

Indian Meteorological Society TROPMET-2018  
National Symposium on  
Understanding Weather and Climate Variability: Research for Society  
24 to 27 October, 2018, BHU, Varanasi

# Climate Services in India

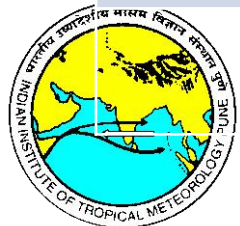
## भारतवर्ष में जलवायु सेवार्ये

अतुल कुमार सहाय  
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भारतीय उष्णदेशीय मौसमविज्ञान संस्थान  
Project Director  
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प्रमुख, जलवायु अनुसंधान एवं सेवार्ये  
भारत मौसम विज्ञान विभाग, पुणे  
Head, Climate Research and Services  
India Meteorological Department

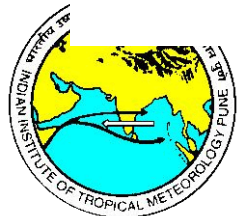
ई-मेल : [sahai@tropmet.res.in](mailto:sahai@tropmet.res.in)



# Background पृष्ठभूमि

## Global Framework for Climate Services

- Components of Modern Climate Services  
आधुनिक जलवायु सेवाओं के अवयव
- Climate Monitoring (जलवायु की निगरानी)
- Climate Data Management (जलवायु आंकड़ा प्रबंधन)
- Capacity building programs (जलवायु अनुसन्धान एवं प्रशिक्षण)
- Climate Prediction (जलवायु की भविष्यवाणी)
- Climate Service Application (जलवायु सेवाओं के अनुप्रयोग) (Disaster आपदा, Agriculture कृषि, Water जल Energy ऊर्जा, Health स्वास्थ्य)



11/30/2018

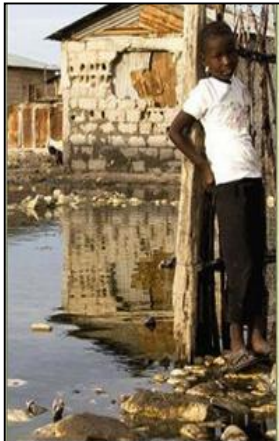


# GFCS Vision

The Global Framework for Climate Services (GFCS) was established in 2009, to enhance the development, delivery, and use of climate information in decision making. Five target user groups have been recognized as GFCS priority areas for developing climate services in all countries.



**Agriculture and  
food security**



**Disaster risk  
reduction**



**Water**



**Health**



**Energy**

**Primary aim of an effective climate service is to optimum use of climate information for societal benefits**

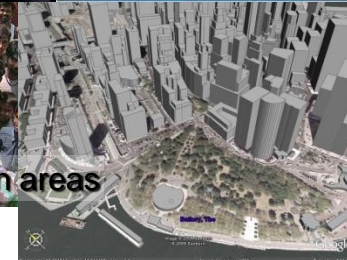
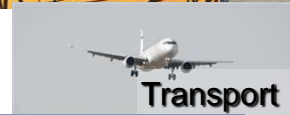
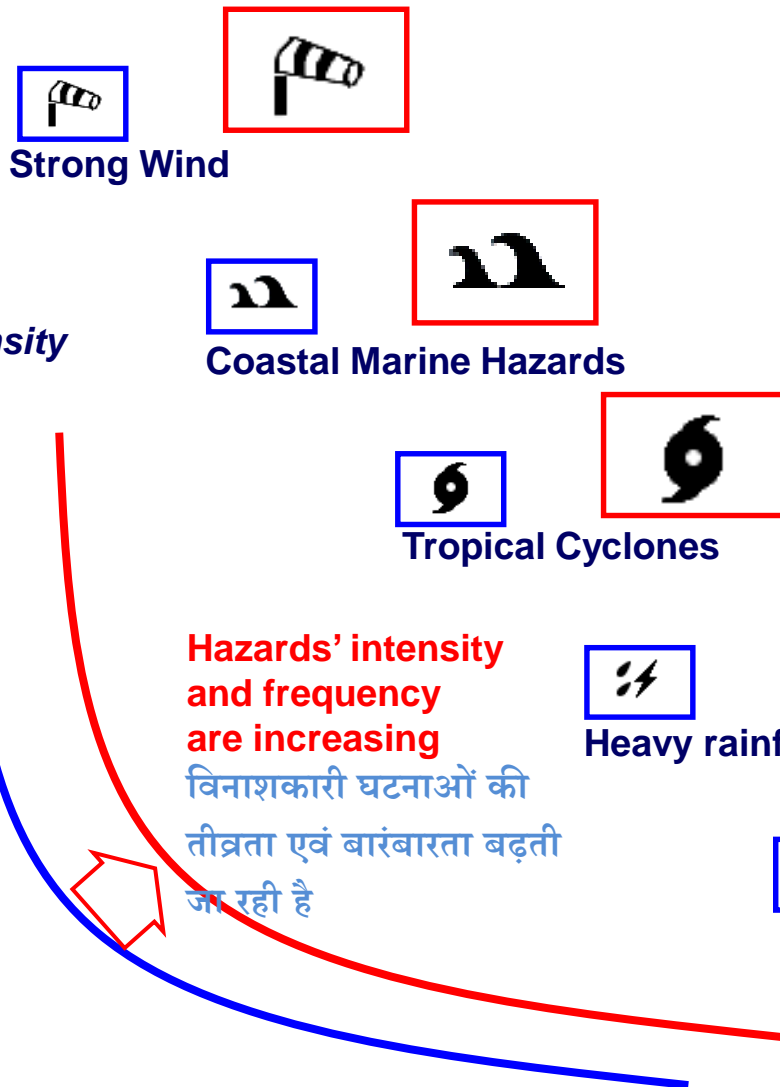
प्रधानी जलवायु सेवा का प्राथमिक उद्देश्य सामाजिक लाभों के लिए अनुकूलतम जलवायु की सूचना देना है



11/30/2018

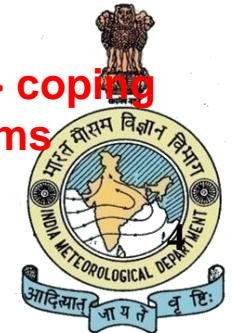
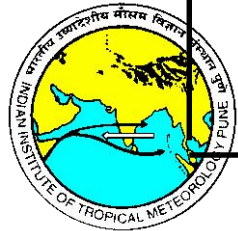


# Why GFCS



**Vulnerability and exposure on the rise !**

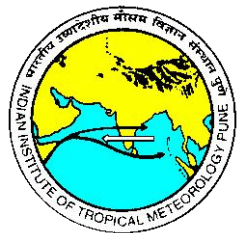
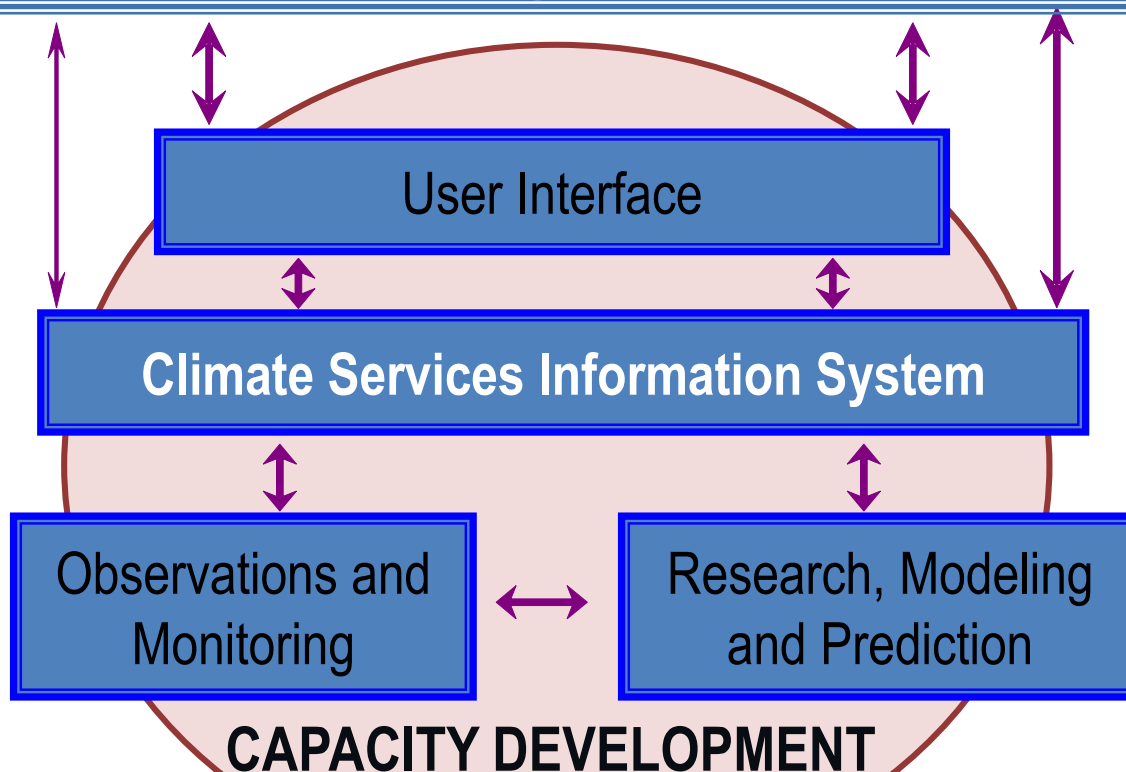
**Need for > coping mechanisms**





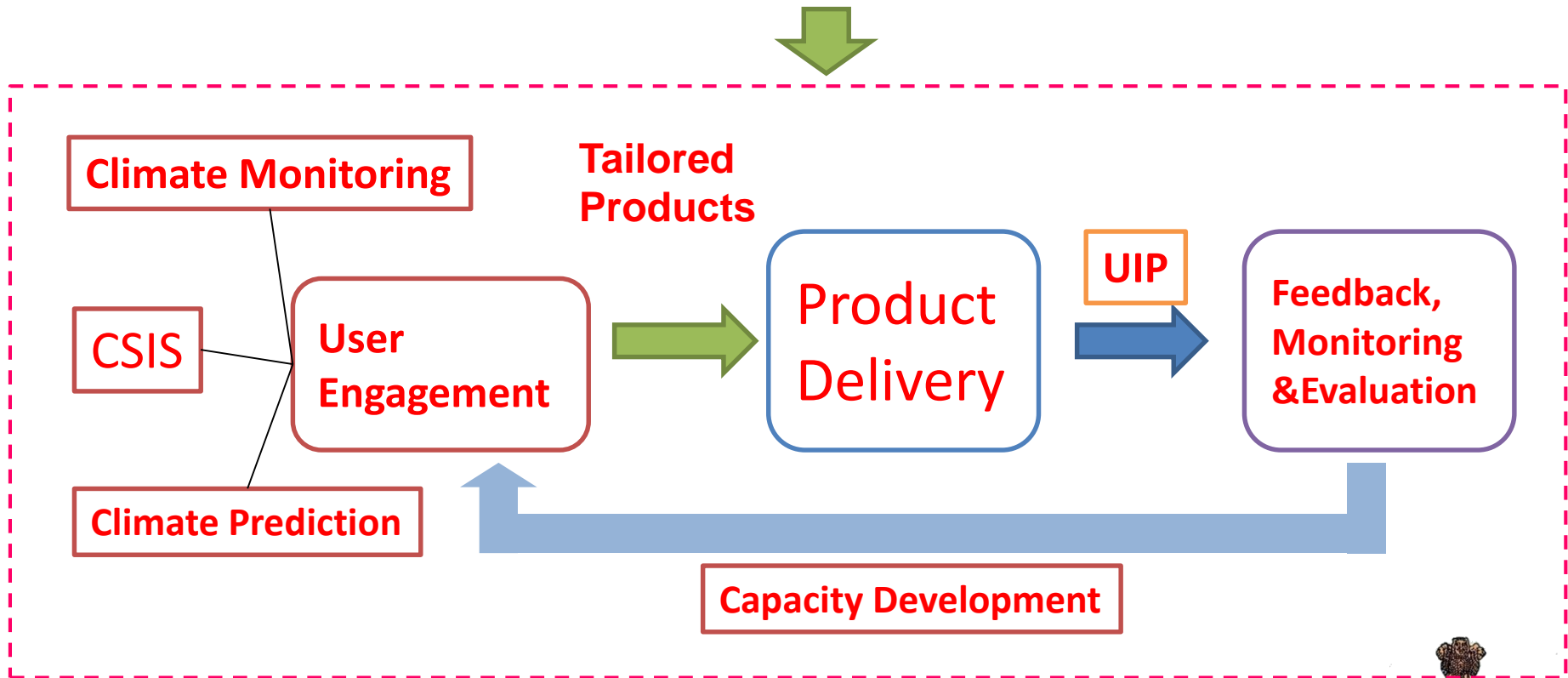
# The 5 pillars of GFCS

**Users – Government, private sector, research – agriculture, water, health, construction, disaster reduction, environment, tourism, transport, etc.**

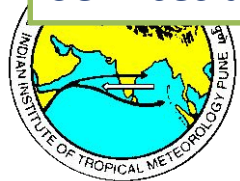


# Method to Transfer from Climate to Services

## Process of developing climate services



Services are developed through ongoing engagement between providers and users.



# IMD is implementing GFCS at National and South Asian Regional Level through its Climate Research and Services office at Pune

Framework for Climate Services has been **built on existing capacities and leverage them through coordination** to address shortcomings.

This Framework enables **greater integration and coordination across disciplines, actors and sectors in the climate services agenda for better use of existing infrastructure, technical capabilities (and resources...)** for improved outcomes in climate-sensitive sectors.



# Pre requisites of effective climate services

- Availability of Climate data
- Existence of Climate monitoring Mechanism
- Appropriate prediction systems
- Sector specific product generation





# Climate Observations

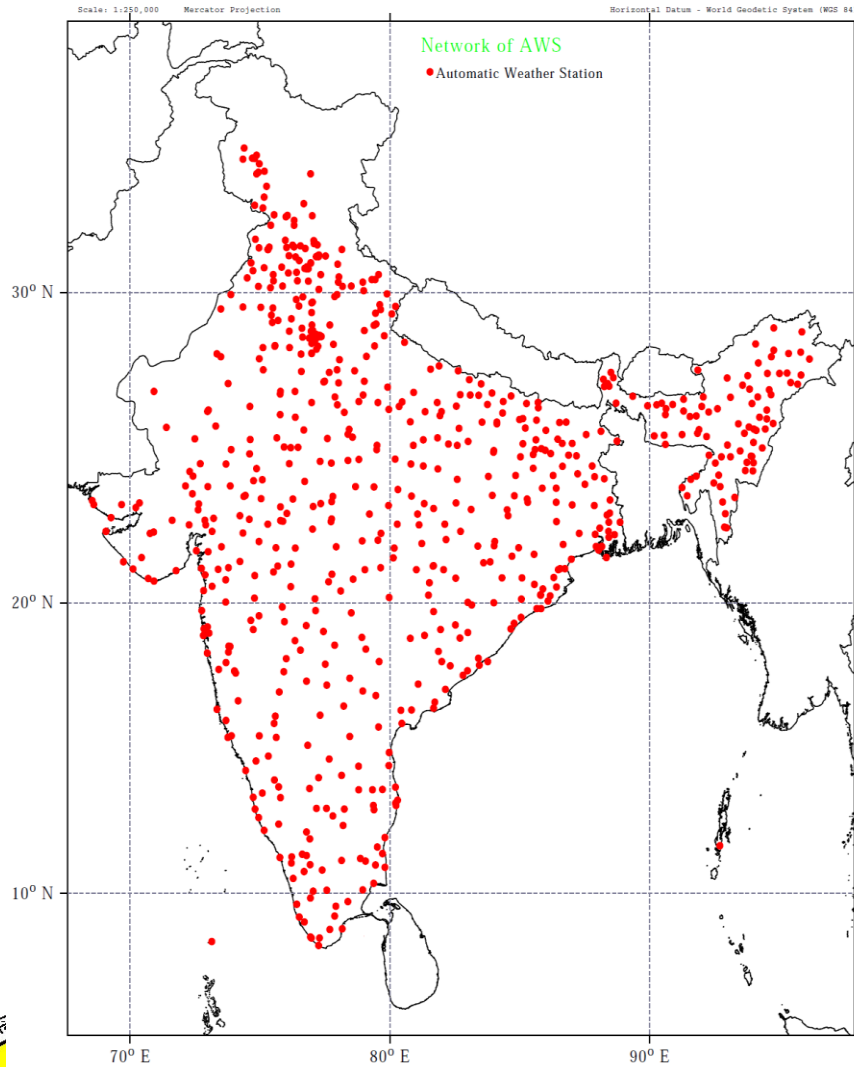
India is fortunate to have some of the oldest meteorological observatories of the world, that include Calcutta (now known as Kolkata) established in 1785, Madras (now known as Chennai), in 1793, Bombay (now known as Mumbai) in 1823 and Shimla in 1841.

With the gradual growth in the expansion of observational network varieties of data have been generated and accumulated in a span of many decades.

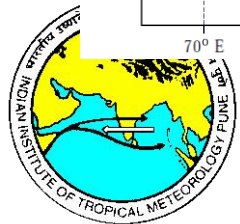
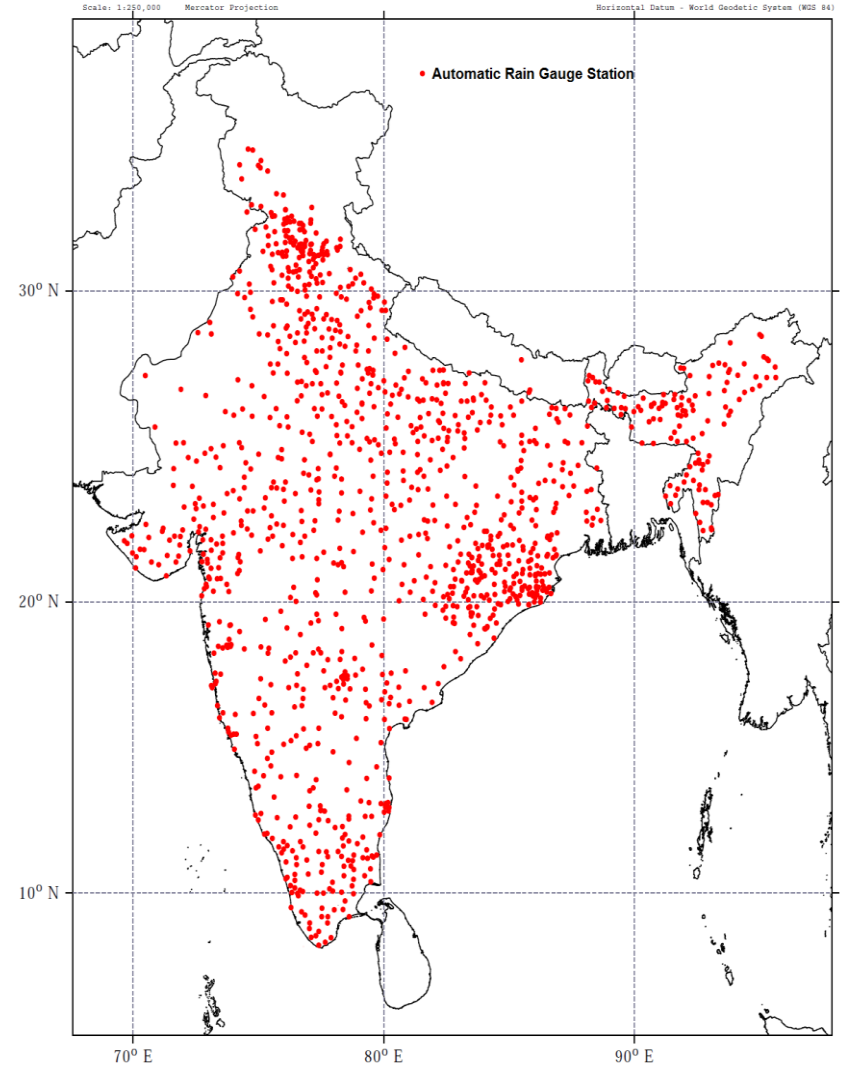


# Climate Observations

**AWS Network (705)**



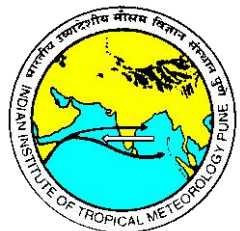
**ARG Network (1380)**



# National Data Centre (NDC)

IMD was established in 1875

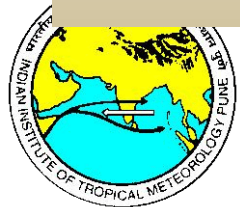
- National Data Centre was created in 1977.
- The objectives of the NDC are
  - Data Keying and Verification of Meteorological Data
  - Data Archival and Supply to Users
  - Computer Training and Software Support



# Data Archival at NDC

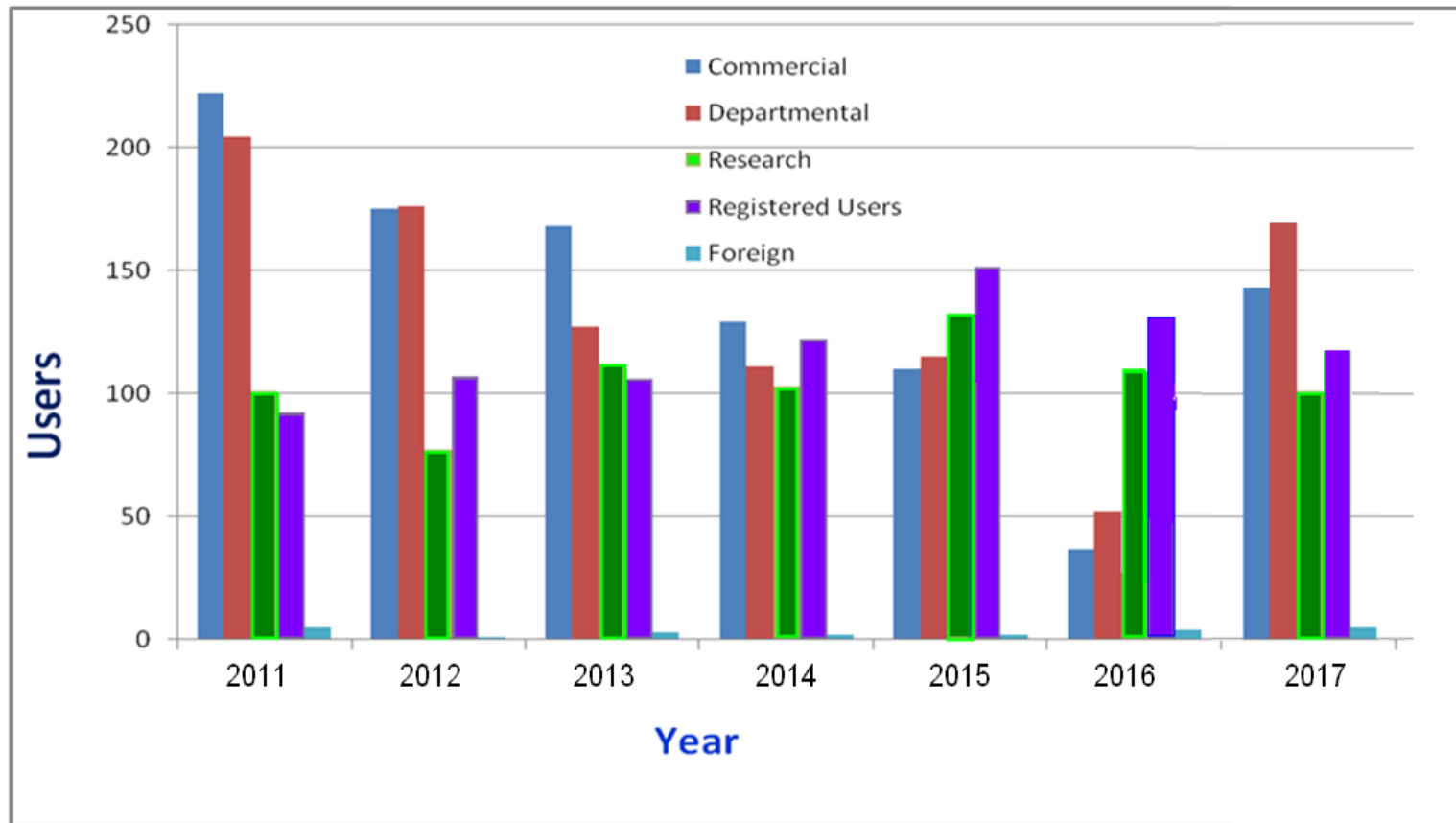


No. of Records in Lakhs





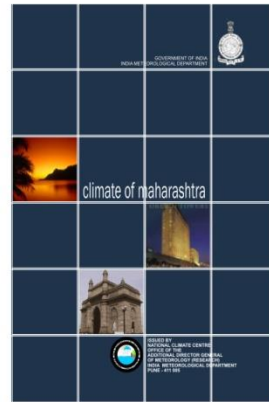
# DATA SUPPLY TO Different Users



# Climate Monitoring and Analysis

Prepares and publishes monthly, seasonal and annual climate diagnostic bulletins for Indian region regularly.

