and power generation and outage. There is a marked relationship between human mortality and thermal stress. During the summer of 2015, prolonged severe heat wave conditions prevailed over Andhra Pradesh and parts of Telangana which claimed more than 2500 lives. The recent research analysis suggests that frequency and duration of heat waves over the country are showing an increasing trend. A part of the increasing trend is attributed to increasing greenhouse gases due to anthropogenic activity. In addition, the ocean conditions over the equatorial Indian and Pacific oceans also contribute to the variability of heat waves over the country.

In view of its social relevance, India Meteorological Department, Ministry of Earth Sciences issued a seasonal outlook for summer temperatures over the country based on the predictions from MMCFS. The model climatology was prepared using retrospective forecasts generated for 27 years (1982-2008) based on the February initial conditions. The model showed moderate skill for summer temperatures over many subdivisions over northwest and central India. The forecast for the 2016 hot weather season was prepared as the average of 47 ensemble member forecasts. The forecast suggested warmer than normal temperatures in all meteorological sub-divisions of the country during the 2016 Hot Weather Season (April to June) with seasonal (April-June) average temperatures over northwest India are expected to be above normal by more than 1.0 °C. The forecast also suggested above normal heat wave (HW) conditions over central and northwest India.

Fig. 18 shows the subdivision wise maximum, minimum and mean temperatures forecast issued by IMD for the 2016 hot weather season (April-June) along with actual subdivision wise temperature anomalies.

(iii) Southwest Monsoon Season (June to September, 2016) Rainfall

Long range forecasts were issued for monthly (for July, August), second half (August + September) and seasonal rainfall over the country as a whole and for seasonal rainfall over four geographical regions (Northwest India, Central India, Northeast India and South Peninsula) with useful skill. In addition to the above long range forecasts, an operational forecast for the monsoon onset over Kerala was issued in May.

Table 3 below gives the summary of the verification of the long range forecasts issued for the 2016 Southwest monsoon. In 2016, all the operational forecasts except that for all India July rainfall were overestimates to the actual rainfalls. The forecast and actual rainfall of July was exactly the same. The actual seasonal rainfalls over central India and northeast India were within the forecast limits and the forecasts were correct. However, all other forecasts including seasonal rainfall forecast for all India, northwest India and south Peninsula, all India rainfall during August and second half of the monsoon season were not correct as the actual rainfall were lower than the lower limits of the respective forecasts. Fig. 19 showing schematic diagram for various operational forecasts for the SW monsoon rainfall issued by IMD.

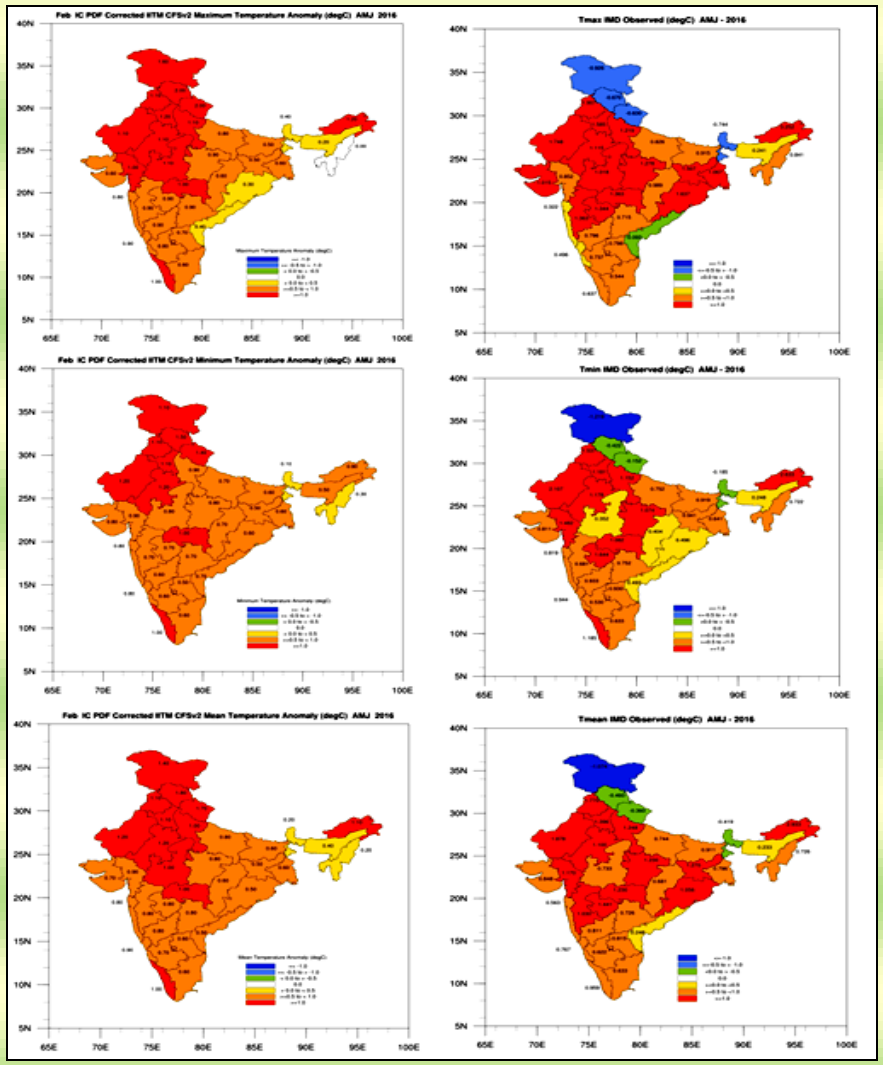


Fig. 18. Subdivision wise maximum, minimum and mean temperatures forecast issued by IMD for the 2016 hot weather season (April- June) along with actual subdivision wise temperature anomalies

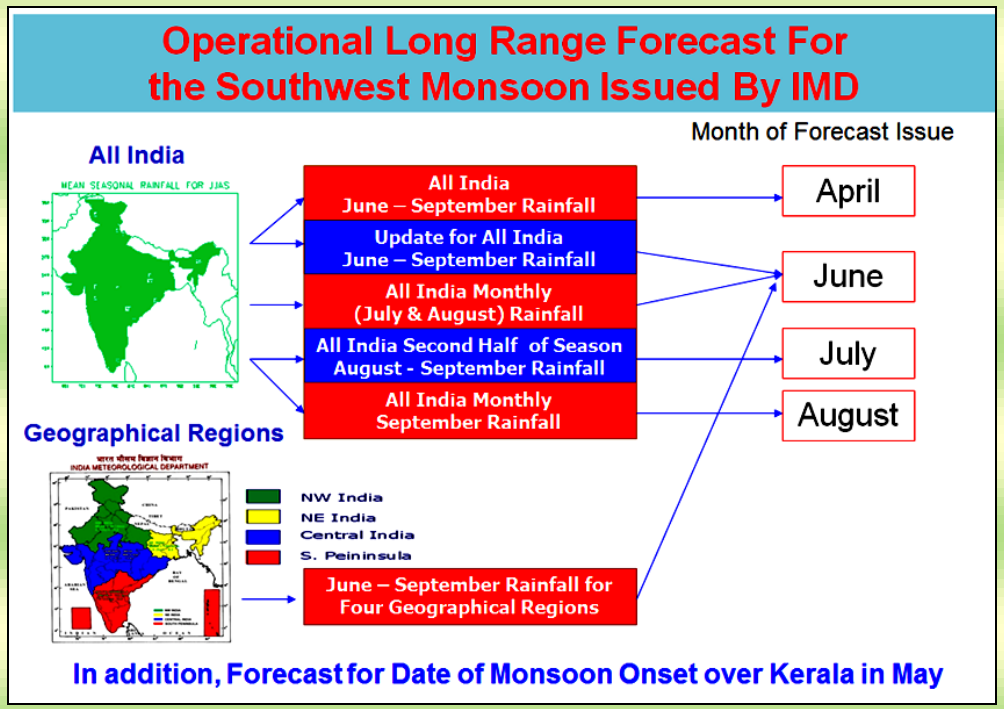


Fig. 19. Schematic diagram for various operational forecasts for the SW monsoon rainfall issued by IMD

TABLE 3

Performance of the operational forecast issued for the 2016 southwest monsoon rainfall

Region	Period	Forecast (% of LPA)		Actual Rainfall (% of LPA)
		22th April	2nd June (Update)	
All India	June to September	106 ± 5	106 ± 4	97
Northwest India	June to September		108 ± 8	95
Central India	June to September		113 ± 8	106
Northeast India	June to September		94 ± 8	89
South Peninsula	June to September		113 ± 8	92
All India	July		107 ± 9	107
All India	August		104 ± 9	91
All India	August to September (issued on 1st August)		107 8	93

The operational forecast for the onset of monsoon over Kerala was prepared using a 6-Parameter principal component regression (PCR) method. The forecast for monsoon onset over Kerala for this year was correct, as the monsoon onset over Kerala took place on 8th June, one day later than the forecast of 7th June ± 4days.

(iv) Northeast Monsoon Rainfall over South Peninsula (October to December)

The long range forecast for the 2016 NE monsoon season (October to December) rainfall over South Peninsula and Tamilnadu was issued in the last week of September 2016. The south Peninsula consisting of five subdivisions (Tamil Nadu, Coastal Andhra Pradesh, Rayalaseema, Kerala and south interior Karnataka) receives about 30% of its annual rainfall during the NE monsoon season (October to December). Tamil Nadu in particular receives about 48% of its annual rainfall during this season. Due to this important fact, IMD has been preparing experimental forecasts for NE monsoon season rainfall over south Peninsula since 1998 using statistical models. IMD also

continuously works to improve the skill of the forecasting models. This year, for preparing the quantitative and probabilistic forecasts for NE monsoon season rainfall over the south Peninsula, a 5-parameter Principle Component Regression (PCR) has been used. Similarly a 4- Parameter PCR model has been used for the forecasting season rainfall over Tamil Nadu.

The long range forecast for 2016 northeast monsoon rainfall (Oct to Dec) over south peninsula was indicated to be normal (90% - 100%) of the Long Period Average (LPA). The LPA of the winter rainfall over North India for the period 1951-2000 is 332.1 mm. However, the corresponding observed rainfall was found to be below normal (35% of LPA).

Similarly the long range forecast for 2016 northeast monsoon rainfall (October to December) over Tamilnadu was also indicated to be normal (90% - 100% of the LPA). The LPA of the North-east monsoon season rainfall over the Tamil Nadu for the base period 1951-2000 is 438.2 mm. However, the corresponding observed rainfall was found to be below normal (38% of LPA).

Future Plans

Improve the skill of existing operational statistical long range forecasting system:

- Operationalization of the coupled dynamical forecasting system for monthly and seasonal forecasts.
- Develop tools for sector specific climate prediction products.
- Generate regional and sub-regional tailored climate prediction products.
- Develop tools for verification of quantitative and probabilistic climate hindcasts and forecast products.
- Generate regional and sub-regional tailored products, relevant to RCC User needs, including seasonal outlooks etc.
- Provide on-line access to products/ services to different users.
- Assess use of climate prediction products and services through feedback from users.
- Coordinate with stake holders to generate 'consensus' statement on regional or sub-regional forecasts.
- Development of tools for LRF at various spatial scales using statistical recalibration of the dynamical model outputs.
- Development of tools for drought prediction.
- Perform verification of RCC quantitative LRF products, including the exchange of basic forecasts and hindcast data.

(ii) Climate Monitoring & Annual Climate Statement

The climate of India during 2016 (in line with the warmer than the normal global temperature) was significantly warmer than the normal. The annual mean land surface air temperature averaged over the country during 2016 was +0.87 °C above the 1971-2000 average, thus making the year 2016 as the warmest year on record since nation-wide records commenced in 1901. The second warmest ever annual mean temperature was recorded in 2009 (+0.85 °C) followed by 2010 (+0.82 °C). The year 2016 was warmer than last year by 0.28 °C. The country averaged seasonal mean temperatures during the winter season (January-February, with anomaly +01.36 °C, third warmest since 1901), the pre-monsoon season (March-May, with anomaly +1.22 °C, second warmest ever since 1901) and the post-monsoon season (October-December, with anomaly +0.75 °C, third warmest since 1901) mainly accounted for the above normal annual temperature for the year.

The 2016 annual rainfall over the country as a whole was 91% of Long Period Average (LPA) value for the period 1951-2000. The annual rainfall deficiency was mainly due to the significantly below average rainfall during the northeast monsoon seasons (55 % of LPA). The northeast seasonal rainfall over core region of

the south peninsula (comprising of 5 subdivisions *viz*., Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu & Puducherry, South Interior Karnataka and Kerala) was the lowest ever recorded for the region (35% of LPA) since last 116 years (1901-2016).

Temperature

The 2016 annual mean land surface air temperature for the country was +0.87 °C above the 1971-2000 average, thus making the year 2016 as the warmest year on record since 1901 (Fig. 20). The other 5 warmest years on record in order were: 2009 (anomaly +0.85 °C), 2010 (+0.82), 2015 (+0.59), 2006(+0.56) and 2002(+0.45). It is important to note that 12 out of 15 warmest years were during the recent past sixteen years (2001-2016). Past decade (2001-2010/ 2007-2016) was also the warmest decade on record with anomalies of 0.46 °C/0.51 °C. The annual mean temperature during 1901-2016 showed an increasing trend of 0.64 °C/100 years (Fig. 20) with significant increasing trend in maximum temperature (1.04 °C/100 years), and relatively lower increasing trend (0.25 °C/100 years) in minimum temperature. However, maintaining rapid rising trend in the minimum temperature during the past three decades, the year witnessed significantly warmer anomaly (+0.78 °C) in the annual minimum temperature. The country averaged season mean temperatures were also above the average during all the four seasons with the winter season (January-February, +01.36 °C) being the third warmest and the pre-monsoon season (March-May, +1.22 °C) being the second warmest since 1901. Monsoon season (June-September) this year with anomaly +0.45 °C was the 5th warmest since 1901 and the post monsoon season (October-December, with anomaly +0.75 °C above average) being the 3rd warmest ever since 1901. The country averaged monthly temperatures were warmer than normal during all the months of the year with temperatures near or over 1 °C above average recorded during the first four months (January to April, 0.93 °C, 1.8 °C, 1.53 °C, and 1.42 °C respectively). Of these four months, January was the fourth warmest since 1901, February and April were the second warmest since 1901 and March was the third warmest since 1901.

Rainfall

The annual rainfall over the country was 91% of Long Period (1951-2000) Average (LPA). Rainfall over the country as a whole during the SW monsoon season, which is the principal rainy season was normal (97% of LPA). During this season, among the four large geographical regions of the country, Central India received highest rainfall (106% of LPA) and East & Northeast India received lowest rainfall (89% of LPA). Northwest India and South Peninsula received seasonal rainfall of 95% of LPA and 92% of LPA respectively.

The northeast monsoon season rainfall over the country as a whole was substantially below normal (55% of LPA) and was the fifth lowest since 1901. The seasonal rainfall over northeast monsoon region of the south peninsula (comprising of 5 subdivisions *viz*., Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu & Puducherry, South Interior Karnataka and Kerala), was also substantially below average (35% of LPA) and was the lowest ever recorded for the region since last 116 years (1901-2016).

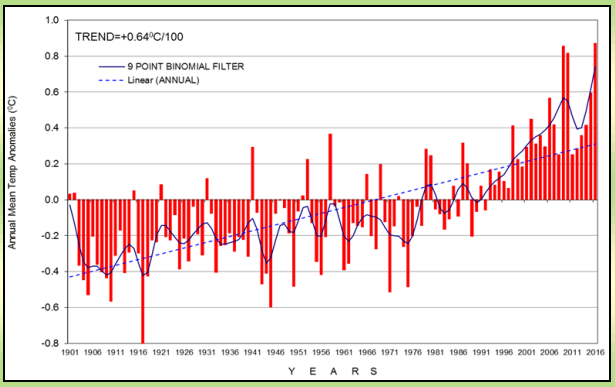


Fig. 20. Annual mean land surface air temperatures anomalies averaged over India for the period 1901-2016 (base period of 1971-2000). The dotted line indicates the linear trend in the time series. The solid blue curve represents the sub-decadal time scale variation smoothed with a binomial filter.

High Impact Weather Events:

During 2016, four cyclonic storms formed over the Bay of Bengal (one each in the month of May, October, November and December). In addition, four depressions formed during the monsoon season (two over the Bay of Bengal, one over the Arabian sea and one over land over central parts of the country) and two during the northeast monsoon season (one each over the Bay of Bengal and the Arabian sea). The country also experienced other high impact weather events like, extreme heavy rainfall, heat and cold waves, snow cover, thunderstorm, dust storm, lightening, floods etc. (Fig. 21). A few are listed below. The causalities mentioned here are based on the media and government reports.

1. During 2016, Phalodi in Rajasthan recorded highest-ever temperature of 51 °C on 19th May. The previous highest ever temperature (50.6 °C) was recorded by Alwar also in Rajasthan in 1956.

2. The severe heat waves over central and peninsular parts of the country during April & May caused deaths of about 700 people mostly from Telangana and Andhra Pradesh.

3. Lightning in various parts of northern, north-eastern, central and peninsular regions of the country during the pre-monsoon and monsoon seasons causing deaths of about 415 people with worst affected being parts of Bihar, Uttar Pradesh, Madhya Pradesh and Odisha.

4. Heavy rain & flood related incidents from different parts of the country during the monsoon season claiming deaths of about 475 people with worst affected state being Bihar where 146 people died during the period 25th July to 3rd September.

