Extended range prediction system for societal applications

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Extended Range Prediction

❖Monsoon Intra-seasonal variability is modulated by synoptic, interannual and decadal variability.

❖On top of this climate change also modulates MISO and hence their prediction is a great challenge.

❖Despite several uncertainties in the representation of climate processes, the climate model in the current generation represents the hydrological cycle to the extent that the mean monsoon is predictable up to certain extent.

❖Significant Progress on Operational forecast at various spatial temporal scale has been made.

❖Since 2011, IITM has started Extended Range Prediction (2-4 weeks) using Climate Forecast System (CFS) coupled model from NCEP, under the "National Monsoon Mission" Project of Govt. of India.

❖This prediction is playing an important role in improving the agricultural and water management, health, disaster management and other sectors.

Extended Range Prediction System
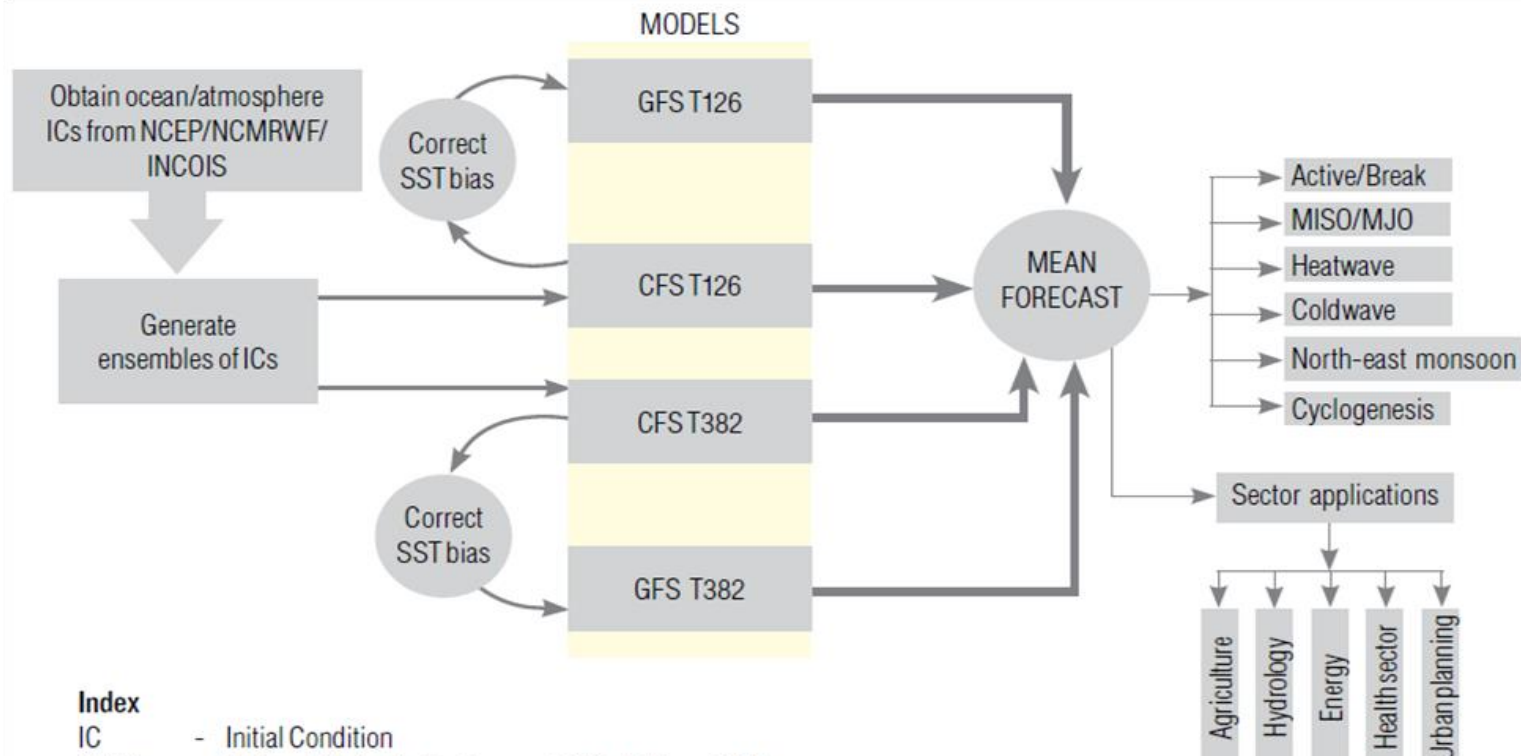
Index
IC   - Initial Condition
NCEP   - National Centre for Environmental Predictions, USA
NCMRWF - National Centre for Medium Range Weather Forecasting
INCOIS   - Indian National Centre for Ocean Information Services
GFS   - Global Forecast System Model
CFS   - Coupled Forecasting System Model
SST   - Sea Surface Temperature
MJO   - Madden-Julian Oscillation
MISO   - Monsoon Intra-Seasonal Oscillation

It has reasonable skill in predicting the extreme rainfall events, genesis and track of tropical cyclones, heat/cold waves, MJO, MISO etc.

Source: India Meteorological Department

EXTENDED RANGE PRODUCTS
https://www.tropmet.res.in/erpas/
https://mausam.imd.gov.in/imd_latest/contents/extendedrangeforecast.php#.