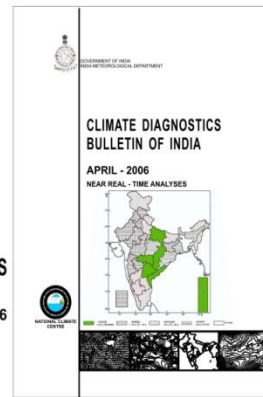
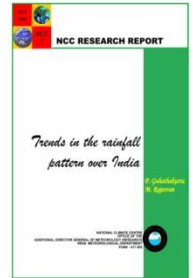
भारतीय क्षेत्र के लिए  
मासिक, मौसमी और  
वार्षिक जलवायु  
नैदानिक बुलेटिन को  
नियमित रूप से  
प्रकाशित करना



climate of maharashtra



NCC RESEARCH REPORT



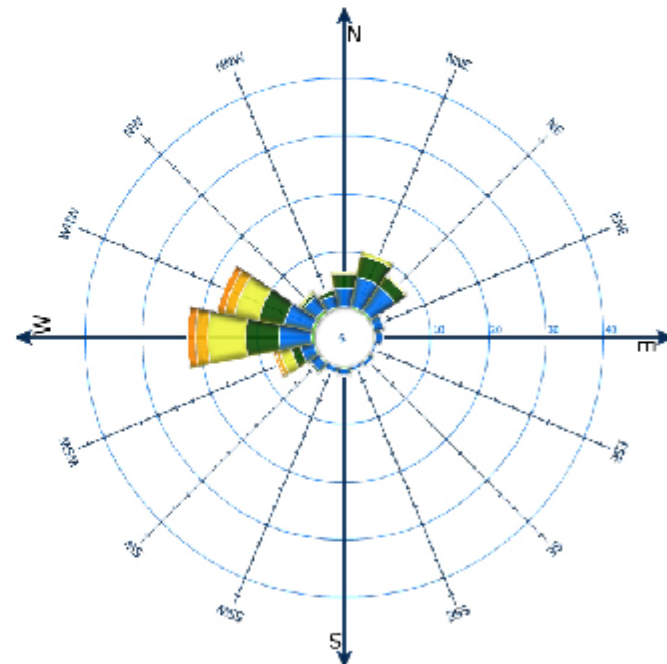
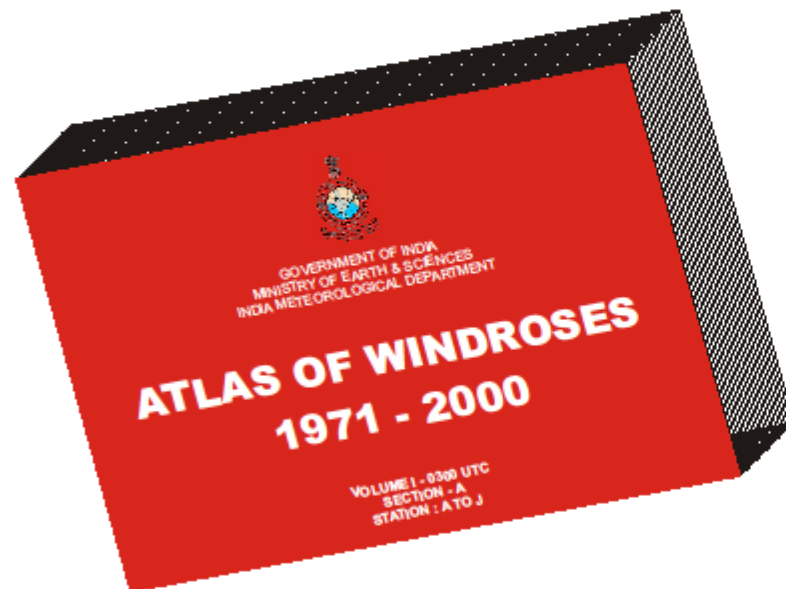
CLIMATE DIAGNOSTICS  
BULLETIN OF INDIA  
APRIL - 2006



# ATLAS OF WIND ROSES 1971-2000

## VOLUME - I

(0300 UTC)





जलवायु सारिNया  
**CLIMATOLOGICAL  
TABLES  
1961-1990**

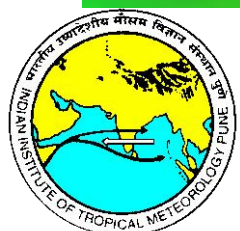


### Climatological Normals

- ◆ The World Meteorological Organization (WMO) defines normals as "period averages computed for a uniform and relatively long period comprising at least three consecutive 10-year periods".
- ◆ Standard normals are computed every thirty years (e.g. 1901-1930, 1931-1960, etc.) and the latest global Standard Normals are from 1961-1990.

### Tables of Normals

- ◆ It contains means of Pressure, Temperature, Relative Humidity, Clouds, Vapour pressure, Rainfall and Wind speed.
- ◆ Extremes of Maximum temperature, Minimum temperature and Rainfall.
- ◆ The Frequencies of Weather Phenomena, Clouds, Wind speed, Wind direction and Visibility.





# RAINFALL ATLAS OF INDIA

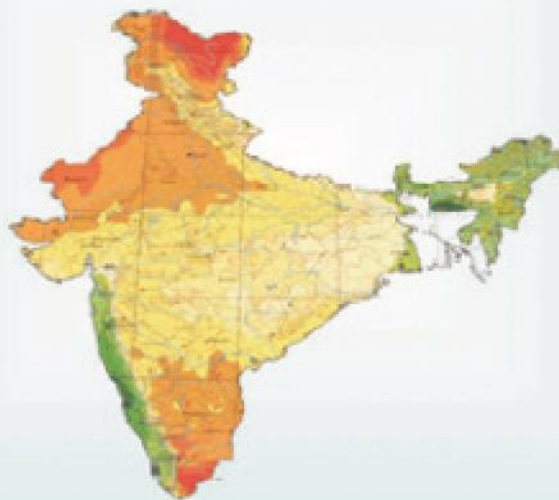


IMD

2012



## RAINFALL ATLAS OF INDIA



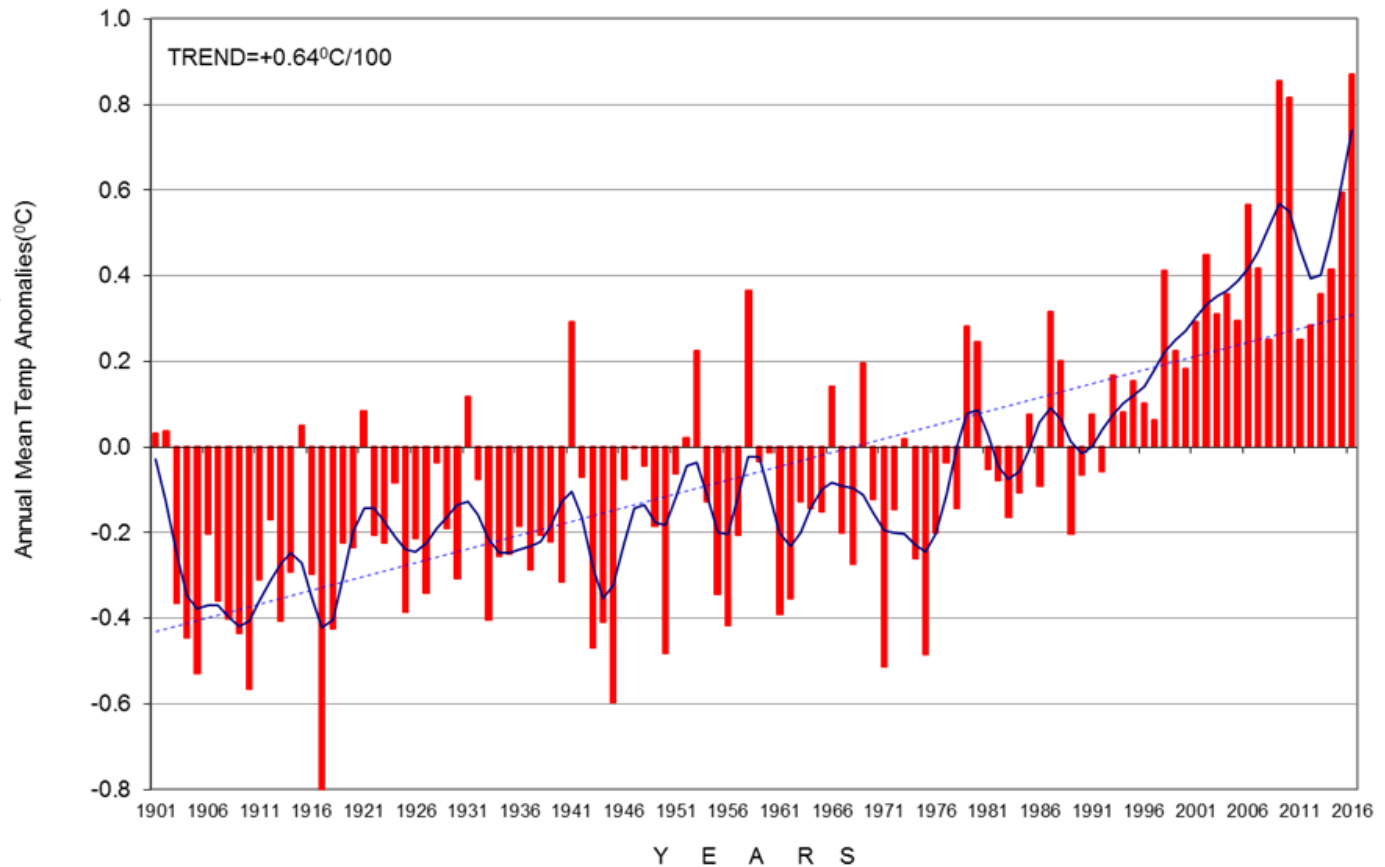
2012

INDIA METEOROLOGICAL DEPARTMENT  
MINISTRY OF EARTH SCIENCES  
GOVERNMENT OF INDIA

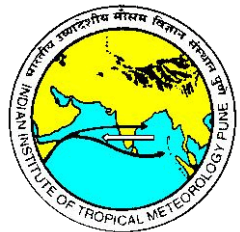


# Climate Data Analysis and Products

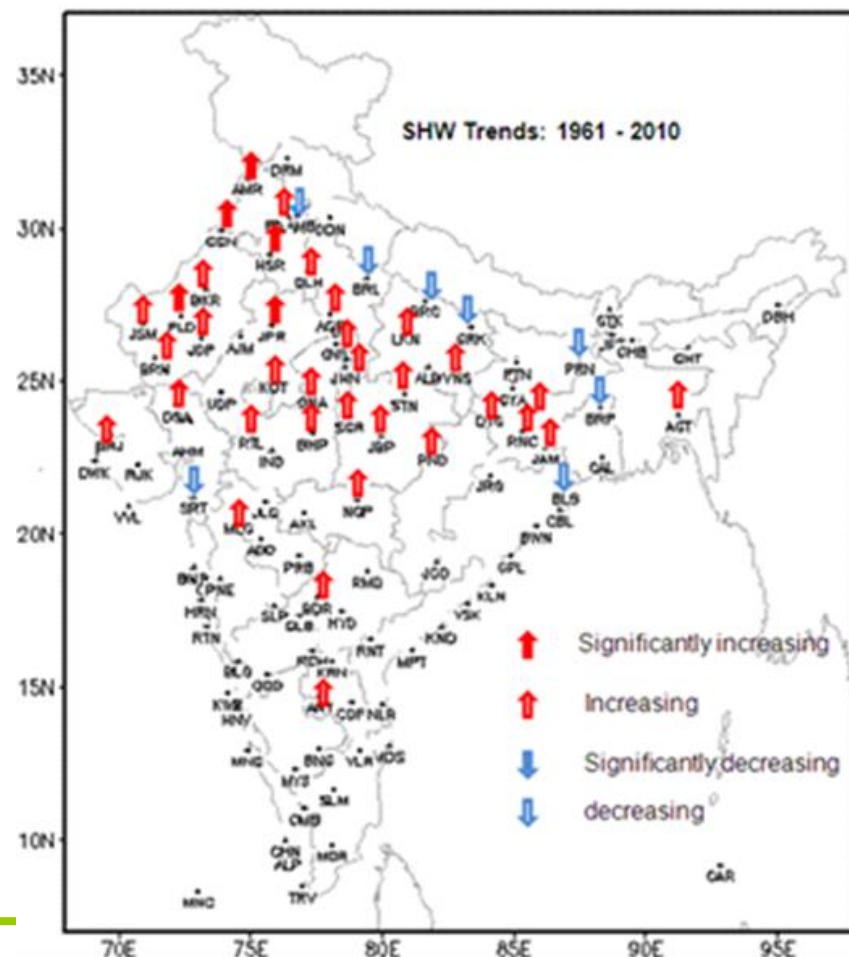
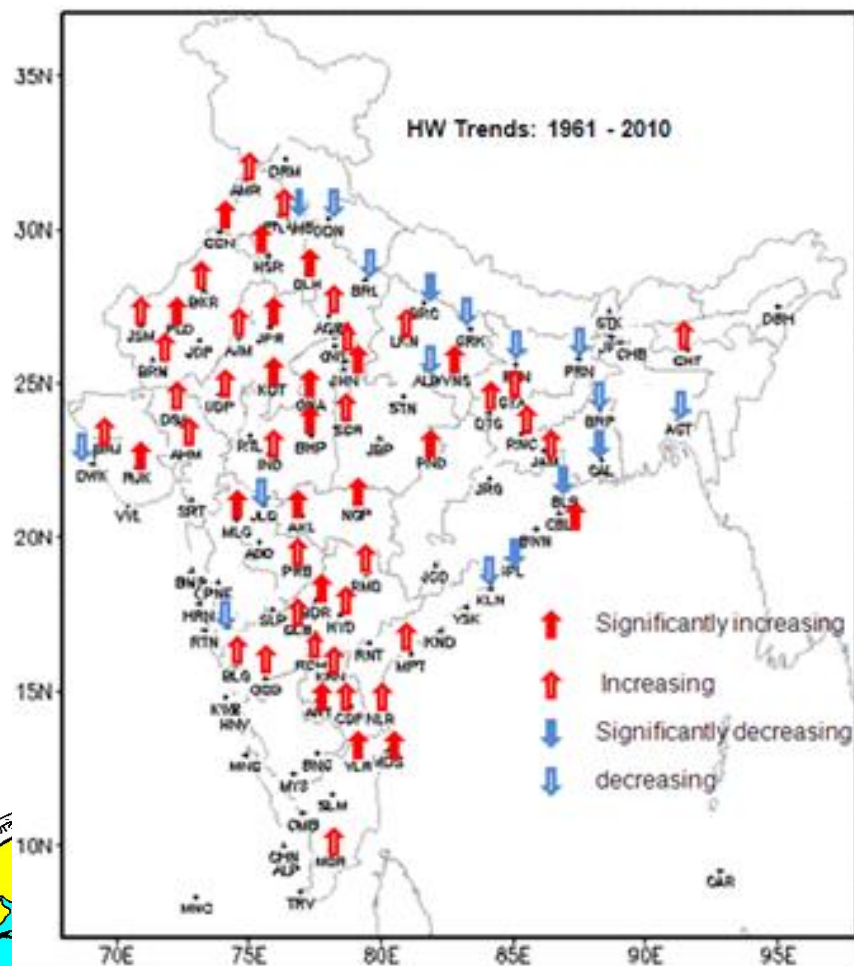
Trend  
 $0.64^{\circ}\text{C}/100\text{yr}$



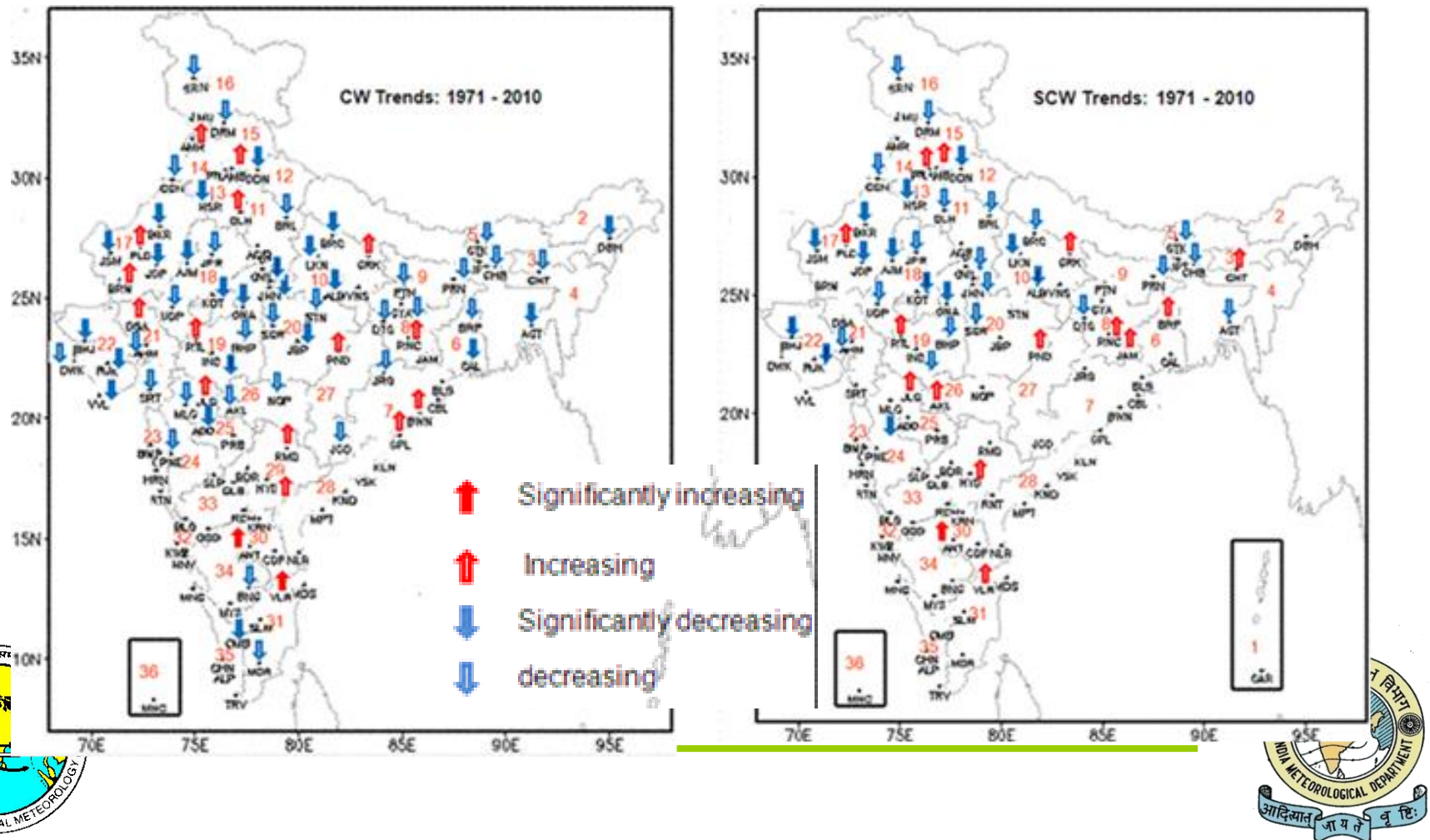
All India annual mean temperature anomaly (1901-2016)



# Long term linear trends in the station wise HW/ SHW days during (Dec to Feb) over the 103 stations (1961 – 2010). (significance level 5%)