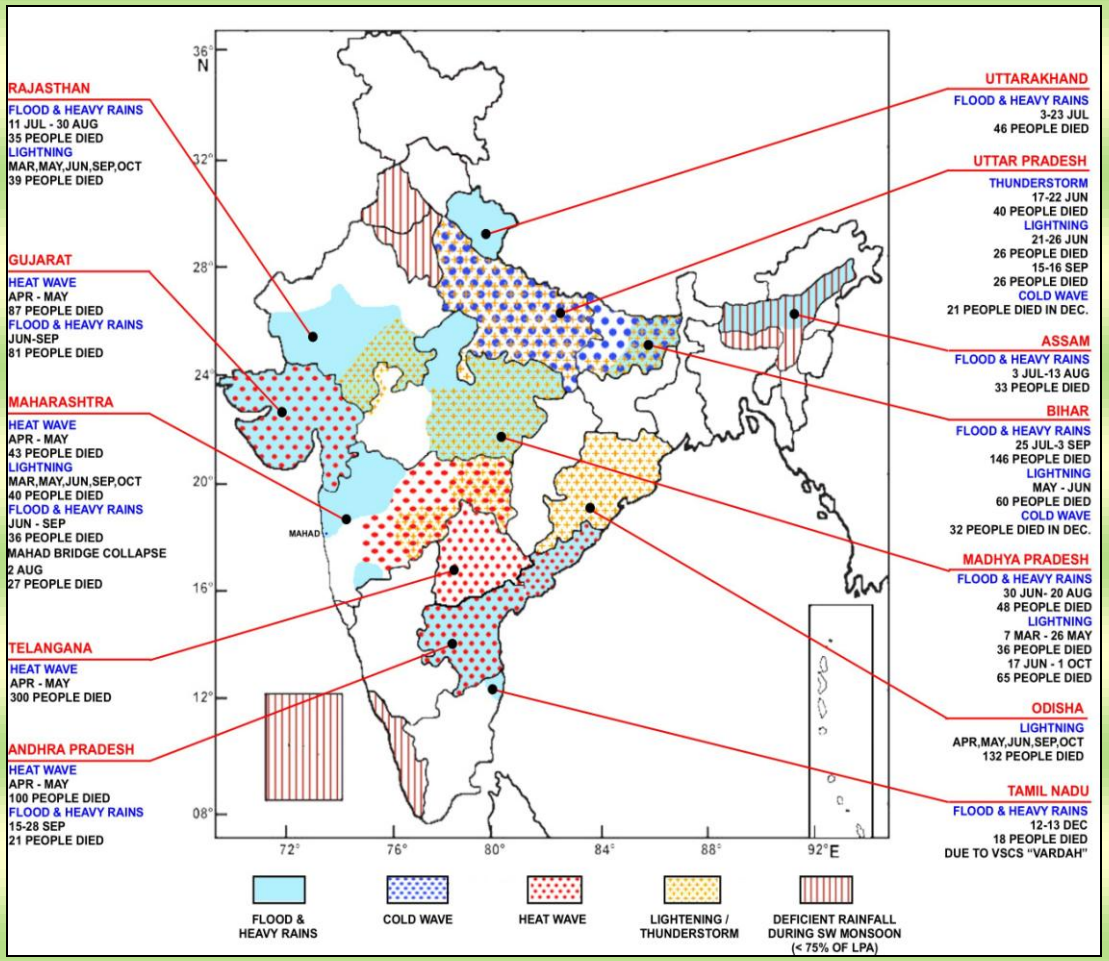


Fig. 21. Major extreme weather events occurred during 2016 and the associated loss of lives

(iii) Supply of Meteorological Data

The National Climate Centre and National Data Centre at IMD, Pune supply meteorological data to different institutes/organizations. The data supplied during 2016 along with the collection of revenue are given below :

- Number of users – 1773
- Departmental users – 168
- Research users – 75
- Commercial users – 103
- Total number of Records – 129898140
- Revenue accrued by sale of Data – Rs. 1,26,84,279 and US $ 1731.

There has been a continuous demand for more recent data by various scientific and operational community for diagnosis and operational forecasters for their references and simulation studies. With the new avenue of agricultural insurance, lot of consultants are desirous to have data for analysis of historical meteorological parameters. Since 2009, IMD has started encouraging registration of educational institutions and those requiring the data for academic purposes with IMD by way of one-time payment. So far, around 300 registered users have been benefitted by this facility. In the last few years there are over 2000 regular data users of which around 800 are from research community. Eventually, by way of service of data to various sectors, the revenue which is now close to Rs 1.3 Crores per annum that accrued to department has been found to increase to nearly 10 times. The out-reach programmes being planned in the Climate Services for various sectors would widen the user fields in the supply management which in turn cast additional revenue accrued to the department. As of date the total holdings of National Data Centre is 26.2 million records covering various types of meteorological data.

(iv) Initiated Data Rescue Schemes

In order to complete historical climate data series that are available in the form of manuscripts, charts and map forms, efforts were taken as plan projects for rescuing them as DATA RESCUE SCHEMES. This was mooted by WMO for making the climate series robust for the evaluation of assessment and predictions from past climate data. Accordingly, following project proposals were initiated for supplementing the data archives with the past data.

- Digitally photographing the analysed weather charts: There are over 8 lakhs analysed weather charts available for photographing and permanently archiving for referencing purposes as requirement by the operational forecasters as well as for scientific research. They have been now made available on a web portal for remote access from www.imdpune.gov.in/ WEBCHARTS. The project was taken up in two phases. The second phase has been completed successfully and made operational since April 2016.

- Auto charts Digitisation Project:

Nearly 80 lakh autographic charts containing the elements of Temperature, Pressure, RH, rainfall, wind, are available at different Regional and Meteorological Centres are preserved for more than 50 to 60 years for want of digitisation. As manual digitized hourly values are available from 1969 only, with an objective to create high-resolution (for lower than hour) data using auto-driven methodology for data extraction, a pilot project was taken up for 16000 charts containing 3 elements (temp, pressure and RH). This project was completed in 2013-14. Around 4 lakhs of data records were extracted and added to the archives. The same has been made operational on day to day basis at RMC Mumbai since September 2015. The second proposal to accomplish is in the pipeline

aiming at remaining parameters of wind and rainfall for implementation in 2016-17.

- Data Rescue of MMR Sheets

In 2009-11, the data rescue project - Phase I for scanning the old manuscripts/Monthly Meteorological Register (MMR) sheets was taken up by which data prior to 1969 were digitized. The list of data digitized is shown in the Table 4.

Subsequently, the remaining 70 % of historical data from different manuscripts / records are proposed Data Rescue Phase II as Plan Project which has been initiated in 2016.

TABLE 4

Digitization of data prior to 1969

Data	Period
8 AM observation registers	1890 - 1931
Monthly Meteorological registers	1931 - 1968
Radiation Data	1968 - 1990
Current Weather of select stations	1960 - 2000

CHAPTER 6

CAPACITY BUILDING, PUBLIC AWARENESS & OUTREACH PROGRAMME

IMD's major initiative in 2016 was to provide capacity building for its officers and staff, personnel from the other organizations in the country as well as from foreign countries particularly personnel from Asia pacific regions through organised training programmes, user workshops, conferences etc. Salient details are as under.

6.1. CONFERENCES & WORKSHOP

Dr. M. Mohapatra, Scientist 'G' presented on "Cyclone Services Achievements during 2015 And Future Plan" in the Annual cyclone Review meeting held at New Delhi on 29th January, 2016.

Smt. Suman Goyal, Scientist 'E' participated in Second session of CBS Inter Programme Expert Team on Satellite Utilization and Product (IPET-SUP-2) at Geneva, Switzerland during 23-26 February, 2016.

Dr. B. Mukhopadhyay, Scientist 'G' participated in a conference on climate change on 4th March, 2016 organised by Sir Parshurambhau College, Pune.

Dr. Mukhopadhyay at the conference on climate change

Dr. D. R. Pattanaik, Scientist 'E' participated and delivered an invited talk on 10th March, 2016 on "Global Framework for Climate Services (GFCS) - Climate and Health" in the Regional Stakeholder Consultation on Climate Services for the Third Pole Region which was organized by IMD and WMO in Jaipur during 9-11 March, 2016.

Discussion on Global Framework for Climate Services (GFCS) - Health sector

Dr. S.O. Shaw, Scientist 'E' attended a panel discussion on "COP 21 and After: Action plan of and for India with special reference to North East India" organized by Assam Engineering College, Guwahati on 26th March, 2016.

Dr. M. Mohapatra, Sc. 'G'; Dr. R. K. Jenamani, Sc. 'F'; Dr. Somenath Dutta, Sc. 'F'; Dr. Kamaljit Ray, Sc. 'F'; Dr. D. R. Pattanaik, Sc. 'E'; Dr. A. K. Mitra, Sc. 'D' participated in the Brain Storming session for preparation of MoES strategy documents on Atmospheric Science on different themes at Indian Institute of Tropical Meteorology on 1st April, 2016.

Shri A. K. Sharma, Scientist 'G', Smt. Suman Goyal, Scientist 'E' and Dr. A. K. Mitra, Scientist 'D' attended 10th SPIE Asia-Pacific Remote sensing (APRS) symposium during 4-7 April, 2016 at New Delhi. Dr. A. K. Mitra, Scientist 'D' presented two scientific papers during the conference.

A video conference with **Dr. Harsha Vardhan**, Hon'ble Minister of Science & Technology and Earth Sciences, focusing on Government's achievements during 2014-16 was organized on 24th May, 2016 at local Press Information Bureau offices. Shri S. M. Metri, Scientist 'D'

represented MC Bengaluru, Shri Rahul M., Scientist 'B' represented MC Goa, Smt. S. Stella, Scientist 'D' represented RMC Chennai and Shri S. Sudevan, Scientist 'E' represented MC Thiruvananthapuram in the conference.

Dr. K. K. Singh, Scientist 'F', Mr. A. K. Baxla, Scientist 'E' and Ms. Priyanka Singh, Scientist 'B' attended a forum on 'Climate Resilient Development in Himalayan and Downstream Regions' during 16-17 June, 2016 at India Habitat Centre, New Delhi organized by Institute of Economic Growth, Delhi International Centre for Integrated Mountain Development, Kathmandu, and Ministry of Agriculture and Farmers Welfare.

Shri K. R. Das, A.M. - I attended a video conference programme of the Hon'ble Prime Minister with all state authorities regarding Flood Preparedness and other issues at Secretariat, Goa on 29th June, 2016.

Shri B. Mukhopadhyay, Scientist 'G' attended the "Brain Storming Session on Lightning Network" held at Indian Institute of Tropical Meteorology, Pune on 30th June, 2016.

The 2nd Meeting of "Joint Working Group" under National Hydrology Project (NHP) held on 9 September, 2016 at IMD under the chairperson Dr. (Smt) Surinder Kaur, Scientist 'F'. Officers of MoWR, CWC and IMD participated in this meeting.

Dr. M. Mohapatra, Scientist 'G' participated as a member of Panel discussion in the United Nation's Economic and Social Commission for Asia and the Pacific (UN-ESCAP)-NIDM regional capacity building workshop on mainstreaming disaster risk reduction in sustainable development and planning on 16th September, 2016 at New Delhi.

Dr. (Smt.) Surinder Kaur, Scientist 'F' attended the panel discussion and delivered a presentation on ' Meteorological Studies for Forecasting Rain included Flood' on 27 September, 2016 in 6th SAARC Regional Training Program on Flood Risk Management at NIDM, New Delhi.

Shri S. B. Thampi, Sc. 'F' and other IMD officials participated as resource person at the one day seminar entitled "Voice of slums in Post Flood Chennai-Future Concerns" held at Loyola College, Chennai on 24th October, 2016.

Shri S. B. Thampi, Sc. 'F' and other IMD officials during the seminar

Dr. N. Chattopadhyay, Scientist 'F', participated in the International Conference on Climate Change, Water, Agriculture and Food Security conducted at ICRISAT, Hyderabad during 2-3rd November, 2016 and presented a paper on "Combating Effect of Climate on Indian Agriculture through Smart Weather Forecasting and ICT Application". He also acted as panel member for "Climate Proofing Agriculture: the role of Public- Private Partnerships and investment" during the conference.

Workshop

Surface Instrument Division, Pune organized a National Workshop on "Atmospheric Instrumentation & Meteorological Sciences: Theory & Challenges" in association with Vishwakarma Institute of Technology, Pune during 19- 21 January, 2016.

Dr. S. Balachandran, Scientist 'E' and Dr. A. K. Mitra, Scientist 'D' participated in the Annual Monsoon workshop 2015 and National Symposium on "Understanding and Forecasting the Monsoon Extremes" at Indian Institute of Tropical Meteorology, Pune during 23-24 February, 2016 and delivered invited talks on "An overview on Northeast Monsoon-2015" and on "INSAT-3D Satellite data utilization for monitoring of south west monsoon 2015" respectively.

Dr. M. Mohapatra, Scientist 'G' participated and presented an invited talk on "Role of IMD in the management of Meteorological hazards in India" in UN-India disaster risk reduction workshop during 8-10 March, 2016 at Hyderabad.

Shri S. C. Bhan, Scientist 'F' participated in a Workshop on Strengthening State Level Heat Action Plan of Odisha organized by Odisha State Disaster Management Authority on 14th March, 2016 at Bhubaneswar.

Dr. S. C. Sahu, Scientist 'F' participated in the state level workshop on learning from heat wave response on 18th March, 2016 at Bhubaneswar.

Dr. Pulak Guhathakurta, Scientist 'F' participated in the Brain Storming Workshop of MoES at National Centre for Antarctic and Ocean Research, Goa during 13 - 14 April, 2016 regarding "Polar Sciences and Global Change in Water Cycle".

Dr. K. K. Singh, Scientist 'F', Mr. A. K. Baxla, Scientist 'E' and Ms. Priyanka Singh, Scientist 'B' attended a workshop on "Climate Change and Agriculture" at National Agricultural Science Complex, New Delhi during 28-29 April, 2016 organised by Department of Science and Technology's Knowledge Network and Indian Council of Agricultural Research.

Dr. G. N. Raha, Scientist 'D' attended a consultation cum workshop on "Building Climate Resilience and Mainstreaming Disaster Risk Reduction Developmental Planning" organized by Sikkim Disaster Management Authority on 6th May, 2016.

Dr. D. M. Rase, A.M. - I participated in one day Regional symposium on Excellence in Training organized by Department of Personnel and Training & Yashwantrao Chavan Academy of Development Administration (YASHDA), Pune on 16th May, 2016.

Dr. S. D. Attri, Scientist 'F' chaired the Session on "Computation of Air Pollution in North India" at a workshop organized by IIT Delhi from 20-21 May, 2016 at Chandigarh.

Dr. S. C. Sahu, Scientist 'F' delivered a lecture on "Flood early warning system, Warning receive & warning dissemination" at Gopabandhu Academy of Administration, Bhubaneswar on 18th April, 2016.

Dr. G. N. Raha, Scientist 'D' delivered a lecture on "Integrated Agro-meteorological services in India" in a workshop conducted by SAMETI Sikkim in collaboration with MANAGE, Hyderabad at SAMETI building, Tadong on 13th May, 2016.

Dr. Geeta Agnihotri, Scientist 'E' delivered a lecture on "Weather system forecasting during Floods" for 73rd All India Watermanship Course at Home Guard and Defence Academy on 20th May, 2016.

Ms. B. Amudha, Scientist 'D', Dr. B. Geetha, AM-II, Dr. K. V. Balasubramanian, AM-I and Smt. Sumathi, AM-II delivered lectures on "Disaster management and Mitigation measures" on 2nd, 16th ,23rd and 28th June, 2016 respectively at RMC Chennai to 146 trainees comprising district administrators and disaster managers of Tamil Nadu.

Dr. M. Mohapatra, Scientist 'G' (Services) participated in a seminar on the theme "Global Initiatives and Indian Environment" organized by Delhi School of Economics, University of Delhi on the eve of World Environment Day and presented a talk on "Role of Early Warning System for disaster risk reduction in India" on 4th June, 2016.

Dr. V. K. Soni, Scientist 'E' attended a workshop on "Evaluation of Research for Planning the 36th Indian Scientific Expedition to Antarctica" held during 9-10 June, 2016 at National Centre for Antarctic and Ocean Research, Goa and presented IMD's plan on 36th Indian Scientific Expedition to Antarctica for Maitri and Bharati Stations, Antarctica.

Dr. Geeta Agnihotri, Scientist 'E' attended Workshop on Performance of Upper Air Observational Network of IMD at DDGM (UI) New Delhi on 12-13 July, 2016.

Shri S. Bagulayan Thampi, Scientist 'F', attended workshop on the performance of Upper air observational network of IMD on 13th July, 2016 and Plan Review meet on 14-15 July, 2016 respectively held at New Delhi.

Ms. Hemlata Bharwani, Scientist 'B' attended one day workshop on 'Strategic Ganga River Basin Planning' on 15th July, 2016 at Conference Room, 4th floor, Mohan Singh Place, Connaught Place, New Delhi.

Shri R. K. Goswami, Scientist 'B' and Shri M. P. Luitel, Meteorologist 'A' attended a workshop on "Hazard Risk and Vulenerability Assessment" at ASDMA conference Hall Dispur on 22nd July, 2016.

Dr. Surinder Kaur, Scientist 'F' and Shri P. K. Gupta, Scientist 'B' attended the workshop on "Design Flood Issues" held on 29th August, 2016 at CWC, New Delhi and made the presentation also.

Dr. A. K. Mitra, Scientist 'D' attended the GSICS Web Meeting on "Lunar Calibration for INSAT-3D through WebEx facility" on 30th August, 2016 at IMD New Delhi. He also made the presentation on the work done on Lunar Calibration. India Meteorological Department is one of member of Global Space base Inter Satellite Calibration System (GSICS) and He nominated member of GSICS Research Working Group (GRWG) from India Meteorological Department Sat. Met Division New Delhi.

Shri Virendra Singh, Scientist 'E' attended first In Orbit test meeting of INSAT-3DR on 31st August, 2016 at Space Application Centre (SAC) Ahmedabad.

Head/Scientist 'E', M. C. Bhopal delivered lecture in one day workshop on 'Climate Change, Global Warming, Extreme weather events and sustainable solution' at Environmental Planning and Coordination Organisation (EPCO) on 1st September, 2016.

Dr. Kripan Ghosh, Scientist 'E', attended the workshop on "Operational Techniques for combining extended and seasonal Forecast and model in Climate risk management in Agriculture" held at Rajmata Vijaya Raje Scindhia University, Gwalior of Agriculture Gwalior during 19-25 September, 2016.

Shri Bikram Singh, Scientist 'E' attended a workshop on "River morphological analysis etc." called by Secretary, Department of Disaster Management, Government of Uttarakhand on 20th September, 2016.

A workshop on **"Standardization of RMC Standard instruments/ equipments and their Calibration with Laboratory Standards"** was conducted by Surface Instrument Division Pune from 19-23 September, 2016. 2 participants were familiarised with calibration of Surface Met. Instruments.

Calibrations in surface laboratory

Dr. Siddhartha Singh, Scientist 'D' attended "Multi-sectoral Workshop on Air Pollution - Translating Recommendations of the Steering Committee on Air Pollution and Health Related issues into Action" organized by Ministry of Health & Family Welfare on 28-29 September, 2016 at New Delhi.

A workshop on **'Computer and Hindi- facilities and utilities'** was arranged in PAC office on 18 October, 2016 as per official language implementation policy.

Shri Y. K. Reddy, Scientist 'F', MC Hyderabad and Shri K. Ramachandra Rao, Sc. 'E', CWC attended a workshop on "Disaster proofing Indian Cities: strengthening emergency services infrastructure during climate extremes" held at Vijaywada on 11th November, 2016 organised by British High Commission, Hyderabad

A consultative workshop on **"Climate Variability in Kerala in Recent Years: Climate Change Perspectives"** was organised by Govt of Kerala in association with IMD and SDMA. **Shri S. B. Thampi**, Sc. 'F', Dr. D. S. Pai, Sc. 'F', Dr. V. K. Mini, Sc. 'D'and Shri N. T. Niyas, Sc. 'C' participated in the Workshop on "Climate Variability in Kerala in Recent Years: Climate Change Perspectives" on 21st November, 2016 held at Thiruvananthapuram and made presentation

Shri Y. K. Reddy, Sc. 'F', MC Hyderabad and Shri K. Ramachandra Rao, Sc. 'E', CWC attended a workshop on "Disaster proofing Indian Cities: Strengthening emergency services infrastructure during climate extremes" held at Vijaywada on 11th November, 2016 organised by British High Commission, Hyderabad.