Rainfall

Mininum temperature

Maximum temperature

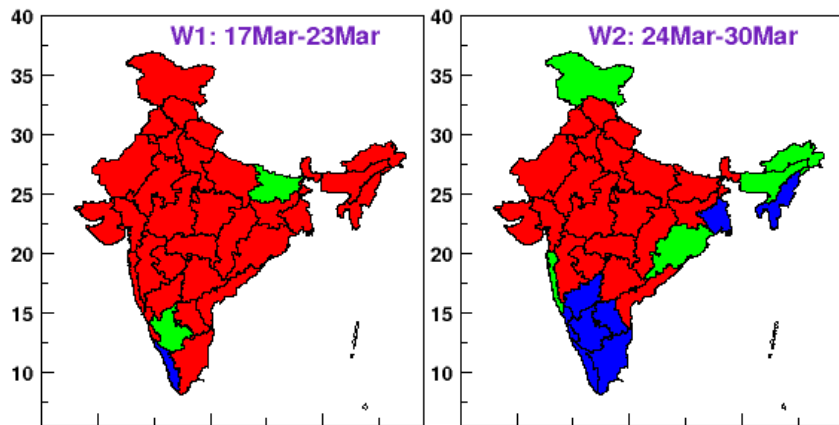Low-level winds

Weekly mean and daily animated products

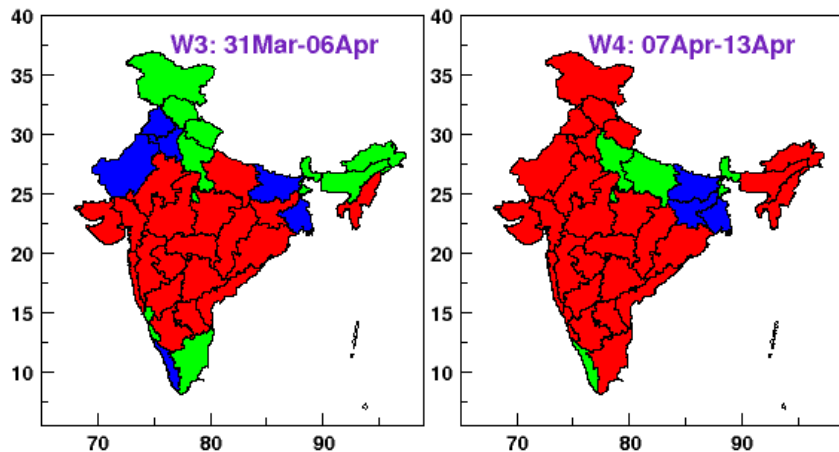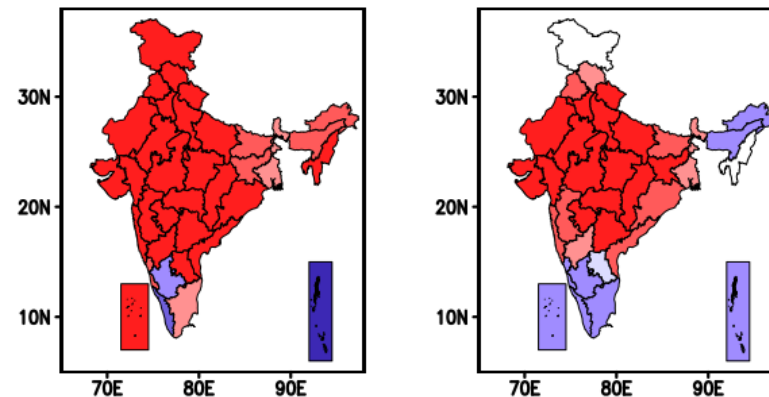# Subdivision-wise categorical forecast of rainfall (MME) IC 16 March 2022
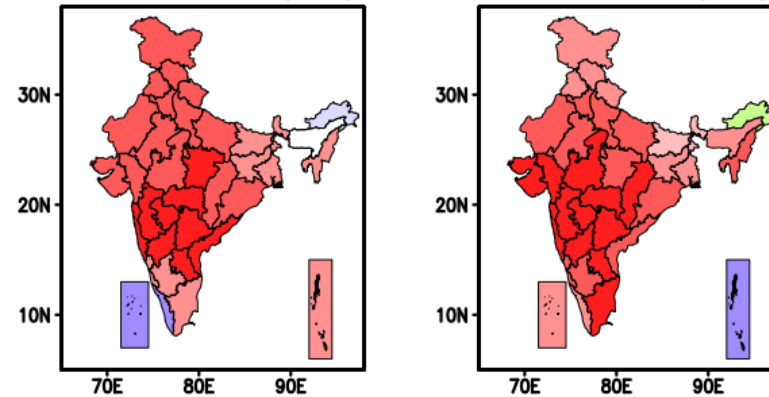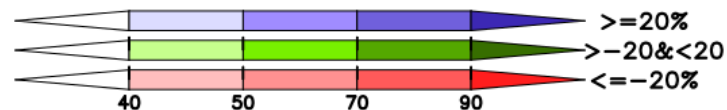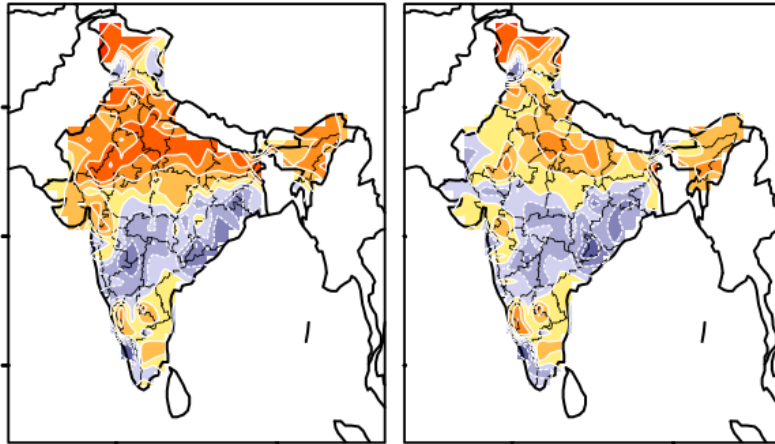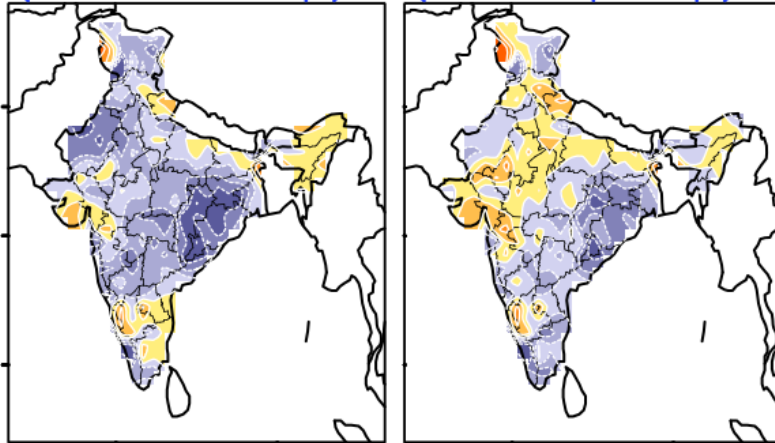
Predicted week wise temperature anomaly (by MME)
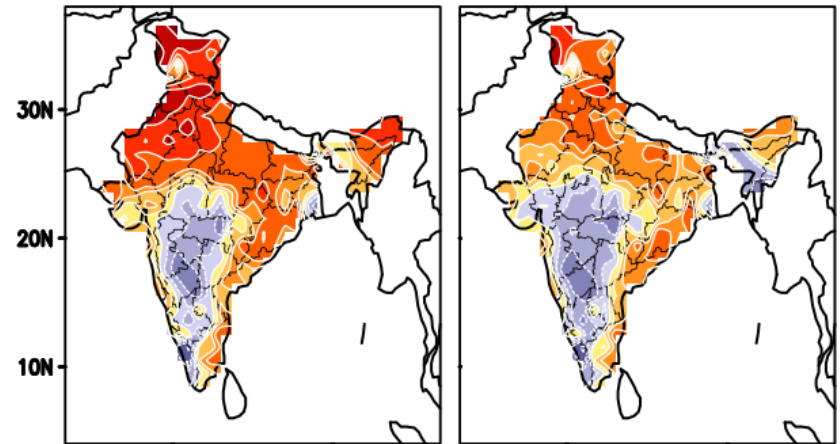

Minimum Temperature Anomaly (°C)
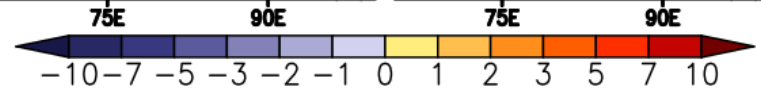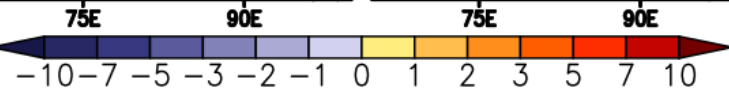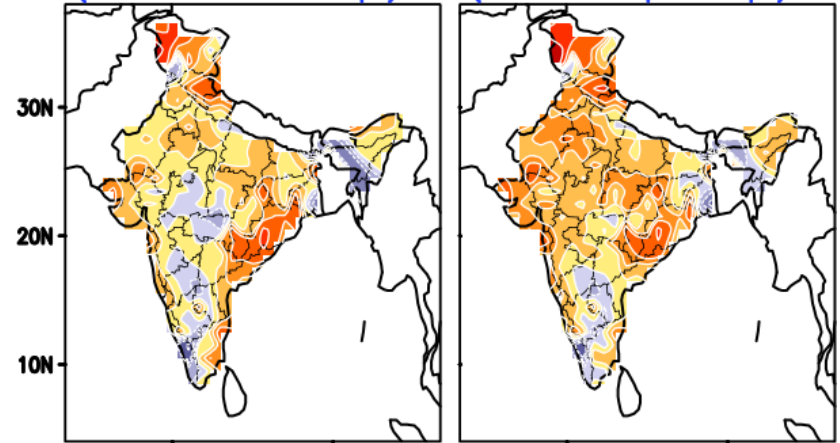(Week1: 17Mar–23Mar) (Week2: 24Mar–30Mar)
(Week3: 31Mar–06Apr) (Week4: 07Apr–13Apr)