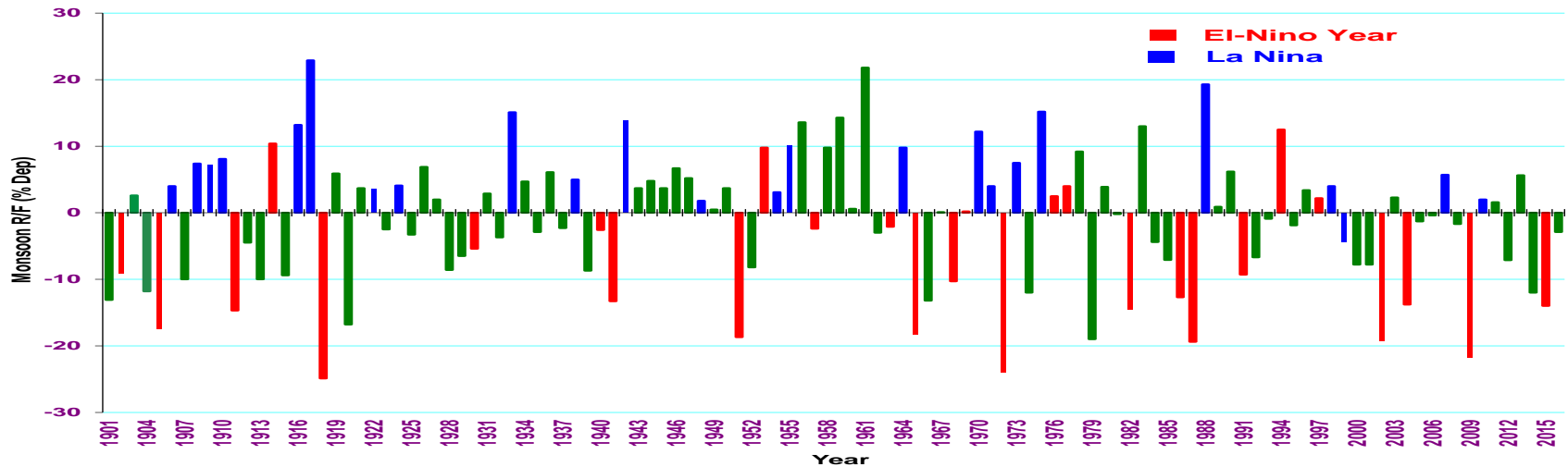
# Long term linear trends in the station wise CW/ SCW days during (Dec to Feb) over the 86 stations (1971 – 2010). (significance level 5%)





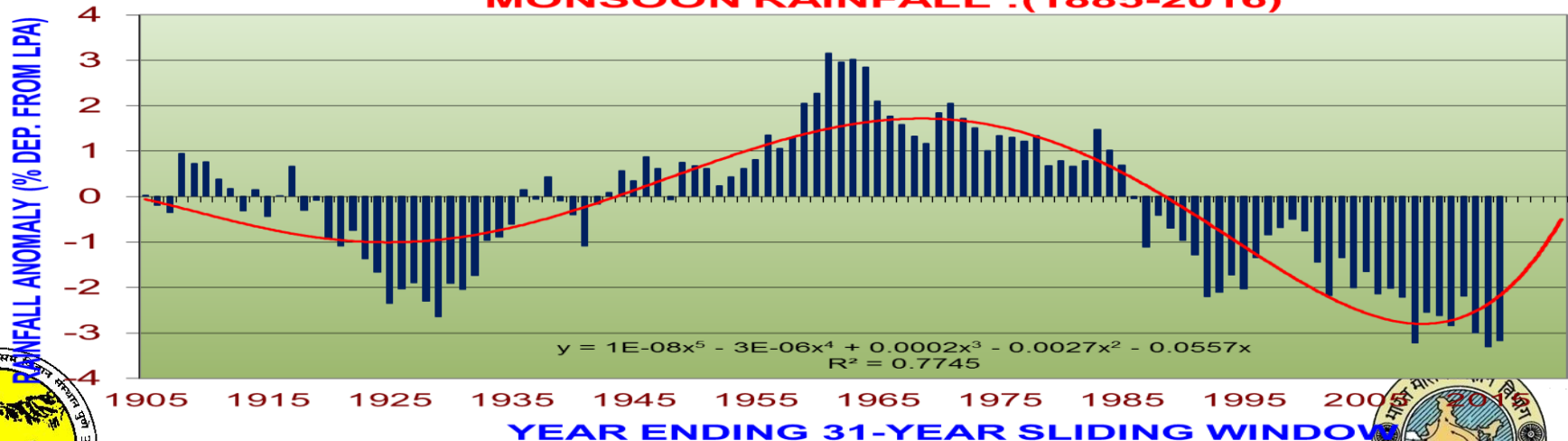
# Climate Data Analysis and Products

All India Monsoon Rainfall ( 1901-2016)

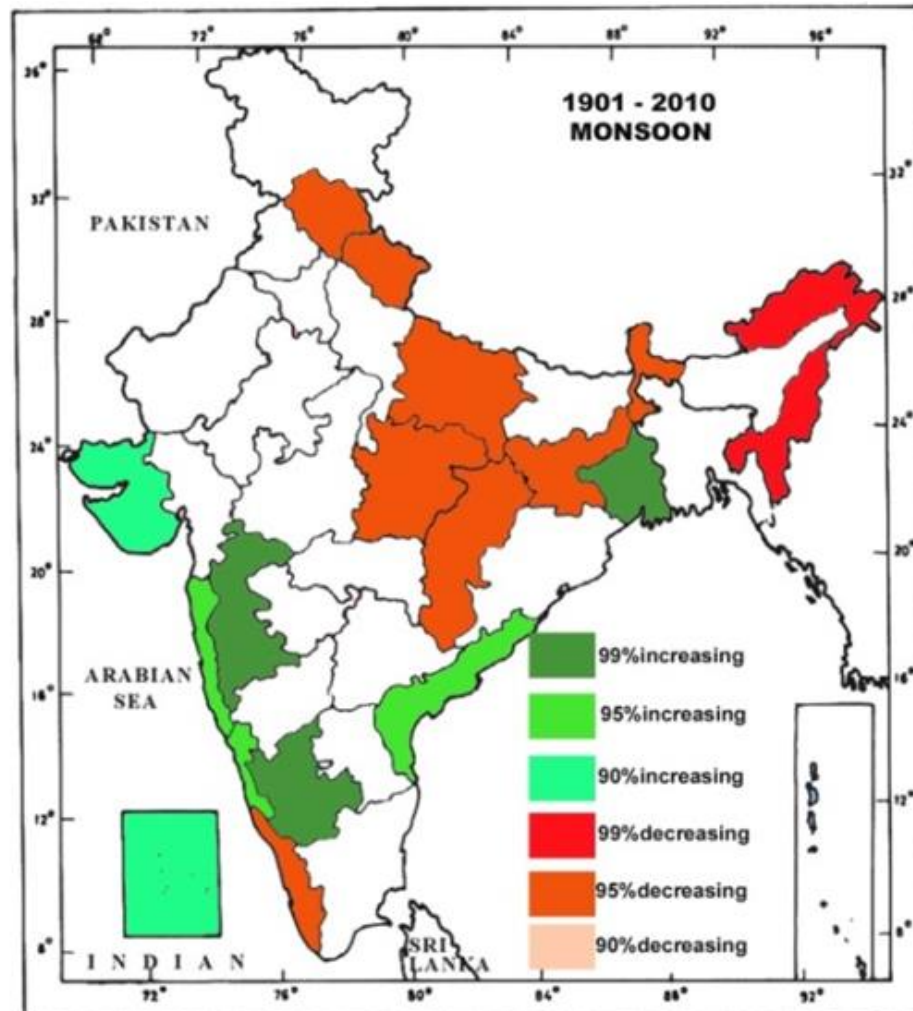


Inter annual variability of all India area weighted seasonal monsoon rainfall

31-YEAR MOVING AVERAGE OF SEASONAL MONSOON RAINFALL :(1885-2016)



# Trends in JJAS rainfall for the 36 meteorological sub-divisions of India for the period 1901-2010



# Climate Forecast Services जलवायु पूर्वानुमान सेवाएं

## दक्षिण एशिया हेतु ऋतु की जलवायु का दृष्टिकोण



- During January 2016, El Niño conditions prevailed over equatorial Pacific Ocean with sea surface temperatures across most of the equatorial Pacific being warmer. The latest coupled model forecast suggests El Niño conditions currently prevailing are likely to become weak during spring.
- The 2016 FMA mean precipitation is likely to be above normal over northeast and central India, parts of north Pakistan, where of Bhutan and northern Myanmar. The mean precipitation is likely to be normal over rest of the countries. The MAM mean precipitation is likely to be above normal over northeast along with central, extreme north and southern India, parts of north Pakistan, Sri Lanka, Nepal and parts of north Myanmar and near normal for rest of the countries.
- The country averaged monthly precipitation is likely to be above normal for Bhutan (all months), Pakistan (for April and May), Myanmar (for March and April, India (for March, April and May), Bangladesh (for February and March), Sri Lanka (for May) and Nepal (for May). Afghanistan is likely to have below normal monthly precipitation for all four months.
- The 2016 FMA mean temperatures are likely to be above normal over all South Asian Countries. The MAM mean temperatures are likely to be nearly similar as that during FMA season.
- The country averaged monthly temperature is likely to be above normal for all South Asian countries for all the months (February, March, April and May).

**DISCLAIMER:**  
(1) The long range forecast presented here are normally expected not to be used for making decisions that have an economic implication.  
(2) The model is only for general circulation and does not take into account climate change.  
(3) The precipitation (in mm) shown in this report are not necessarily compared to the historical (baseline).

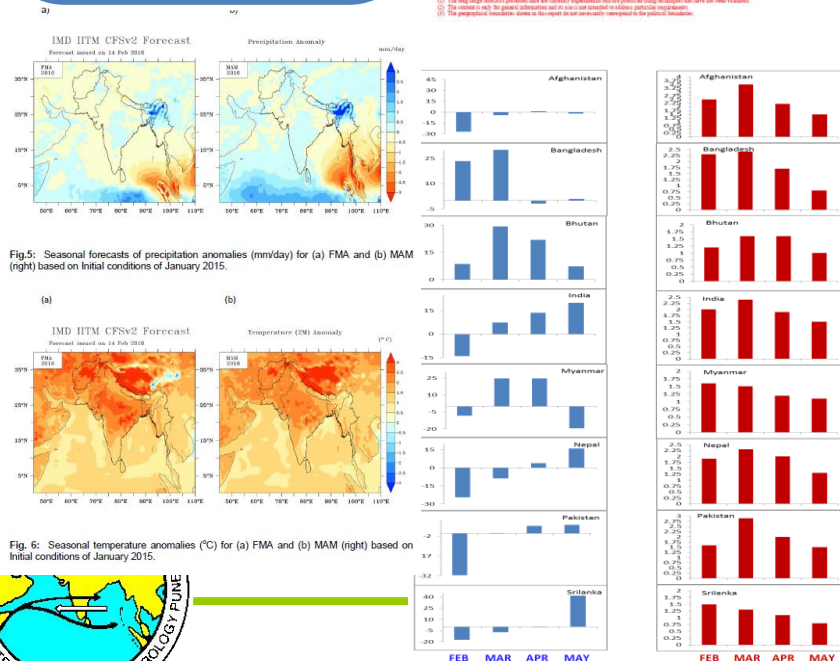


Fig.5: Seasonal forecasts of precipitation anomalies (mm/day) for (a) FMA and (b) MAM (right) based on initial conditions of January 2015.

Fig.6: Seasonal temperature anomalies (°C) for (a) FMA and (b) MAM (right) based on initial conditions of January 2015.



### I. Current Sea Surface Temperature (SST) Conditions over Pacific & Indian Oceans

During January 2016, positive SST anomalies ( $>1^{\circ}\text{C}$ ) were observed along entire equatorial Pacific Ocean, east of  $180^{\circ}$  (Fig.1a). Anomalous  $2^{\circ}\text{C}$  were observed over east equatorial Pacific with warmest anomalies ( $>2^{\circ}\text{C}$ ) observed over western part. Positive SST anomalies ( $>1^{\circ}\text{C}$ ) were also observed (scattered) over southeast Pacific Ocean off the west coast of North America. Cool SST anomalies were observed in the subtropical north and south Pacific. From December to January (Fig.1b) there was SST cooling of the magnitudes  $-0.5^{\circ}\text{C}$  to  $-2^{\circ}\text{C}$  over many parts of equatorial Pacific, northern and southern subtropical Pacific. The warming of SSTs ( $0.5^{\circ}\text{C}$  to  $1^{\circ}\text{C}$ ) was seen over a smaller region south of equatorial Pacific Ocean off western coast of South America.

During January 2016, warm SST anomalies of  $0.5^{\circ}\text{C}$  were observed over most parts of Indian Ocean (Fig.1) with anomalies  $2^{\circ}\text{C}$  observed over south Arabian Sea, Bay of Bengal off eastern coast of India and parts of equatorial and subtropical south Indian Ocean. However, slight positive anomalies which were observed over parts of East Indian Ocean close to maritime continent continue to be warm in January also. During the last two months, cooling of SSTs ( $-0.5^{\circ}\text{C}$ ) was observed over many areas of Arabian Sea, Bay of Bengal, West and East Indian Ocean over maritime continent and subtropical south Indian Ocean (Fig.1b). Warming in the Aphasia region (East coast of southern Africa) continues but in Ningaloo region (west coast of Australia) warm SST anomalies have been replaced by cool SST anomalies.

### 1.1. El Niño Southern Oscillation (ENSO) conditions over the Pacific Ocean

The monthly time series of Niño 3.4 SST anomalies for the last 12 months (Fig.2a) suggest that the strong El Niño conditions ( $>1^{\circ}\text{C}$ ) that prevailed since July are continuing. However, the El Niño conditions are peaking during December but weakening in January. Associated with this, warm subsurface anomalies (Fig.2b) were observed in the eastern tropical Pacific east of date line and cool subsurface anomalies were observed in the western Pacific, overlying the date line towards west.

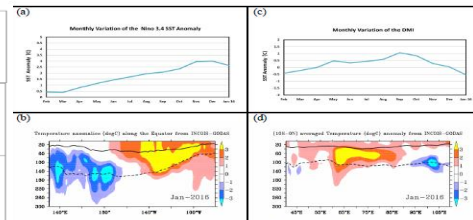


Fig.2: (a) Monthly variation of Niño 3.4 SST anomaly for the last 12 months and (b) equatorial depth-section of ocean temperature anomalies in the equatorial (5°S-5°N) Pacific Ocean for the month of January 2016. (c) Same as (a) but for Dipole Mode Index (DMI), and (d) same as (b) but for the tropical Indian Ocean (10°S-10°N). The anomalies were computed based on the 1981-2010 periods. The solid dark line is the  $^{\circ}\text{C}$  isotherm and the dashed line is thermocline depth. Data Source: INCOIS-GODAS.

### II. FMA SST Anomaly Forecast : January 2016 IC

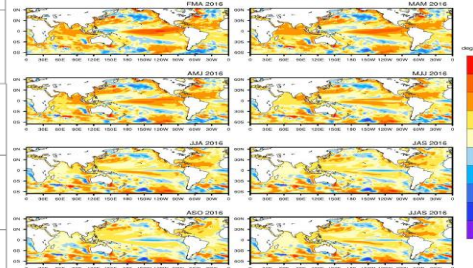


Fig.3: Forecasted Seasonal mean SST anomalies for 3 monthly seasons (a) February through April (FMA), (b) May through July (MAM), (c) August through October (ASO), and (d) November through January (JJA).

## ENSO तथा IOD पूर्वानुमान बुलेटिन (प्रति माह)

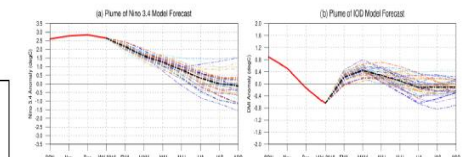


Fig.4: Plume of (a) Niño 3.4 SST anomalies, (b) Indian Ocean Dipole Mode Index forecasted by high resolution CFSv2. The forecasts were performed for bias and variance. The solid line is the observed SST anomaly (NCEP) and dashed black line is the ensemble SST anomaly forecast mean of 39 members (CFSv2). The individual ensemble member forecasts are shown in light dotted lines of different colors.

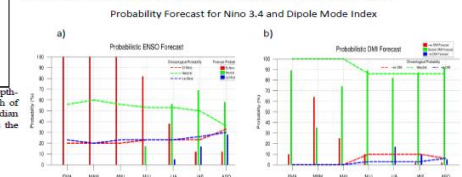


Fig.5: Probability forecast along with climatological probability of (a) Niño 3.4 and (b) Indian Ocean Dipole Mode Index from high resolution CFSv2.

The probability forecast suggests that El Niño conditions will persist till MJJ and then turn to neutral during JJA and will continue to be neutral during the remaining period. However El Niño conditions will become moderate during MJJ. During JJA, there is stronger probability for weak El Niño conditions. And later during JAS and ASO season, the probability of neutral condition increases and reaches maximum. Thus, the forecast indicates strong El Niño conditions which persisted during the winter, further decay to moderate/weak El Niño conditions during spring and almost neutral in the coming summer season.

The DMI probability forecast shows negative IOD mode conditions to remain neutral during most of the forecast period except during MAM when it is likely to be positive temporarily. The forecast indicates strong probability for IOD to be neutral during the monsoon season.

Prepared by ESSO-ITM and ESSO-IMD with inputs from ESSO-INCOIS and ESSO-NCMIRW.





# Seasonal Climate Outlook for South Asia



Earth System Science Organization (ESSO)  
Ministry of Earth Sciences (MoES)  
India Meteorological Department  
WMO Regional Climate Centre  
(Demonstration Phase)  
Pune, India  
**SEASONAL CLIMATE OUTLOOK FOR SOUTH ASIA**  
(September to December 2018)

- Currently, ENSO neutral conditions are prevailing over equatorial Pacific Ocean and the latest MMCFS forecast indicates that there is possibility of development of weak El Niño conditions during OND season or thereafter.
- The spatial pattern of forecasted precipitation anomalies using August initial conditions for SON indicates positive precipitation anomalies are likely over parts east and northeast India, Nepal, Bhutan, Bangladesh and Myanmar and whole of Sri Lanka and negative precipitation anomalies are likely over rest of the South Asian region. Forecast for OND season suggests positive precipitation anomalies are likely over parts of north Pakistan, parts of central to north India and east India, Nepal, Bhutan and Myanmar and negative precipitation anomalies are likely over rest of the South Asian region.
- In general, the country averaged monthly precipitation is likely to be normal to above normal for Afghanistan, Bangladesh, Bhutan, Myanmar and Sri Lanka and it is likely to be normal to below normal for India, Nepal and Pakistan during September to October. However, the country averaged monthly precipitation is likely to be normal to above normal for Bhutan, India, Nepal and Pakistan and it is likely to be normal to below normal for Afghanistan, Myanmar and Sri Lanka November to December except Bangladesh where it is likely to be below normal during November and above normal during December.
- Temperature anomaly forecast for SON and OND 2018 seasons indicates positive temperature anomalies are likely over most parts of South Asia for both the seasons.
- The country averaged monthly mean temperature anomaly forecast indicates normal to above normal temperatures are likely during most of the forecasted months for all South Asian countries from September to December.

## MMCFS Precipitation Anomaly Forecast

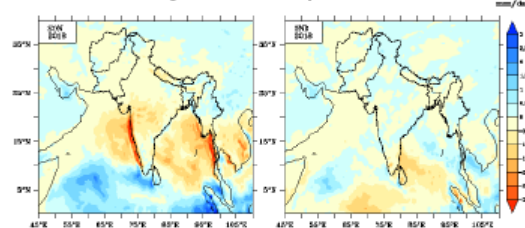


Fig.5: Seasonal forecasts of precipitation anomalies (mm/day) for (a) SON (left) and (b) OND (right) based on initial conditions of August 2018.

## MMCFS Temperature Anomaly Forecast

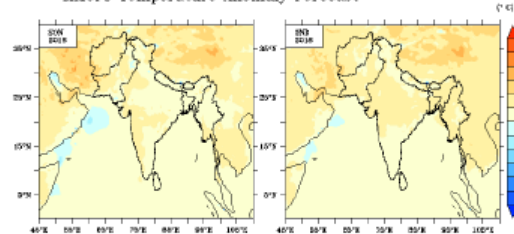


Fig. 6: Seasonal mean temperature anomalies (°C) for (a) SON (left) and (b) OND (right) based on initial conditions of August 2018.