Centre for Advanced Training, IITM Pune organized three days National Workshop on **"NWP on Probabilistic Forecast"** during 6-8 December, 2016 at IITM Pune. The workshop was inaugurated by Director IITM. Forecasters from State Meteorological Centres and Regional Meteorological Centres of IMD participated in the training workshops. The resource persons from IMD, NCMRWF and IITM explained how to use the available model products and also how to use the ensemble products for probability forecast.

6.2. MEETINGS

Shri S. Bagulayan Thampi, Scientist 'F' and Shri Virendra Singh, Scientist 'E' participated in a meeting on the WMO project on Severe Weather Forecast Demonstration – Bay of Bengal (SWFDP-BoB) on 6th January, 2016 at conference hall (HQ), New Delhi.

Shri L. Ramesh Babu, Scientist 'D' along with Shri Somashekara Bhatta AM-I, AMO Bengaluru attended the monthly "Airport Facilitation Committee" meeting conducted by KIAL, Bengaluru on 12th January, 2016.

Shri R. B. Verma, Scientist 'D' attended a meeting on Disaster management conducted by Disaster Management Division under Ministry of Home Affairs on 13th January, 2016.

Dr. S. K. Roy Bhowmik, Scientist 'F' attended CTCZ Subgroup meeting on 20th January, 2016 at Indian Institute of Science, Bangaluru.

Dr. Jayanta Sarkar, Scientist 'E' had a meeting with the CEO Green Environment Services, Ahmedabad on 27th January, 2016.

Dr. A. C. Lyngdoh, Scientist 'D' attended a meeting at Meghalaya main Secretariat, Shillong organised by Meghalaya Basin Development Authority (MBDA) on the 2nd February, 2016.

Shri D. Joardar, Scientist 'E' attended HPC committee meeting under the chairmanship of Dr. M. Ravichandran, Scientist 'G' Indian National Center for Ocean Information Services (INCOIS) on 8th February, 2016 at INCOIS, Hyderabad and furnished details of floating point calculation for each application/code to be operationally executed for productions and storage requirement for next five years in IMD.

Dr. S. C. Sahu, Scientist 'F' attended meeting of the state Steering committee on heat wave action plan on 22nd February, 2016 in Orissa State Disaster Mitigation Authority (OSDMA), Bhubaneswar.

Shri S. B. Thampi, Scientist 'F' participated in a meeting of committees constituted by Secretary, MoES in connection with the preparation of vision document and also to chalk out the work plan on 2nd March, 2016 and 31st March 2016 at National Institute of Ocean Technology, Chennai.

Dr. Geeta Agnihotri, Scientist 'E' attended a meeting of State Level Coordination Committee on Crop Insurance (SLCCCI) at Samruddhi Video Conference Hall, Agriculture Department on 4th March, 2016.

Dr. M. Mohapatra, Scientist 'G' (Services) chaired a meeting for interaction among all collaborators of Heat Action Plan to review the preparedness for providing temperature forecast guidance for the above plan on 9th March, 2016 at IMD HQ.

"Ahmedabad Heat Action Plan (HAP) 2015"

IMD has been actively supporting the Ahmedabad Heat Action Plan (HAP) 2015 by providing early warning of heat wave to Ahmedabad Municipal Corporation and Indian Institute of Public Health (IIPH), Gandhinagar. An Interaction meeting of all the collaborators of HAP 2016, under the chairmanship of Shri Kamal Kishore, Member, National Disaster Management Authority (NDMA) New Delhi, was organized on 9th March 2016 at HQ to review the preparedness for the Heat Action Plan 2016 in view of expansion of the plan to Surat, Nagpur region (5 cities) and Bhubaneswar region (2 cities). High level officers from NDMA, State Disaster Management Authority, State Health Department, Public Health Foundation of India, IIPH Ahmedabad, IIPH Bhubaneshwar, National Research Development Corporation and IMD participated in the meeting.

Interaction Meeting of Collaborators of HAP 2016

Dr. M. Mohapatra, Scientist 'G' participated in the 1st meeting of Indo-Russia joint commission for cooperation in the field of Disaster management on 22nd March, 2016 at New Delhi and presented the Early warning system of IMD.

Shri S. B. Thampi, Scientist 'F' attended the 36th State Level Coordination Committee Meeting on Crop Insurance on 29th March, 2016 organized by the Agriculture Ministry, Government of Tamil Nadu.

Shri D. Joardar, Scientist 'E' and Dr. Anand Kumar Das, Scientist 'D' attended a meeting in Indian Institute of Science (IISC), Bangalore before the 'Need Aspects Committee' under the chairmanship of Prof. Ravi Nanjundiah, to justify future HPC requirement in respect of number of processors, total computing power in TFlops and disk storage in PBytes in each of envisaged programs in ESSO-IMD. Scientists from ESSO-IITM, ESSO-INCOIS and ESSO-NCMRWF were also present in the meeting in support of programs of respective institutes.

Dr. Surinder Kaur, Scientist 'F' chaired the "Pre-Flood Meeting on Preparedness" which was held on 29th March, 2016 between IMD and Central Water Commission officers at New Delhi.

Dr. S. O. Shaw, Scientist 'E' attended a meeting on preparedness of flood at the office of Chief Secretary of Assam, on 12th April, 2016.

Dr. G. C. Debnath, Scientist 'F', Shri S. Sengupta, Scientist 'E' and sixteen members of Damodar Valley Corporation , Central Water Commission and Bharat Sanchar Nigam Limited participated in the 63rd Annual Meeting of the Damodar Valley Corporation Advisory Committee (Met) held at DVC Tower, Kolkata on 13th April, 2016 for reviewing the activities of DVC Met. Unit during 2015-2016 and to chalk out action plan for 2016-2017.

Dr. S. C. Sahu, Scientist 'F' attended meeting with Chief Minister of Odisha (i) regarding heat wave and drinking water issues at Odisha Secretariat on 19th April, 2016 and (ii) for the preparedness of Cyclone "ROANU" at Bhubaneswar on 19th May, 2016.

Shri N. T. Nyas, Scientist 'C' attended State Level Technical Committee meetings on Crop Insurance convened by Director of

Agricultulture, Thiruvananthapuram on 21st April, 28th April, 18th May and 25th June, 2016.

Dr. K. K. Singh, Scientist 'F', Mr. A. K. Baxla, Scientist 'E' and Ms. Priyanka Singh, Scientist 'B' attended 4th National Steering Committee Meeting of the Climate Change Knowledge Network in Indian Agriculture (CCKN-IA) Project on 25th April, 2016 at New Delhi organized by a German institution, GIZ and Ministry of Agriculture and Farmers Welfare.

Ms. Mamta Yadav, Scientist 'B' attended a meeting of the committee constituted for collection of bathymetric and other important data on the important rivers in Odisha with the objective of flood modeling and development of early warning system at Bhubaneswar on 26th April, 2016.

Shri R. Balasubramanian, Scientist 'D' attended a meeting on "Overview of state level kharif planning-2016 for Maharashtra", under the Chairmanship of Hon'ble Chief Minister of Maharashtra at Mumbai on 28th April, 2016.

Shri K. Santosh, Scientist 'E' attended the meeting of Disaster Management Department, "Monsoon Preparedness 2016" chaired by Chief Secretary, Govt. of Kerala on 3rd May, 2016.

Shri B. K. Mandal, Scientist 'E' and Shri Radhey Shyam Sharma, Scientist 'B' had a meeting with the Director, Land Survey, regarding weather forecasting techniques & Climate Change on 13th May, 2016.

Dr. G. C. Debnath, Scientist 'F' attended the Pre-monsoon Preparedness Meeting 2016 on 17th May, 2016 chaired by Chief Secretary, Govt. of West Bengal.

Dr. V. K. Mini, Scientist 'D' attended a Monsoon preparedness meeting convened by the Chief Minister at the secretariat, Goa Govt. on 19th May, 2016 and explained IMD's long range forecast about monsoon performance, onset date for SW Monsoon 2016 and the details of systems in place for issuing weather forecast and warnings.

Shri R. Balasubramanian, Scientist 'D' attended a meeting on "Interim Findings from Field Interactions on Climate Services in Maharashtra" organized by The Energy and Research Institute (TERI) at Pune on 24th May, 2016.

Dr. Sanjib Bandyopadhyay, Scientist 'E' attended a meeting on the status of weather data for crop insurance and other purposes with Additional Chief Secretary, Govt. of West Bengal on 24th May, 2016.

Dr. M. Mohapatra, Scientist 'G' (Services) participated in a Twittter conference programme as an expert on cyclones and floods organised by National Disaster Management Authority at New Delhi to respond to the queries raised by public through twitter online on 27th May, 2016.

Dr. Somenath Dutta, Scientist 'F' attended a meeting of the committee for review of the CAT & other training programs on 27th May, 2016 at Indian National Centre for Ocean Information Services, Hyderabad.

Dr. Shirish Khedikar, Scientist 'B' participated in the 44th "Joint Agresco Meet 2016" and gave presentation on "Activities and Services to farmers of Maharashtra by IMD" held at Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola during 28 - 30 May, 2016.

Dr. K. K. Singh, Scientist 'F' attended a brainstorming meeting on "Future Thrust and Strategies for Agrometeorological Research, Education and Extension in India" during 30-31 May, 2106 organized by Central Research Institute for Dryland Agriculture, Hyderabad.

Dr. S. C. Sahu, Scientist 'F' attended a meeting of the State Executive Committee constituted under the Disaster Management Act 2015 at Secretariat, Bhubaneswar on 9th June, 2016.

Dr. N. Chattopadhyay, Scientist 'F' and Dr. Geeta Agnihotri, Scientist 'E' participated in the "Regional Review Meeting of Gramin Krishi Mausam Sewa (Karanataka)" & "Forecasting

Agricultural Output Using Space, Agrometeorology and Land Based Observations (South zone)" held during 9 - 10 June, 2016 at University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bangalore.

Dr. V. K. Mini, Scientist 'D' attended the State Executive Committee meeting of State Disaster Management Authority convened by the Chief Minister at the secretariat, Goa Govt. on 14th June, 2016 to discuss the setting up of State Disaster Response Force.

Dr. M. Mohapatra, Scientist 'G' (Services) participated in the meeting to discuss the draft proposal for the renewed and expanded SAARC Disaster Management Centre (SDMC) at National Disaster Management Authority on 15th June, 2016.

Dr. P. K. Nandankar, Scientist 'F' attended a meeting on "Hazard Risk Vulnerability Analysis in Pune" held at Collector's Office, Pune on 16th June, 2016.

Dr. Geeta Agnihotri, Scientist 'E' attended a meeting in the Planning Department, Bengaluru regarding collection of rainfall data from Raingauge centres by Directorate of Economic and Statistics on 18th June, 2016.

Shri S. M. Metri, Scientist 'D' attended a meeting of the 'State Level Committee to Monitor Season, Crop Condition and Drought Relief Measures' in the Chambers of additional Chief Secretary and Development Commissioner, Vidhana Soudha on 20th June, 2016.

Shri A. K. Sen, Scientist 'E' attended a meeting of Crisis Management Group (CMG) of Bihar Govt., chaired by Hon'ble Chief Minister of Bihar on 22nd June, 2016 and made a brief presentation on current weather situation and prospects of South West Monsoon for current year in Bihar.

Shri S. Bagulayan Thampi, Scientist 'F' participated in the Selection Committee meeting to review the performance of the Assistant Directors (Technical) on contract, conducted by National Institute of Wind Energy, Chennai on 23rd June, 2016.

Shri A. K. Sharma, Scientist 'G' and Shri R. B. Verma, Scientist 'D' attended the meeting to review the progress of the project "Installation of DTH based Digital Cyclone Warning Dissemination System" on 29th June, 2016 at ISRO Bengaluru.

Dr. M. Mohapatra, Scientist 'G' participated in the meeting under the chairmanship of Shri R. K. Jain, Member, NDMA on 1st July, 2016 at NDMA Bhawan, New Delhi to discuss the preparations for the 2nd Meeting of the BRICS Ministers for Disaster Management in August, 2016.

Shri S. M. Metri, Scientist 'E', Shri L. Ramesh Babu, Scientist 'D', Shri N. Ramdoss, Meteorologist 'B' and Shri S. N. R. Gopal attended meeting at KIAL Bengaluru regarding New South Parallel Runway on 4th July, 2016.

Shri L. Ramesh Babu, Scientist 'D', attended meeting regarding Emerging Technologies and Development in Air Traffic Management-Industry Perspective organized by ATC Association, Bengaluru on 9th July, 2016.

Dr. L. S. Rathore, the then DGM, Shri S. B. Tyagi, Scientist 'E' and Dr. A. K. Das, Scientist 'D' participated in the meeting under National Hydrology Project on 13th July, 2016 at MoWR, Shram Shakti Bhawan, New Delhi.

Agromet Advisory Services under GKMS

Meeting of the **"Working Groups in implementation of Agromet Advisory Services" under Gramin Krishi Mausam Sewa (GKMS)"** on 19th July, 2016. The main objectives of the meeting was to apprise the present status of mandated works and plans for implementation of various activities under GKMS project. Shri B. Mukhopadhyay, Sc. 'G',

Meeting of the "Working Groups in implementation of Agromet Advisory Services"

IMD, Pune; Dr. S. Pasupalak, Hon'ble Vice Chancellor, OUAT, Bhubaneshwar; Dr. K. K. Singh, Scientist 'F', IMD, New Delhi; Shri S. C. Bhan, Scientist 'F', IMD, New Delhi; Dr. N. Chattopadhyay, Scientist 'F' IMD, Pune; DDGMs, Officer-In-Charges of State Agromet Centre (SAMC), Scientists from RMCs, MCs, Principal Nodal Officers, Nodal Officers and Technical Officers of Agrometeorological Field Units (AMFUs) participated in the meeting.

Shri S. Bagulayan Thampi, Scientist 'F' and Shri K. Santhosh, Scientist 'E', attended the meeting of working groups in implementation of Agromet Advisory Services Under GKMS and operationalisation of block level weather forecast and Agromet Advisories during 19-20 July, 2016 at Pune.

Block Level Weather Forecast and Agromet Advisories

Meeting on **"Operationalisation of Block Level Weather Forecast and Agromet Advisories"** on 20th July, 2016. The main objective of this meeting was to devise roadmap for "Implementation of Block Level Forecast & Advisories. Dr. L. S. Rathore, the then DG, IMD, New Delhi; Shri B. Mukhopadhyay, Scientist 'G', IMD, Pune; Dr. K. K. Singh, Scientist 'F', IMD, New Delhi; Shri S. C. Bhan, Scientist 'F', IMD, New Delhi; Dr. N. Chattopadhyay, Scientist 'F', IMD, Pune; Dr. S. Pasupalak, Vice Chancellor, Odisha University of Agriculture and Technology, Odisha, Dr. M. Datta, Former Joint Director, ICAR, Lembucherra, Tripura, Dr. Padmakar Tripathi, Former Registrar and Dean, Indian Institute of Technolgy (IIT), Roorkee, Uttarkhand, Dr. Swati P. Sardesai,

Block level weather Forecast and Agromet advisories

Deputy Director General (DDG), National Informatic Centre (NIC), Pune and Shri V. H. Deshpande, Scientist E, NIC, Pune and Shri C. S. Lobo, Director, Watershed Organisation Trust (WOTR), Pune Scientists from RMC/MCs, Principal Nodal Officers, Nodal Officers and Technical Officers of Agrometeorological Field Units (AMFUs) participated in the meeting.

Shri D. Saha, Scientist 'F' and Dr. K. Ghosh Scientist 'E', participated in the meeting of working Groups in "Implementation of Agromet Advisory Service under GKMS & Operationalisation of block level weather forecast and Agromet Advisories", during 19-20 July, 2016 held at JCADA Pune.

Shri Sunit Das, Scientist 'D', attended an emergency meeting called by the Chief Minister of Assam at Brahmaputra Guest house on 24th July, 2016 to "Review Flood situation in Assam".

Dr. N. Chattopadhyay, Scientist 'F', attended meeting of High level Project Advisory and Monitoring Committee (PAMC) to evaluate and monitor the progress of plan scheme Gramin Krishi Mausam Sewa (GKMS) of IMD to improve the quality of Agromet Advisory Services for the farming community in the country was held on 29th July, 2016 at Mausam Bhavan, IMD New Delhi.

Shri Bikram Singh, Scientist 'E' attended a meeting under the chairmanship of Chief Secretary, Government of Uttarakhand on 8th August, 2016 where a presentation on setting up of Hydro-meteorological network in Uttarakhand was made by In-charge, Karnataka state natural disaster monitoring

center (KSNDMC) and a MOU was signed by the state government with KSNDMC.

Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences and Dr. M. Mohapatra, Scientist 'G' participated in the Interactive Session of Heads of various Departments with Assistant Secretaries of Central Government in different Ministries at New Delhi on 12th August, 2016.

Dr. K. J. Ramesh, Director General of Meteorology, IMD and Dr. M. Mohapatra, Scientist 'G' participated in the meeting for "Identification and finalization of various programs beyond XII Plan" at MoES on 16th August, 2016.

Dr. Geeta Agnihotri, Scientist 'E' and Shri L. Ramesh Babu, Scientist 'D' attended meeting regarding "Construction of RETs to enhance Runway capacity" at Kempegowda International Airport, Bengaluru (KIAB) at Taj Bengaluru, opposite to Kempegowda International Airport (KIA) passenger Terminal Building, Bengaluru on 16th August, 2016.

Dr. S. Balachandran, Scientist 'F', attended Technical Committee meeting on "Coastal Disaster Risk Reduction project "(CDRRP) under World Bank Project held at Chennai on 22nd August, 2016.

Dr. S. O. Shaw, Scientist 'E', attended the "61st (Adjourned) meeting of Brahmaputra Board" at Guwahati held on 22nd August, 2016.

A meeting amongst the scientist of IMD, SAC (ISRO) and NCMRWF under the chairmanship of Scientist - SG, SAC (ISRO) was held on 2nd September, 2016 at the conference Hall, Mausam Bhawan to finalize the additional data products from INSAT-3DR.

Dr. Manorama Mohanty, Scientist 'D', attended meetings organised by Principal Sec., Agriculture Department regarding "Monsoon status 2016" on 2nd July, 2016 and "Crop cutting experiments in agricultural field" on 8th September, 2016.

Dr. (Smt) Surinder Kaur, Scientist 'F', attended "6th and 7th meeting of the Supervisory Committee on Cauvery" on 12th September, 2016 in New Delhi to discuss water related issues on Cauvery basin.

Shri G. Raja Ramesh, Meteorologist 'B', attended as a member from IMD in the Selection committee regarding appointment of Met. Observer on temporary basis at Krishi Vigyan Kendra, Sirsi", organized by University of Agriculture Sciences, Dharwad on 15th September, 2016.

Dr. Jayanta Sarkar, Scientist 'F', attended a meeting on "Artificial rainfall experiment in Gujarat" chaired by Hon. Revenue Minister of Gujarat government Shri Bhupendrasinh Chudasma at Gandhinagar on 21st September, 2016.