Maximum Temperature Anomaly (°C)
(Week1: 17Mar–23Mar) (Week2: 24Mar–30Mar)
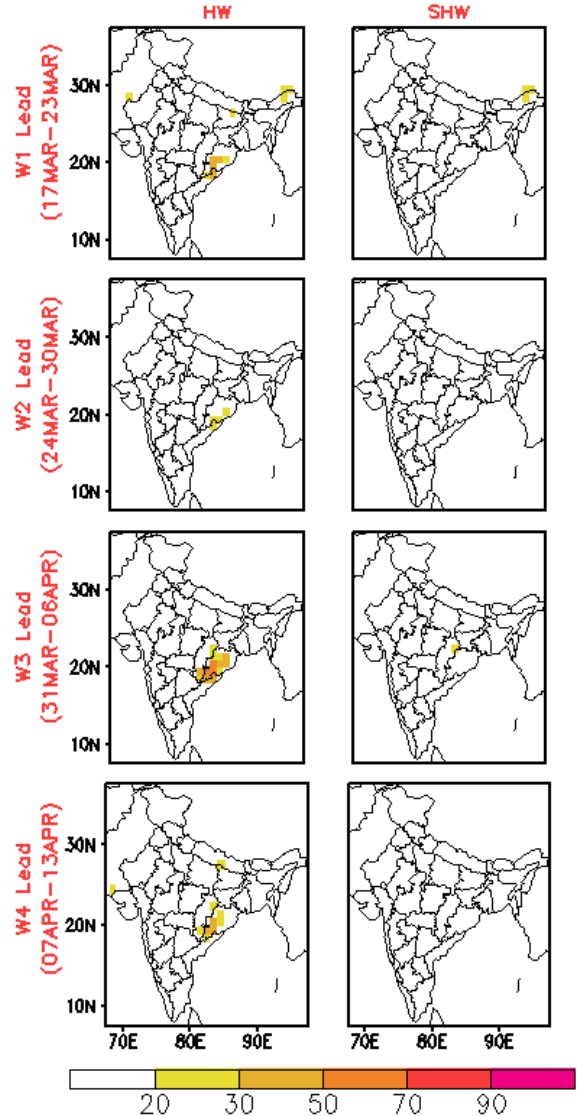(Week3: 31Mar–06Apr) (Week4: 07Apr–13Apr)

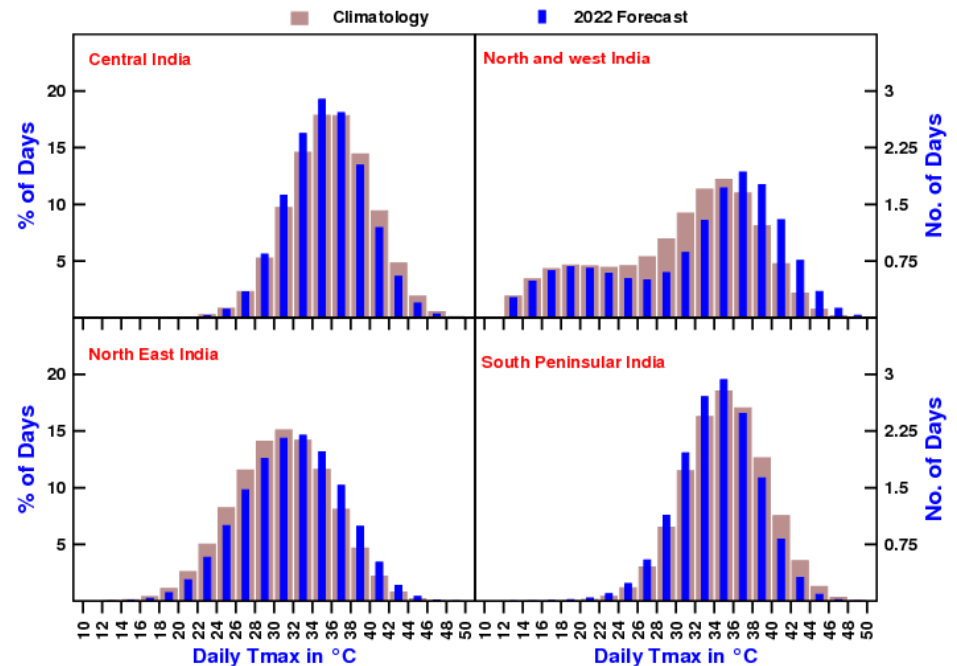# Probability of heat waves and severe heat waves

HW: Heat wave **SHW: Severe heat wave**

Prediction from IC=20220316

Temperature Histogram for 4-homogeneous regions of India

Temperature Forecast and Climatology for the period 17Mar - 31Mar

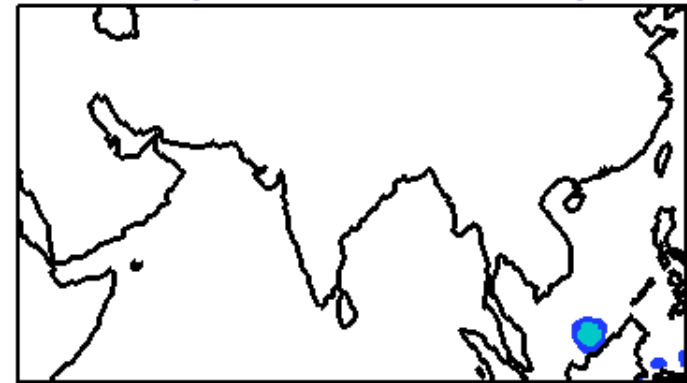# Cyclogenesis Forecast

Cyclogenesis & Evolution Probability (%) from CGEPS–IGPP
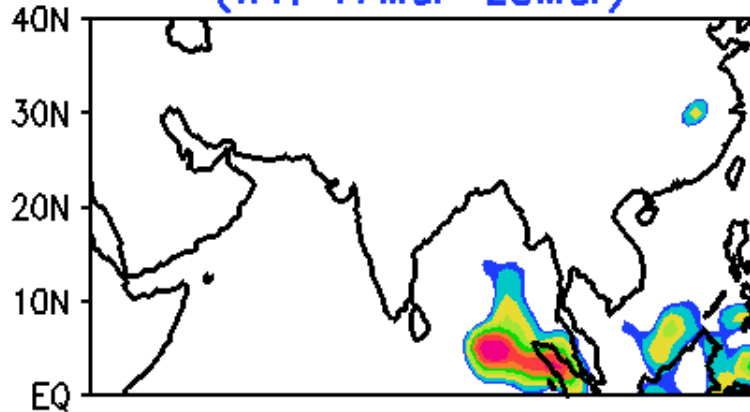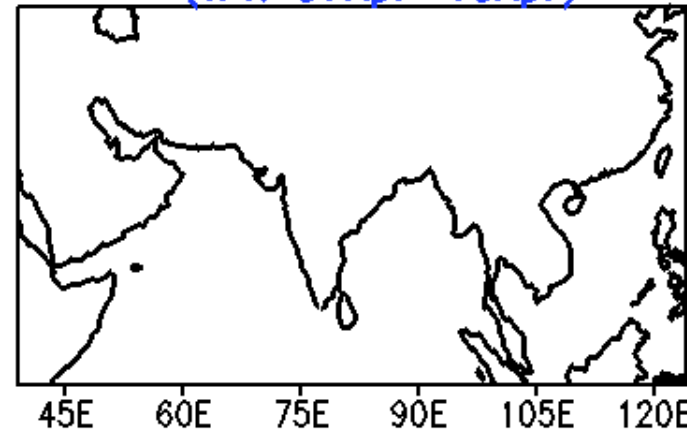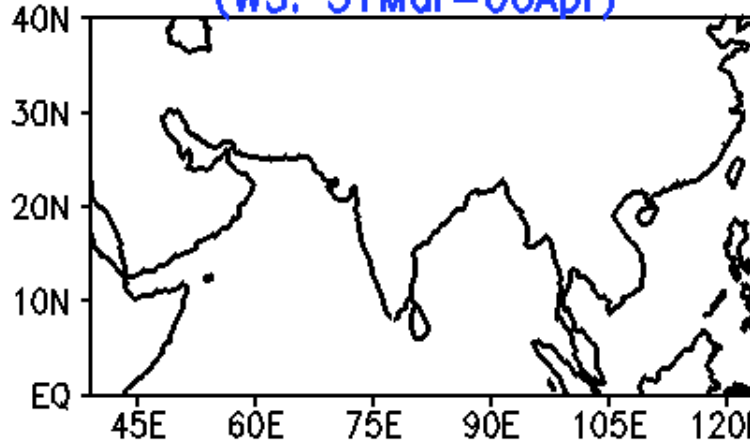
MJO Forecast