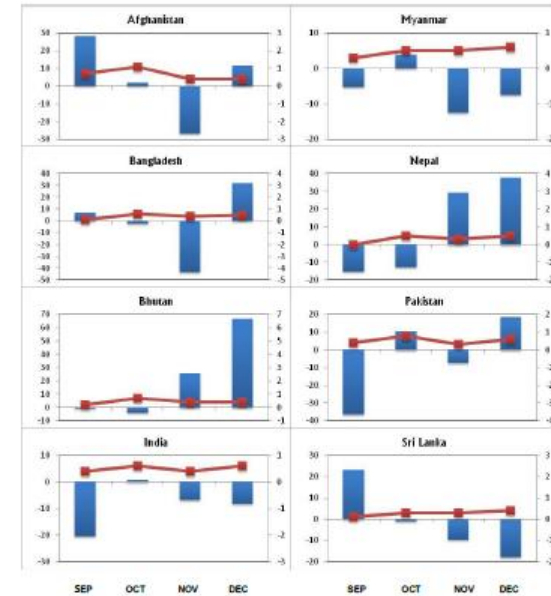


Fig.7: Monthly country averaged rainfall forecast expressed as percentage departures (%) during September to December, 2018. (The normal range for country averaged monthly precipitation is taken as -10% to +10%). (Left Vertical Axis Scale)

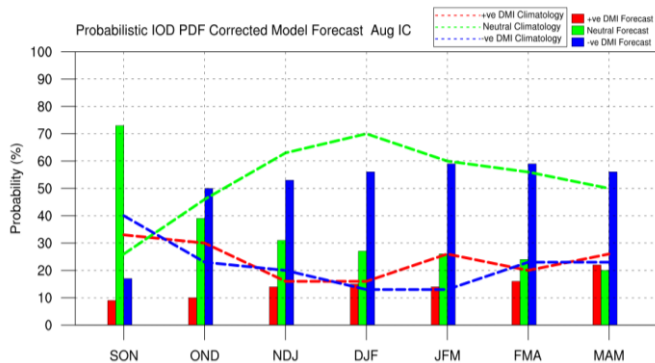
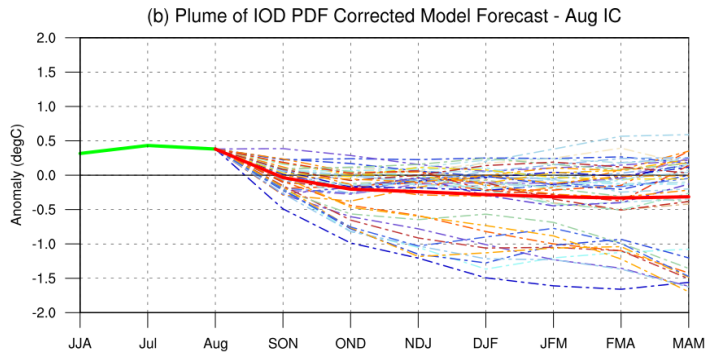
Fig.8: Monthly country averaged temperature anomaly (°C) forecast during September to December, 2018. (The normal range for country averaged monthly temperature is taken as -0.25°C to +0.25°C). (Right Vertical Axis Scale)



11/30/2018

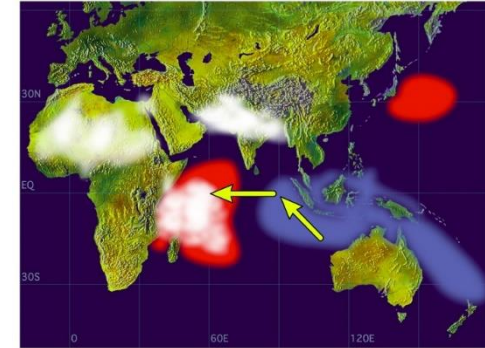


# Indian Ocean Dipole: IMD-IITM CFS

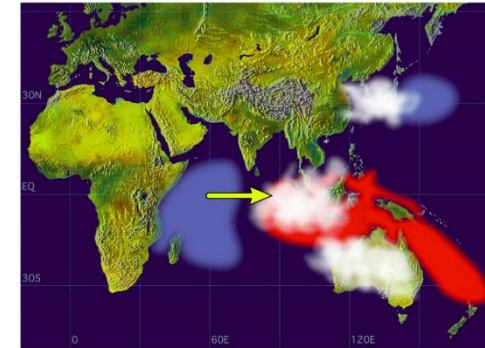


**IOD forecast: The current neutral conditions are likely to turn to negative IOD conditions during the later part of the year.**

Positive Dipole Mode

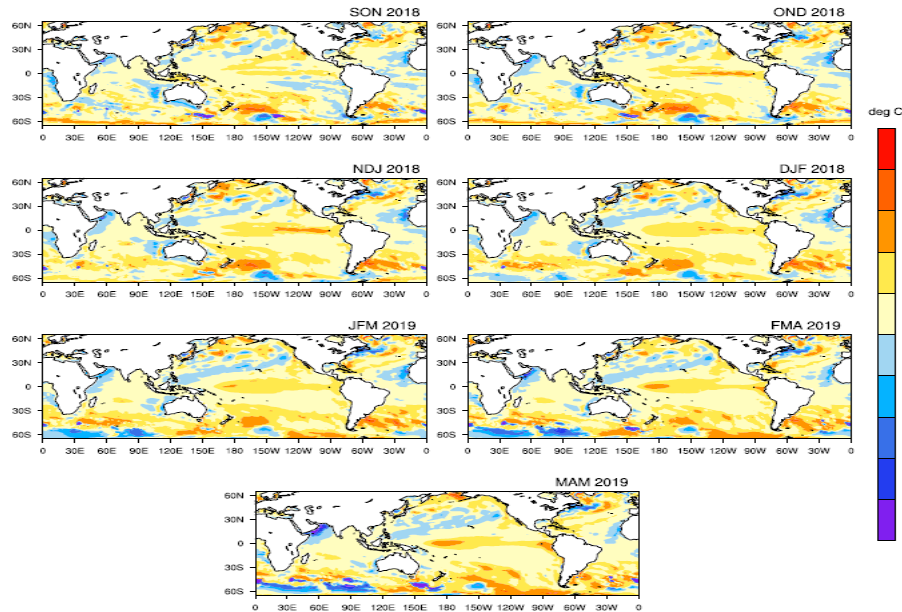


Negative Dipole Mode



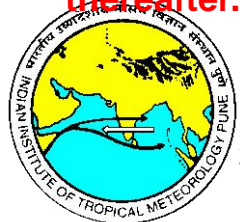
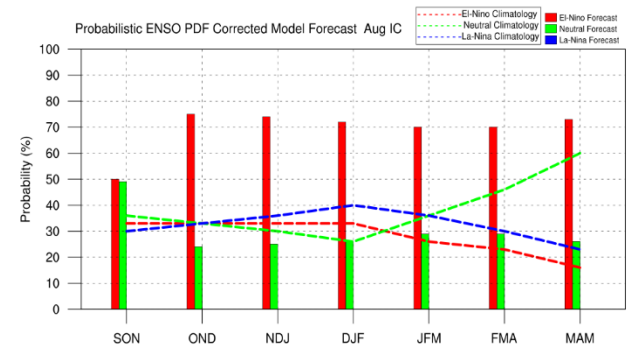
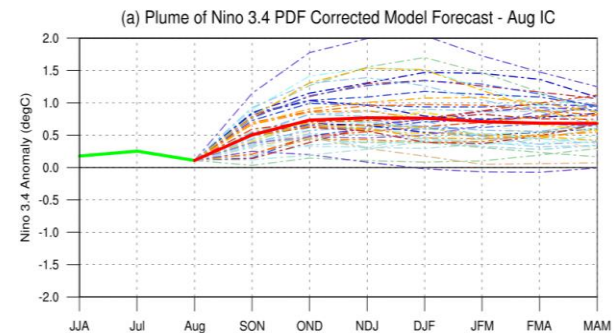
# ENSO Forecast - MMCFS: August IC

MMCFS SST Anomaly Forecast : Aug 2018 IC



Currently, ENSO neutral conditions are prevailing over equatorial Pacific Ocean and the latest MMCFS forecast indicates there is possibility of development of weak El Niño conditions during OND season or thereafter.

Plume of Nino 3.4 PDF Corrected Model Forecast – Mar IC



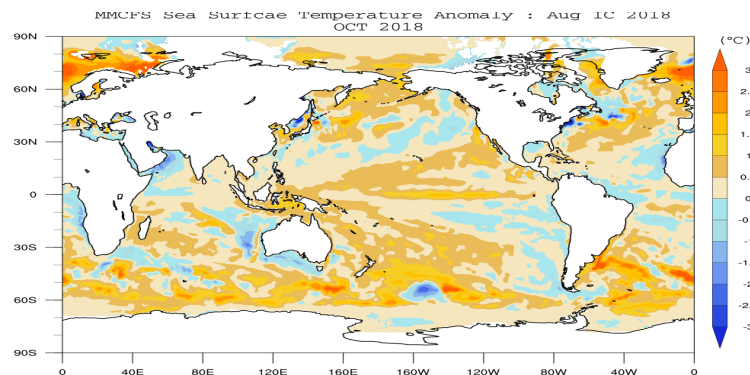
30-Nov-18



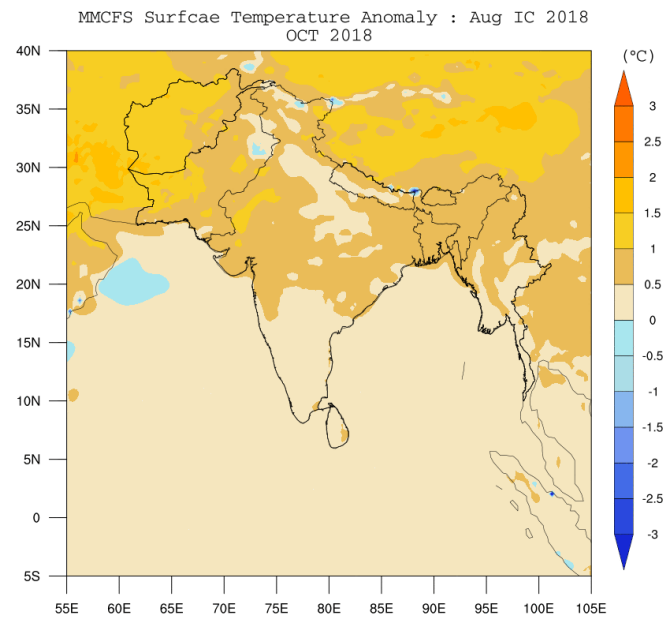


# Products based on CFS: LRF Maps

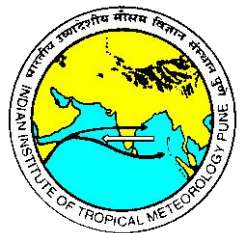
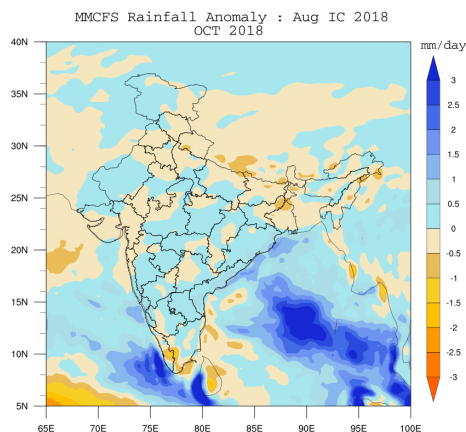
## Global SST Ano. Forecast



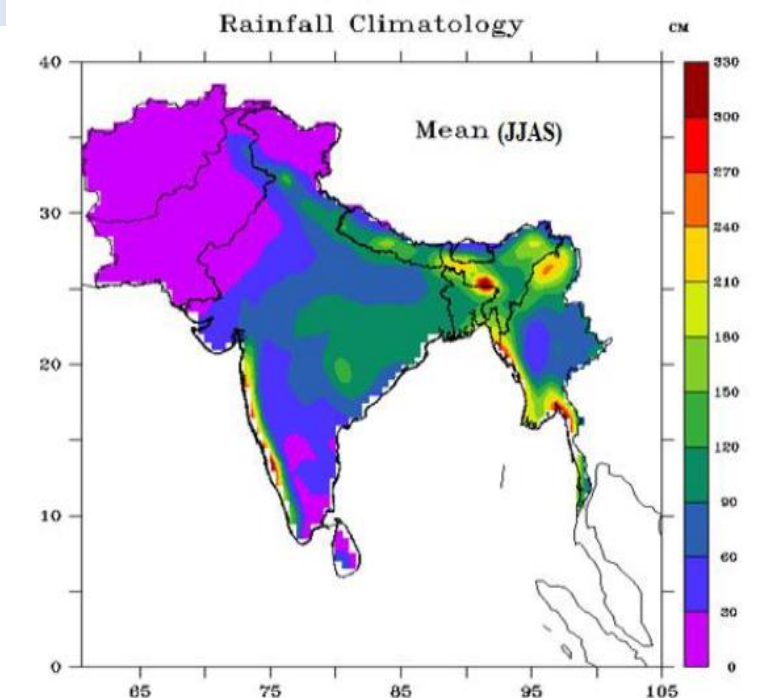
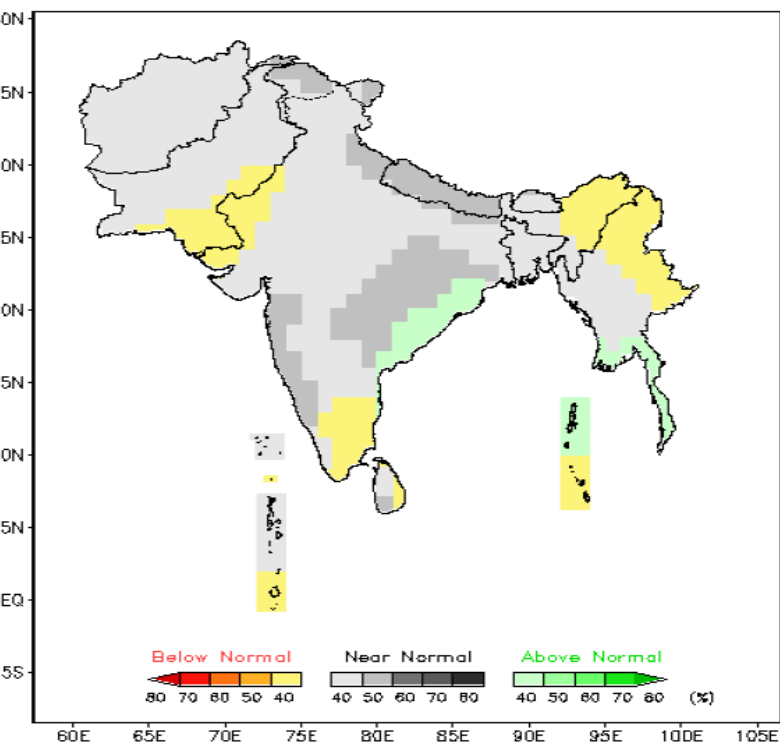
## South Asia 2m Temp. Ano. Forecast



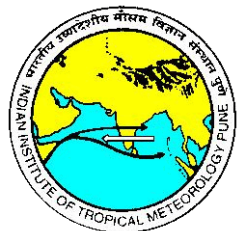
## India Rainfall Ano. Forecast



# SASCOF-12 Consensus forecast of 2018 SW Monsoon Rainfall over South Asia (issued in April every year)

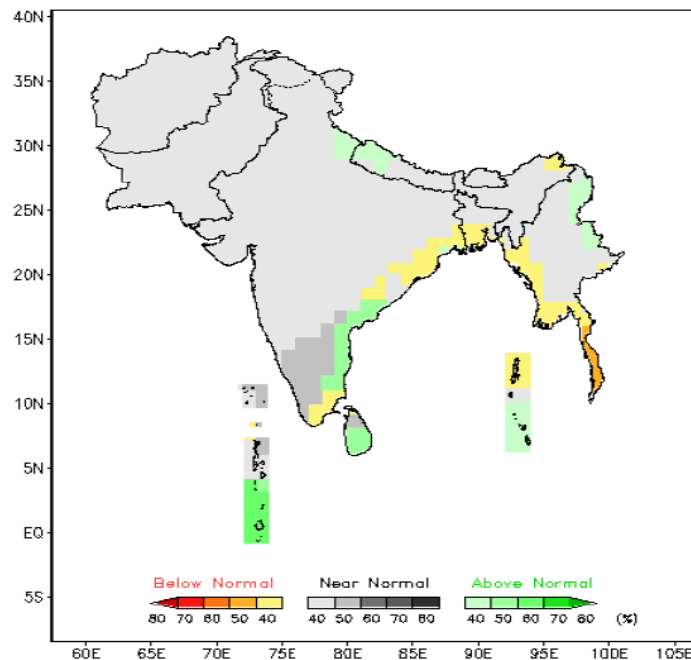


Normal rainfall is most likely during the 2018 southwest monsoon season (June –September) over most parts of South Asia. However, above normal rainfall is likely over some areas of east central India and southeastern parts of the region. Below- normal rainfall is likely over some areas of southern, northwestern and North Eastern parts of South Asia



# Consensus Forecast Map: 2018 Northeast Monsoon Season (OND)

## OND Precipitation



- Some part of Southeast Peninsular India, most parts of Sri Lanka, southern parts of Maldives and some areas of northeastern part of the South Asia region are likely to receive above normal rainfall during the 2018 OND season. Below normal is most likely over southeastern part of the region, along the coastal areas adjacent to the north Bay of Bengal and southeastern most areas of Peninsular India. Normal rainfall is most likely over remaining areas of the region including northwest and central areas that generally receive very little rain during the season.
- **Normal to slightly above normal temperatures are likely during the 2018 OND season over most part of the region.**



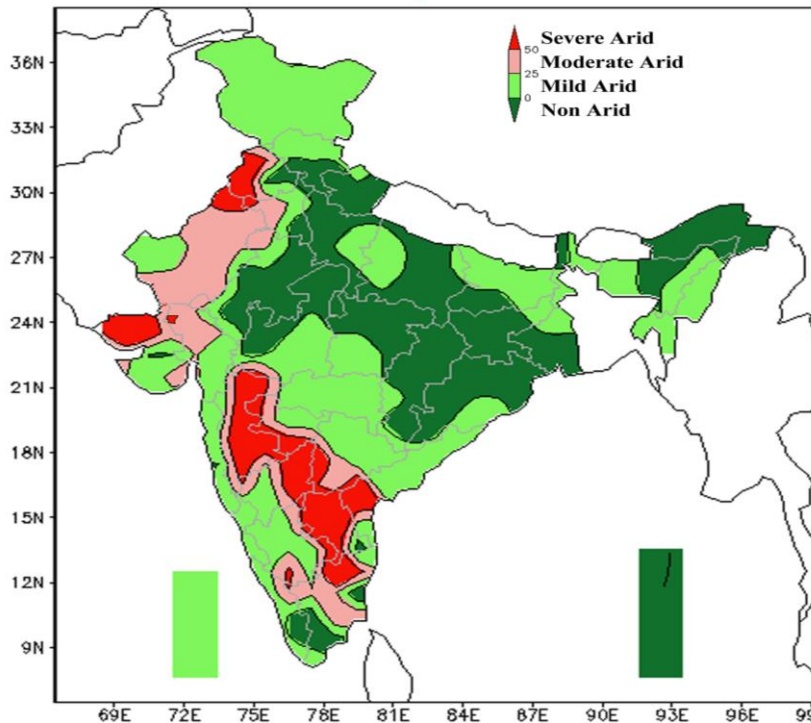
# Hydrological Services



# Drought monitoring activities

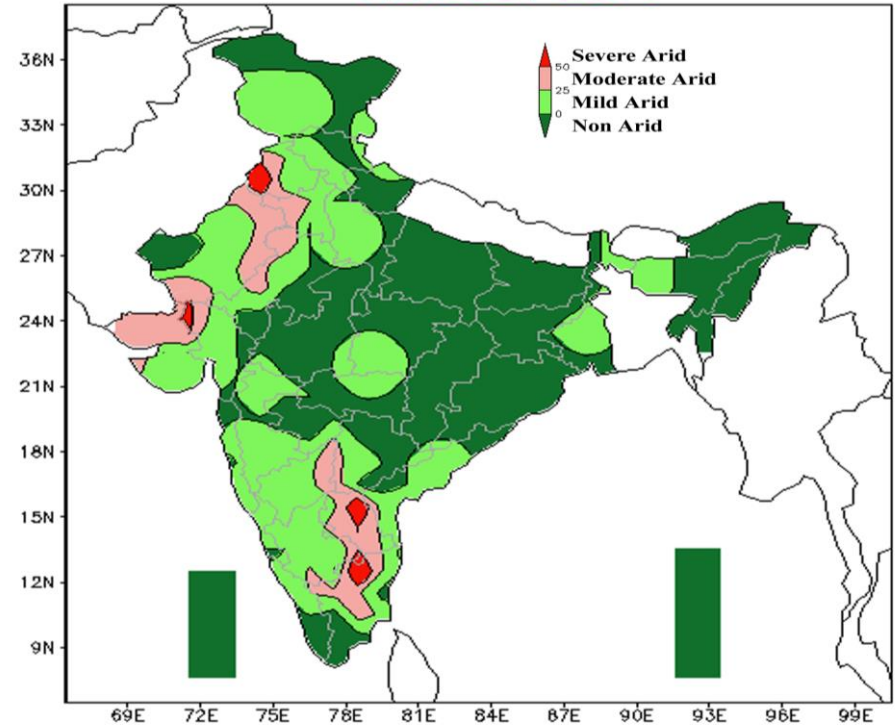
INDIA METEOROLOGICAL DEPARTMENT  
WEEKLY ARIDITY ANOMALY MAP

03-09 Sept. 2018



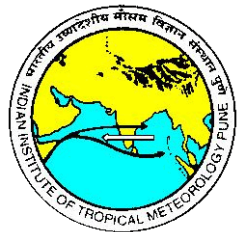
INDIA METEOROLOGICAL DEPARTMENT  
MONTHLY ARIDITY ANOMALY MAP

AUGUST 2018



**Aridity Anomaly Index : Started in the year 1967 at IMD Pune.**

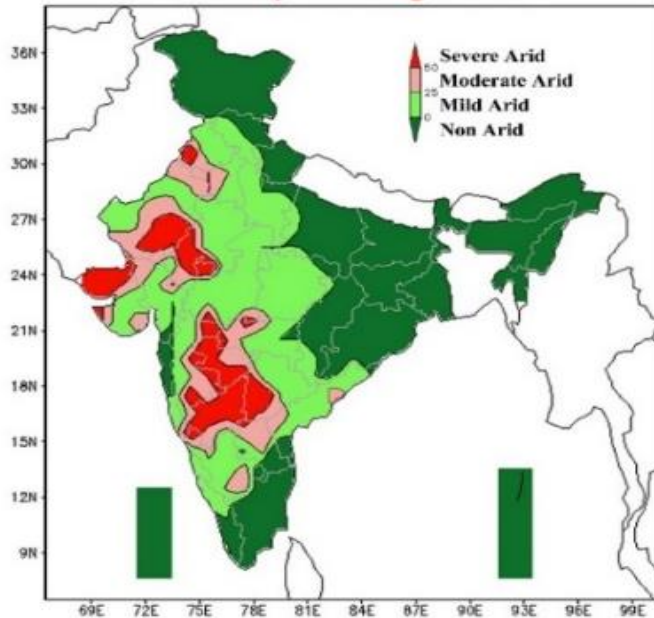
**It is very important index for monitoring agricultural drought. Monitored in Weekly and monthly scale.**