Dr. N. Chattopadhyay, DDGM (Agrimet) participated in the second meeting of the Management Group (MG) of the Commission for Agricultural Meteorology (CAgM) held at World Meteorological Organization (WMO), Geneva, Switzerland during 17-20 October, 2016, to make a comprehensive report of CAgM activities of different Expert team and Task team needs to prepare final report for the intersession period for onward submission to the Commission for the Commission for Agricultural Meteorology (CAgM) meeting will be held in 2018.

International Brainstorming Meeting on "Air Quality and Climate Impacts"

International Brainstorming meeting on **"Air Quality and Climate Impacts"** was organized in New Delhi during 5-7 October, 2016 by EMRC, IMD in collaboration with Finnish Meteorological Institute, WMO, UNEP and WHO. The meeting was inaugurated by Dr. M. Rajeevan, Secretary, MoES. Dr. D. R. Pattanaik, Sc. 'E' and Dr. V. K. Soni, Sc. 'E' attended the meeting and delivered talks on "Heat Wave and

Dr M. Rajeevan, Secretary, MoES delivering inaugural address in International Brainstorming meeting on "Air Quality and Climate Impacts"

Health" and "Environmental monitoring and Research Activities of IMD" respectively.

Dr. N. Chattopadhyay, DDGM (Agrimet) has been invited to participate in Developers Meeting on the GFCS-Relevant Climate Data, Products, and tools from 6-8 December, 2016 at Geneva under the auspices of the World Meteorological Organization (WMO) Commission for Climatology (CCI) Implementation Coordination Team on Climate Services Information System (ICT-CSIS).

6.3. TRAINING

Barometer Calibration and meteorological instruments training was conducted for **Mr. Htay Lwin**, Executive Engineer and **Mr. Zaw Min Htwe,** Deputy Superintendent of Department of Meteorology and Hydrology, Myanmar from 15-19 February, 2016.

Dr. M. Mohapatra, Scientist 'G' participated in training programme on "Disaster Risk Reduction Strategies for Sustainable Development Planning & Policy Instruments" during 17-18 February, 2016 at New Delhi organised by National Institute of Disaster Management (NIDM)**.**

Familiarization training imparted to 13 Officers from Air Force Administrative College (AFAC), Coimbatore on **"Satellite Meteorology"** during the period from 14 -15 March, 2016.

Training of **"GPS based radiosounding systems"** was imparted to IMD officers and staff at 13 locations by the Engineers from M/S Jinyang Industrial Company, Korea.

IMD officers and staff undergoing training of GPS radiosounding systems

Most of the officers and staff members **of M.C. Ahmedabad** have undergone awareness training regarding Quality management system for obtaining ISO 9001:2008 certification.

Dr. G. C. Debnath, Scientist 'F' inaugurated the Intermediate Met. Training Course Batch No. 240 at RMC Kolkata Training Centre at Salt Lake, on 11th April, 2016. Dr. Sanjib Bandyopadhyay, Scientist 'E', Course Director, and Dr. Sanjib Sen, Scientist 'E' were also present.

Inauguration of Intermediate Met. Training Batch No. 240 at RMC Kolkata

Shri Vivek Sinha, Scientist 'E' imparted Aviation Competency Training at RMC Guwahati on 6th May, 2016.

A short duration course on "Agrometeorology" for foreign trainees was conducted during 9 - 20 May, 2016 in Agrimet Division, Pune.

A training programme was organized by Hydromet Division at New Delhi during 26 -27 May, 2016 on "**revised mkRAIN software"** for processing of rainfall data to prepare rainfall statistics for the districts, met-subdivisions and states of India.

Dr. L.S. Rathore with trainees during mkRAIN software training programme

Dr. Ashok K. Das, Scientist 'D' attended the four weeks hands-on Hydrometeorological & Hydrologic services training at Bureau of Meteorology, Australia during 30th May - 25th June, 2016.

Agromet Service Cell conducted one month training of Met- II trainees of Agromet discipline on "Crop Yield Forecasting Modelling, Agricultural statistics, Drought Monitoring, challenges of medium range weather forecast, climate change and agriculture" with effect from 6th June, 2016.

O/o ADGM(R), Pune conducted "**Summer Placement Course**" for Agricultural Engineering students during 6th June to 1st July, 2016. Eighteen students from different agricultural engineering colleges underwent the training.

Agricultural Engineering students at IMD Pune

Forty Nine students of B. Tech. / M. Tech. / M. Sc. of various institutes joined Delhi HQ for six weeks **Summer Internship** and eleven student joined RMC Guwahati for four weeks Summer Internship during June, 2016.

Dr. P. Khare, Scientist 'E' attended "Aviation Competency Assessment" training conducted by Central Aviation Meteorological Division, New Delhi during 20 - 22 June, 2016.

Training of Agro-meteorological field unit offiers on **"Modelling cum climate risk management"** was held at Jorhat from 20-24 June, 2016. Mr. A. K. Baxla & Dr. Kripan Ghosh were the resource persons for the same.

Dr. K. Ghosh, Scientist 'E' participated in the training entitled "Hands on Practice on modeling cum climate risk management"as a resource person, held at OUAT Bhubaneswar during 23-29 July, 2016.

International Training program

Twenty two (22) participants representing 13 countries visited DWR Visakhapatnam on

Participants of International Training program

29th July, 2016 as a part of their International Training program sponsored by Ministry of External Affairs (MoEA) under ITEC-SCAAP on "Community based disaster management". Shri R. Bibraj, Scientist 'B' explained to them about the role and preparedness of Doppler Weather Radar stations during Disasters following which they had an interactive session with the staff.

Shri L. Ramesh Babu, Scientist 'D' and Shri Somashekhara Bhatta have given training to the new recruitees of Airport Authority of India on the subject "Applications of Meteorology in Aviation" on 16th August, 2016.

AWS and ARG training was conducted by Surface Instrument Division Pune from

AWS and ARG training

29 August to 2nd September, 2016 for RMC Chennnai.

WMO's Tropical Cyclones Forecasters Training 2016

The **WMO's Tropical Cyclones Forecasters Training 2016** was conducted by Regional Specialised Meteorological Centre (RSMC), New Delhi during 19-30 September 2016 at India Meteorological Department (IMD), New Delhi. The training aimed at capacity building of the tropical cyclones (TCs) forecasters in the region by understanding the latest developments in observations, monitoring, modeling, prediction and warning services of TCs over the region and carrying out the practical examples in these aspects. There were 20 participants including 3 from WMO/ESCAP Panel member countries viz. Bangladesh, Maldives and Pakistan, 11 from Area Cyclone Warning Centres (ACWCs) and Cyclone Warning Centres (CWCs) of IMD and 6 from National Weather Forecasting Centre & RSMC New Delhi. The training programme was inaugurated by Dr. K. J. Ramesh, DGM, IMD on 19th September. The resource persons for this training programme included experts from IMD, National Centre for Medium Range Weather Forecsating (NCMRWF) and Indian Institute of Technology (IIT), Delhi. It also included two field visits of half day each to NCMRWF and National Institute of Disaster Management (NIDM).

Regional Training Workshop for capacity development in coastal multi hazard early warning system was jointly organised by IMD & Indian National Centre for Ocean Information Services (INCOIS), Hyderabad and sponsored by UN-ESCAP at Hyderabad during 19-23 September, 2016. During the workshop, **Dr. M. Mohapatra**, Scientist 'G' delivered a lecture on "Cyclone Warning Services of IMD", **Dr. D. R. Pattanaik,** Scientist 'E' delivered a lecture on Severe Weather Forecast Demonstration Project and Role of RSMC and **Dr. Naresh Kumar**, Scientist 'D' delivered a lecture on Thunderstorm & Heat Wave Warning on 20th September, 2016.

A delegation of trainees from **South Asian association for Regional Cooperation (SAARC) member countries** undertaking training at NIDM visited IMD on 28th September, 2016.

Shri G. B. Shah, Meteorologist 'A' and Shri Y. D. Bijani, Meteorologist 'A' attended training on WMO's Tropical Cyclone from 19-30 September, 2016 at DGM, New Delhi.

Shri R. N. Saha participated in the training on "Standardization of RMCs standard instruments/ equipments and their calibration with laboratory standard" held at Shivaji Nagar, Pune during 19-23 September, 2016.

Nowcast Training Workshop

Two Days Nowcast training Workshop, New Delhi

A two days Nowcast Training Workshop was successfully conducted by the Nowcast Division during 4-5 October, 2016 at New Delhi. The Hon'ble Director General of Meteorology, Dr. K. J. Ramesh, inaugurated the workshop and approximate 75 participants including resource persons, attended the workshop.

Shri S. H. Bhagwat, Met. - 'A' attended the Radiation Instrument training programme from 17-21 October, 2016 at M.T.I., Pune.

Shri S. B. Thampi, DDGM participated in the National Institute of Advanced Studies (NIAS-DST) Training Programme on "Policy for Science and Science for Policies" for irector/Divisional Heads held at Indian Institute of Science, Bangalore during 7-11 November, 2016.

Ms. B. Amudha, Sc. 'D' delivered a lecture on 16th November, 2016 at Met. Training Centre, IMD, Pashan, Pune on the topic "Survey on alternatives for decent and obsolete instruments - WMO IOM 117" to the trainees from RA-II and RA-V attending the WMO sponsored training on "Instruments Maintenance and Calibration" being held from 15 November to 12 December, 2016.

Ms. B. Amudha, Sc. 'D' with trainees

Training on GNSS equipment maintenance, calibration, configuration and troubleshooting, the principle of GNSS meteorology will be conducted at New Delhi in the month of December, 2016 to IMD officials posted in the remote site.

WMO Group Training course on Instruments Maintenance and Calibration

Considering the importance of maintenance and calibration of meteorological instruments for weather forecasting and climate monitoring activities in South East Asia, WMO has organized a group training course on "**Instrument Maintenance and Calibration**", at the Meteorological Training Institute of the India Meteorological Department, Pune India from 3-28 November, 2016. The training focussed participants to acquire knowledge and practical skills in the science of measurement as well as the care and calibration of meteorological instruments.

Trainees during WMO Group training

6.4. LECTURES

Dr. M. Mohapatra, Scientist 'G' delivered a lecture on "Cyclone Warning System & Communication in India" on 13th January, 2016 at 5 day national level training programme on "Communication Systems in Disaster Situations" during 11-15 January, 2016 conducted by National Institute of Disaster Management (NIDM), New Delhi.

Shri S. C. Bhan, Scientist 'F' delivered a lecture on "Weather Analysis from Observations to Forecasting" during the National Workshop on "Atmospheric Instrumentation and Meteorological Sciences: Theory & challenges" organized by Viswakarma Institute of Technology (VIT) Pune in association with IMD during 19-21 January, 2016 at VIT Campus, Pune.

Dr. S. Balachandran, Scientist 'E' delivered a lecture on "Cyclone Disaster Management" to stakeholders of state on 27th January, 2016 in a training programme on "Disaster Management for All Sectors" arranged at Anna Institute of Management, Chennai.

Dr. Jayanta Sarkar, Scientist 'E' delivered lectures on Rainfall climatology for agricultural planning & effects of temperature on crops to Departmental Met. Gr.II trainees Batch No.21, during 8-12 February, 2016 at IMD, Shivajinagar, Pune.

Dr. S. C. Sahu, Scientist 'F' delivered lectures on "Disaster need assessment, weather forecasting, warning and dissemination system

for preparedness, evacuation and other measures" and "Climate change adaptation and disaster need assessment" on 22nd February, 2016 at Gopabandhu Academy of Administration, Bhubaneswar.

Shri J. L. Gautam, Scientist 'E' delivered a lecture on "Real time Earthquake monitoring and data processing in National Centre for seismology" on 26th February, 2016 in a training programme conducted by National Hydroelectric Power Corporation (NHPC) from 25-27 February, 2016 on "Seismological consideration in hydropower design & accelerograph data processing" at NHPC Limited Corporate Office, Faridabad.

Shri G. K. Das, Scientist 'D' delivered a lecture on "Heavy to Very Heavy Rainfall/ Meteorological Flood during Monsoon Season in Eastern India in Recent Years" at a seminar on "Natural Disaster Phenomenon-Contemporary Development" held at Department of Atmospheric Sciences, University of Kolkata on 26th February, 2016.

Dr. D. Pradhan, Scientist 'G' visited Indian Statistical Institute Kolkata and Indian Institute of Technology, Kharagpur on 2nd March, 2016 and delivered lectures on Dual Polarised Radar and Doppler Weather Radar utilization. He also discussed with Director, IIT about the installation of DWR and GPS based Radio Sonde system at IIT Kharagpur.

डॉ जयंत सरकार, वैज्ञानिक 'ई' ' ने जी आई. डी. एम., गॉधी नगर में "आपदा प्रबंधन" के विषय पर दिनांक 29 मार्च, 2016 को व्याख्यान दिया।

Shri Somashekhara Bhatta, Meteorologist 'B' gave lecture on "Mathematical Application in Meteorology" at Maharani College, Bengaluru on 1st July, 2016.

Dr. Jayanta Sarkar, Scientist 'F' delivered lecture on "Agrimeteorology of Field Crops, Effect of temperature on crops, Micrometeorology, Crop yield forecasting models" to the trainees of Met. - II Training Course Batch No. 22 at Meteorological Training Institute, Pune from 13-22 July, 2016.

Shri Arun Kumar V. H., Scientist 'B', delivered lecture to the "Naval Observers" on 1st August, 2016 at Sat. Met. Division.

Dr. (Smt.) Suman Goyal, Scientist 'E' and Shri Rizwan Ahmed, Meteorologist 'A' delivered lectures to the "Pre-Antarctic training of IMD nominees for 36th (ISEA) Indian Scientific Expedition to Antarctica" on 19th August, 2016 at Sat. Met. division.

Dr. M. Mohapatra, Scientist 'G' delivered a lecture on "Role of IMD in Disaster Management" at National Telecom Institute for Policy Research, Innovation and Training (NTIPRIT), Ministry of Telecom and IT on 14th September, 2016.

Shri M. V. Guhan, Meteorologist 'A' delivered lectures in the "Farmers' Awarness Programme" held at Rice Research Station, Aduthurai on 21st September, 2016.

Dr. K. V. Balasubramanian, Meteorologist 'B' Shri RM. A. N. Ramanathan, Meteorologist 'A', Shri M. V. Guhan, Meteorologist 'A', Smt. Sumathi, Meteorologist 'A' , Dr.(Mrs) B. Geetha, Meteorologist 'A', Shri Johnson, Scientific Assistant and Shri M. Veera Kumar, SRF, RMC Chennai delivered lectures on "Disaster management and Mitigation measures" during July - September, 2016 on 8 occasions at RMC Chennai to 320 trainees comprising district administrators to disaster managers of Tamil Nadu state in a training programme organised by Anna Institute of Management, Chennai.

6.5. AWARENESS & OUTREACH PROGRAMME

Farmers' Awareness Programme: Farmers' awareness programmes were organised at 7 Agromet Field UnitsUs across the country. Besides, the Nodal Officers/Technical Officers participated in number of awareness programme and taken active initiatives in popularising the GKMS. AMFUs also arranged

field visits, field demonstration, farmers' interaction and also participated in Kisan Mela.

Outreach programs

IMD officials participated in "**Climate change**, weather forecasting and risk management in Agriculture" on 2nd May, 2016 at AMFU, Parbhani.

IMD officials participated in 44th "**Joint Agresco Meet 2016**" which is annually organized by all four Agricultural Universities of Maharashtra State and gave presentation on "Activities and Services to farmers of Maharashtra by IMD" held at Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola during 28-30 May, 2016.

IMD officials participated in the "**7th Agrovision - 2016"** from 11th November to the 14th November, 2016 conducted at Reshim Bagh Ground in Nagpur.

Visitors

41 cadets from NBC Coy Course-06 were familiarized with surface meteorological instruments on 6th January, 2016 at IMD, Pune.

"World Bank Implementation Support Mission including Country Director, World Bank" visited Odisha from 13 - 18 January 2016. In this connection, Dr. S. C. Sahu, Scientist 'F' was on tour to Doppler Weather Radar Paradip during 14 - 15 January, 2016.

14 students of M.Sc. (Geophysics) from **BHU** were on study tour to Sat. Met. Division on 18th January, 2016.

70 students and 2 Faculty members of **Parul Polytechnic Institute, Civil Engineering Department,** Vadodara visited M.C. Ahmedabad on 20 & 21 January 2016 in two batches (20+20) respectively and were shown the observatory and briefed about forecasting.

150 students B. A. Geography of Nowrosjee Wadia College, Deptt. of Geography, Pune were familiarized with "**Surface meteorological instruments**" from 27- 29 January, 2016 at IMD, Pune.

314 students from various local schools visited **Sat. Met. Division** during January - March, 2016.

40 students from **GMERS, Sola Medical College** visited **M.C. Ahmedabad** on 27th January, 2016 in two batches. They were shown the observatory and briefed about the preparedness and response with regard to Cyclone forecast.

Dr. M. Rajeevan, Secretary, MoES & Chairman ESSO, New Delhi visited Surface Instrument Workshop, Pune on 2nd February, 2016 and also inaugurated Met. Museum.

50 students from AISSMS, polytechnic college, Pune visited Surface Met.Instruments lab, IMD, Pune from 2-4 February, 2016.

60 students belonging to Computer Science & I.T. streams of Jawaharlal Nehru Institute of Technology, Pune, visited the **Surface Meteorological Instruments lab, IMD, Pune** on 17th February, 2016.

80 students from P.V.P. College of Architecture Pirangut, Pune visited Surface Meteorological Instruments Lab, IMD, Pune on 2nd March, 2016.

Dr. Harsha Vardhan, Hon'ble Minister of Science & Technology and Earth Sciences, visited IMD Pune on 1st April, 2016. Dr. N. Chattopadhyay, Scientist 'F' gave a presentation on "Agromet Advisory Services to Farmers" on the occasion.

Dr. Harsha Vardhan addressing officials at IMD Pune

Ms. Anuradha Mitra, Joint Secretary and Finance Advisor, Ministry of Earth Sciences visited RMC Kolkata, Alipore Office on 13th April, 2016 and had a meeting with the DDGM and other senior officers regarding financial aspects.

Ms. Anuradha Mitra, Joint Secretary and Finance Adivisor, MoES visited RMC Kolkata, Alipore Office

Shri A. S. Khati, Joint Secretary, MoES visited MC Thiruvananthapuram on 27th April, 2016 for inspection and to oversee activities in connection with observance of "Swachhta Pakhwada". He also held discussion with officers and staff on various office matters.

Dr. Guillermo 'Gui' Baigorria from School of Natural Resources, Department of Agronomy and Horticulture, University of Nebraska-Lincoln visited Agromet Service cell (ASC), New Delhi on 25th May, 2016. An Interactive session on Crop climate advice management tool, "Crop Climate Org." was organized between Dr. Baigorria**,** ASC officials & research fellows.