MJO Filtered spatial anomalies
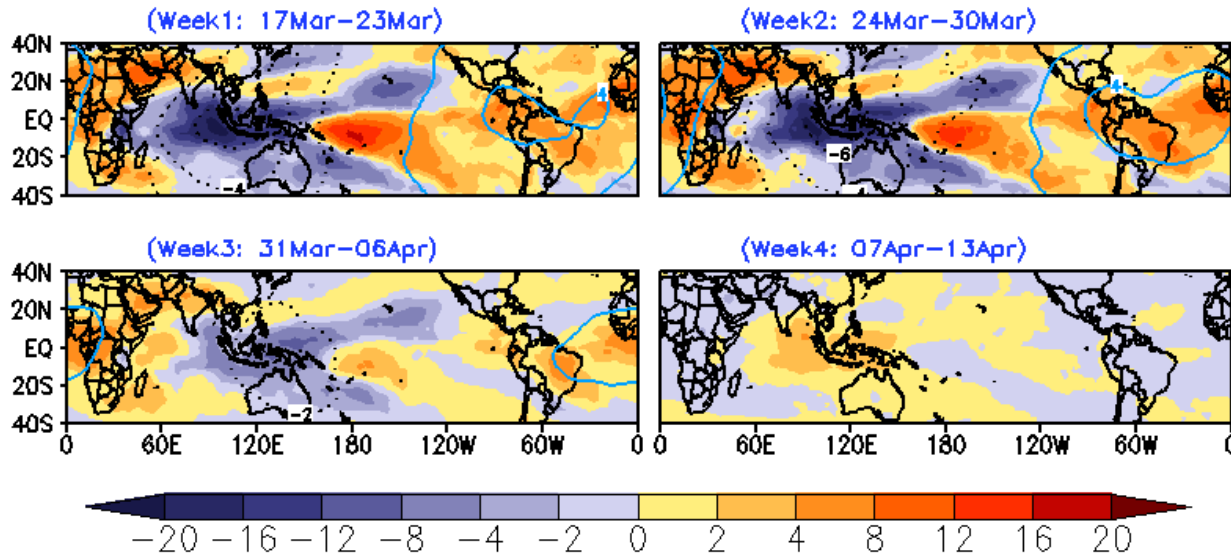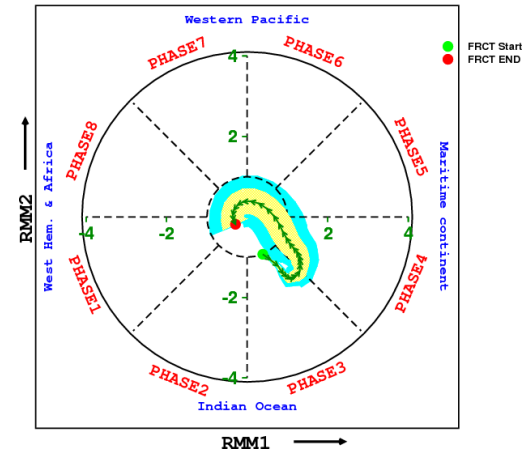OLR (shaded) and Chi at 200hPa (contour x10^6)
contour from -10 to 10 by 2

(Week1: 17Mar-23Mar) (Week2: 24Mar-30Mar)
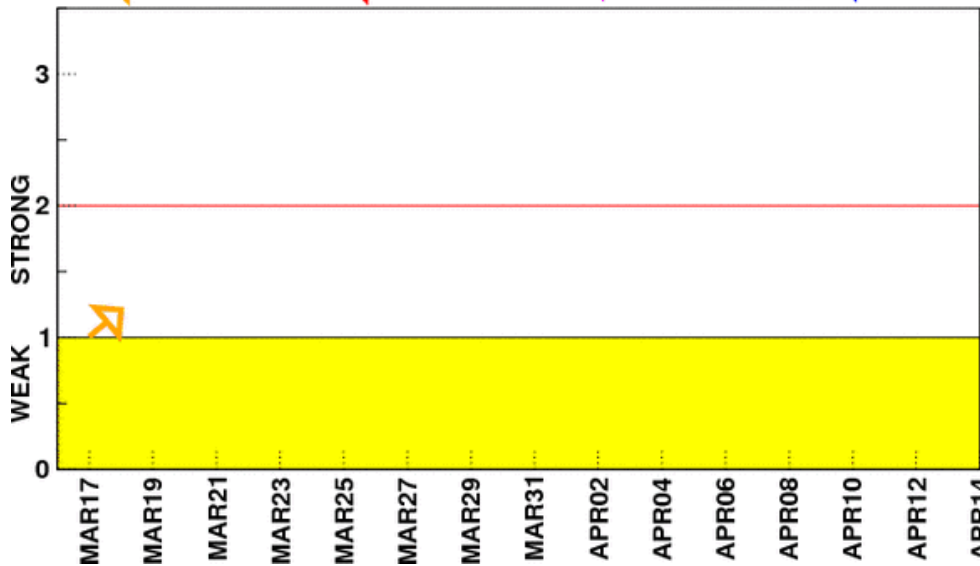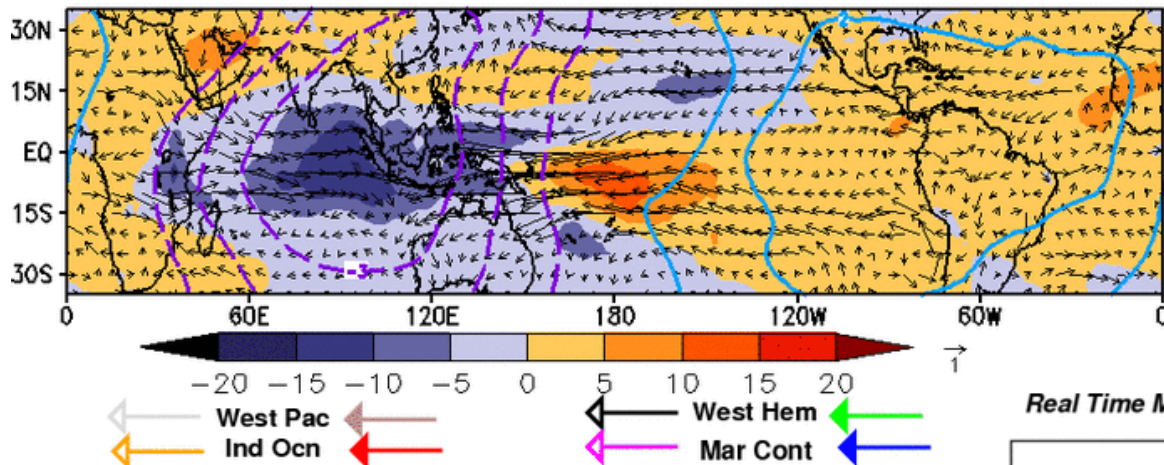(Week3: 31Mar-06Apr) (Week4: 07Apr-13Apr)