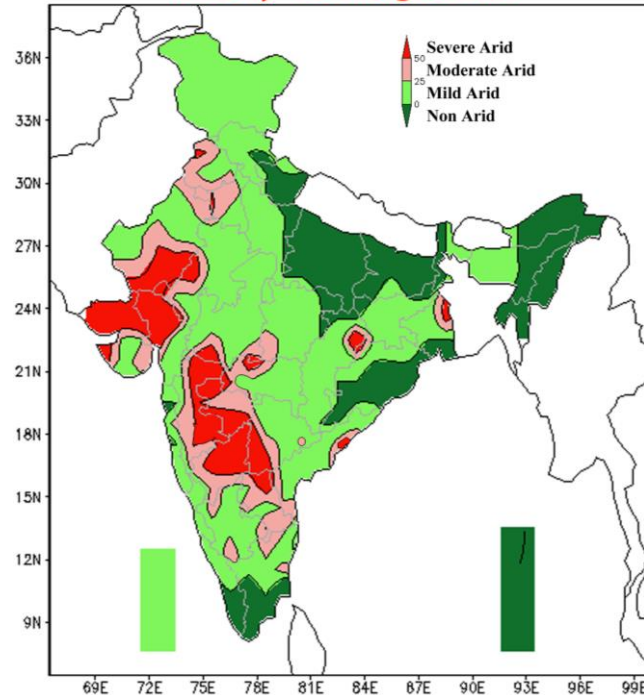
# Drought monitoring activities

INDIA METEOROLOGICAL DEPARTMENT  
ARIDITY ANOMALY OUTLOOK MAP  
30 July- 05 Aug. 2018



OUTLOOK

INDIA METEOROLOGICAL DEPARTMENT  
WEEKLY ARIDITY ANOMALY MAP  
30 July- 05 Aug. 2018



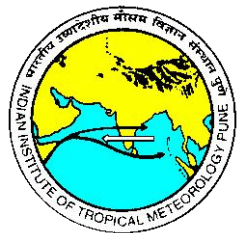
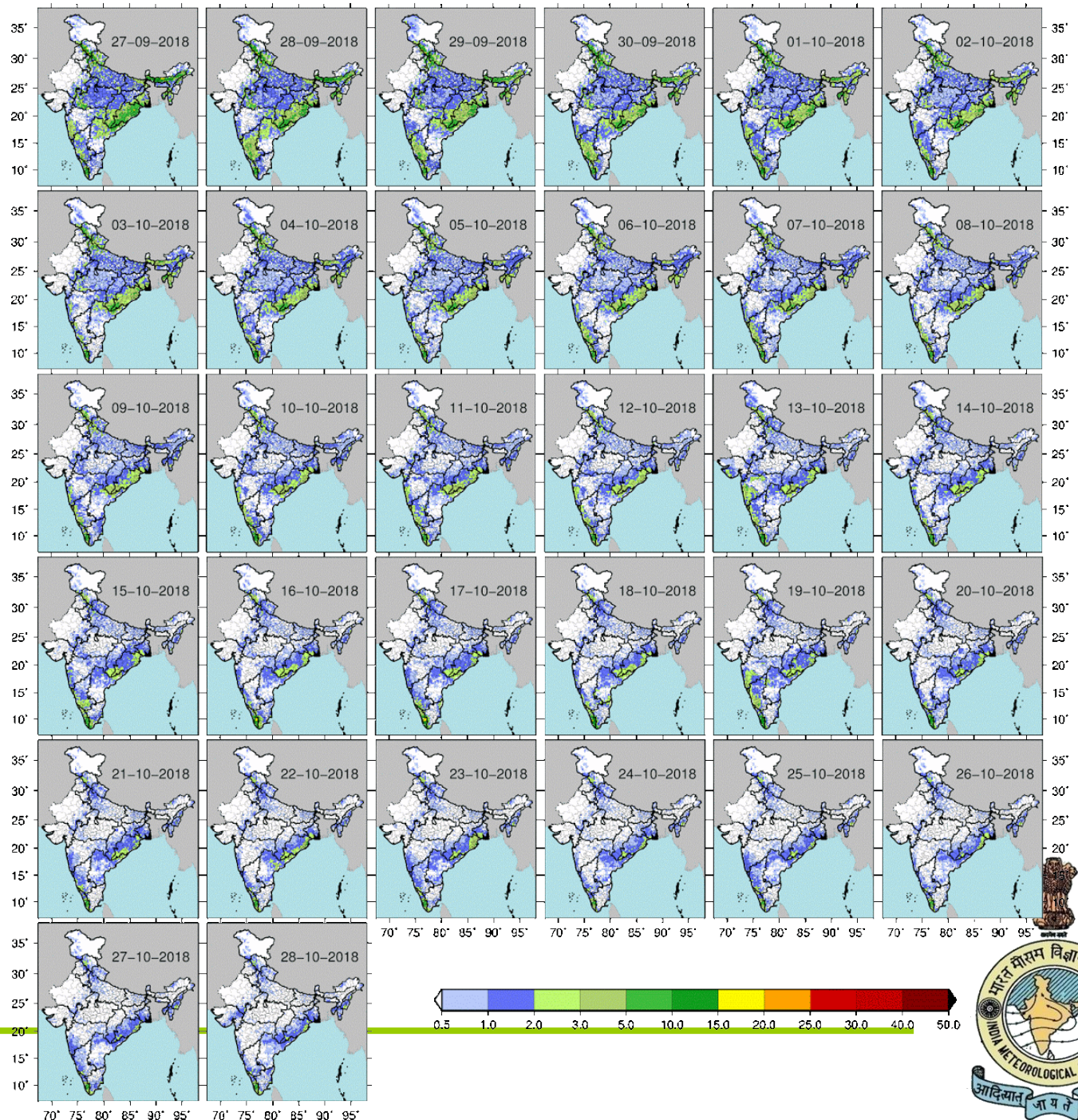
ACTUAL

Also  
generating  
weekly  
outlook  
aridity  
anomaly  
outlook map  
based on  
GFS weekly  
rainfall  
forecast



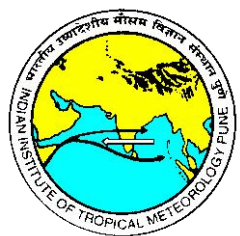
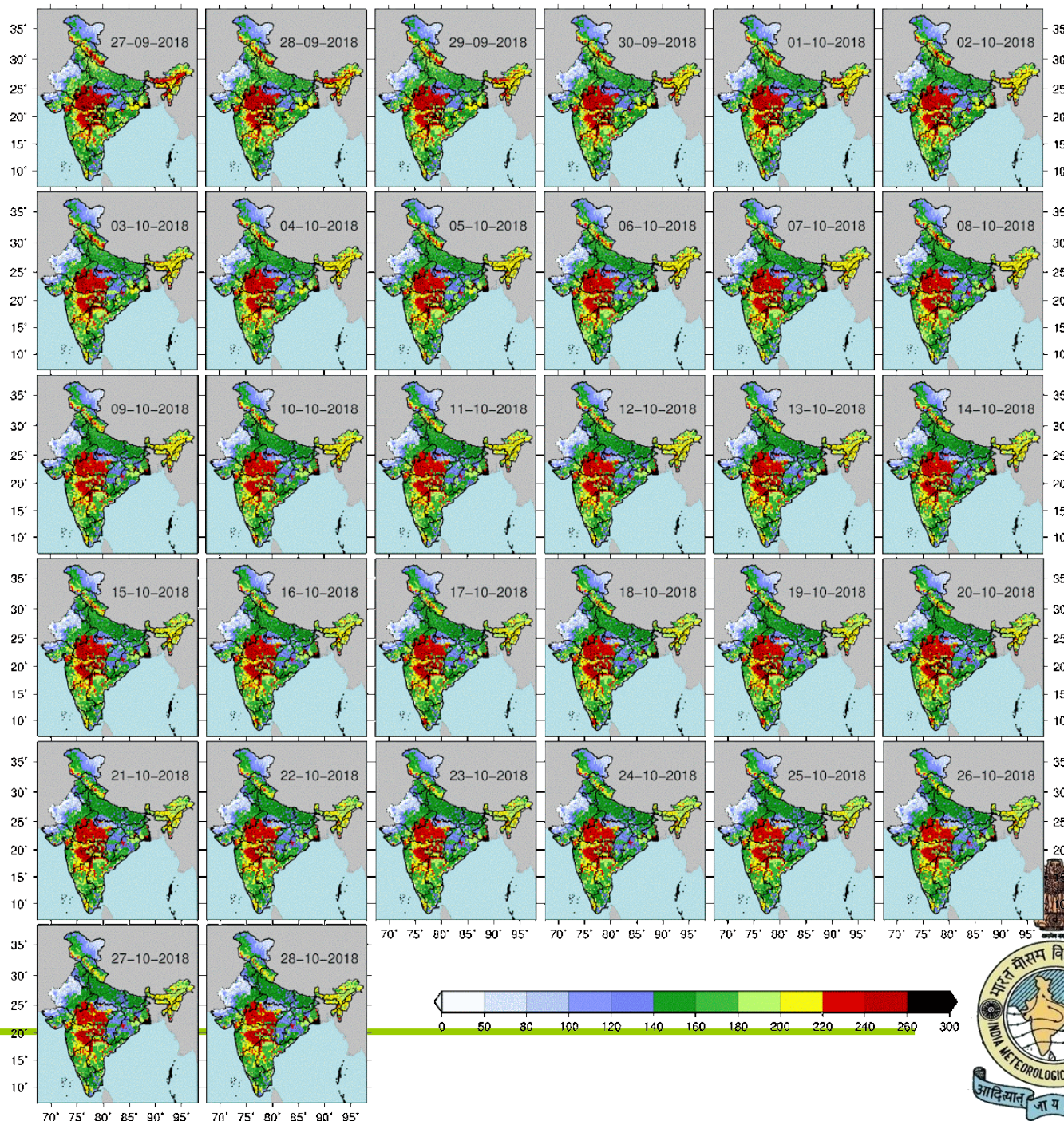


# Daily forecasted Runoff IC 26Sep2018





# Daily forecasted Soil moisture IC 26Sep2018

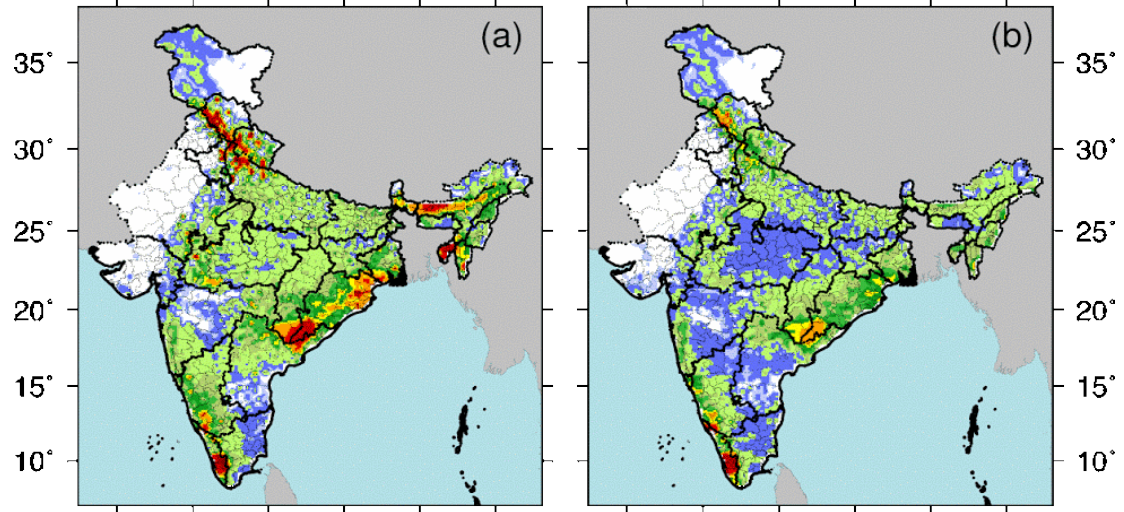




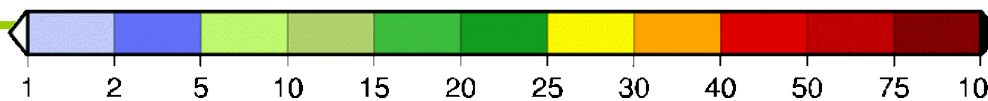
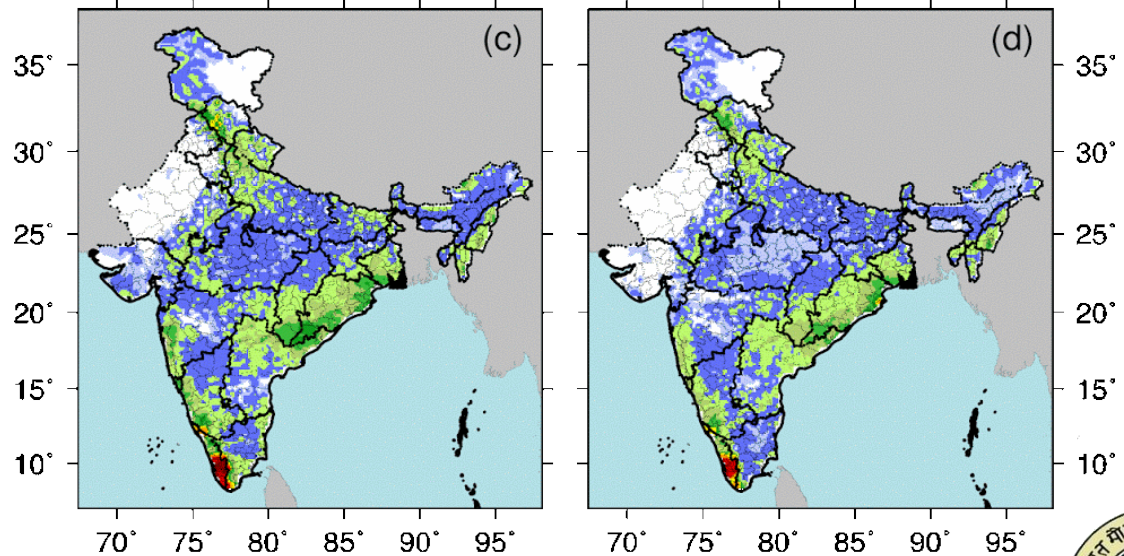
# Weekly Runoff (mm)

**Weekly  
forecasted  
runoff  
IC 26Sep2018**

Week 1, 28.09.2018–04.10.2018 Week 2, 05.10.2018–11.10.2018



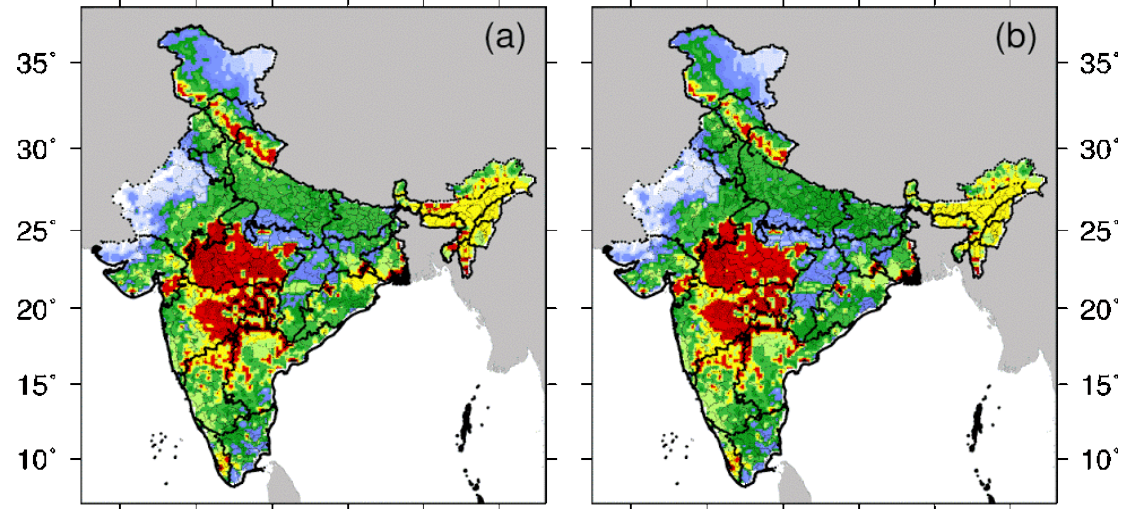
Week 3, 12.10.2018–18.10.2018 Week 4, 19.10.2018–25.10.2018



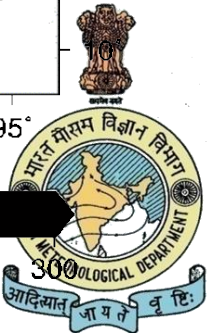
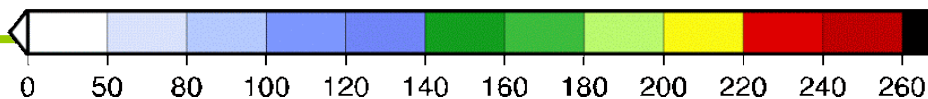
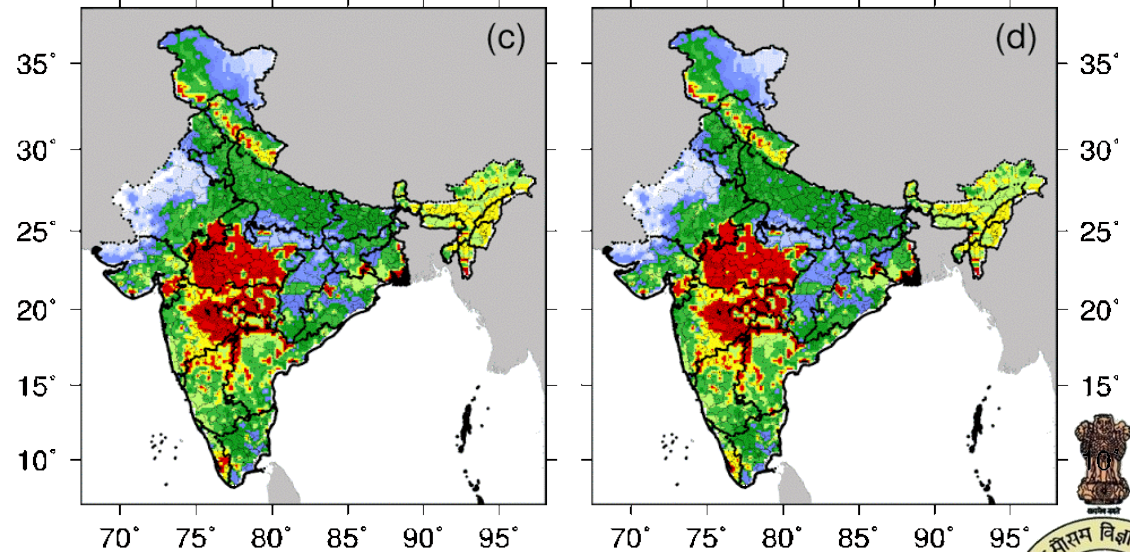
# Weekly soil moisture (mm)

## Weekly forecasted soil moisture IC 26Sep2018

Week 1, 28.09.2018–04.10.2018 Week 2, 05.10.2018–11.10.2018



Week 3, 12.10.2018–18.10.2018 Week 4, 19.10.2018–25.10.2018

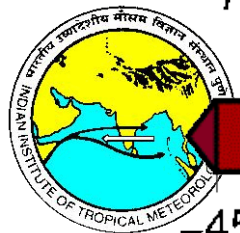
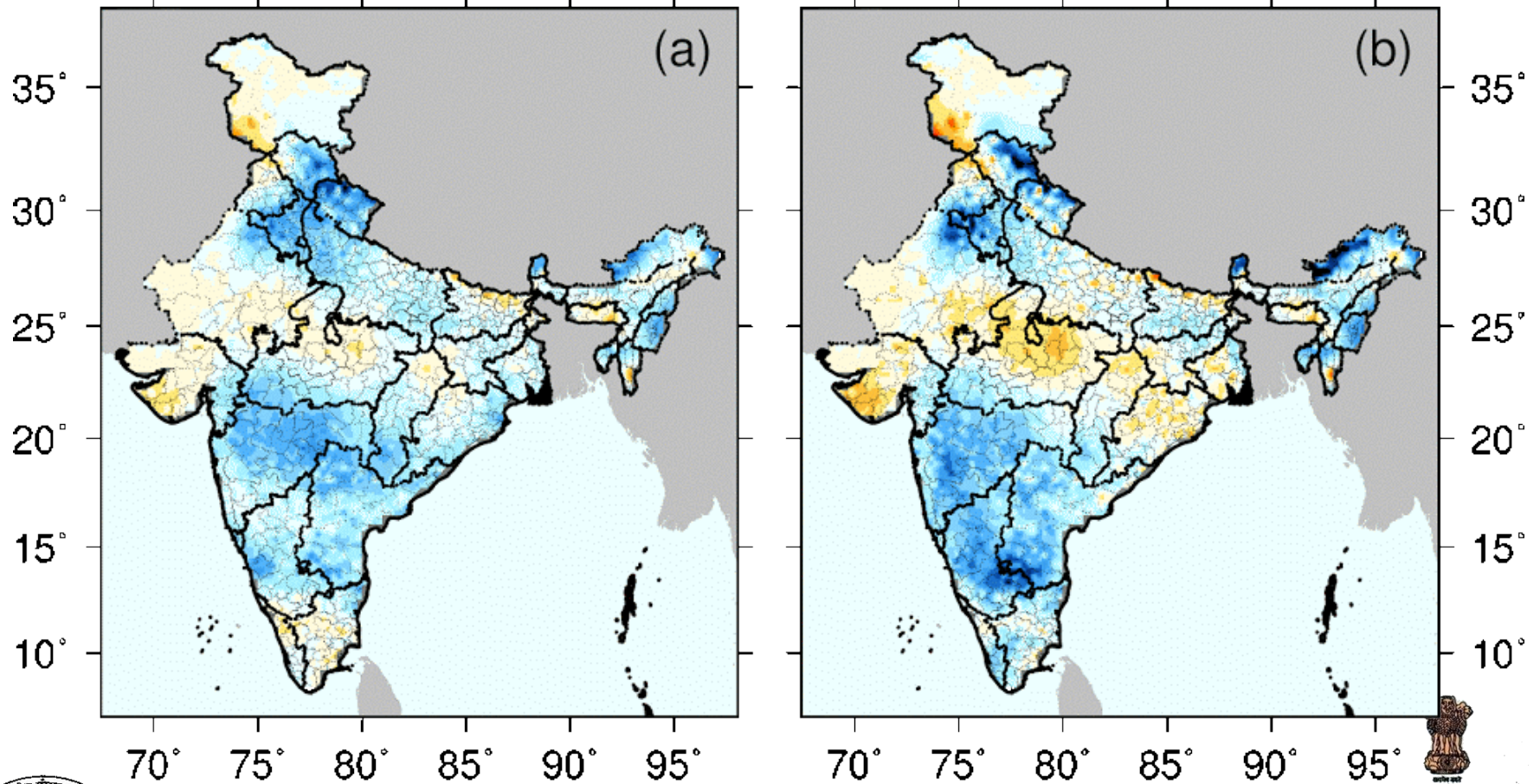




# Anticipated weekly soil moisture change (mm)

w.r.t. previous week, 14.10.2018–20.10.2018

Week 1, 21.09.2018–27.09.2018    Week 2, 28.09.2018–04.10.2018



# Service to Agriculture Sector





# Why do farmers need climate services

## Ready!

### Seasonal

- Select cultivars
- Purchase appropriate seeds
- Choose alternative livelihoods
- Sensitize Community

## Farmer Early Actions Across Time Scales

## Set !

### Sub-seasonal

- Anticipate wet/dry spells variations in temperature
- Manage risk in harvest operations
- Plant/clear fields
- Warn community on hazards

## Go!

### Short range

- Determine right harvest time
- Decide timing of pesticide/fertilizers application
- Evade crop losses
- Evacuate community
- 

**Access to relevant climate information can empower farmers to anticipate and confront climate related risks and opportunities**



# **National Agromet Advisory Service Bulletin**

## **Based on**

## **Extended Range Weather Forecast**

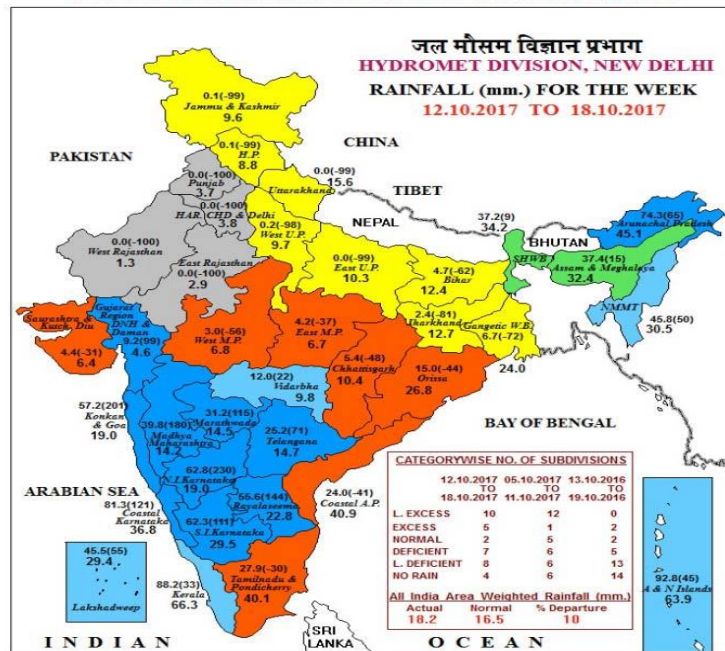
Validity – 27 October – 9 November 2017  
Date of issue : 27 October



# REALIZED RAINFALL

12<sup>TH</sup> TO 18<sup>TH</sup> OCTOBER, 2017

भारत मौसम विज्ञान विभाग  
INDIA METEOROLOGICAL DEPARTMENT

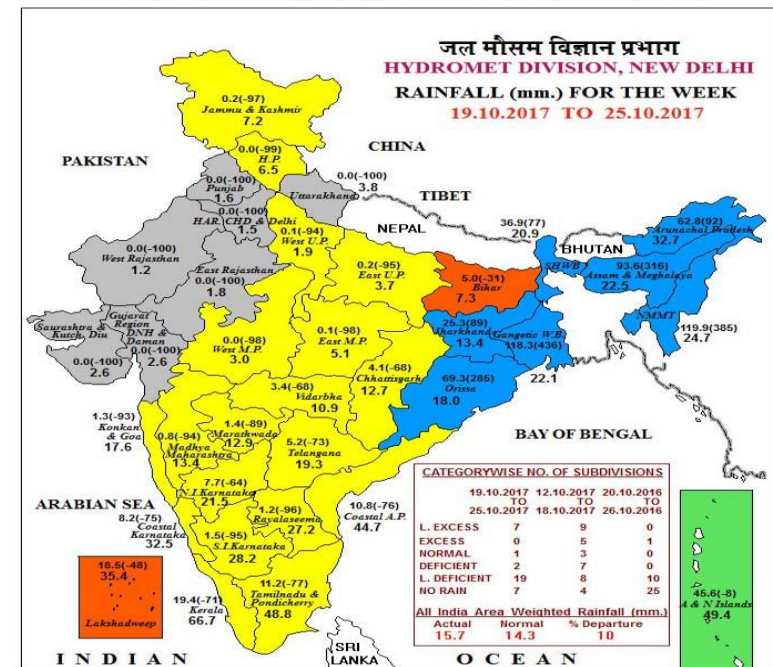


LEGEND: ■ L. EXCESS (+60% OR MORE) ■ EXCESS (+20% TO +59%) ■ NORMAL (+19% TO -19%)  
■ DEFICIENT (-20% TO -59%) ■ L. DEFICIENT (-60% TO -99%) ■ NO RAIN [-100%] ■ NO DATA

NOTES:  
[a] Rainfall figures are based on operational data.  
[b] Small figures indicate actual rainfall (mm.), while bold figures indicate Normal rainfall (mm.).  
Percentage Departures of Rainfall are shown in Brackets.