Dr. Baigorria, Agromet Service Cell officials and research fellows

Dr. L. S. Rathore, DGM and Dr. S. O. Neil Shaw, Scientist 'E' visited Shillong to attend dedication ceremony of Doppler Weather Radar Cherapunjee to the nation by Hon'ble Prime Minister of India on 27th May, 2016. The next day, they visited DWR Cherapunjee and addressed to the officers & staff of RMC Guwahati.

Dr. L. S. Rathore, DGM and Dr. S.O. Shaw, Sc. 'E' at the DWR Cherapunjee

Shri Prashant Jagtap, Mayor, Pune visited IMD Pune on 14th June, 2016 and held discussion with senior officers.

Dr. M. Rajeevan, Secretary, MoES visited RMC Chennai on 24th June, 2016 and had

Shri S. B. Thampi and Dr. S. Balachandran felicitating Dr. M. Rajeevan

interaction with officers in-charge of various units. 645 students and staff members from various universities / colleges / schools visited RMC Chennai as a part of their academic schedule during April-June, 2016. A brief presentation about the functions / various activities of IMD was given.

413 students from various local schools and 25 students from Delhi Paramedical and Management Institute, New Delhi visited **IMD, H.Q., New Delhi** during April-June, 2016.

80 students of College of Veterinary Science, Assam visited **RMC Guwahati** on 5th May, 2016.

Visit of Nepalese Delegates

Exposure visit for **Nepalese Delegates** (for two days) was organized at Agrimet Division from 11-12 July, 2016. Thirteen trainees from Nepal

Exposure visit for Nepalese Delegates

visited the Agrimet Division. Lectures were delivered, visit was organized at Central Agromet Observatory and National Informatics Centre, Pune. Participants interacted with the Scientists.

Eleven number of students from (NTTES) Institute of Technology and Science, Mirza completed four weeks practical training during their summer break at **RMC Guwahati** office on 20th July, 2016.

Dr. L. S. Rathore, DGM and Dr. S. O. Shaw, Scientist 'E' visited M.O Cherrapunjee which was recently shifted from rented house to the existing site of ISRO Radar building, during 23-24 July, 2016.

One Hundred Eighty Seven (187) students from different educational institutes/schools visited IMD HQ for familiarisations of meteorological observational & forecasting systems during July, 2016.

Thirteen (13) trainees from **School of Naval Oceanology and Meteorology (SNOM) Naval Base, Kochi** was on OJT during 31st July, 2016 to 6th August, 2016 at IMD HQ, New Delhi.

One hundred eighty one (181) students in two batches from **VIBGYOR High School, NIBM, Pune** visited Surface Lab on 2nd & 4 August, 2016.

Fifty (50) students from Angel High school and Junior college, Loni Kalbhor, Pune visited **Surface Lab** on 10th August, 2016.

Two (2) faculty members and 35 students of Central Institute of Technology, Kokrajhar visited **RMC Guwahati** on 12th August, 2016.

Fifty (50) students and 2 Faculties of J**. J. International school, Ahmedabad** visited M. C. Ahmedabad on 19 August, 2016.

Sixty (60) students (T.Y.B.E.) (Civil Engineering) from **Vishvakarma Institute of Information Technology Pune** visited Surface Lab on 19 August, 2016 and Forty (40) students (S.Y.B.E.) (Instrumentation) from AISSMS, Institute of Information Technology, Pune visited Surface Lab on 22nd August, 2016.

Three thousand two hundred (3200) students including staff members from various universities / colleges / schools visited RMC, Chennai as a part of their academic schedule during July-August 2016. A brief presentation about the functions / various activities of IMD was given.

One hundred thirty (130) students B.E. (E & TC) from **ISPM Rajashri Shahu College of Engineering , Pune** visited Surface Lab on 23 and 24 August, 2016.

Sixty (6) students (T.Y.B.E.) Civil Engg. from Vishwakarma Institute of Information Technology, Pune visited Surface Lab on 2 September, 2016 and 80 students (T.Y.B.E.) from **Pimpri Chinchwad college of Engineering, Nigdi, Pune** visited Surface Lab on 6th September, 2016.

Shri Bikram Singh, Scientist 'E' delivered a lecture to 35 students of B. Arch. with 2 faculty members of school of Architecture & Planning, Graphic Era Hill University, Dehradun who visited Met. Centre Dehradun on 6th September, 2016.

Trainees from Graphic Era Hill University, Dehradun

One hundred twenty (120) students (T.Y.B.E.) (Civil Engineering) from Dr. D. Y. Patil school of

Engineering and Technology, Pune visited Surface Lab on 8 and 9 September, 2016 and Thirty two (32) students of Prof. Waghare, Pune visited **Seismo lab** on 9 September, 2016.

A group of Experts **from Indian Institute of Public Administration (IIPA)** visited NWFC on 9th September, 2016. Shri Charan Singh, Sc. 'E' made a presentation on various activities of IMD. Dr. Naresh Kumar, Scientist 'D' explained the operational forecasting system.

One hundred thirty (130) students B. E. (E and TC) from **ISPM Rajashri Shahu college of Engineering, Pune** visited Surface Lab on 13 and 14 September, 2016.

Seventy (70) students of Prof. Kulkarni, Pune visited Seismo lab on 14 September, 2016, Sixty five (65) students from **Nowrosji Wadia College, Pune** visited Seismo lab on 19th September, 2016 and Seventy (70) students of Prof. Danole, Pune visited Seismo lab on 20th September, 2016.

One hundred fifty (150) students T.Y.B.E. (Civil) from **Rajashri Shahu College of Engineering, Pune** visited Surface Lab on 19 and 20th September, 2016.

Thirty nine (39) students from **ICCM engineering College, Aurangabad** visited Seismo lab on 21 September, 2016 and Forty (40) students B.E. (E and TC) from International Centre of Excellence in Engineering and Management Aurangabad visited Surface Lab on 21st September, 2016.

Twenty (20) students from **Womens College, Agartala** alongwith one Lecturer visited M. C. Agartala on 23rd September, 2016.

Forty nine (49) students from **JSPM Engineering College, Pune** visited Seismo lab on 28th September, 2016.

A delegation of trainees from **South Asian association for Regional Cooperation (SAARC)** member countries undertaking training at NIDM visited IMD on 28th September, 2016.

Additional Secretary, Home, Government of India visited NWFC on 28th September, 2016. Dr. M. Mohapatra, Scientist 'G' briefed him about the weather forecasting services of IMD and dissemination mechanism.

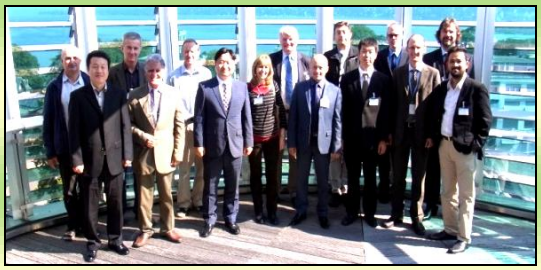
Under INDO-UK joint project on monsoon dynamics under MONSOON MISSION PROGRAMME M.C. Ahmedabad started extra RS/RW ascent on special days from 16th May to October, 2016.

Foreign Deputation of IMD Scientists

Shri Virendra Singh, Scientist 'E' attended the 13th session of WMO Consultative Meeting (CM-13)at Geneva during 28-29 January, 2016 for high level policy matter on satellite focusing on the vision of WIGOS(WMO Integrated Global Observing System) comparing space based component system in 2040, data exchange policy and architecture for climate monitoring from space.

Dr. (Mrs.) Kamaljit Ray, Scientist 'F' was on foreign deputation to Hong Kong during 25-29 July, 2016 to participate in "4th International Symposium on Nowcasting and Very Short Range Forecast 2016 (WSN 16)". She presented a paper on 'Nowcast Services in India'.

Dr. Ashim Kumar Mitra, Scientist 'D' was on foreign deputation to Geneva, Switzerland during 20-22 September, 2016 to participate in the "2nd Meeting of the Coordination Group for the Direct Broadcast Network for Real-time Relay of Low Orbit Satellite Data (DBNet)".



Dr. A. K. Mitra, Sc. 'D' during the meeting at Geneva, Switzerland

Dr. S. Balachandran, Scientist 'F' was on foreign deputation to Myanmar during 27-29

September, 2016 to participate in South Asian Climate Outlook Forum (SASCOF-9).

WMO-TECO 2016 conference at Madrid

World Meteorological Organization (WMO) organized WMO Technical Conference on Instruments and Methods of Observations (TECO-2016) during 27th September, 2016 to 30th September, 2016 at Madrid, Spain. The research work entitled "Global climate observation system upper air network (GUAN) standard - compatible network of India Meteorological Department (IMD)" authored by M. I. Ansari, Ranju Madan and D. Pradhan, was accepted by the international programme committee of TECO-2016 under the topic "Traceability, uncertainty and standardization of meteorological and environmental measurements" .

Shri M. I. Ansari, Scientist 'D' was deputed by the office to attend the conference and present the paper.

Shri M. I. Ansari, Sc. 'D' during the conference

Dr. R. K. Jenamani, Scientist 'F' was on foreign deputation to Hong Kong during 22-23 July, 2016 to participate in Meeting of the "Aviation Research and Development Projects (AvRDP) Scientific Steering Committee (SSC)".

Her Excellency Ms Melba Pria, Ambassador of Mexico in India visited IMD New Delhi on 5th August, 2106 to discuss with DGM about collaboration between Meteorological Services of both the countries.

Dr. Ananda Kumar Das, Scientist 'D' was on foreign deputation to Nay Pyi Taw, Myanmar during 6-9 September, 2016 to participate in the Workshop on 'Implementation of New Numerical Weather Prediction(NWP) and Impact Base Forecast and Warring Techniques'.

Dr. Pulak Guhathakurta, Scientist 'F' was on foreign deputation to Seychelles during 19-23 September, 2016 to participate in South West Indian Ocean Climate Outlook Forum (SWIOCOF-5).

Dr. D. S. Pai, Scientist 'F' was on foreign deputation to Bangkok during 25-26 September 2016 to attend meeting at "The Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) Office Bangkok and to Myanmar" during 27-29 September 2016 to attend South Asian Climate Outlook Forum (SASCOF-9).

6.6. IMPORTANT EVENTS 2016

IMD Foundation Day 2016

The **141st IMD Foundation Day** was celebrated on 15th January, 2016 at Mausam Bhawan Lawns, New Delhi in the august presence of Dr. Harsh Vardhan, Hon'ble Minister of Science & Technology and Earth Sciences. Dr. Rajeevan, Secretary MoES also graced the occasion with his presence. Dr. L. S. Rathore, DGM while addressing the gathering, welcomed the Hon'ble Minister and Secretary MoES to IMD's Foundation Day and showcased IMD's achievements of the previous year comprising mainly of initiatives in the field of Digital India, infrastructure development, services and steps taken in the direction of Make in India like installation of Drishti Transmissometer system at airports. Hon'ble Minister while applauding IMDs confident strides into forecasting appreciated the sincerity and dedication of the IMD personnel in working round the clock and providing excellent services to the nation in terms of better and accurate forecasts emphasizing that accurate forecasts for rain and cyclones saved life of thousands. Information provided through SMS to about 1 crore farmers and fisherman reflects in a direct increase of the

Dr. Harsh Vardhan Inaugurating the function and Release of books on celebration of 141st IMD Foundation Day 2016

GDP. He suggested working in Arctic and Antarctica, inside sea for new searches and also setting our goal in the field of climate change.

National Science Day

The National Science Day was celebrated in IMD office premises, Shivajinagar, Pune on 27th February, 2016. All the offices in IMD, Pune participated in the celebration. On this occasion an exhibition was arranged in the main building of IMD Pune. ADGM(R) inaugurated the exhibition. It was attended by a large number of students, scientists, scholars, journalist and general public. All visitors marked their comments with great enthusiasm in feedback register.

World Meteorological Day

World Meteorological Day was celebrated on 23rd March, 2016 at DGM's Office New Delhi and other offices of the department. The theme chosen for this year was "Hotter, Drier, Wetter, Face the Future". An open house and meteorological exhibits were organized at RMC Chennai, AMO Chennai and DWR Chennai for students, teachers and public. About 500 students from different schools and colleges of city along with general public visited the office. They were explained of the various activities of Regional Meteorological Centre, Chennai.

A scientific meeting on the occasion of the **WMO Day** was arranged at RMC Chennai in which Guest of Honor was Prof. S. Kanmani, Director, Centre for Environmental Studies, Dept. of Civil Eng., Anna University, Chennai and the Chief Guest was Prof. A. Ramachandran, Former Director, Centre for Climate Change and Adaptation Research, Anna University, Chennai. This function was attended by various scientific organizations, students from Univ. of Madras, Anna University and colleges, IMS Chennai Chapter members and retired IMD officers.

IMD officials during WMO day

An open house and meteorological exhibits were organized on WMO Day at MC Bangalore. About 400 visitors visited the Observatory and they were explained the function of Automatic Weather Station, Surface Observatory, WRF-HPC model, Surface and Upper Air instruments, variation of temperature and rainfall and weather forecasting techniques etc.

Scientific talks on "**Satellite based Agro Meteorology**" by Dr. P. P. Nageswara Rao, Professor, Karnataka State Remote Sensing Applications Centre, Bengaluru and on "Climate Change" by Dr. Ramakrishna

Danmle, Professor Department of Physics, Bangalore University were also arranged.


IMD open day: Visitors ask, when will city get rain

How the clouds decide a farmer's fate

Newspaper cuttings of WMO Day celebration

CDR Karaikal celebrated WMO Day with about 700 visitors including 10 media, students and public visiting the office.

WMO Day was celebrated with much enthusiasm at CSO, Shillong office Campus in collaboration with State Council of Science, Technology & Environment (SCSTE), Govt. of Meghalaya. Dr. S. Choudhury, Director, Science & Technology, Admin. Incharge, North Eastern Council, Development of North Eastern Region, Shillong was the Chief Guest and Prof. Manmohan Singh, Dean of Education, North Eastern Hill University, Shillong & Mr. A.S. Suting, Officer on Special Duty, SCSTE, Meghalaya and other officers were also present apart from teachers & 240 students from 8 Schools.

WMO Day celebrations at CSO Shillong

मौसम कार्यालय अहमदाबाद में विश्व मौसम विज्ञान दिवस मनाया गया था । उसके उपलक्ष्य में कार्यालय प्रांगण में मौसम की जानकारी देने वाले उपकरणों की एक प्रदर्शनी का आयोजन किया गया।

मौ. का . अहमदाबाद में विश्व मौसम विज्ञान दिवस

AMS Coimbatore celebrated **WMO Day** by inviting Shri G. Prakash Reddy, Airport Director, Shri V. Pradeep Kumar, Joint General Manager (Air Traffic Control) and Shri Joven Varghese, Assistant Manager (Security) of Coimbatore international Airport and had discussion on global warming and climate change. The officer-in-charge of AMS Coimbatore, Shri A. Raja, A.M. - I briefed about the theme for this year's World Meteorological Day and the need to strengthen climate change adaptation in addition to mitigation.

WMO Day was celebrated at RMC Office Alipore, Kolkata with much enthusiasm and zeal. Posters and banners depicting the event, the theme of WMO Day 2016, operation of various meteorological instruments and technical activities of RMC Kolkata were displayed at vantage points in the office compound. Slide shows and documentary films on activities of IMD and on subjects like meteorology, seismology, radar, astronomy etc. were presented in the form of power-point projections on screen at Seminar Hall. A class-room type lecture was also arranged simultaneously at Conference Room for the enthusiastic pupils of different institutions who visited the Centre on that day. An

Students visiting RMC Kolkata on WMO Day

exhibition was arranged at the foyer of the main building. Necessary briefing of exhibits was constantly given to the visitors during the exhibition. Significance of this year's WMO Day Motto: "Hotter, Drier, Wetter - Face the Future" was also explained to the visitors.

मौसम केंद्र रायपुर में विश्व मौसम दिवस 2016 का आयोजन डॉ. एम. राजवेल, वैज्ञानिक 'डी' के निर्देशन में किया गया| इसके तहत बुधवार दिनॉक 23 मार्च, 2016 को मौसम संबंधी उपकरणों तथा पूर्वानुमानों की जानकारी हेतु मौसम केंद्र, रायपुर का कार्यालय प्रात: 11 बजे से सायं 4 बजे तक आम जनता के लिए खुला रहा।

INTERNATIONAL WOMEN'S DAY

International Women's Day was celebrated at 'Vrishti' hall in Mausam Bhawan Complex, New Delhi on 8th March, 2016. This is the first time the day was observed by the IMD New Delhi Office. Dr. Kamaljit Ray, Scientist 'F' and Chairperson, ICC welcomed the Guest of Honor, Prof.Tripurari Sharma, Director Acting, National School of Drama and other senior officials of IMD. Dr. L.S. Rathore, DGM, addressed the gathering and emphasized on the importance of beginning the awareness on gender parity at home. Prof. Tripurari Sharma, Director, Acting, National School of Drama was the Guest of Honour at the event. A playwright

Dr. L. S. Rathore welcoming the guest

of repute, she was the Indian representative at the First International Women Playwrights Conference held in USA in 1986. In 2013 she was conferred with the Sangeet Natak Akademi Award for her contribution to the field of Theatre Direction. Prof. Tripurari Sharma engaged the audience with her talk with the wisdom which can be acquired only through vast experience. Dr. Surinder Kaur, Scientist 'F', the senior most woman officer of IMD shared some of her experiences on working in IMD. Shri A.K. Sharma, Scientist 'G' was the Chief Guest of the function and delivered talk on this years' theme "Planet 50-50 by 2030: Step It Up for Gender Equality". Shri S.B. Tyagi, Scientist 'E' gave a brief presentation on awareness of harassment at work place. Formal vote of thanks on behalf of the organizers was proposed by Smt. Ranju Madan, Scientist 'F'. The response from the officials of IMD New Delhi office was encouraging as was evident from the participation.

Earth Day and Swachhta Pakhwada Celebration

In order to create awareness amongst school children about caring the Mother Earth, an Inter-school Speech and Slogan Making competition on the theme "**Caring Mother Earth**" was organised on Earth Day, *i.e.*, 22nd April, 2016 as part of celebration of "Swachhta Pakhwada".

In all 78 students from 20 schools of Delhi and NCR registered their names for the competition. Participation certificates, gifts and refreshments were given to all the contestants. Dr. K. J. Ramesh, Advisor MoES was the Chief Guest and the panel of judges comprised of Dr. D. Pradhan, Scientist 'G', Gr. Captain Ravinder Vishen, Scientist 'E' and Dr. Kamaljit Ray, Scientist 'F'. The entire programme was organised under the chairmanship of Dr. S.I. Laskar, Scientist 'D' and took place at the "Vrishti Hall" Mausam Bhawan. The prize distribution ceremony was held on 26th April, 2016. Dr. L. S. Rathore, DGM gave away the prizes. He congratulated the winners and lauded the efforts of all the participants.

Slogan Making Competition

Prize Distribution Ceremony

The "Earth Day 2016" was also celebrated at **RMC Kolkata Office**, MCs and various outstations on 22nd April, 2016. An essay contest on this year's topic "Caring Mother Earth" was also held at Alipore office. Shri Debdip Chakraborty, AM-II delivered a presentation on his Antarctica Expedition.