Real Time MJO forecast based on 20220316

MJO Forecast

Dey et al. 2019, Pageoph
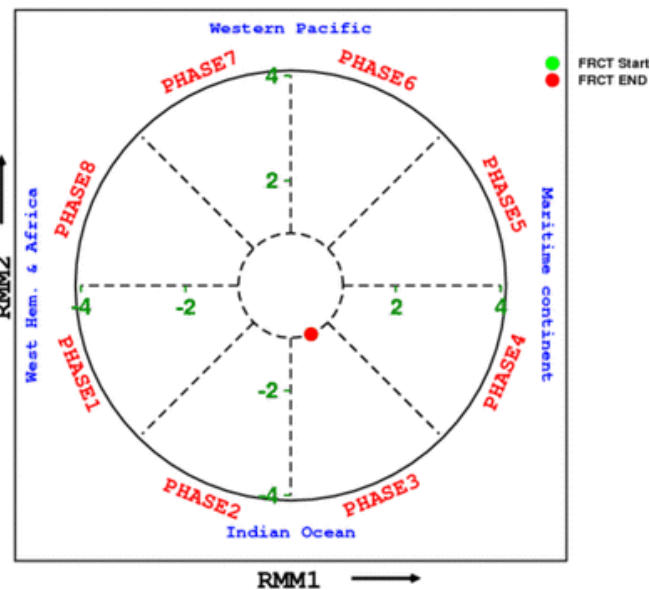
EXTENDED RANGE PRODUCTS Applications

1) **Agromet bulletins based on 2-weeks weather forecast issued once in a week by CRIDA and IMD**
http://www.cropweatheroutlook.in/crida/amis/contingencyPlan/NAAS.jsp

2) **Hydrological and land surface products are given by IIT Gandhinagar and IMD**
https://sites.google.com/iitgn.ac.in/expforecastlandsurfaceproducts/erf-weekly-forecast-cumulative/weekly-soil-moisture
https://www.imdpune.gov.in/hydrology/Drought_Monitoring.html
https://www.imdpune.gov.in/hydrology/hydrg_index.html

3) **Health bulletin issued by IMD**
https://imdpune.gov.in/hydrology/health.html

4) **The South Asia Drought Monitoring System (SADMS) weekly bulletin is produced by the International Water Management Institute (IWMI)**
https://www.iwmi.cgiar.org/tools/drought-bulletin/2021/2-south_asia_drought_outlook-2021-june-issue-2.pdf

Heat Wave PRODUCTS Applications

Average Heat Wave days during March-June

1951-1960
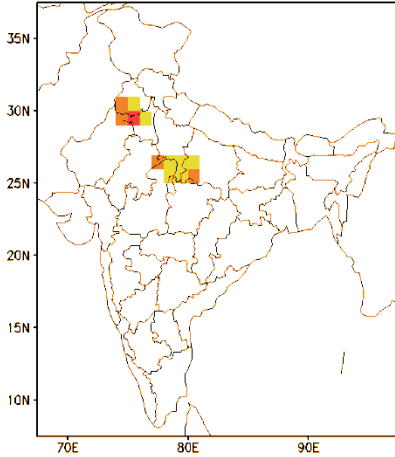
1961-1970
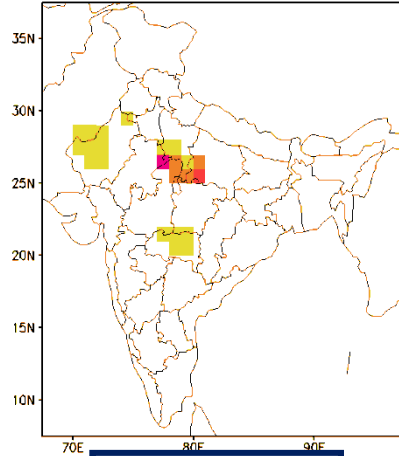
1971-1980
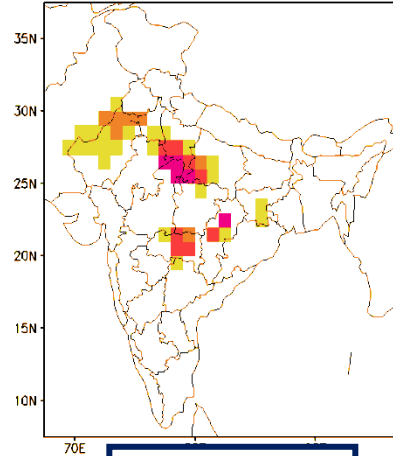
1981-1990
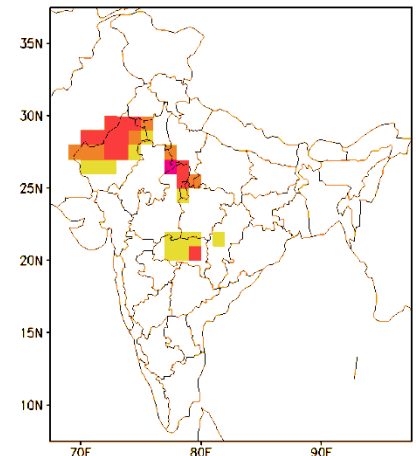
1991-2000
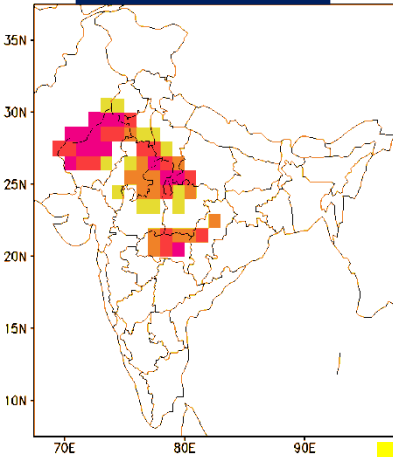
2001-2010
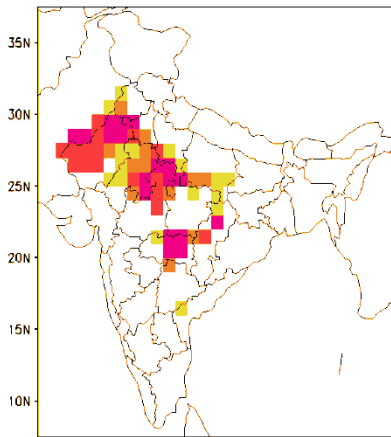
2011-2017
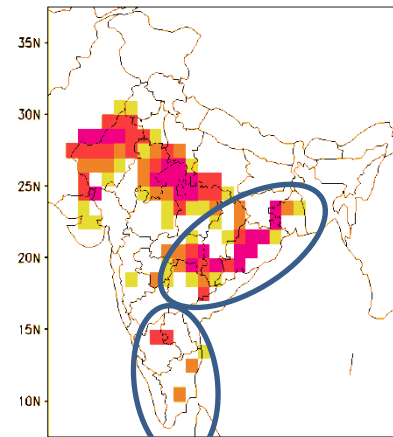
A large region of southern parts and east coast regions are mostly affected by HWs in recent decades (no. of HW days also increasing)