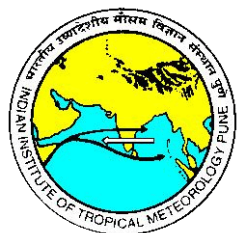
19<sup>TH</sup> TO 26<sup>TH</sup> OCTOBER, 2017

भारत मौसम विज्ञान विभाग  
INDIA METEOROLOGICAL DEPARTMENT



LEGEND: ■ L. EXCESS (+60% OR MORE) ■ EXCESS (+20% TO +59%) ■ NORMAL (+19% TO -19%)  
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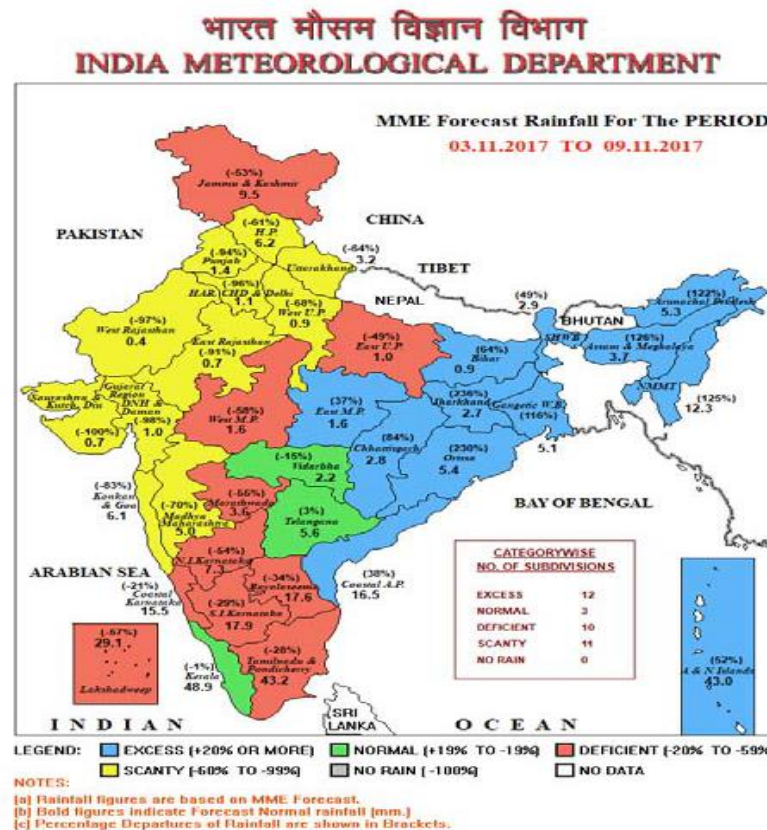




# EXTENDED RANGE FORECAST: Sub-division-wise rainfall forecast maps for the next 2 weeks (IC –25 October)

27th October to 2<sup>nd</sup> November 2017

3<sup>rd</sup> to 9<sup>th</sup> November 2017



# Strategic Agricultural Planning based on rainfall during next two weeks till 09th November 2017

## Agromet Advisories

**Kerala :** Rainfall received during the period of **01 to 26 October 2017 is 27% deficit compared to the normal**. The **extended range weather forecast** for next two weeks are **excess and normal**, respectively.

**ADVISORIES :** Time to start second crop of paddy in some areas – weeds of first crop should be ploughed and field leveling done for replanting; apply first dose of fertilizers in banana plantation; control soft rot in ginger etc

**Maharashtra :** Rainfall received during 1-26 October 2017 in major meteorological sub-divisions : **Vidarbha: 57.5 mm (3% surplus); Marathwada: 100.2 mm (49% surplus); Madhya Maharashtra: 112.4 mm (52% surplus) and Konkan: 153.6 mm (34% surplus)** The extended range weather forecast provided for next two weeks: **Vidarbha (scanty and normal); Marathwada (scanty and deficient); Madhya Maharashtra (scanty for both weeks) and Konkan (scanty for both weeks).**

### ADVISORIES:

#### Marathwada

- Sowing of rabi sorghum should be done as early as possible to avoid loss of soil moisture which may affect germination
- Sowing of rabi sunflower should be done as early as possible.
- Picking of cotton should be done early in the morning to keep cotton clean

#### Vidarbha

- Undertake harvesting/threshing of matured soybean and keep the produce safely during the first week as scanty rainfall is forecasted.
- Adoption of minimum tillage planting is advisable for rabi sowing to conserve residual soil moisture.
- With prevailing condition of decline in humidity and increase in maximum temperature, foliar spray of 2% DAP (200 g DAP +10 litre water) mixed with 4 ml Planofix at boll development stage is advisable in cotton to reduce boll shedding and improve boll growth. etc



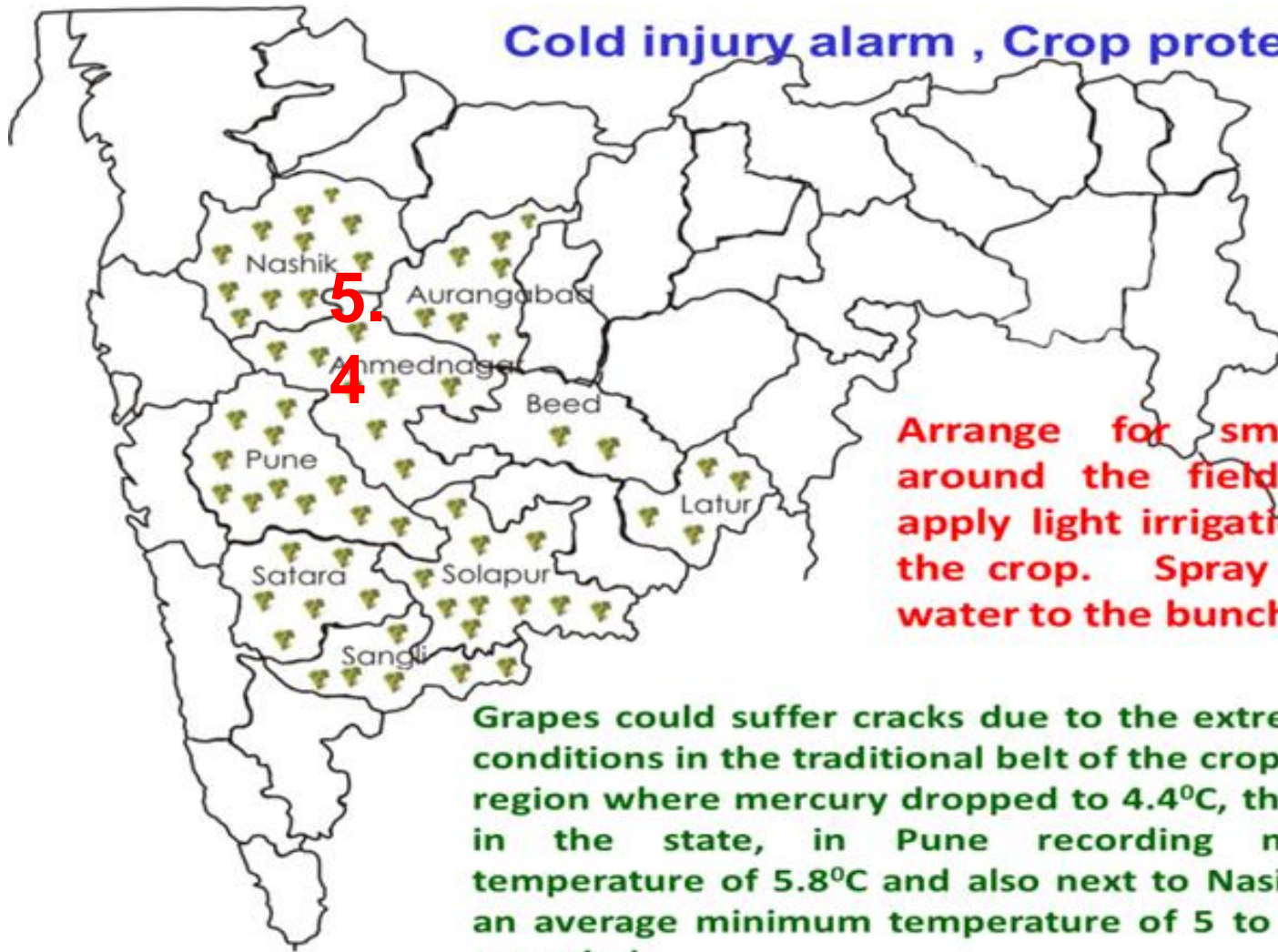
# Crop Situation in Andhra Pradesh (Kharif-2015) **One example of use of advisories on sowing short-duration, less water requiring crops, such as pearl millet and pulses.**

District	Actual area sown in Kharif (ha)		Original crop in the area
	2015	Normal	
Pearl millet			
Kurnool	8273	7095	Cotton, Castor, Rice
YSR Kadapa	2377	2035	Rice
Chittoor	2403	2134	Groundnut
Anantapur	2421	1782	Groundnut
Black gram			
Guntur	1066	359	Cotton, Rice
Prakasam	5181	1466	Cotton, Rice
Kadapa	1279	327	Rice
Green gram			
Anantapur	12380	618	Groundnut
YSR Kadapa	2069	342	Rice





## Cold injury alarm , Crop protection



Arrange for smoking around the field and apply light irrigation to the crop. Spray fresh water to the bunches.

Grapes could suffer cracks due to the extreme cold conditions in the traditional belt of the crop in **Nasik** region where mercury dropped to  $4.4^{\circ}\text{C}$ , the lowest in the state, in Pune recording minimum temperature of  $5.8^{\circ}\text{C}$  and also next to Nasik where an average minimum temperature of 5 to  $6^{\circ}\text{C}$  was recorded.

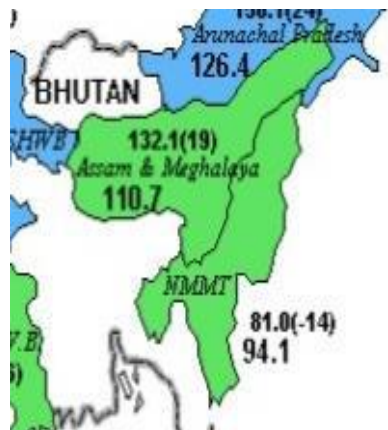


**Continuous rainfall was observed during 2<sup>nd</sup> half of July 2016 over Assam region.**

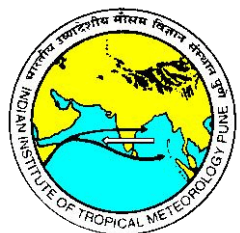
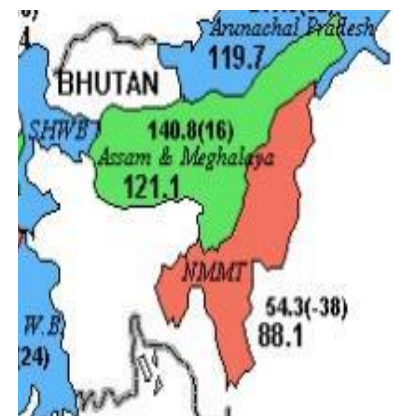
**Due to occurrence of flood during July, transplanting was delayed and paddy in those flood affected areas was expected to be in the early tillering stage during August/September.**

भारत मौसम विज्ञान विभाग  
INDIA METEOROLOGICAL DEPARTMENT

RAINFALL (mm.) FOR THE WEEK  
14.07.2016 TO 20.07.2016



RAINFALL (mm.) FOR THE WEEK  
21.07.2016 TO 27.07.2016

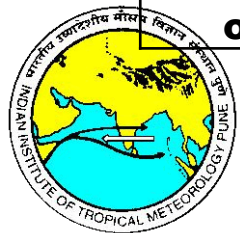


**On 2nd August 2016, deficit of rainfall was forecasted over Assam region. Thus after floods sunny days with high temperature and high humidity during August were forecasted which is conducive for insect infestation which is usually found to be maximum in the early tillering stage of *Sali* rice. Therefore, following advisories were issued on 2<sup>nd</sup> August,**

**Advisories for pest**

- **Sunny days/high temperature after continuous and heavy rainfall for long period (1 to 2 weeks) during August is very conducive for heavy infestation of rice (which is at tillering stage) with *Rice Hispa*. Therefore farmers are advised to be ready for tackling the situation.**
- ***Rice hispa* can be controlled by spraying with *Chloropyrifos 20 EC* or *Monocrotophos 40 EC* @1.5 ml per liter of water.**
- **It is advised to spray recommended insecticides when there is one damage leaf per hill due to attack of leaf folder or appearance of one adult hispa per hill is observed.**

**View of rice field at Narayanpur, Lakhimpur during 2016**

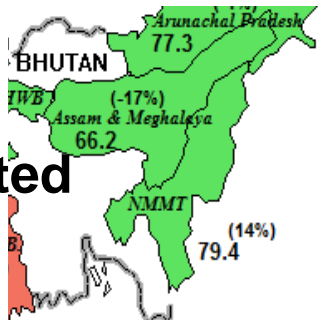




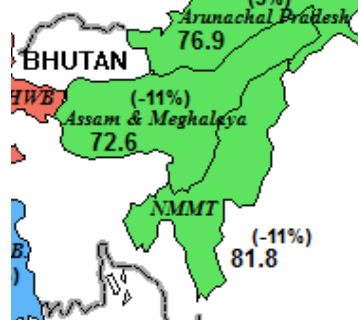
भारत मौसम विज्ञान विभाग  
INDIA METEOROLOGICAL DEPARTMENT

Forecasted

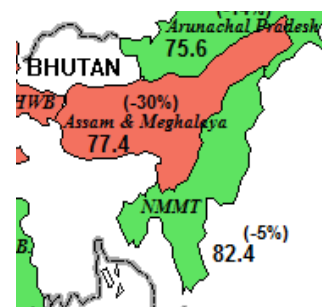
MME Forecast Rainfall For The PERIOD  
29.07.2016 TO 04.08.2016



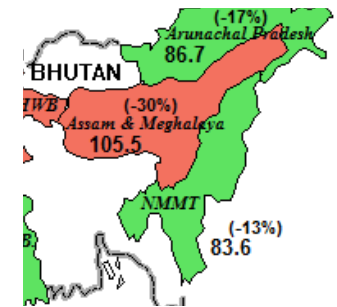
MME Forecast Rainfall For The PERIOD  
05.08.2016 TO 11.08.2016



MME Forecast Rainfall For The PERIOD  
12.08.2016 TO 18.08.2016



MME Forecast Rainfall For The PERIOD  
19.08.2016 TO 25.08.2016



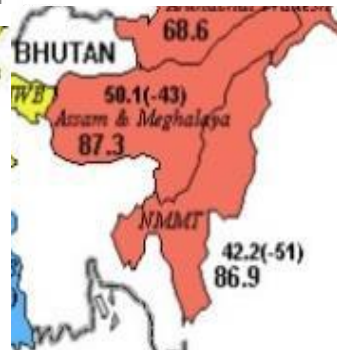
भारत मौसम विज्ञान विभाग  
INDIA METEOROLOGICAL DEPARTMENT

Observed

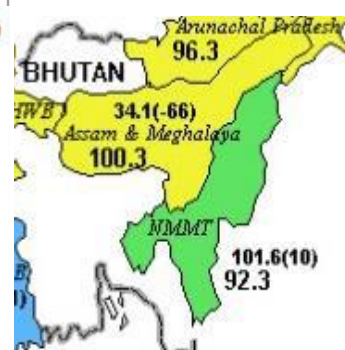
RAINFALL (mm.) FOR THE WEEK  
28.07.2016 TO 03.08.2016



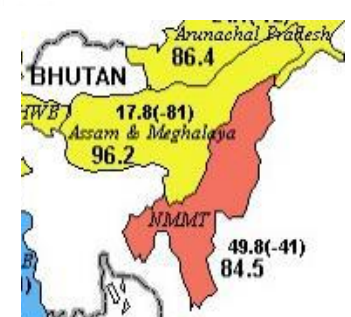
RAINFALL (mm.) FOR THE WEEK  
04.08.2016 TO 10.08.2016



RAINFALL (mm.) FOR THE WEEK  
11.08.2016 TO 17.08.2016

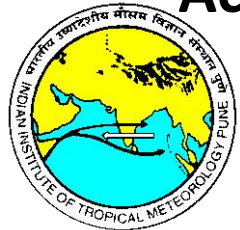


RAINFALL (mm.) FOR THE WEEK  
18.08.2016 TO 24.08.2016



# Health Guidance

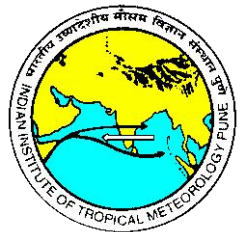
- Malaria Case Study
- Acute Diarrheal Disease



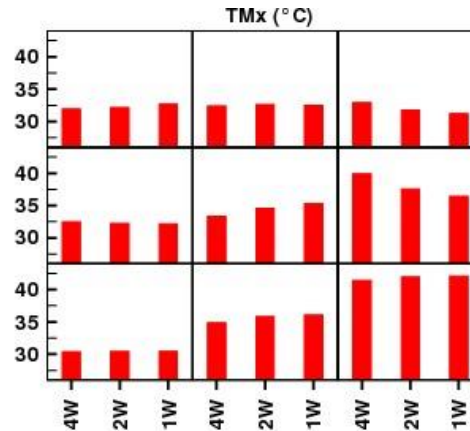
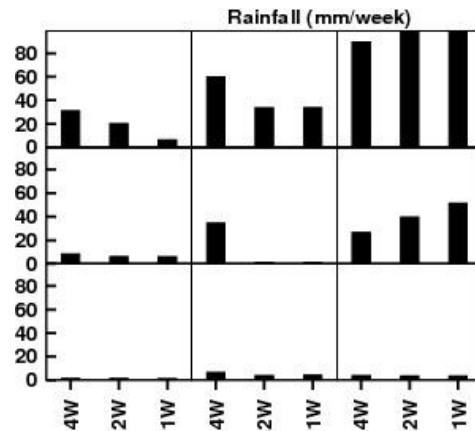


**One forth of the total deaths around the globe (more than 8 lacs children per year) due to diarrhea occur in India which is also the third leading cause of childhood mortality.**

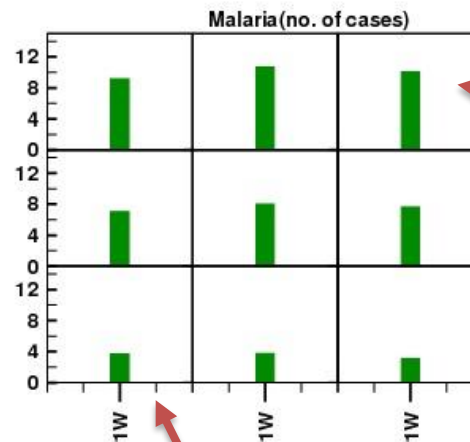
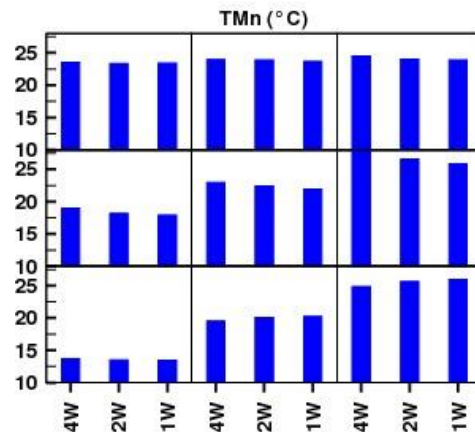
**The data for climate variables (Weekly Mean Maximum Temperature, TMx, Weekly Mean Minimum Temperature, TMn and Weekly total Rainfall, R/F) and also the health data for ADD (Acute Diarrhoea disease) Malaria (MAL) for two cities Pune and Nagpur has been used to find out the relationship between health and climate.**



# Nagpur Malaria



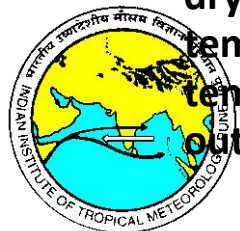
wet spell, increased minimum temperature and decreased maximum temperature are more conducive for outbreak of MAL.