"**Swachhta Pakhwada**" was observed during 22 - 29 April 2016 at **Central Seismological Observatory Shillong** and "Earth Day" was celebrated on 22nd April, 2016. The office premises were cleaned by the officers and staff. Some students and teachers from a local school were invited and were explained the basic concepts of Seismology, Meteorology, Radiation and their relation with Mother earth. An essay competition on "**Caring Mother Earth**" was also held on the occasion of "Earth Day".

Swachhta Pakhwada

Swachhta Pakhwada at RMC Guwahati

"**Swachhta Pakhwada**" was observed in all the offices of **RMC Guwahati** during 14-29 April, 2016 and "EARTH DAY' was celebrated on 22nd April, 2016 at RMC Guwahati office.

Anti-Terrorism Day

"**Anti-Terrorism Day**" was observed on 20th May, 2016 at various offices of IMD and the pledge was administered to officers/staff members.

Anti-Terrorism Day being observed at MC Bengaluru

Yoga Day Celebrations

Regional Meteorological Centre, Kolkata celebrated "**International Day of Yoga 2016**" in collaboration with Isha Foundation at Alipore Office. The representative members of Isha Foundation, Ms. Mahek Mahalani and Ms. Sangeeta Agarwal started practice session with

Yoga Day Celebrations - 21st June, 2016

audio visual demonstration. Around seventy enthusiastic participants were following the instructions on screen with great attention and practicing the Yoga as well with serious note. The practice lasted for almost one hour for the seven steps of Upa-Yoga. The steps were 1) Yoga for health 2) Yoga for success 3) Yoga for well-being 4) Yoga for peace 5) Yoga for joy 6) Yoga for inner exploration 7) Yoga for love.

'International Day of Yoga' celebrated at RMC Kolkata

International Day of Yoga was celebrated at Meteorological Centre Ranchi with a Yoga Session led by Shri Radheshyam Sharma, Scientist 'B'. All officers & staff members practiced different Yoga Asanas / pranayama. After the yoga Session, Shri Sharma briefed the officers and staff members about benefits of Yoga in the daily life.

Yoga Day was celebrated with great enthusiasm at **Bharati Station, Antarctica**. The station leader Shri V. Ragavendra, Scientist 'E', National Remote Sensing Centre, conducted the program with all members of Indian Scientific Expedition to Antarctica (ISEA). Shri T. R. Pakki and Shri Sharad B. Gurusale, IMD team members participated in the celebrations along with rest of the members.

Yoga Day Celebrations at Bharati, Antarctica

The Yoga training was conducted by Shri Mohit Nirwan, JRF, Defence Research and Development Organisation who is a member of 35th ISEA, under the project "Effect of Yogic practices in Antarctica". As a part of this project he conducts Yoga classes for all members every morning.

Meditation as Medicine

A lecture on "**Meditation as Medicine**" was organized by Prajapita Brahma Kumaris Ishwariya Vishwa Vidyalaya at HQ on the occasion of International Yoga Day. The programme included a brief talk on the subject, guided meditation and audience interaction.

BK Piyush and BK Girija during a discourse on "Meditation as Medicine"

हिन्दी पखवाड़ा, 2016

भारत मौसम विज्ञान विभाग में हिन्दी पखवाड़ा का आयोजन 1 सितम्बर से 15 सितम्बर, 2016 तक किया गया। समारोह की अध्यक्षता महानिदेशक महोदय डॉ. के. जे. रमेश ने की। इस समारोह के मुख्य अतिथि देश के प्रसिद्ध कवि श्री लक्ष्मी शंकर वाजपेयी जी थे। समारोह का शुभारंभ महानिदेशक महोदय डॉ. के. जे. रमेश, डॉ. एम. मोहापात्रा, वैज्ञानिक 'जी', डॉ. एस. के. पेशिन, वैज्ञानिक 'जी', डॉ. एस. के. कुन्डु, वैज्ञानिक 'जी' तथा मुख्य अतिथि प्रसिद्ध कवि श्री लक्ष्मी शंकर वाजपेयी जी ने संयुक्त रूप से दीप प्रज्जवलित करके किया। इस अवसर पर माननीय गृह मंत्री श्री राजनाथ सिंह द्वारा भेजे गए संदेश को सुश्री रेवा शर्मा, वरिष्ठ हिन्दी अधिकारी ने समारोह में पढ़कर सुनाया। हिन्दी पत्रिका मौसम मंजूषा के 23वें अंक का विमोचन भी महानिदेशक महोदय द्वारा पर किया गया तथा हिन्दी में सर्वाधिक पत्राचार करने के लिए राजभाषा चलशील्ड श्री आर. सुरेश, वैज्ञानिक 'एफ', सी. ए. एम. डी. को प्रदान की गई। समारोह में पखवाड़ा के दौरान आयोजित हुई हिन्दी प्रतियोगिताओं के विजेताओं को नकद पुरस्कार और प्रमाण पत्र महानिदेशक महोदय ने प्रदान किए। समारोह में कार्मिकों एवं बच्चों द्वारा सांस्कृतिक एवं अन्य कार्यक्रम प्रस्तुत किए गए।

श्री गौरव दहिया महानिदेशक महोदय द्वारा हिन्दी टंकण में प्रथम पुरस्कार प्राप्त करते हुए

मौसम केन्द्र, अहमदाबाद में हिन्दी पखवाड़ा का आयोजन

मौसम केन्द्र, अहमदाबाद में हिन्दी पखवाड़ा का आयोजन 5 सितम्बर से 15 सितम्बर, 2916 को किया गया। इस अवसर

आर. एम. सी., चेन्नै में हिंदी पखवाड़ा का आयोजन

पर राजभाषा हिंदी के प्रयोग में वृद्धि हेतु विभिन्न प्रतियोगिताओं का आयोजन किया गया तथा 14 सितंबर, 2016 को हिन्दी दिवस मनाया गया।

क्षेत्रीय मौसम विज्ञान केंद्र, चेन्नै में हिन्दी पखवाड़ा 15 सितंबर से 29 सितंबर, 2016 तक मनाया गया। इस अवसर पर बेंगलूर, हैदराबाद, तिरुवनंतपुरम, चक्रवात डिटेक्शन क्षेत्र के राडार कार्यालयों में कार्मिकों के लिए विभिन्न प्रतियोगिताएँ आयोजित की गई। हिन्दी दिवस का समापन समारोह 29 सितंबर, 2016 को आर. एम. सी., चेन्नै में आयोजित किया गया। श्री एस. बी. थम्पी, वैज्ञानिक 'एफ' ने समारोह की अध्यक्षता की। श्री के. मुथु कुमार, अतिरिक्त महानिदेशक, पत्र सूचना कार्यालय, सूचना एवं प्रसारण मंत्रालय, चेन्नै इस समारोह के मुख्य अतिथि थे। श्रीमती चंद्र रंगन, हिन्दी सह-अधिकारी ने सरकारी कामकाज में हिन्दी की प्रगति पर वार्षिक रिपोर्ट पेश की। इस अवसर पर हिंदी भाषण, हिंदी गीत आदि प्रतियोगिताओं का आयोजन किया गया। स्टाफ के सदस्यों के साथ स्कूली बच्चों ने भी हिंदी गीत प्रतियोगिता में भाग लिया। प्रतियोगिता में विजेताओं को पुरस्कार वितरित किए गए।

मौसम केंद्र, गुवाहाटी में हिंदी पखवाड़ा का आयोजन

मौसम केंद्र, गुवाहाटी में हिंदी पखवाड़ा का आयोजन 1 सितंबर से 14 सितंबर, 2016 तक किया गया।

SOLAR ECLIPSE, 2016

A total **solar eclipse** occurred on 9th March, 2016 which was visible as partial solar eclipse from India at the time of sunrise. An

Solar eclipse on 9th March, 2016

observation of the event was made from the rooftop of Positional Astronomy Centre (PAC), Kolkata building by setting up 11" and 6" telescopes. Reporting of the event was made to local print and electronic media and local electronic media ETV news made live telecast of the event from PAC office.

Positional Astronomy Centre, Kolkata had made an observational programme on Transit of Mercury over the disc of the Sun on 9th May, 2016 afternoon in the PAC Office building. A large number of public gathered on the occasion to see the event by projection method through telescope.

Observation on Transit of Mercury over the disc of the Sun

Felicitation to DGM for efficient Meteorological Services at IGI Airport

Delhi's Indira Gandhi International Airport (IGIA) has bagged the first position in the world for the second consecutive year in 25-40 Million Passengers Per Annum category. The

Hon'ble Ministers and IMD officers at IGI Airport

rankings were announced by the Airports Council International for the "2015 Airport Service Quality Awards" in February, 2016. It is also named as the second best airport for Asia Pacific region in all categories and services. As a follow up action to share this world recognition and credibility with all major stake holders including staffs and officers of local Met Watch Offices who have been working tirelessly with best of their capacity, a grand felicitation program was organized on 7th June, 2016 at New Delhi by Delhi International Airport Limited - the joint venture consortium of GMR Group, Airport Authority of India and Frankfort Airport. Respected Union Ministers Shri Arun Jaitley, Shri M. Venkaiah Naidu, Dr. Mahesh Sharma, Shri Ashok Gajapathi Raju, Shri Kiren Rijiju and GMR founder chairman Shri Grandhi Malikarjuna Rao graced the occasion with their presence. Dr. L. S. Rathore, DGM, Dr. R. K. Jenamani, Scientist 'F' and Mr. Narendra Nigam, Scientist 'E' represented IMD in this felicitation function. On behalf of IMD, Dr. L. S. Rathore, DGM was felicitated by Shri Arun Jaitley, Union Minister of Finance and Corporate Affairs for providing needful Meteorological Infrastructure and for efficient Aviation Meteorological Services at IGI airport.

Dr. Harsh Vardhan, Hon'ble Union Minister, MoES visited IMD Pune on 1st April, 2016 and addressed the officers and staff members. A presentation on "Agromet Advisory Services to Farmers" was made.

IMD organised First Meeting of **Steering Committee of South Asia Flash Flood Guidance System of WMO** during 26-28 April, 2016 at New Delhi.

Hon'ble Union Minister of Science & Technology and Earth Sciences Dr. Harsh Vardhan presided over a video conference on 24th May, 2016 on achievement of two-years by Ministry of Science &Technology and MoES. IMD Scientists at 12 stations in India participated in the video conference at local Press Information Bureau (PIB) offices and arranged local hospitality.

Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences and Dr. M. Mohapatra, Scientist 'G' participated in the Interactive Session of Heads of various Departments with Assistant Secretaries of Central Government in different Ministries at New Delhi on 12th August, 2016.

Media Interaction

Cyclone warnings were disseminated for the first time through social networking site like Face book and twitter during cyclone Roanu (17-22 May, 2016).

Dr. A. C. Lyngdoh, Scientist 'D' attended discussion panel on Earthquake Disaster Management at Doordarshan Kendra Shillong on 12th January, 2016.

Dr. Geeta Agnihotri, Scientist 'E' attended Mass Media Meeting at Doordarshan on 19th February, 2016 and on 9th March, 2016.

A talk in Tamil by Shri S. B.Thampi, Scientist 'F'on the theme of World Meteorological Day-2016 "Hotter, Drier, Wetter, Face the Future" was broadcasted in AIR Chennai 'A' Channel on 23rd March, 2016.

An interactive session on **WMO Day-2016** theme comprising **Dr. S. R. Ramanan**, Scientist 'F', Smt. S. Stella, Scientist 'D', Shri N. Meenatchi Nathan, Scientist 'D' and Shri A. Prasad, AM Gr.II was telecasted in two parts on 23rd March, 2016 and on 30th March, 2016.

Dr. Geeta Agnihotri, Scientist 'E' briefed DD, E.TV Kannada, Raj TV, TV 9, AIR and Times of India on theme of World Meteorological Day.

Dr. G.C. Debnath, Scientist 'F' RMC Kolkata participated in a talk on WMO Day 2016 at Akash Bani Bhavan, All India Radio.

A talk in Tamil on "**Types of clouds**" by Shri S. B. Thampi, Scientist 'F' was broadcasted in AIR Chennai 'A' Channel on 30th March, 2016.

Shri S. B. Thampi, Scientist 'F' participated in a chat show on "Summer 2016" at Doordarshan on 8th April, 2016.

Dr. G. C. Debnath, Scientist 'F' participated in a programme on current heat wave situation over West Bengal at Akashvani Bhawan, All India Radio on 16th April, 2016.

Dr. S. C. Sahu, Scientist 'F' participated in a talk on "Grisma Raudra Prabaha and Panipag Bibhag" at Doordarshan on 20th April, 2016.

Dr. S. Sen, Scientist 'E' participated in a live discussion on a television channel on 8th May, 2016 regarding the Transit of Mercury over the disc of the Sun.

Shri S. S. Mairal, AM-II participated in a discussion on monsoon and kharif crops in the programme "Amchi Mati Amchi Manasa" conducted by Doordarshan, DD Sahyadri on 20th June, 2016. He also delivered a talk on "Long Range Forecast and Kharif Planning for Pune region" on All India Radio on the same day.

Dr. G. C. Debnath, Scientist 'F' attended a talk show at Doordarshan kendra Kolkata on 2nd August, 2016 conducted by Disaster Management named "**Durjog Mokabila**".

Shri B. P. Yadav, Scientist 'F', participated in a one hour Panel discussion for DD Kishan "VaadSamvaad" on "Improvements in weather & monsoon forecasting and its applications in agriculture sector" on 5th August, 2016.

Dr. S. C. Sahu, Director-in-Charge, M.C. Bhubaneswar participated in live broadcast on Bajrapat Biparjyay (Lightning Hazard) in Doordarshan, Bhubaneswar on 6 August 2016.

Dr. Jayanta Sarkar, Scientist 'F' attended a discussion on 'Science Serial on understanding and managing disaster' held at All India Radio, Ahmedabad on 11th August, 2016.

Dr. Geeta Agnihotri, Scientist 'E', attended Mass Media Meeting at Doordarshan Kendra on 5th September, 2016.

Shri G. K. Das, Scientist 'D', participated as expert for the talk show " Durjog Mokabila on Flood" a live TV programme on DD Bangla held on 13th September, 2016.

Dr. K. V. Balasubramanian, A. M. Gr. I gave five talks on "different aspects of Science and Technology and on Hiroshima Day" and broadcasted in Tamil in AIR Chennai for duration of 5 minutes during 1-8 August, 2016.

CHAPTER 7

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 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. For the year 2015 it has an IMPACT FACTOR (IF): 0.306 and 5-year Impact factor 0.238 calculated by Thomson Reuter U.S.A. The rating score given by National Academy of Agricultural Sciences (NAAS) for the year 2015 is 6.18. IMD Scientists published 71 research paper/books in Mausam/Met. Monograph/Met Reports and National & International Journal during 2016.

7.1. RESEARCH CONTRIBUTIONS PUBLISHED IN 'MAUSAM'

M. S. Swaminathan and R. Rengalakshmi "**Impact of extreme weather events in Indian agriculture : Enhancing the coping capacity of farm families**", *Mausam*, **67**, 1, 1-4.

V. U. M. Rao and B. Bapuji Rao,"**Coping strategies for extreme weather in dryland agriculture**", Mausam, **67**, 1, 5-14.

B. Gangwar, N. Subash and N. Ravisankar, "**Farming system approach to meet the challenges from extreme weather**", Mausam, **67**, 1, 15-26.

L. S. Rathore, D. R. Pattanaik and S. C. Bhan , "**Weather extremes : A spatio-temporal perspectives**", Mausam, **67**, 1, 27-52.

M. V. S. Ramarao, J. Sanjay and R. Krishnan, "**Modulation of summer monsoon sub-seasonal surface air temperature over India by soil moisture-temperature coupling**", Mausam, **67**, 1, 53-66.

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7.4. OTHER PUBLICATIONS

New monthly rainfall series for districts, states, sub-divisions, homogeneous regions and country as whole has been approved by DGM and will be operational as IMD's official rainfall series from 1st January, 2017.

The following publications have been published by ARDE, Pune carried out jointly in collaboration mode by ARDE, Pune, School of Artillery - Nasik and IMD Pune.

(i) A "**Rough and Ready Pamphlet**" Method for Deducing "Meteors" for Artillery (Surface Target) Fire METB3.

(ii) A "**Rough and Ready Pamphlet**" Method for Deducing "Meteors" for Artillery (Surface Target) Fire METCM.

CHAPTER 8

FINANCIAL RESOURCES AND MANAGEMENT PROCESS

8.1. FINANCIAL RESOURCES AND MANAGEMENT

Budget Estimates

Budget provisions for the department during the financial year 2016-17 were as follows:

Budget Estimates (Plan)
B.E. (Revenue) Rs. 126.60 Crores
B.E. (Capital) Rs. 115.00 Crores

8.2. PLAN SCHEMES

To upgrade the forecasting capabilities, various plan schemes being implemented during XII Five Year Plan as follows:

1. The scheme **"Atmospheric Observations Systems Network"** being implemented at total estimated cost of Rs. 700 Crore. The scheme encompasses various activities in an integrated manner to ensure the sustenance & augmentation of observations & enhancement of facilities required for the weather forecasting services during 12th Five Year Plan. Major achievements/outcomes of the scheme during 12th FY plan are as follows:

- Augmentation of Doppler Weather Radar Network increased from 14 in 2012 to 24 in 2016. Four more are in advanced stage of commissioning. Portable X-band DWR was installed and commissioned at Srinagar. Comprehensive AMC of DWRs was awarded.

- The GPS based Radiosonde network expanded from 10 in 2012 to 43 stations with 6 stations meeting WMO GCOS Network (GUAN) standard.

- Surface observational network was augmented by increasing the number of AWSs from 550 to 675 (including 127 Agro AWS) and ARGs from 750 to 1330 ARGs into the network leading to availability of meteorological observations over all districts of the country. High accuracy GNSS receivers were procured to validate the mean station level pressure of observatories. 158 Digital Station Barometers were installed to upgrade the surface observatories and 42 more are under installations. High Wind Speed Recorder network expanded to 20 stations for better monitoring of high wind speeds associated with tropical cyclones. Radiation network augmented with 45 UV-B Radiometers, 10 Solar Trackers, 20 Pyranometers, and 4 Electronic Sunshine Recorders. AWS observatories established at Pahalgam, Chandanwadi and Baltal to provide current weather services for Shri AmarnathjiYatra.

- Environmental Monitoring Network was augmented with modern systems such as: Network of Multi-wavelength Nephelometer (12 Stations), Black Carbon Monitoring Network (16 Stations), Athelometer, sky radiometer network (12), UV-VIS Spectrophotometer (1 Nos.), Semi-microbalance (1 No.). High Volume Air Samplers (12 Nos.) and Ion Chromatograph (1No.) also to be inducted soon into the network. GPS based ozonesonde system, HWSR & Surface Meteorological Observatory has been established at Bharati, Antarctica.