8   10   12   15
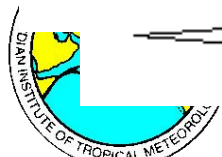
Heat wave and Monsoon Rainfall
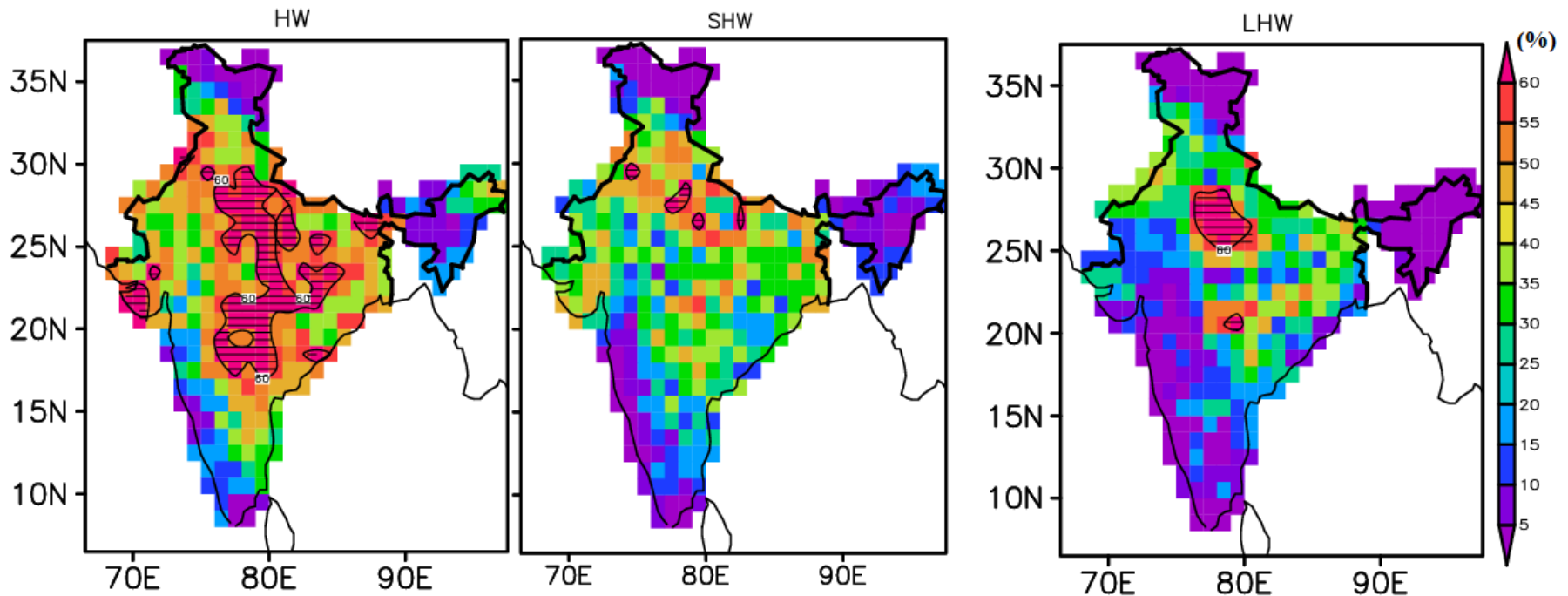
The area under hatches indicates the probability of occurrence of above normal frequency of particular categorical heat-wave spell is more than 60% chances when the antecedent (Lag-1)AISMR is reported as deficit. (1950-2019)

The Role of Antecedent Indian Summer Monsoon Rainfall on the occurrence of Heatwaves over India and the crop productivity in the present global warming era

Murali,Sahai et al, under review

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

Tmax
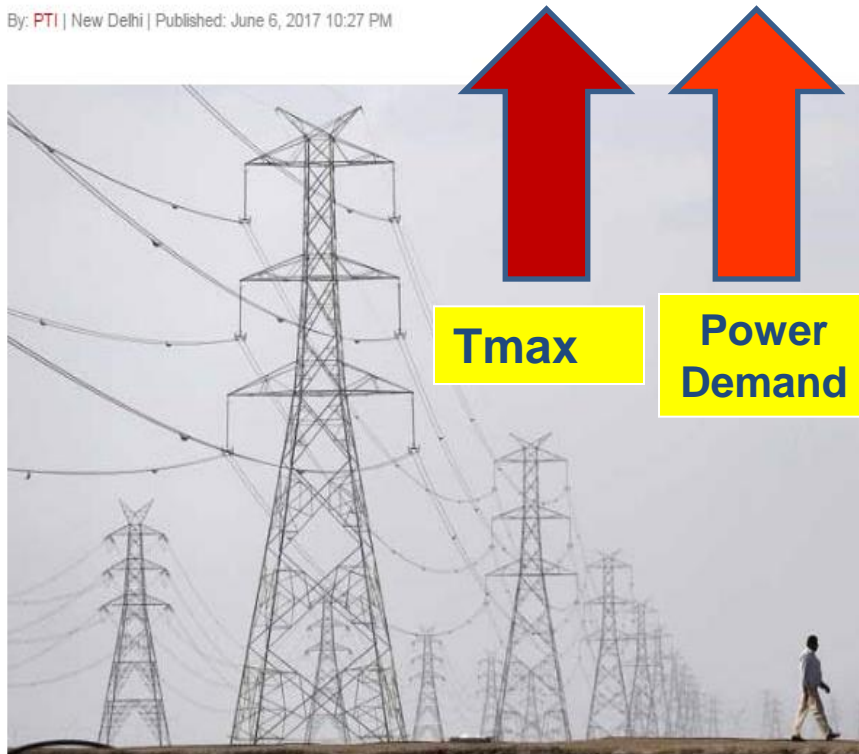
Power Demand

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.

Therefore extended range forecast and outlook of Tmax and heat wave is very important for agriculture, drinking water availability, power generation and distribution and health