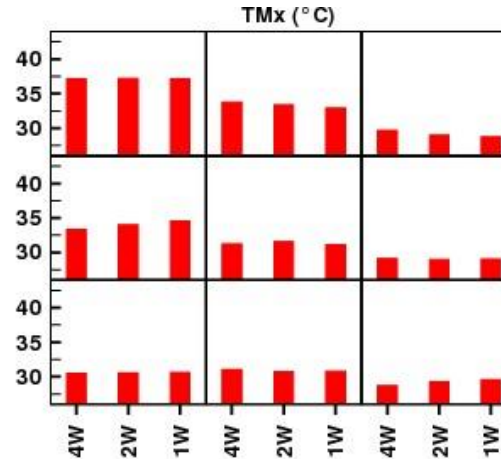
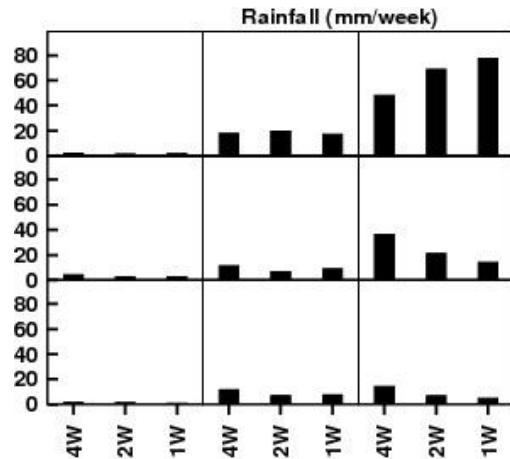
Highest No. Class (3,1)

dry spell, lower than normal minimum temperature and lower maximum temperature are less conducive for outbreak of MAL.

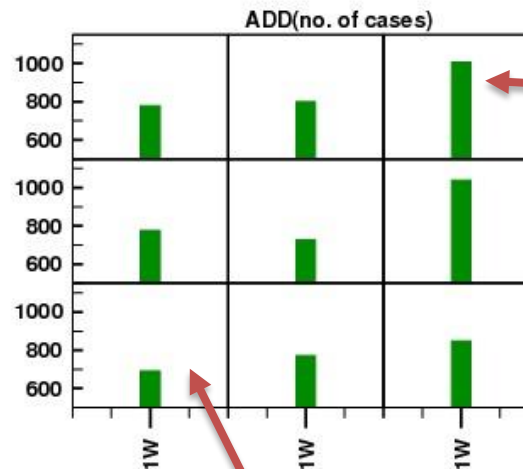
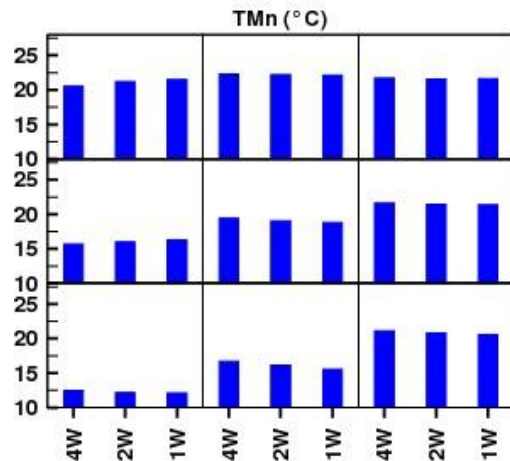
Lowest No. Class (1,3)



# PUNE ADD



Wet spell, increased minimum temperature and decreased maximum temperature are more conducive for outbreak of ADD.



Highest No. Class (3,1)

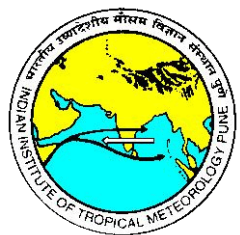
Lowest No. Class (1,3)



# Probabilistic weekly evolution of transmission window for Malaria Plasmodium Falciparum

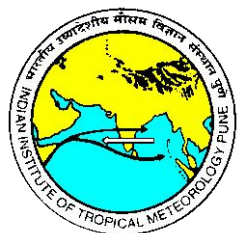
First week (08<sup>th</sup> to 14<sup>th</sup> June 2018):

1	<b><u>75</u></b> probability level		Major districts of Andhra Pradesh, Some districts of Uttar Pradesh, Gujarat, Tamil Nadu, few districts of Himachal Pradesh, Haryana, Bihar, North Eastern states, Odisha, Telangana & Karnataka
2	<b><u>55-75</u></b> probability level		Major districts of Bihar, Jharkhand, Chhattisgarh, West Bengal, some districts of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Uttar Pradesh, North Eastern states, Odisha, Gujarat, Maharashtra, Telangana, Andhra Pradesh, Tamil Nadu, few districts of Madhya Pradesh.& Karnataka.
3	<b><u>35-55</u></b> probability level		Major districts of Odisha, some districts of Jammu & Kashmir, Himachal Pradesh, North Eastern states, West Bengal, Rajasthan, Madhya Pradesh, Chhattisgarh, Odisha, Gujarat, Maharashtra, Telangana, Andhra Pradesh, few districts of Uttarakhand, Uttar Pradesh, Bihar, Sikkim, Jharkhand, Karnataka.
4	<b><u>Less than 35</u></b> probability level		Major districts in rest of states.



# Power Sector

Power consumption increase for the use of AC/Coolers during heat-wave and also with the use of room heater and Geyser during Cold Wave.



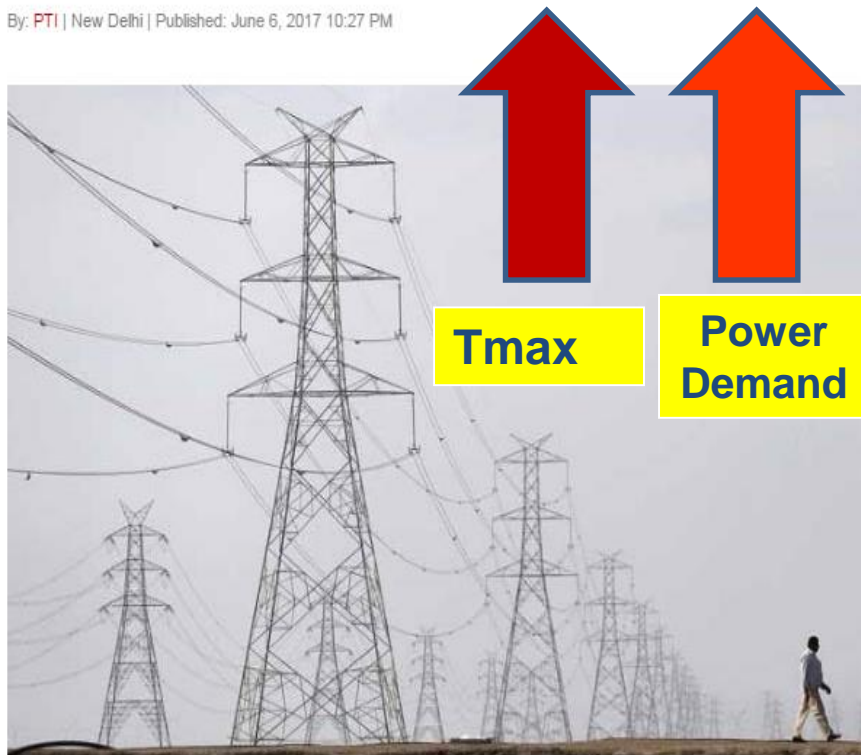


# News Clipping of 6<sup>th</sup> June 2017

## Power demand in Delhi crosses 6,500 MW mark

The peak power demand in the national capital shot up to an all time high of 6,526 MW today, with many areas facing outages due to local faults as the heatwave condition continued in the city.

By: PTI | New Delhi | Published: June 6, 2017 10:27 PM



The hot summer months this year have pushed the peak power demands to record levels, with April

The peak power demand in the national capital shot up to an all time high of 6,526 MW today, with many areas facing outages due to local faults as the heatwave condition continued in the city. The soaring temperature has put pressure on power demand which rose to 6,526 MW at 3.31 pm, the highest ever recorded level in Delhi, the figures provided by the Power Department said. Yesterday, the peak power demand was recoded at 6,361 MW, the second highest in this summer season. With mercury hovering over 44 degrees Celsius mark for the past two days, the peak power demand rose to record levels and also led to outages in many parts of the city due to local faults.

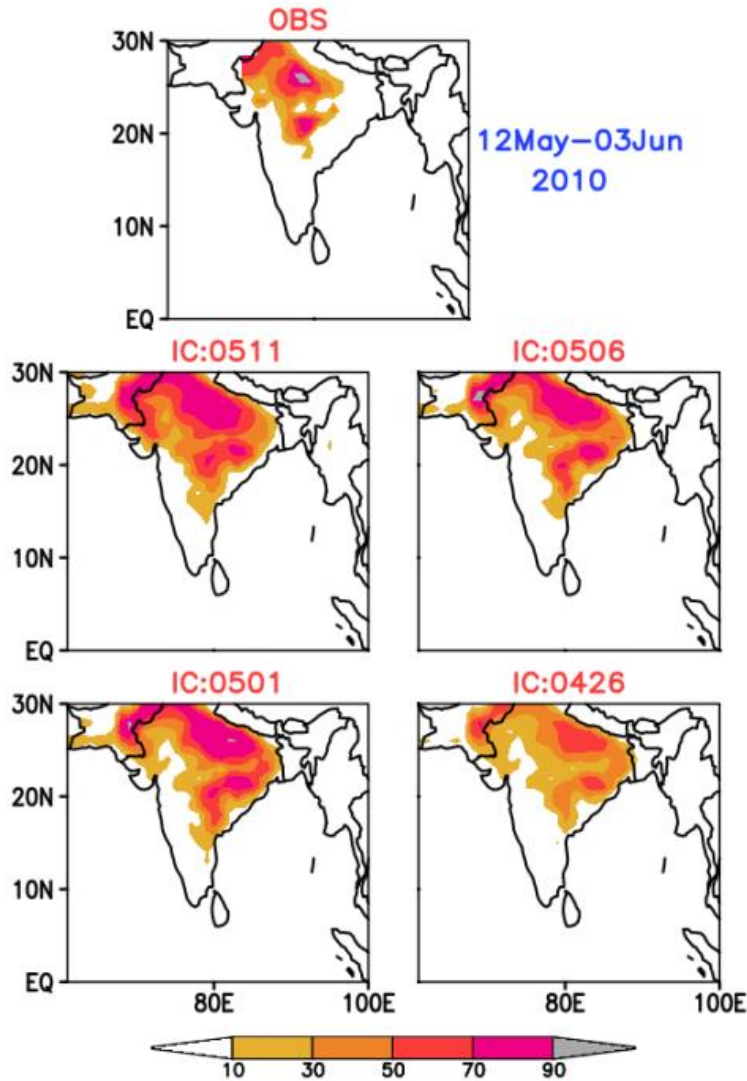
Scheduled power cuts by the distribution companies (discoms) BSES and Tata Power Delhi Distribution Limited (TPDDL) also added to people's miseries in the sweltering heat. Delhi Chief Minister Arvind Kejriwal today directed the government officials to report the unscheduled power cuts to him on daily basis. He also directed the discoms to increase the capacity of their call centres for satisfactory disposal of consumer's

complaints

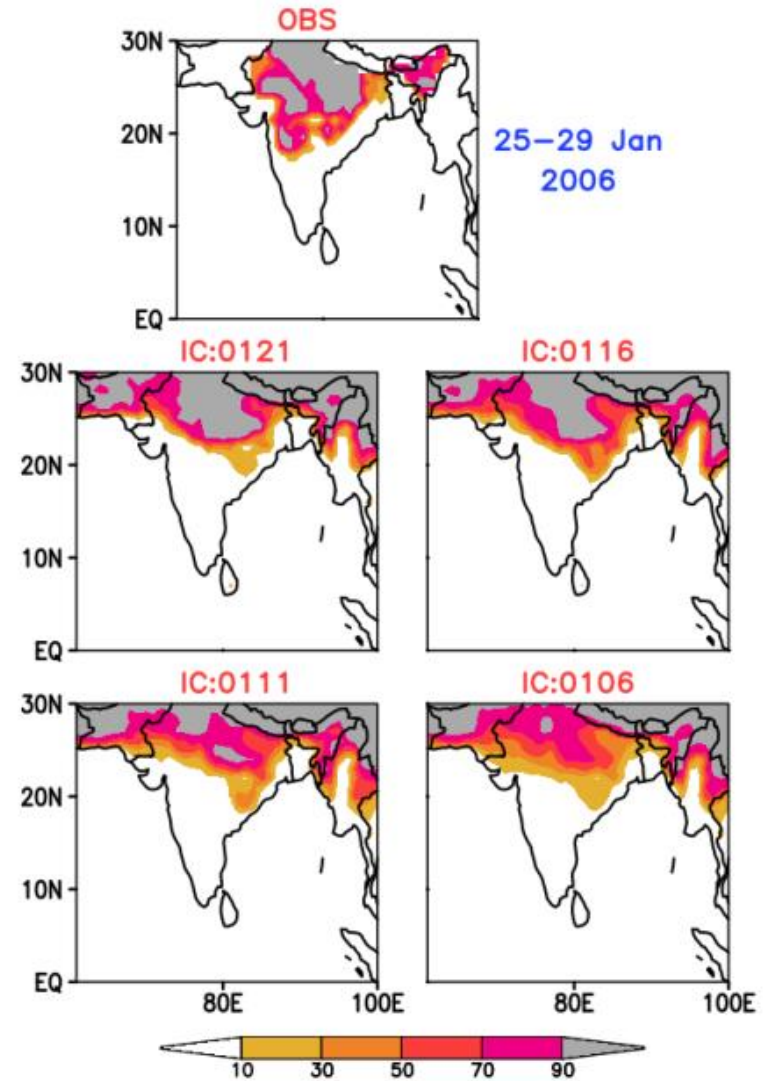
# Probability forecast of extremes in temperature – Few Examples

## चरम तापमान पूर्वानुमान की प्रतिशत संभावना – कुछ उदाहरण

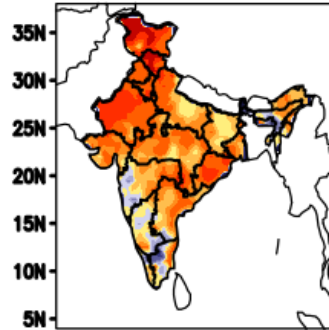
### Heat Wave ( $>44^{\circ}\text{C}$ ) Spell



### Cold Wave ( $<10^{\circ}\text{C}$ ) Spell



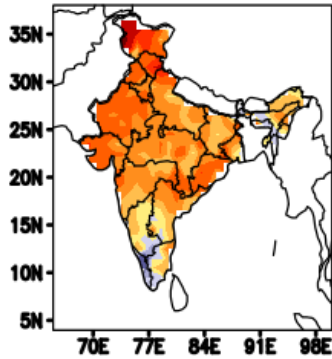
Tmax Anomaly  
26Mar\_01Apr 2018  
Observation



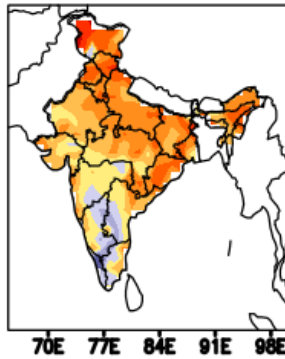
# Heat Wave Event (26 March to 08 April 2018)

## उष्ण-लहर घटना (26 मार्च से 8 अप्रैल 2018 तक)

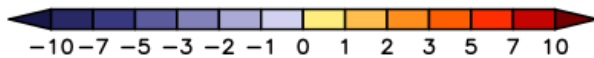
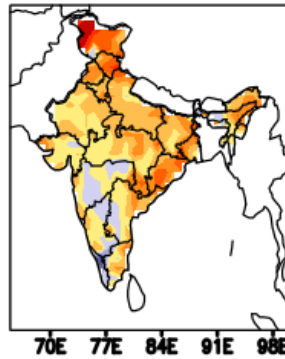
MME, IC=0321



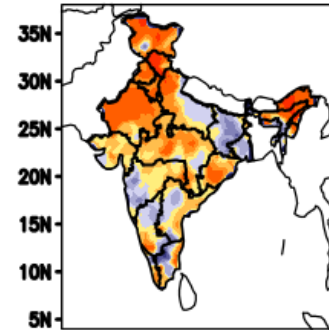
MME, IC=0314



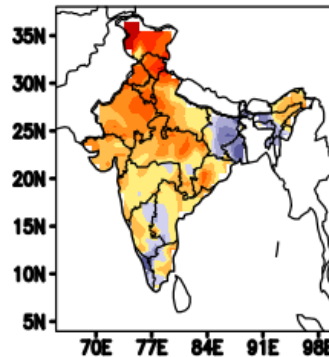
MME, IC=0307



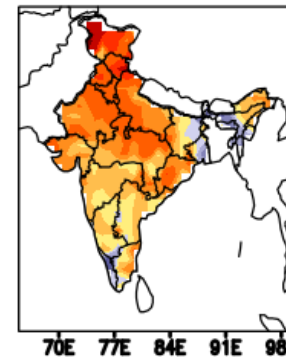
Tmax Anomaly  
02Apr\_08Apr 2018  
Observation



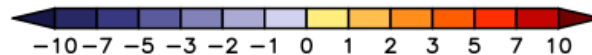
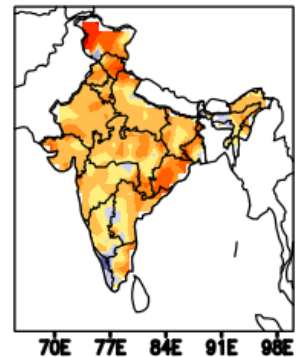
MME, IC=0328



MME, IC=0321



MME, IC=0314

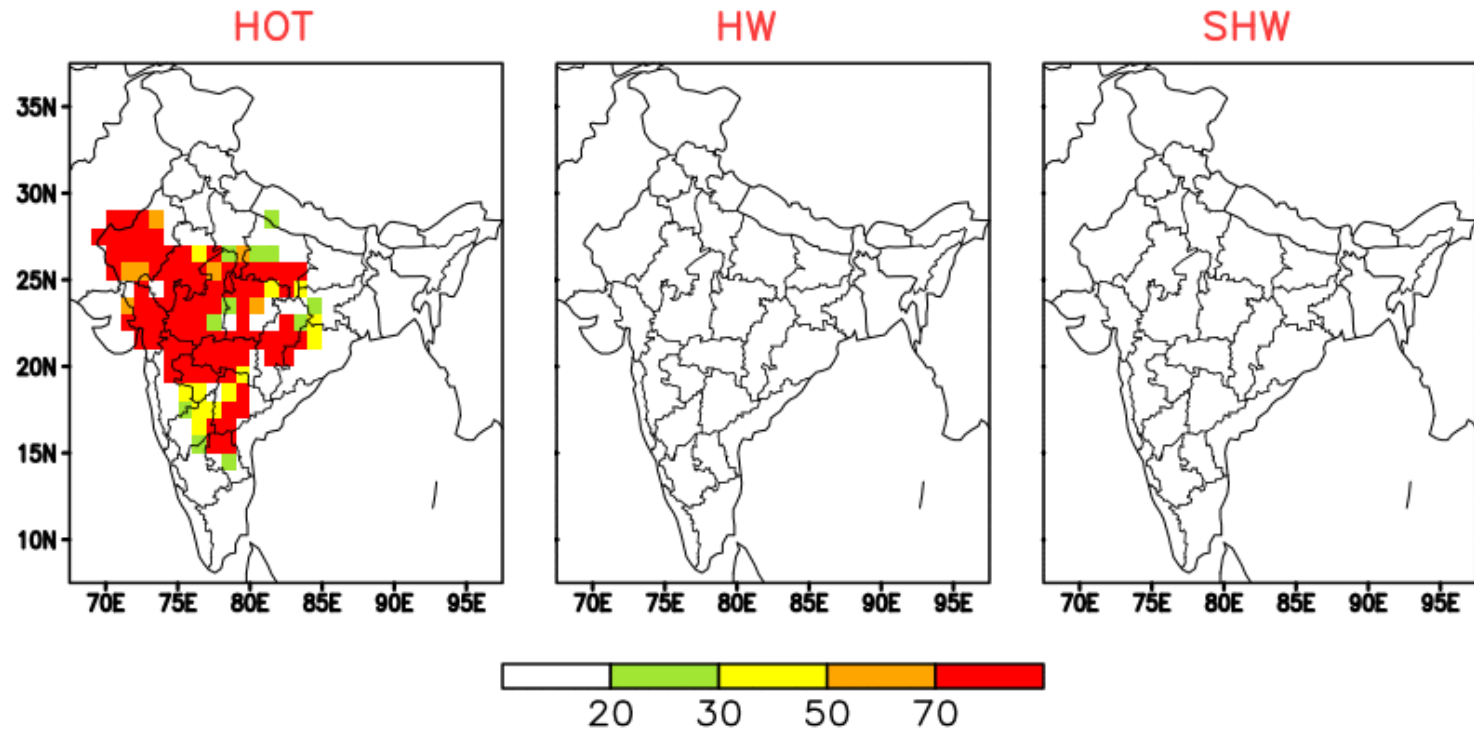


# Heat wave Probability of occurrence

**HOT:** Hot day    **HW:** Heat wave    **SHW:** Severe heat wave

Forecast Valid Time=19APR2018

Probability of Occurrence for:

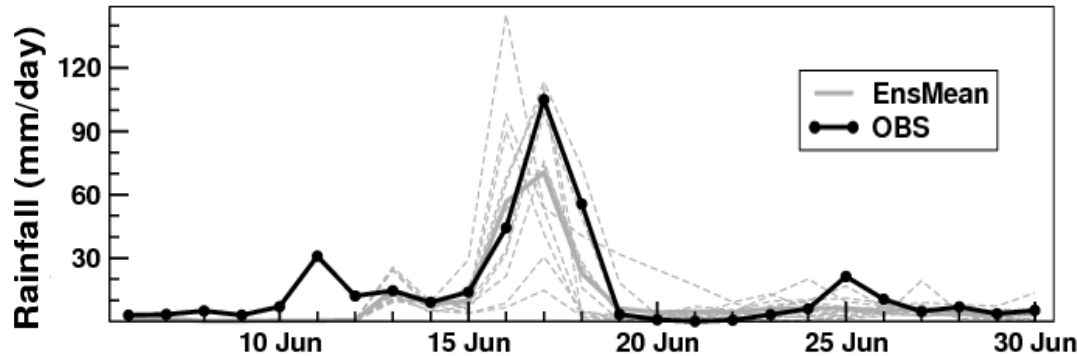




# **Disaster Management: Extremes (Cyclones, heat waves, cold waves, heavy rainfall events) prediction**

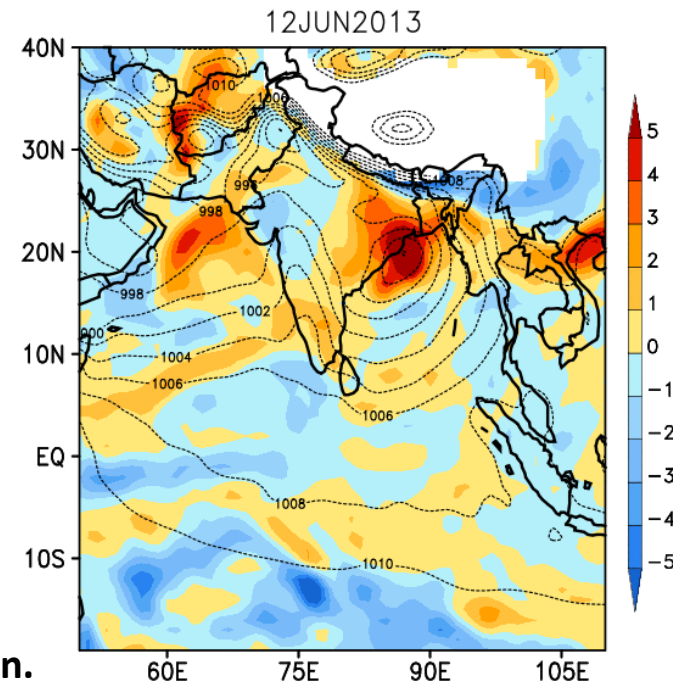
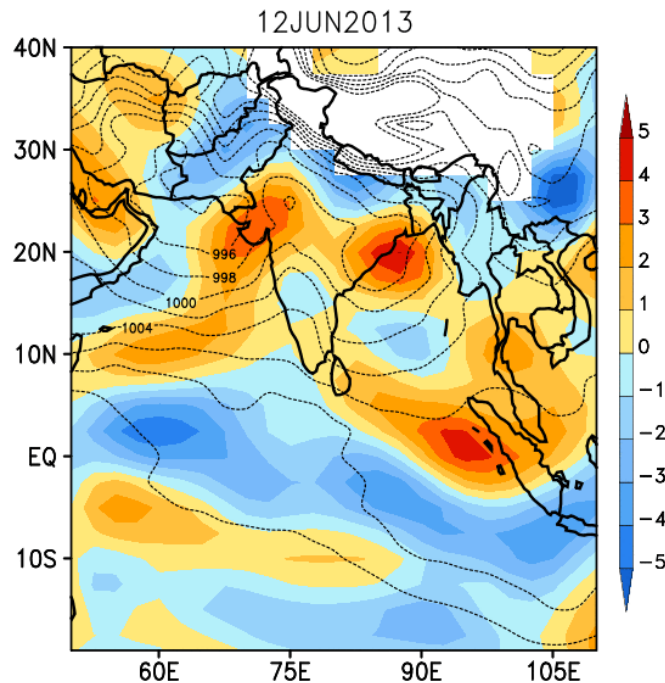
# Prediction of Heavy Rainfall Events

IC: 05 June



Uttarakhand event in  
June 2013  
जून 2013 की उत्तराखंड  
की घटना

Evolution of Potential Vorticity (PV;  $\times 10^{-7} \text{ s}^{-1}$ ) anomalies at 700 hPa and mean sea level pressure

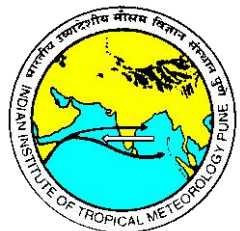
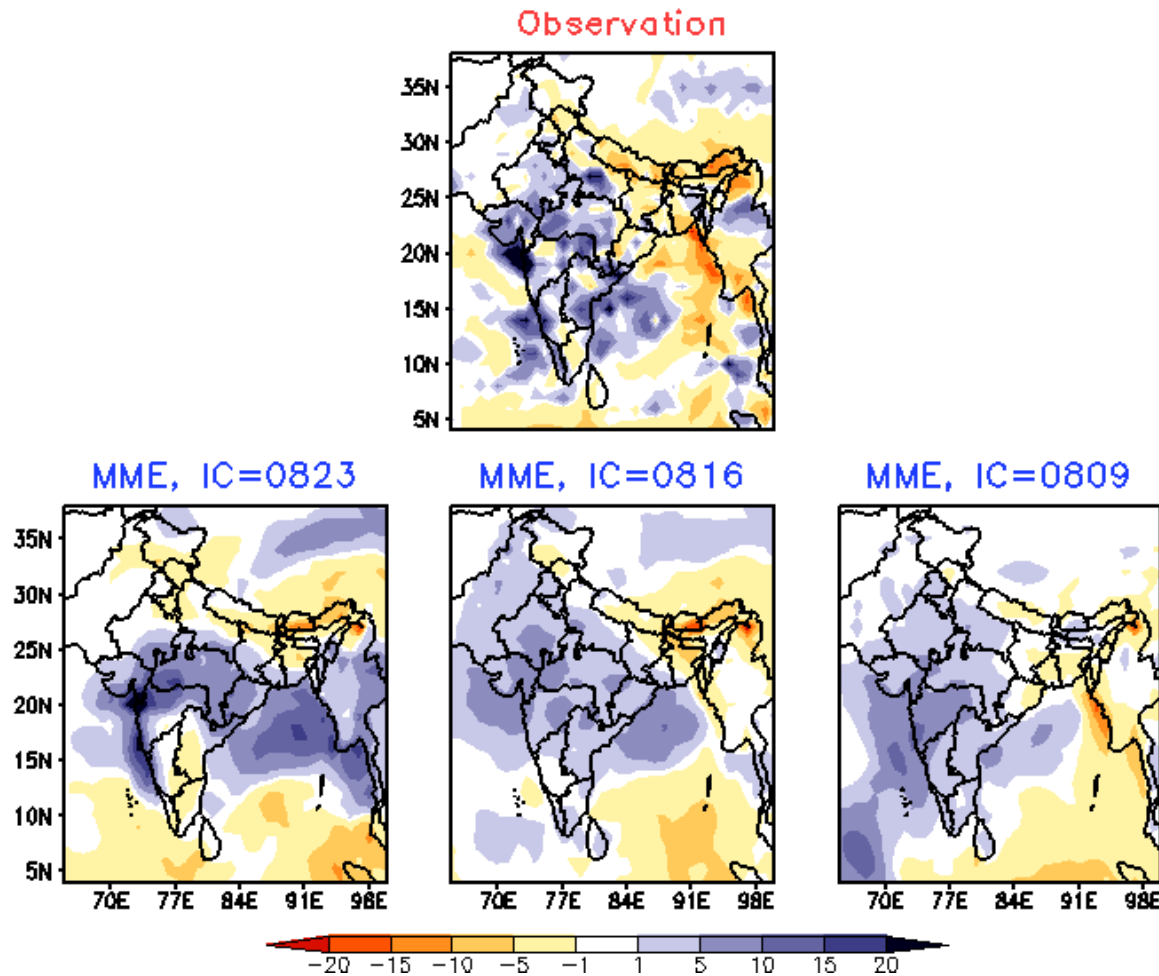


Joseph et al 2016, Clim. Dyn.

# Prediction of Mumbai Heavy Rainfall Event

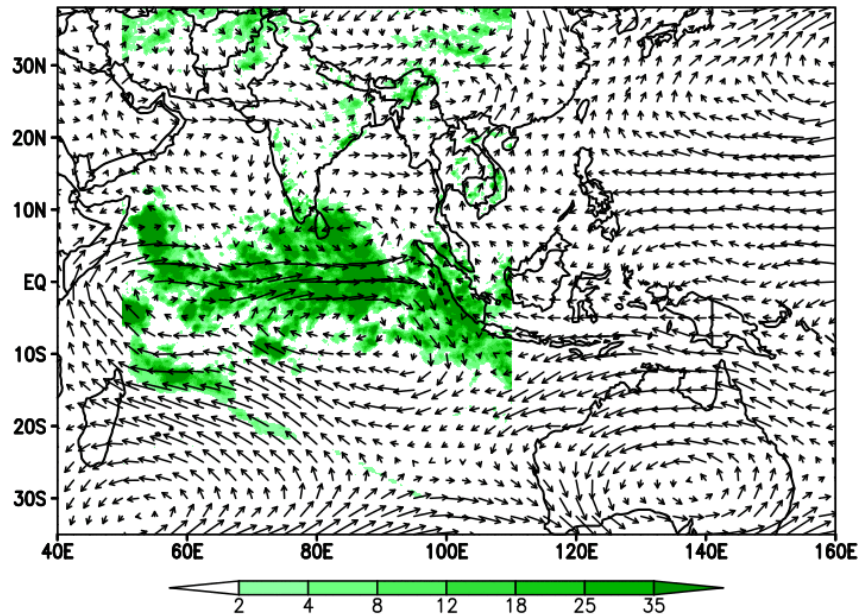
## मुंबई की चरम घटना का पूर्वानुमान

Rainfall Anomaly (mm/day) for the week: 24aug–30aug 2017



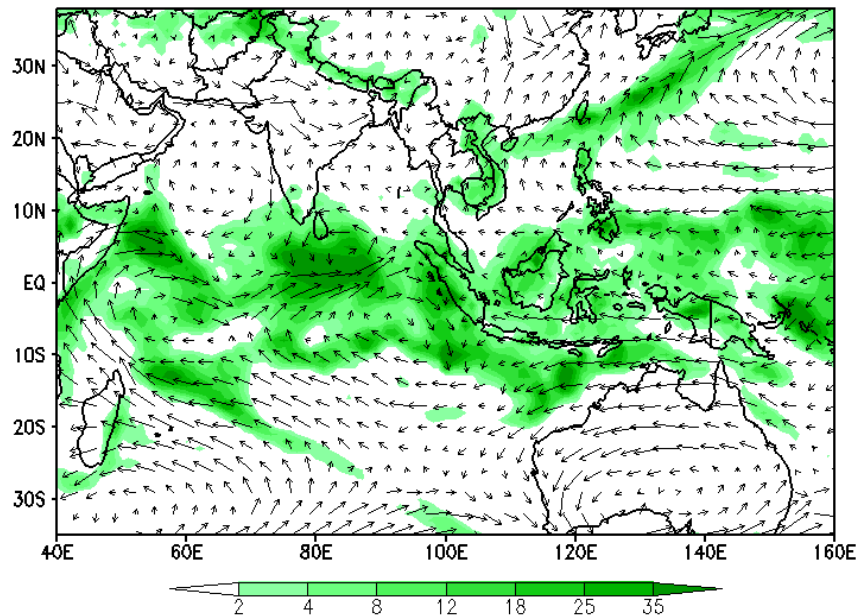
OBS, Time = 00Z12MAY2016

Rainfall (shaded, mm/day) & 850hPa winds (vector, 20°)



MME, Forecast Valid Time = 00Z12MAY2016

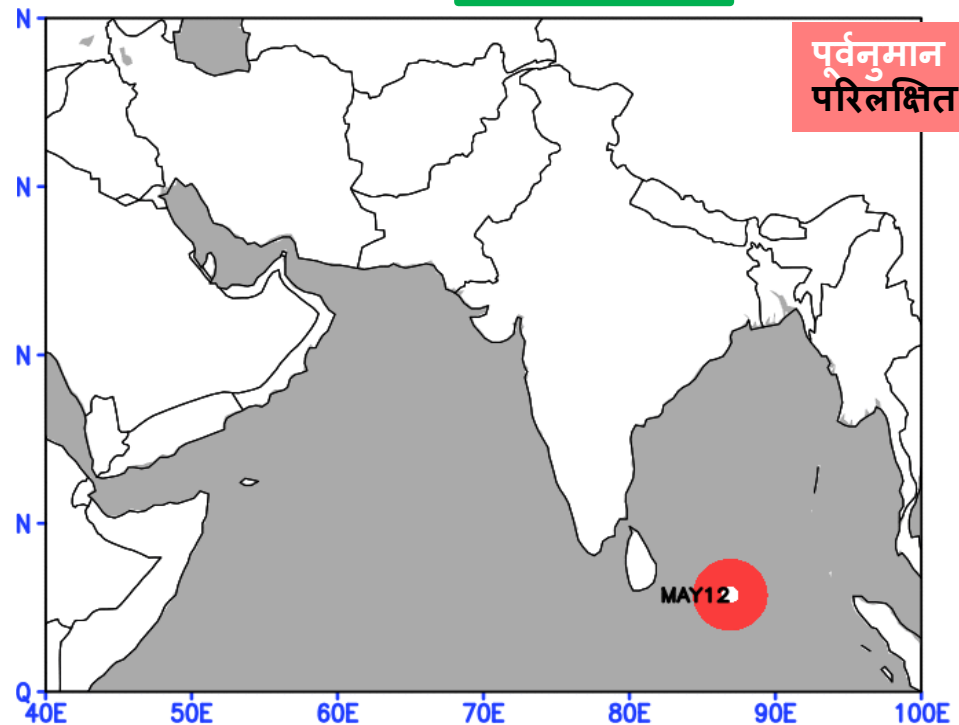
Rainfall (shaded, mm/day) & 850hPa winds (vector, 20°)



# Cyclogenesis का पूर्वानुमान

मई, 2016 में Roanu चक्रवात

IC: 11 मई



पूर्वानुमान  
परिलक्षित



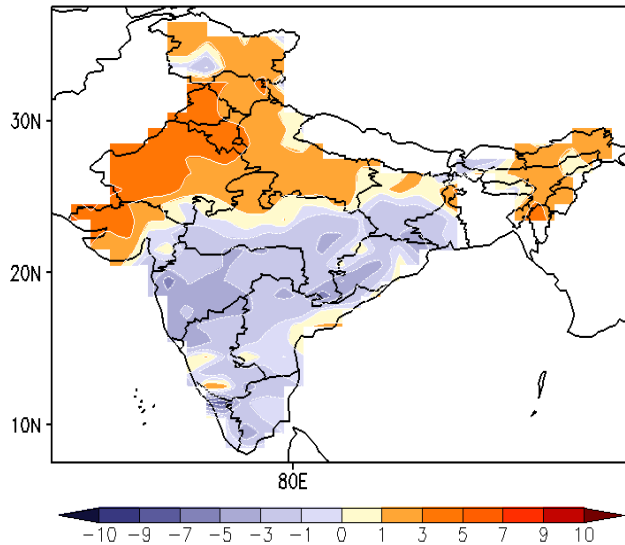


# Cold Event during winter 2017

## 2017 के जाड़े के दौरान शीतलहर की घटना

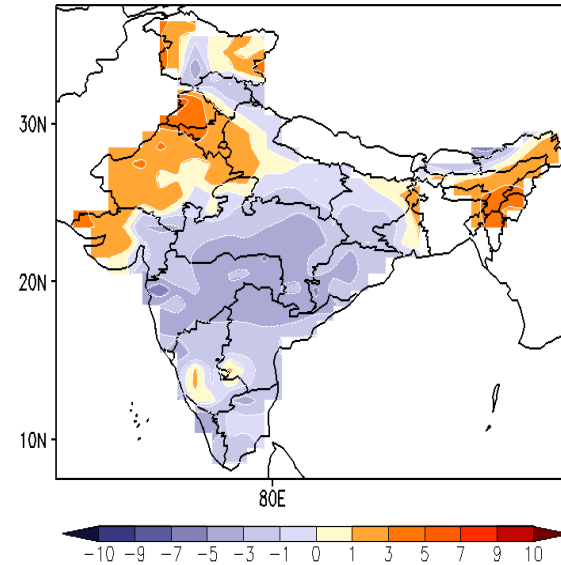
### Observed and Forecasted Tmin Anomaly during 06-20 January 2017

Observation Minimum Temp. Anomaly, Valid Time=00Z06JAN2017  
Minimum Temp. Anomaly in  $^{\circ}\text{C}$

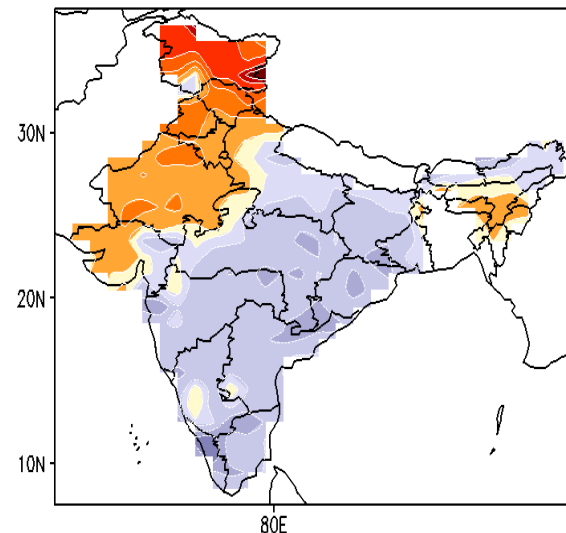


**OBS**

MME, Forecasted Min. Temp Anomaly, Valid Time=00Z06JAN2017  
Minimum Temp. Anomaly in  $^{\circ}\text{C}$

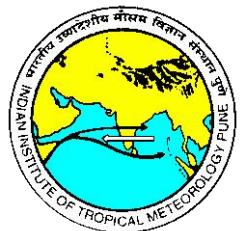


MME, Forecasted Min. Temp Anomaly, Valid Time=00Z06JAN2017  
Minimum Temp. Anomaly in  $^{\circ}\text{C}$



**IC:0104**

**IC: 1228**



# Heat Wave in May 2017 मई, 2017 में उष्ण लहर (ल्)

IC: 10मई

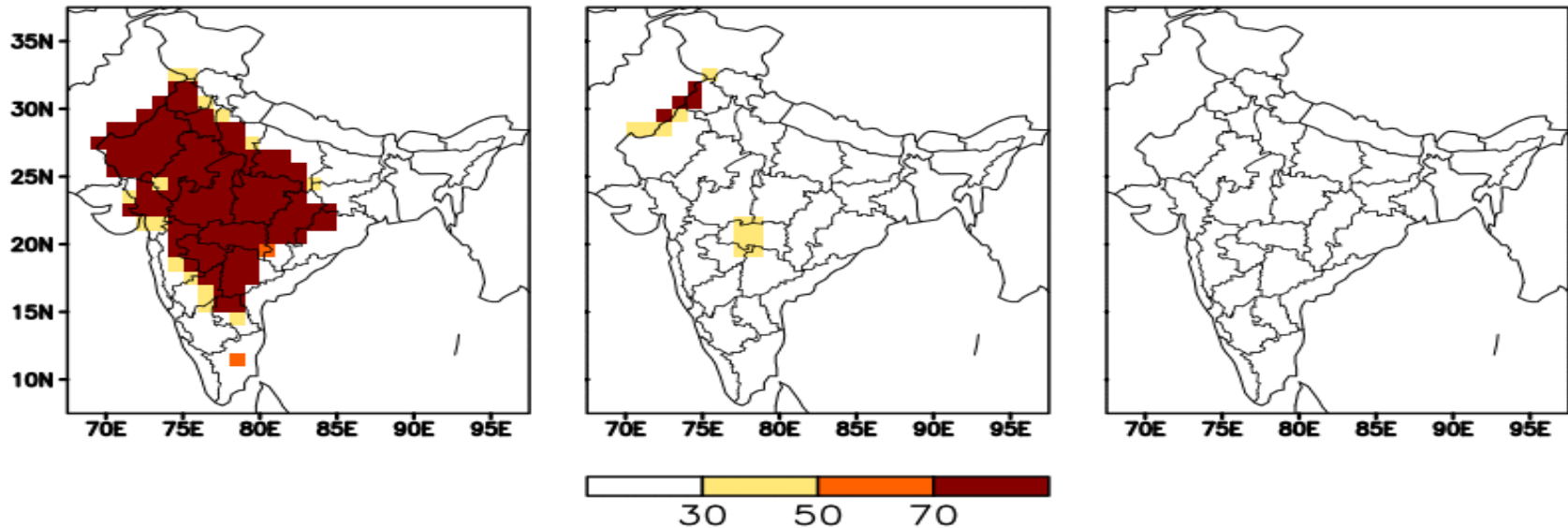
Forecast Valid Time=11MAY2017

Probability of Occurrence for:

HOT

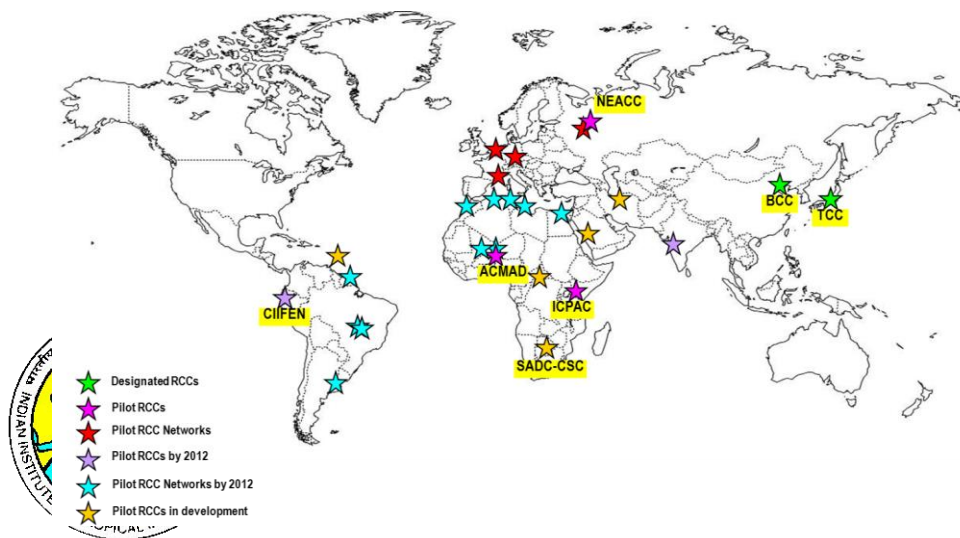
HW

SHW



# Future development of Climate Service

- ✓ Enhance Five Pillars of GFCS
- ✓ Improve Climate Prediction Accuracy
- ✓ To perfect the Climate Service Information System
- ✓ Extend Climate Service Field
- ✓ Strengthen the User Partnership





Thank You All



11/30/2018