- Automatic Message Switching Systems (AMSS) commissioned at Nagpur and Guwahati to enable data availability at enhanced speed for the dissemination of Meteorological Observations, Satellite data, Radar Data and other Numerical Weather

Prediction (NWP) products to all IMD Centers, National Meteorological Centers (NMCs) of the Region and NMCs/Regional Telecom Hub (RTHs). Global Information System Centre (GISC) was installed at Pune under WMO WIS (WMO Information System) programme and due to that; IMD status has risen from Regional to International level Global data dissemination centre. Use of FM and community radio was started for dissemination of warnings to increase the reach out. SMS alerts of weather warnings dissemination started through Department of Electronics and Information Technology (DietY) to enhance the service on large scale under the Prime Ministers "Digital India" programme.

- Warning Decision Support System (WDSS) were installed at Radar stations to improve the Operational Nowcast and very short range forecast system. Android based apps are being developed and released for dissemination of weather forecast and warning products over mobile phone and tabs.

- Digitization of Autographic Charts was done.

- GIS based Customized Rainfall Information System introduced to provide real-time rainfall information. Quantitative precipitation forecast (QPF) to CWC for flood forecast purposes increased to 146 river sub-basin

- A new website has been designed and launched in the year 2014 and soft copy versions of all language editions of Rashtriya Panchang of 2016-17 AD have uploaded on website for free downloading by the users.

2. The scheme **"Satellite meteorology"** was approved for implementation by the SATMET Division at HQ at total estimated cost of Rs. 70 Crore. The scheme encompasses various activities in an integrated manner to provide the vital satellite images and data required for weather forecasting & warnings. Major achievements/outcomes of the scheme during 12th FY plan are as follows:

- INSAT-3D, Kalpana-1 and INSAT-3A satellite data products generated routinely and disseminated through website in real time with increased resolution.

- Satellite Bulletins describing satellite images and products also being prepared and disseminated 3-hourly in normal weather and hourly in severe weather.

- A web based satellite products analysis tool called "RAPID" hosted on webpage.

- A nowcasting tool for satellite images developed and hosted on satellite webpage as well as RAPID.

- Cal/Val campaign for establishing a Calibration site for INSAT-3D and subsequent satellite carried out at Bhuj, Gujarat.

- GNSS data processing center started with 5 stations, now 23 more stations were added (2 more in pipeline).

- INSAT-3D derived Winds and radiances are being assimilated in NCMRWF as well as in IMD NWP models

3. The scheme "Gramin Krishi Mausam Sewa" being implemented at total estimated cost of Rs.165.25 Crore. The scheme encompasses various activities in an integrated manner to provide weather information based advisories before various stages of farming. Currently, 19.4 million farmers are using this information through mobiles. Major achievements/outcomes of the scheme during 12th FY plan are as follows:

- District level Agromet Advisories increased from 539 districts in 2012 to all 636 districts through Agro-Met Field Units.

- Mission Outreach - Registration of farmers in the country is taken up aggressively to enhance dissemination of Agromet Advisories

through SMS. Agromet advisories dissemination increased from 3.94 million to 19.4 million farmers in the country.

- Farmer Awareness Programmes have been organised by all the AMFUs across the country to customize the services on continuous basis.

- Agromet products using remote sensing and GIS are generated and incorporated for better Agromet Advisories.

- Attempts are made for weekly NDVI maps, sowing suitability of crops, Surface soil moisture, Soil moisture index.

4. The scheme "**Augmentation of Aviation Meteorological Services**" being implemented at a total estimated cost of Rs. 115 Crore. The scheme encompasses various activities in an integrated manner for upgradation of Airport Meteorological Instruments (AMIs) at runway locations for the major airports by commissioning of Airport Weather Observing System, Transmissometers and Aviation Weather Decision Support Systems etc. to provide crucial service to the national and international civil aviation sector so as to fulfil the requirements prescribed by the International Civil Aviation Organization (ICAO) and the Director General of Civil Aviation of India (DGCA) from time to time. These services were provided through 18 Aerodrome Meteorological Offices (AMO) and 54 Aeronautical Meteorological Stations (AMS) located at national and international airports across the country. Major achievements/ outcomes of the scheme during 12th FY plan are as follows:

- NAL Bangalore in association with IMD has developed the indigenous Drishti Transmissometer Systems, 20 systems have been successfully installed.

- NAL Bangalore in association with IMD developed an indigenous AWOS, and two such systems installed.

- Automatic Weather Observation Systems were successfully introduced at two heliports for helicopter operations.

- IMD made Airport Met Instruments (7) and Wind Instrument (15) installed.

- AMDAR Implemented at Mumbai FIR as ATS component.

- Central Aviation Met Division of IMD was awarded ISO 9001: 2008 on 28th February 2016. With this all the four MWO and CAMD are now ISO certified organizations.

- Trail landing at Kannur International Airport was successfully accomplished; IMD provided the necessary meteorological support during the operation.

5. The scheme "**Climate Services**" being implemented at total estimated cost of Rs. 55.40 Crore. The scheme encompasses various activities in an integrated manner to create facilities for providing Climate Services through the establishment of a Regional Climate Centre (RCC)-South to cater to the need of a comprehensive set of specialized climate services for the country and for South Asia region. Major achievements/outcomes of the scheme during 12th FY plan are as follows:

- Re-organization of the office of Research IMD Pune (Integration of all sections) Research office -LRF, NDC, NCC, R&D division, Marine section, Hydrology, DRU and RCPS as the Climate Services Division.

- Data rescue and archival of complete met records in digitized form.

- Seasonal Climate Outlook Forums for South Asia and monthly ENSO & IOD Forecasts has been introduced.

- Seasonal Outlook for Temperatures for the Hot Weather Season (April-June) was introduced in 2016. Cold weather Season Outlook will also be issued during Nov., 2016.

- Gridded daily rainfall data sets of various spatial resolutions and Experimental Monthly and seasonal global forecasts for temperature and rainfall.

- Moisture stress monitoring system using Aridity Anomaly Index and Standardized Precipitation Index (SPI) for the districts of India in monthly and weekly scales.

- Impact of deficient rainfall is assessed by forecasting SPI using IMD GFS weekly district rainfall forecast and artificial neural network technique developed and District SPI forecast maps generated in every week during SW monsoon.

- Evaluated extended, monthly and seasonal forecasts/hindcasts generated by the Coupled Forecast System (CFS) so as to utilize the products for seasonal monsoon prediction from 2017.

6. The scheme **"Integrated Himalayan Meteorology Programme for Western & Central Himalayas"** being implemented at total estimated cost of Rs. 117.7 crores covering four states namely Jammu & Kashmir, Himachal Pradesh, Uttarakhand, and Sub Himalayan West Bengal. The scheme encompasses various activities in an integrated manner to improve mountain weather and climate monitoring and forecast services over the Himalayan region covering four states namely Jammu & Kashmir, Himachal Pradesh, Uttarakhand, and Sub Himalayan West Bengal through commissioning of state of art systems like Doppler Weather Radar, Snow Gauges, and augmentation of Automatic Weather Stations, Automatic Rain Gauges etc. Major achievements/outcomes of the scheme during 12th FY plan are as follows:

- RFP documents for commissioning of DWR, GPS based radiosonde, and AWS/ARG/SG etc. are completed.

- Land for DWR at Mussoorie has been identified and MoU is finalized.

7. The Scheme **"Training in Operational Meteorology"** being implemented at total estimated cost of Rs. 55.81 Crore. The scheme encompasses various activities in an integrated manner to upgrade the training infrastructure and facilities to conduct training courses for new entrants, career progression courses, job oriented short term courses in specialized topics and training programme for all S&T operational personnel of MoES and for other Government organizations. Major achievements/outcomes of the scheme during 12th FY plan are as follows:

- Common International Hostel/ Guesthouse is made functional in collaboration with IITM at Pashan Pune.

- One year Ab-initio Met Gr-II training to newly recruited Trainee Meteorologist Grade-II completed.

- Advanced Meteorological Training courses of officers from Indian Navy, Indian Coast Guard and foreign concluded.

- Six months Advanced Training in General Meteorology and Instruments, Communication & Information systems disciplines re-structured into 2 months e-learning program and 4 months class room contact training program.

- Intermediate training program for scientific assistants of IMD.

- Short term tailor made international training programs conducted.

Plan Scheme Monitoring

Plan Scheme Procurement Monitoring package is being run successfully for online monitoring of the schemes and various stages of procurements under approved plan schemes.

All the Project Directors/ Associated Project Directors of the schemes enter the procurement details and keep updated their status on the METNET till the final payment is made.

Continuation of the Schemes beyond 12th Five Year Plan

An independent Review Committee was constituted by the Ministry of Earth Sciences to review the Plan schemes being implemented in IMD under 12th Five Year Plan for continuing these schemes after 12th FYP during 2017-20 & beyond. The Committee discussed the status of implementation of the schemes with respect to objectives & deliverables, shortfalls and manpower provision. Major achievements/outcomes of these schemes were also evaluated.

The committee found the performances of all the schemes, viz: (i) Atmospheric Observation System Network (ii) Satellite Meteorology (iii) Gramin Krishi Mausam Sewa (iv) Augmentation of Aviation Meteorological Services (v) Climate Services (vi) Integrated Himalayan Meteorology Programme for Western & Central Himalayas and (vii) Training in Operational Meteorology under ACROSS and REACHOUT programs of MoES to be satisfactory during XII FY Plan. Considering the fact that some of these schemes could not be completed in all aspects, these schemes were needed to be carried forward during 2017-20 & beyond. Even completed projects with respect to operation & maintenance need to be continued for the sustenance of observational network & infrastructure. Therefore, the committee strongly recommended the continuation of all the schemes during 2017-20 & beyond for improved functional efficiency of weather, climate and related hazard detection, monitoring and warning services. The recommendations of the Committee have been approved by the Secretary, MoES.

Citizen's/Client's Charter

Citizen's/Client's Charter in English language has already been 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. In order to promote Hindi Language, Citizen's/Client's Charter has been printed in Hindi and displayed (duly framed) along with English version.

8.3. REVENUE GENERATED DURING THE YEAR 2016

(i). Sale of Meteorological Data

RCs/MCs	Total revenue received by sale of meteorological data during the month (Amount in Rupees)											
	Jan	Feb	Mar	April	May	June	July	August	Sep	Oct	Nov	Dec
DGM New Delhi	50050			50050							49500	
DGM SATMET												
DGM NHAC												
DGM (Pub.)	76250			50400	32490	18000	3600	4425	4425	5800	3100	2540
RMC New Delhi											19489	-
Jaipur				43028	41085	37457	33262	29555		22121	20535	-
Lucknow	13805			5233		2986	11856	8309	9250	9488	8413	-
Srinagar	3250			1400	13900	3300	1900	23750	6200	1400	1436	3400
Chandigarh	17833			4852	5623	10265	34041	8934	3869	7476	138272	5166
Shimla				28361	20628	4265	30504	41611				12426
Dehredun												-
RMC Mumbai						43564		227310		16388	69064	-
Ahemdabad								48685	38390			-
RMC Nagpur	14508	32116		39635	147898	48394	62183	58393	36012	54797		27495
Bhopal				1235		9758	1175	5060	17475	1418		1147
RMC Kolkata		365541		18723		14100		16850		49193		-
Bhubneshwar	121792				7619	92014	68227	59035		20357	15730	117548
Agartala				6919		15336	6827		1705	10322	4840	1724
Gangtok	65469	2939			8375	13630	11060	55122	2913	4600		-
RMC Guwahati	100605			73160	33965	44108	23897	135020	39359	40114	53313	10973
RMC Chennai	150854	94915		127922	113052	138163	126863	195918	100008	122931	83351	18452
Thiruvananthapuram	21324	125623		34411	42133	5640	241416	157858	5120	5510	39019	146182
Hyderabad	65669	219815		45290	123055	140565	57387	82735	50495	43515	206590	50905
Bangalore	23322	44781		5780	225720	362140	59995	38564	32030	52125	6370	29890
ACWC Chennai	14050	23596		31109	nil	7179	nil	23970	14418	2403	26433	-
CWC Visakhapatnam	5756	NIL		15375	5154	1718	20210	1293	nil	3134		-
O/o ADGM (R)	693215	895325		341307	4651121	2912814	612573	448900	494296	892930	1601654	1055440

CHAPTER 9

STATUS OF SC/ST/OBC AS ON 01.01.2016

(i) Status of SC/ST/OBC as on 01.01.2016 (Group wise)

	Representation of SCs / STs / OBCs as on 1.1.2016				Appointments by Promotion during the calendar year		
Groups	No. of Employees	SCs	STs	OBCs	SCs	STs	Total
Group A	150	20	09	25	02	-	23
Group B (Gaz.)	1294	221	92	-	100	28	558
Group B (Non- Gaz.)	1410	230	80	348	06	03	33
Group C	1637	523	161	171	02	-	15
TOTAL	4491	994	342	544	110	31	629

(ii) Status of SC/ST/OBC as on 01.01.2016 (Pay Scale Wise)

	Representation of SCs / STs / OBCs as on 01.01.2016				Appointments by promotion during the calendar year		
Pay Scale in Rs.	No. of Employees	SCs	STs	OBCs	SCs	STs	Total
PB-3 + GP 5400	-	-	-	-	-	-	-
PB-3 + GP 6600	4	-	1	3	-	-	-
PB-3 + GP 7600	67	13	4	20	-	-	1
PB-4 + GP 8700	60	07	3	2	2	0	09
PB-4 + GP 8900	18	-	1	-	-	0	13
PB-4 + GP 10000	-	-	-	-	-	-	-
75500-80000	1	-	-	-	-	-	-
TOTAL	150	20	09	25	2	0	23

CHAPTER 10

राजभाषा नीति का कार्यान्वयन

राजभाषा गौरव पुरस्कार

महामहिम राष्ट्रपति श्री प्रणब मुखर्जी ने मौसम - मंजूषा के 22वें संस्करण में प्रकाशित डॉ एस. के. पेशिन वैज्ञानिक 'जी' हिंदीतर भाषी क्षेत्र के लिये उत्कृष्ट लेख "अंटार्कटिका पर ओजोन" तथा श्री रामहरि शर्मा वैज्ञानिक सहायक को हिंदी भाषी वर्ग में उनके लेख "वायुमंडल की सैर" को दिनांक 14 सितम्बर, 2016 को राष्ट्रपति भवन में राजभाषा गौरव पुरस्कार (तृतीय) प्रदान किए।

डॉ एस. के. पेशिन वै. 'जी' महामहिम राष्ट्रपति से पुरस्कार प्राप्त करते हुए

श्री रामहरि शर्मा वै. स. महामहिम राष्ट्रपति से पुरस्कार प्राप्त करते हुए

संसदीय राजभाषा समिति द्वारा निरीक्षण

संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 18 जनवरी, 2016 को मौसम वेधशाला ओखा का राजभाषायी निरीक्षण किया गया। इस निरीक्षण बैठक में मुख्यालय से उपमहानिदेशक (प्रशा. एवं. भंडार) तथा वरिष्ठ हिंदी अधिकारी ने भाग लिया। निरीक्षण के दौरान मुख्यालय की हिंदी अधिकारी तथा वरिष्ठ अनुवादक भी उपस्थित रहे।

संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 20 मई, 2016 को मौसम कार्यालय सांताक्रूज, मुंबई का निरीक्षण किया गया। इस निरीक्षण में मुख्यालय के उपमहानिदेशक (प्रशा. एवं भंडार) श्री ए. के. शर्मा तथा वरिष्ठ हिंदी अधिकारी, सुश्री रेवा शर्मा ने भाग लिया निरीक्षण के दौरान श्रीमती एम. अनुराधा, वरिष्ठ अनुवादक भी उपस्थित रही।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 20 जून, 2016 को

बाढ़ मौसम कार्यालय जलपाईगुड़ी का निरीक्षण सिलीगुड़ी में किया गया जिसमें वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा ने भाग लिया।

संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 27 जुलाई, 2016 को मौसम कार्यालय सफदरजंग का निरीक्षण किया गया। इसमें सुश्री रेवा शर्मा, वरिष्ठ हिंदी अधिकारी तथा श्रीमती एम. अनुराधा, वरिष्ठ अनुवादक उपस्थित रहे।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 10 सितम्बर, 2016 को मौसम केंद्र हैदराबाद का निरीक्षण किया गया। इस निरीक्षण में डॉ. देवेन्द्र प्रधान वैज्ञानिक 'जी' ने मौसम विज्ञान के महानिदेशक का कार्यालय नई दिल्ली की ओर से भाग लिया। इस निरीक्षण में वरिष्ठ हिंदी अधिकारी तथा वरिष्ठ अनुवादक ने भाग लिया।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 16 सितम्बर, 2016 को विमानन मौसम कार्यालय चेन्नै का निरीक्षण तिरूपति में किया गया जिसमें महानिदेशक महोदय डॉ. के. जे. रमेश ने भाग लिया।

माननीय संसदीय राजभाषा समिति की दूसरी उपसमिति द्वारा दिनांक 15 अक्टूबर, 2016 को प्रादेशिक मौसम केंद्र, कोलकाता का निरीक्षण किया गया। इस निरीक्षण बैठक में महानिदेशक महोदय डॉ के.जे.रमेश तथा वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा ने भाग लिया। निरीक्षण के दौरान हिंदी अधिकारी श्रीमती सरिता जोशी भी उपस्थित रही।

संगोष्ठी / कार्यशाला / व्याख्यान

मौसम केंद्र भुवनेश्वर में दिनांक 4 मार्च, 2016 को आयोजित हिंदी संगोष्ठी में सुश्री रेवा शर्मा,

वरिष्ठ हिंदी अधिकारी और श्रीमती सरिता जोशी, हिंदी अधिकारी ने भाग लिया। हिंदी संगोष्ठी का विषय "दिन प्रतिदिन के जीवन में मौसम विज्ञान की उपयोगिता: जलवायु परिवर्तन के विशेष संदर्भ में" रहा। हिंदी में वैज्ञानिक एवं तकनीकी विषयों पर व्याख्यान देने के लिए आई आई टी भुवनेश्वर के प्रोफेसर पी. सी. पांडे

विशिष्ट अतिथि रहे। इनके अलावा एकाउंटेंट जनरल के कार्यालय भुवनेश्वर, प्रादेशिक मौसम केंद्र नागपुर, प्रादेशिक मौसम केंद्र मुंबई, प्रादेशिक मौसम केंद्र कोलकाता, मौसम केंद्र भुवनेश्वर तथा कार्यक्रम के सफल एवं सुचारू रूप से आयोजन और संचालन व व्याख्यान देने के लिए वरिष्ठ हिंदी अधिकारी और हिंदी अधिकारी को मिलाकर इस कार्यक्रम में कुल 10 के लगभग वक्ताओं ने भाग लिया।