Example -1

Real-time forecast made on 16th May 2018

Prob of ocurr: Obs (100%) & Model (varying)
Valid time =17MAY2018

HW spell: 18May-01Jun 2018
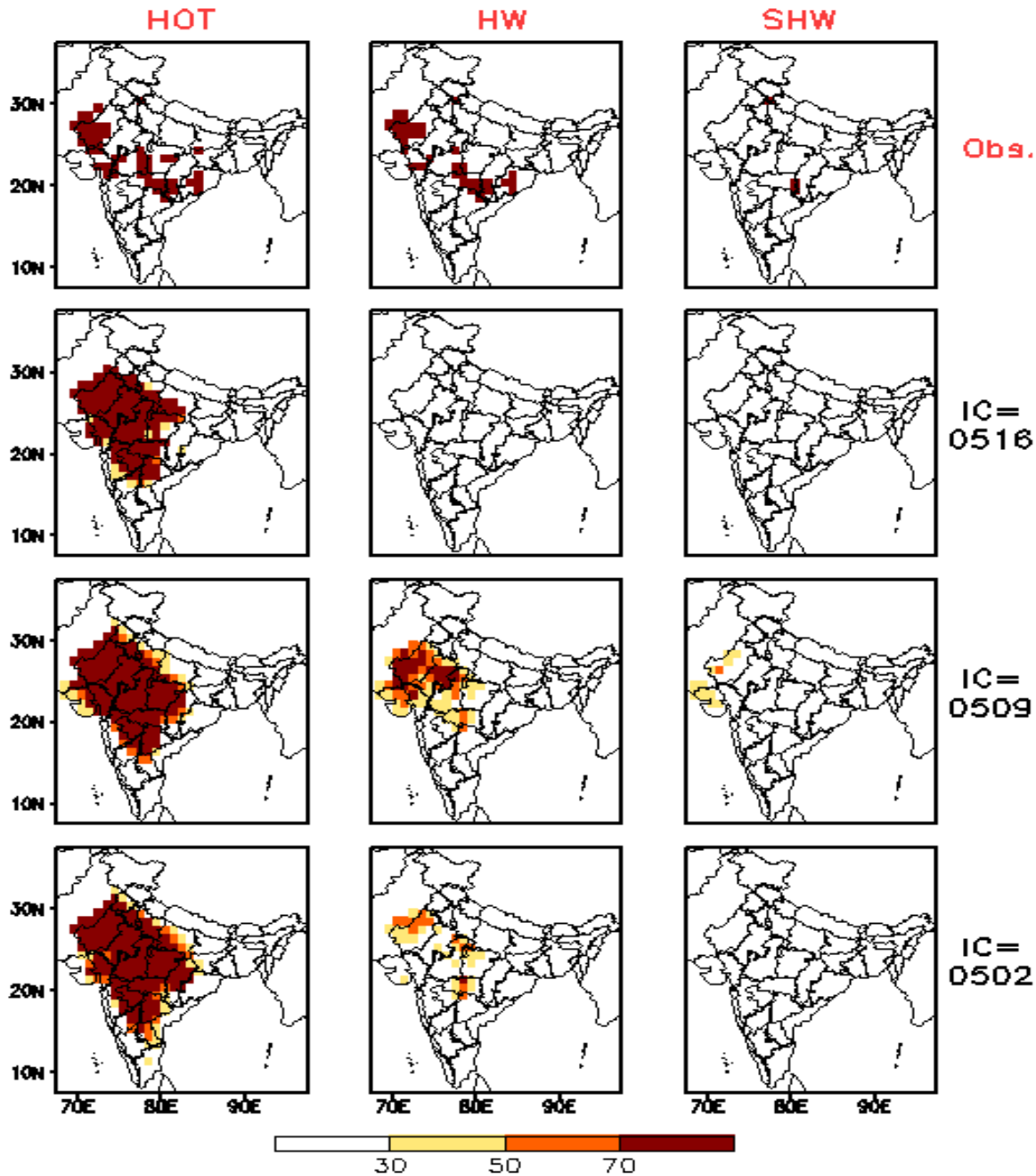
Probabilities of heat waves and severe heat waves : OBS vs MME
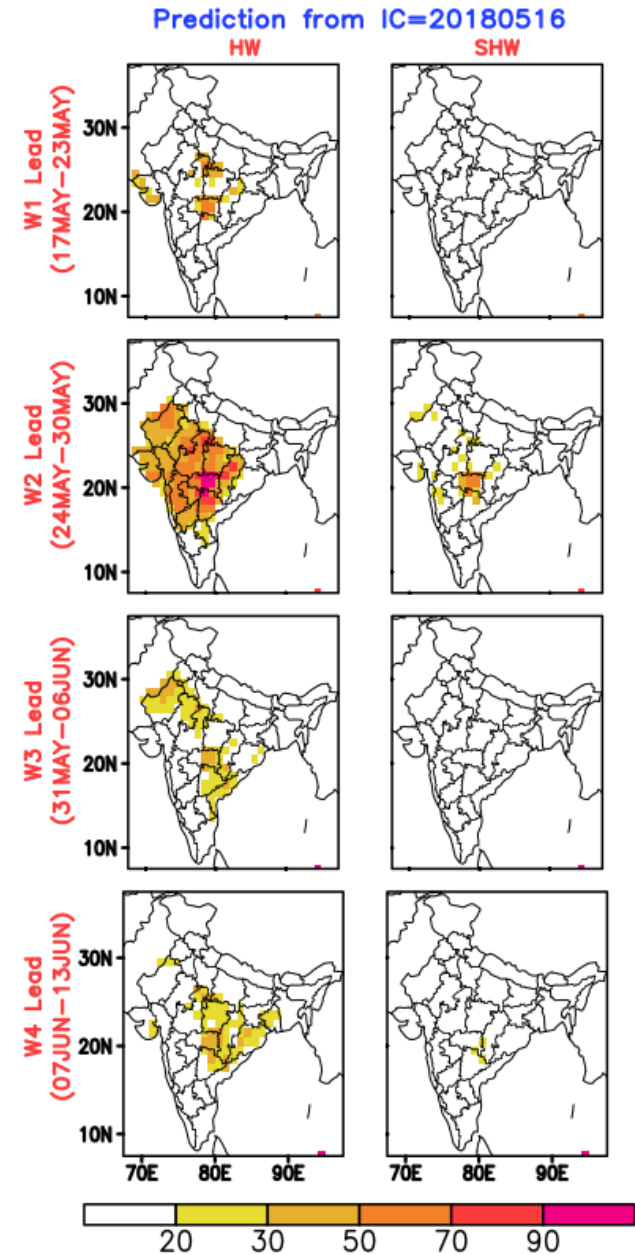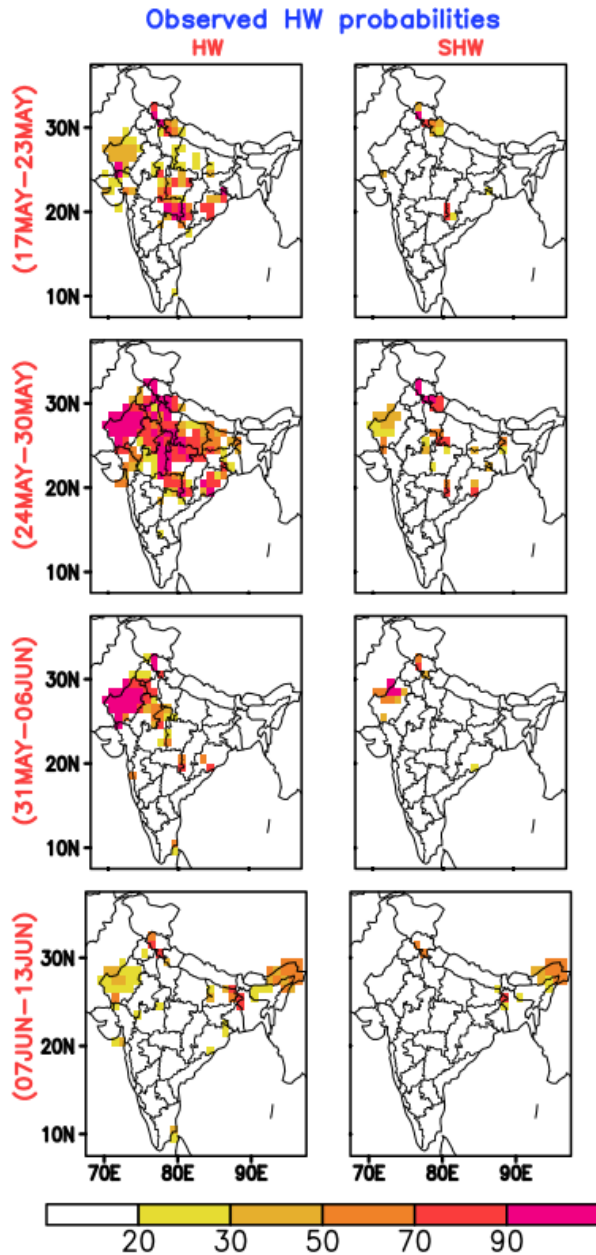
How might humidity influence the effects of heat?