राजभाषा विभाग, गृह मंत्रालय के दिनांक 28 मई, 1993 के का. ज्ञा. सं. 20034/ 53/93-रा.भा. (आर.ए.) के अनुपालन में महानिदेशक महोदय के आदेशानुसार भारत मौसम विज्ञान विभाग (मुख्यालय) द्वारा दिनांक 25-26 अप्रैल, 2016 को वृष्टि सभागार में पाँचवी अखिल भारतीय विभागीय हिंदी संगोष्ठी का वृष्टि सभागार में सफल आयोजन किया गया। इस संगोष्ठी का उद्घाटन महानिदेशक महोदय डॉ. लक्ष्मण सिंह राठौड़ के द्वारा किया गया। इस संगोष्ठी में विभाग के पूरे देश से आए 24 अधिकारियों और कर्मचारियों ने उत्साहपूर्वक भाग लिया और प्रेजेंटेशन प्रस्तुत किए।

विश्व हिंदी कार्यान्वयन परिषद (परिवर्तन जनकल्याण समिति) द्वारा दिनांक 26-28 मई, 2016 तक तिरूवनंतपुरम, केरल में आयोजित अखिल भारतीय राजभाषा हिंदी सम्मेलन एवं कार्यशाला में वरिष्ठ हिंदी अधिकारी, सुश्री रेवा शर्मा तथा हिंदी अधिकारी, श्रीमती सरिता जोशी ने भाग लिया।

मौविउमनि (उ.वा.उ.) नई दिल्ली द्वारा दिनांक 25 जुलाई, 2016 को कार्यशाला आयोजित की गई जिसमें मुख्यालय की वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा ने राजभाषा हिंदी और मानक वर्तनी पर तथा श्रीमती एम. अनुराधा वरिष्ठ अनुवादक ने टिप्पणी और सामान्य भविष्य निधि संबंधी विषयों पर व्याख्यान दिए।

मुख्यालय में दिनांक 26 जुलाई, 2016 को वैज्ञानिक विषयों एवं राजभाषा पर हिंदी व्याख्यान आयोजित किए गए। इसमें

डॉ. दुर्गादत्त ओझा ने वर्तमान समय में नैनो टेक्नोलॉजी का योगदान और जल-अमृत या विष नामक दो विषयों पर व्याख्यान दिए और श्री उमेश मेहता ने राजभाषा हिंदी का महत्व और हिंदी लेखन को प्रोत्साहन नामक दो विषयों पर व्याख्यान दिए।

इसमें महानिदेशक महोदय द्वारा अखिल भारतीय विभागीय हिंदी संगोष्ठी 2016 में भाग लेने वाले प्रतियोगियों को प्रमाण-पत्र भी वितरित किए गए।

उपकार्यालयों का राजभाषायी निरीक्षण

मुख्यालय की वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा, हिंदी अधिकारी श्रीमती सरिता जोशी और वरिष्ठ अनुवादक श्रीमती एम. अनुराधा ने दिनांक 17 जनवरी, 2016 को मौसम वेधशाला ओखा, दिनांक 19 जनवरी, 2016 को मौसम वेधशाला द्वारका, दिनांक 20 जनवरी, 2016 को मौसम कार्यालय वेरावल तथा दिनांक 22 जनवरी, 2016 को मौसम केंद्र अहमदाबाद का राजभाषायी निरीक्षण किया।

दिनांक 22 जनवरी, 2016 को मौसम केंद्र अहमदाबाद में एक कार्यशाला आयोजित की गई जिसमें सुश्री रेवा शर्मा, वरिष्ठ हिंदी अधिकारी ने 'राजभाषा हिंदी व निरीक्षण प्रश्नावली विषय' पर तथा श्रीमती सरिता जोशी, हिंदी अधिकारी ने 'कम्प्यूटर और हिंदी-सुविधाएँ व उपयोग' विषय पर तथा श्रीमती एम. अनुराधा, वरिष्ठ अनुवादक ने 'वार्षिक कार्यक्रम के निर्धारित लक्ष्यों' पर व्याख्यान दिया।

वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा तथा हिंदी अधिकारी श्रीमती सरिता जोशी द्वारा दिनांक 3 मई, 2016 को मौसम केंद्र बंगलुरू

का राजभाषायी निरीक्षण किया गया। मौसम केंद्र बंगलुरू में राजभाषा कार्यान्वयन समिति गठित की गई और दिनांक 2 मई, 2016 को पहली बैठक आयोजित की गई। श्रीमती सरिता जोशी हिंदी अधिकारी द्वारा दिनांक 4 मई, 2016 को "कम्प्यूटर और हिंदी- सुविधाएँ और उपयोग" विषय पर प्रेजेटेंशन दिया गया तथा कम्प्यूटर पर हिंदी में कार्य करना सिखाया गया।

दिनांक 23 मई, 2016 को सुश्री रेवा शर्मा, वरिष्ठ हिंदी अधिकारी और श्रीमती एम. अनुराधा, वरिष्ठ अनुवादक ने प्रादेशिक मौसम केंद्र, मुंबई का राजभाषायी निरीक्षण किया और आवश्यक दिशानिर्देश दिए।

वरिष्ठ हिंदी अधिकारी सुश्री रेवा शर्मा तथा हिंदी अधिकारी श्रीमती सरिता जोशी द्वारा दिनांक 30 मई, 2016 को मौसम केंद्र तिरूवनंतपुरम का राजभाषायी निरीक्षण किया गया और आवश्यक दिशानिर्देश दिए गए।

वरिष्ठ हिंदी अधिकारी और वरिष्ठ अनुवादक ने दिनांक 20 जून, 2016 को बाढ़ मौसम कार्यालय जलपाईगुड़ी का राजभाषायी निरीक्षण किया। निरीक्षण के दौरान कम्प्यूटर पर यूनिकोड के द्वारा कार्य करना भी सिखाया गया।

दिनांक 18 जुलाई, 2016 को राजभाषा विभाग के उपनिदेशक द्वारा मुख्यालय नई दिल्ली का राजभाषायी निरीक्षण किया गया।

वरिष्ठ हिंदी अधिकारी और हिंदी अधिकारी द्वारा दिनांक 17-18 अक्टूबर, 2016 को कोलकाता स्थित कार्यालयों का राजभाषायी निरीक्षण किया गया। दिनांक 18 अक्टूबर, 2016 को खगोल विज्ञान केंद्र, कोलकाता में हिंदी कार्यशाला का आयोजन किया गया जिसमें हिंदी अधिकारी श्रीमती सरिता जोशी ने 'कम्प्यूटर और हिंदी - सुविधाएं एवं उपयोग' विषय पर प्रेजेंटेशन दिया। कार्यालय के अधिकारियों और कर्मचारियों को कम्प्यूटर पर हिंदी में काम करने का प्रशिक्षण दिया गया।

CHAPTER 11

MISCELLANEOUS

11.1. HONOURS AND AWARDS

IMD Awards

Best RMC/MC/MOs Awards and Awards to IMD Scientists/employees were given on 141st IMD Foundation Day celebrations.

Best RMC : RMC Kolkata;

Best MC : MC Chandigarh;
Best MO : M.O. Dhubri, RMC Guwahati; M.O. Dgha, RMC Kolkata; M.O. Satna, RMC Nagpur; M.O. Knnur, RMC Chennai; M.O. Solapur, RMC Mumbai, M.O. Safderjung; RMC New Delhi.

Best Group' A' Officers

Ms. V. K. Mini, Scientist 'D', M.C. Goa, RMC Mumbai; Shri A. K. Das, Scientist 'D', NWP,DGM office, New Delhi.

Dr. A.K. Das receiving the best employee award

Best Group 'B' Officials

Shri R. P. Sharma, A.M. - I, DGM(NWFC), New Delhi; Smt. Sarita Joshi, Hindi Officer, DGM, New Delhi; Smt. Usha Krishnan, A.M. - II, ADGM(R), Pune; Smt. Mausami Dutta, S. A., F.M.O. Jalpaiguri, RMC Kolkata; Shri. K. Biju, S.A., M.O. Kannur, RMC Chennai; Shri Ravinder Kamble, S. A., DDGM (SI), Pune; Smt. A. E. Kujur, Asstt., DGM (Vigilance), New Delhi.

Best Group 'C' Officials

Smt. Surabhi Purohit, UDC, MC Bhopal, RMC Nagpur; Shri P. Mallick, UDC, RMC Kolkata, Alipore; Shri Uttam G. Alhat, Mech. Gr. 1, DDGM (SI), Pune; Shri N. Swadesh Rao , Staff Car Driver, CWC Visakhapatnam, RMC Chennai.

Best MTS

Shri Satish Kumar, DGM (H), New Delhi; Shri Jagat Singh, DGM (CPU), New Delhi; Shri Sanjay Barua, RMC Kolkata; Shri A. C. Das, AMO Mohanbari, RMC Guwahat; Shri Anil Kumar, DGM New Delhi; Shri Laxmi Narayan Shukla, MC Bhopal, RMC Nagpur; Shri Arulsamy, AMO Chennai; Shri K. M. Raveendran, AMS Kozhikode, RMC Chennai.

MoES AWARD 2015-2016

Ministry of Earth Sciences celebrated its foundation day on 27th July 2016 at Vigyan Bhawan, New Delhi. Various award were presented to officials from different organisations of MoES.

Certificate of Merit

1. Dr. V.K. Soni, Scientist 'E' DGM, New Delhi.

2. Smt. Sunitha Devi S., Sc. 'E' ADGM (R), Pune.

Best Employee Award for the year 2015-16

1. Shri Satendra Kumar, Asst. Met.-II, DGM (NWP), New Delhi.

2 Smt. Preetha A. Menon, S.A., ADGM (R), Pune.

3. Shri Awadhesh Prasad, S.A., Agromet. Services Cell.

4. Smt. Chhaki Eden Bhutia, UDC, MC Gangtok.

5. Shri R. Namrath, MTS, MC Bengaluru.

WMO-Professor Vilho Vaisala Award - 2016

WMO-Professor Vilho Vaisala Award-2016 for the Development and Implementation of the Instruments and Methods of Observation in Developing Countries is awarded for the work on the technical document WMO - IOM - 117 entitled "Survey on alternatives for dangerous and obsolete instruments : evaluation of the questionnaire and recommendations for alternatives" by **Ms. B. Amudha, Scientist 'D'**, RMC Chennai and Dr. Rabia Merrouchi from Morocco. The work was done during her tenure as member of the WMO - Expert Team of Regional Instrument Centres 2010-14.

Ms. B. Amudha, Scientist 'D' receiving the WMO-Professor Vilho Vaisala Award-2016 in TECO-2016 conference at Madrid, Spain

Ms. B. Amudha, Scientist 'D', RMC Chennai was awarded the coveted prize in the TECO - 2016 conference held at Madrid, Spain on 28th September, 2016. She is the first from India Meteorological Department and the second Indian to receive the Vaisala award from WMO.

Indian Meteorological Society (IMS) Young Scientist Award

Indian Meteorological Society (IMS) Young Scientist Award for the best research paper published on "Tropical Meteorology" for the year 2014 was presented to Dr. D. R. Pattanaik, Sc. 'E' during the opening ceremony

Dr. D. R. Pattanaik, Sc. 'E' receiving the award from Dr. Dr. Pradeep K. Panigrahy, Hon'ble Minister Government of Odisha

of TROPMET- 2016 in Bhubaneswar on 18th December, 2016 for the research paper authored by him and Arun Kumar entitled "A hybrid model based on latest version of NCEP CFS coupled model for Indian monsoon rainfall forecast" published in Atmospheric Science Letters (2014), DOI: 10.1002/asl2.513. Dr. D. R. Pattanaik, Sc. 'E' receiving the award from Dr. Pradeep K. Panigrahy, Hon'ble Minister Government of Odisha IMS Award for best paper published on "Weather and Climate Services" (Formerly Bhavanarayana Award); (2013-2014) was given to Dr. S. D. Kotal and his collaborators Dr. S. K. Bhattacharya and Dr. S. K. Roy Bhowmik for their paper entitled "Development of NWP Based Objective Cyclone Prediction System (CPS) for North Indian Ocean Tropical Cyclones - Evaluation of Performance" published in Tropical Cyclone Research and Review (2014), Vol. 3, 162-177. DOI 10.6057/2014TCRR03.03 Media Interaction

Asian Benchpress Championship at Tashkent Uzbekistan

Shri A. K. Sharma, Met. 'B' *receiving the award*

Asian Benchpress Championship at Tashkent Uzbekistan during 14-20 October, 2016. Shri A.

K. Sharma, Meteorologist 'B' was selected as a member of Indian Team by Indian Powerlifting Federation which is affiliated to Asian, Commonwealth and World Powerlifting Federation and is recognised by Ministry of Youth Affair Government of India and also by Indian Olympic Association to participate in above Asian Benchpress Championship and won a Gold Medal in Benchpress Championship.

Appreciation Received

- Hourly location specific forecasts for 15 August for Red Fort Area and for 1 September for Race Course are appreciated by PMO.

- Nowcast issued for heavy rainfall over Hyderabad is appreciated by Min of States, Home Affair, Govt of India and City Municipal Corporation Hyderabad.

- Appreciation letter received from Indian Maintaining Foundation for extreme usefulness of weather forecast provided by IMD for their Mountain expeditions since 2001.

- Appreciation from Indian Army for the weather support provided to them for six mountain expeditions over different peaks of Himalayas in August & September 2016.

- Appreciation received from Eastern Naval Command of Indian Navy for expedition on Mt. Saser Kangri in August 2016 for weather support provided to them.

11.2. MEDIA INTERACTION

A special bulletin was commenced by NWFC w. e. f. 1st August, 2016 on observed and heavy rainfall warnings for next 5 days and sent to all concerned authorities including NDMA and MHA etc.

As per the recommendations of 43rd Session of Panel on Tropical Cyclones held at New Delhi during 2-6 May, 2016, Yemen joined WMO/ESCAP Panel member countries. IMD made arrangements to send tropical weather outlook daily and tropical cyclone advisory bulletins every three hourly to Yemen from 9th August, 2016.

In connection with the preparation of a documentary film by Vigyan Prasar on life and work of Dr.(Ms.) Anna Mani former Deputy Director General of IMD, the production team conducted interview with Dr. K. J. Ramesh, DGM, IMD, Dr. M. Mohapatra, Scientist-G (Services), Dr. D. Pradhan Scientist-G (Instruments) and Shri B. P. Yadav, Scientist-F on 19th September, 2016.

Archana Kapoor Productions carried out video shooting at IMD for production of a film by NDMA to showcase disaster management in India on 29th September, 2016. The film will be screened on the occasion of Asian Ministerial Conference on Disaster Risk Reduction to be held at New Delhi during November, 2016.

11.3. ADDRESSES OF VARIOUS MET. CENTRES

Delhi Region

Director
Meteorological Centre,
SCO-2455-56, (First Floor),
Sector 22 C,
CHANDIGARH - 160 022.
e-mail: chandimet@yahoo.com

Director
Meteorological Centre,
Mausam Bhawan,
Budhsinghpura,
Sanganer,
JAIPUR – 302 01.
e-mail: mcjpr@imd.gov.in
mcjaipur2007@yahoo.com

Director
Meteorological Centre,
Civil Aerodrome, Amausi,
LUCKNOW - 226 009.

e-mail: amo.lkn@imd.gov.in

Director
Meteorological Centre,
Ram Bagh Complex,
SRINAGAR – 190 015.
e-mail: lotusladakh@gmail.com

Director
Meteorological Centre,
Survey of India Compound,
17, E.C. Road, Karanpur,
DEHRADUN-248 001.
e-mail: mcdehradun@yahoo.co.in

Director
Meteorological Centre,
Bibra House, Cliffend Estate,
SHIMLA – 171 001.
e-mail: mc.sml@imd.gov.in

Chennai Region

Director
Meteorological Centre,
Central Observatory, Palace Road,
BANGALORE – 560 001.
e-mail: mcbng@imd.gov.in
amo.bng@imd.gov.in

Director
Meteorological Centre,
Hyderabad Airport,
HYDERABAD – 500 016.
e-mail: mchyd@imd.gov.in
amo.hyd@imd.gov.in

Director
Meteorological Centre, Observatory,
THIRUVANANTHAPURAM – 695 033.
e-mail: mc.trv@imd.gov.in
mctrivandrum@gmail.com

Mumbai Region

Director
Meteorological Centre,
Civil Aerodrome,
AHMEDABAD - 380 012.
e-mail: mc.ahm@imd.gov.in
mchm@rediffmail.com

Director
Meteorological Centre,
Altinho, Panaji
GOA – 403 001.
e-mail: mc.goa@imd.gov.in

Kolkata Region

Director
Meteorological Centre,
Civil Aerodrome,
BHUBANESHWAR - 751 009.
e-mail: mc.bwn@imd.gov.in
imdbbsr@ori.nic.in

Director
Meteorological Centre,
Ladaki Mansion,
Baluwakhan,
GANGTOK – 737 101.
e-mail: mc.gtk@imd.gov.in
gangtokmet@gmail.com

Director
Meteorological Centre,
Civil Aerodrome,
PATNA – 800 014.
e-mail: mc.ptn@imd.gov.in
aviationmcpatna@gmail.com

Director
Meteorological Centre,
Civil Aerodrome,
RANCHI – 834 002.
e-mail: mc.rnc@imd.gov.in
metranchi@gmail.com

Nagpur Region

Director
Meteorological Centre,
Mausam Vigyan Kendra,
Arera Hills, Satpura Post Office,
BHOPAL 462 004.
e-mail: mc.bhp@imd.gov.in
mcbhopal@rediffmail.com

Director
Meteorological Centre,
Lalpur,
RAIPUR
e-mail: mc.rpr@imd.gov.in
rsrw.rpr@gmail.com

Guwahati Region

Director
Meteorological Centre,
Naharlagun Helipad complex,
ITANAGAR – 791 110.
e-mail: mc.itn@imd.gov.in
weqaatheritn@sancharnet.in

Director
Meteorological Centre,
P.O. Agartala Aerodrome,
AGARARTALA – 791 110.
e-mail: mc.agt@imd.gov.in
amo.agt@imd.gov.in

INDIA METEOROLOGICAL DEPARTMENT (IMD)

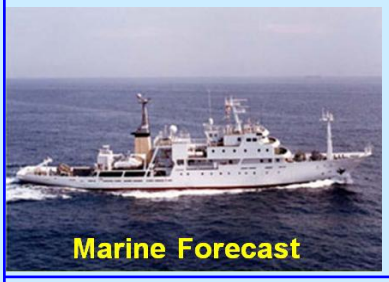
Ministry of Earth Sciences (MoES)

Weather Forecasting and Warning Services for Public Safety and Socio Economic Benefits

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

India Meteorological Department through its Regional and State Meteorological Centres provides weather and climate services to different parts of the country.

With the modernization of observational systems, improvement in numerical modelling and better forecast skills, IMD has improved its forecasting and warning services of weather and climate in recent time, enabling the disaster managers to minimize loss of life and property pertaining to the hazardous severe weather systems like Tropical Cyclone, Heavy Rainfall, Snowfall, Local Severe Storms, Fog, Heat Wave and Cold Wave etc.



IMD IN THE SERVICE OF THE NATION SINCE 1875

Mausam Bhawan, Lodi Road, New Delhi -110 003 Website - http://www.imd.gov.in Toll Free No.- 18001801717

भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

पृथ्वी विज्ञान मंत्रालय, भारत सरकार

Ministry of Earth Sciences, Govt. of India

http://www.imd.gov.in/