Probability of heat waves and severe heat waves
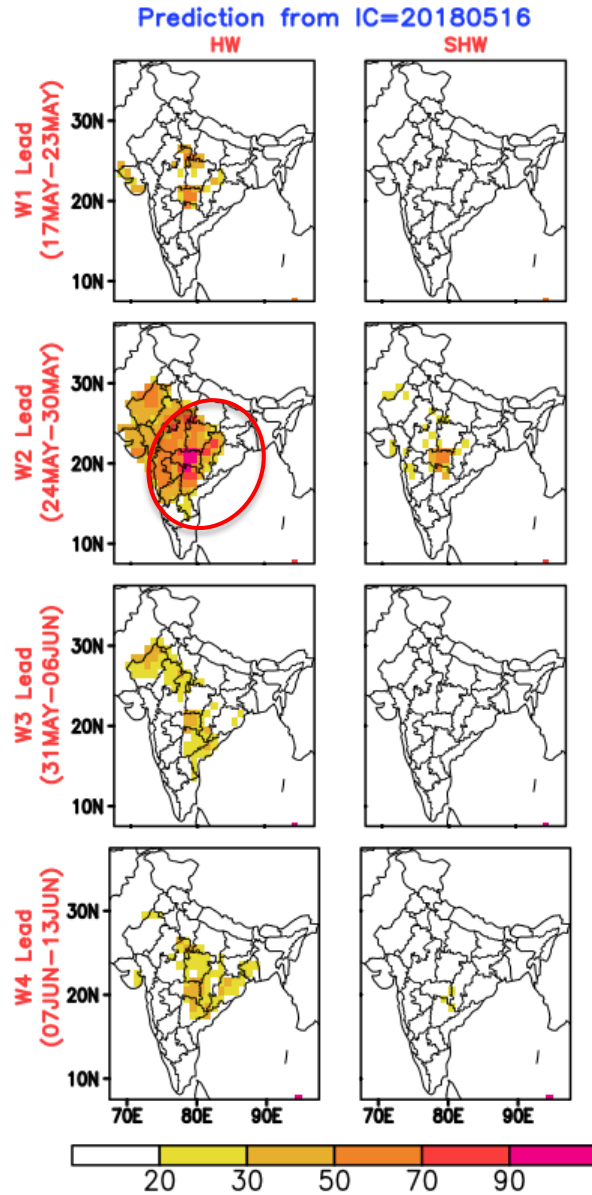
2m relative humidity forecast (MME)
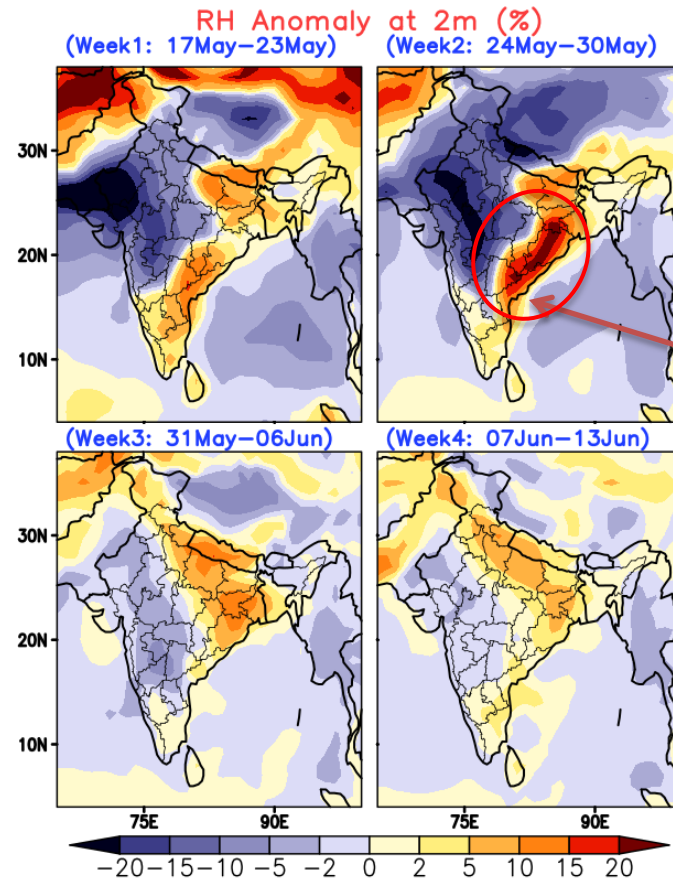
Regions where humidity may worsen the effects of heat

Relative humidity forecasts are experimental!

Heatwave Forecast used for Disaster Risk Reduction

Heat-wave Related Deaths in India
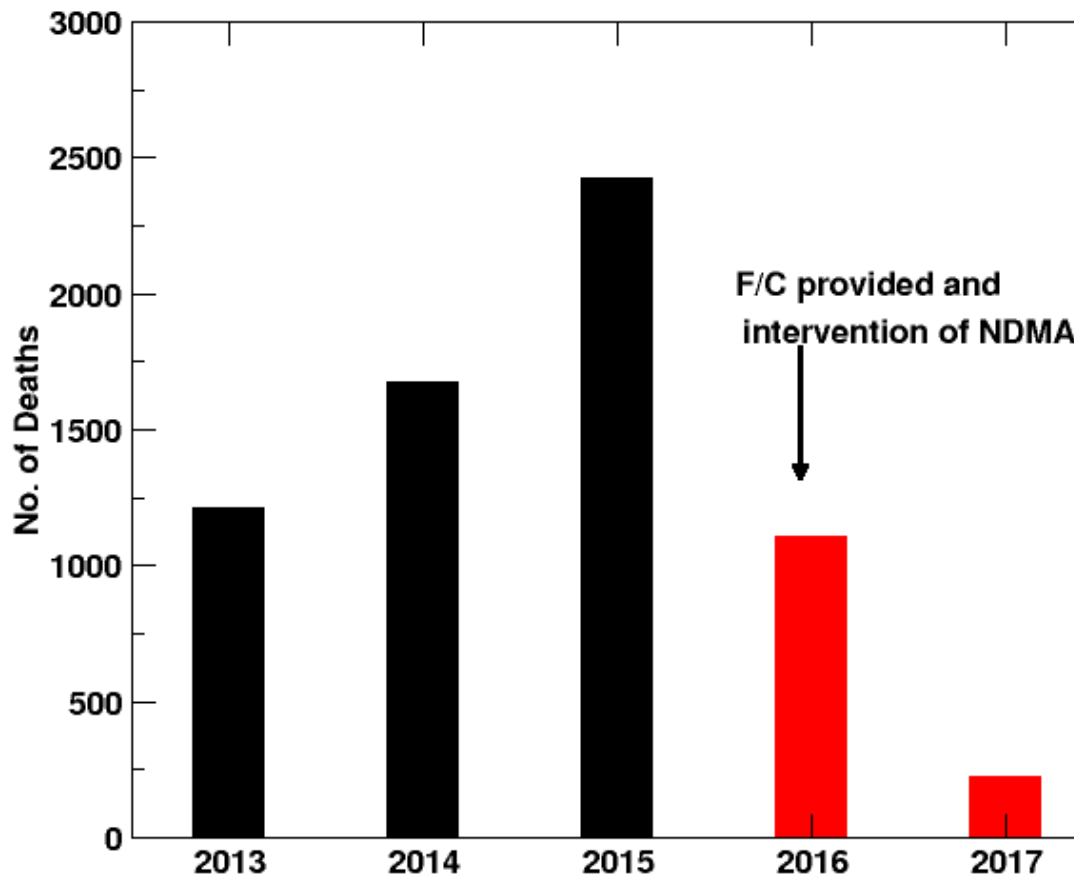
Years	Deaths due to heat wave
1992 -2020	25692
2011-2015	6973
2016-2021	1743

F/C provided and intervention of NDMA

2019 226
2020   4
2021   4

**2016: 0.71°C (Warmest year since 1901)
2017 3rd warmest, 2021 5th, 2019 8th, 2020 9th**

Hydrological PRODUCTS Applications

STANDARDIZED PRECIPITATION INDEX OUTLOOK
SPI Condition From 12 July To 8 August 2018

Using ERF 4 Week Forecast as on 11 July
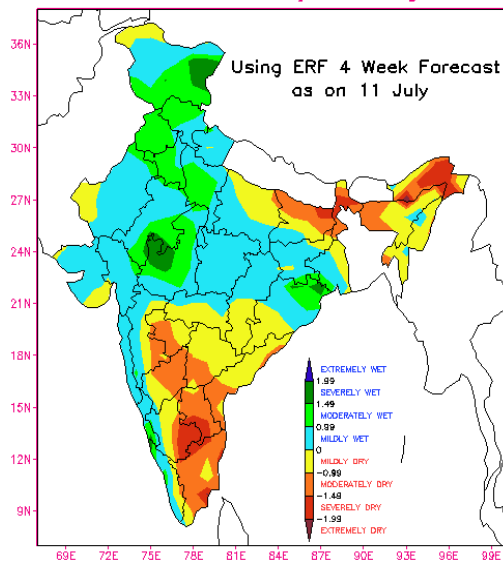
STANDARDIZED PRECIPITATION INDEX
Cumulative For Period 12 July To 8 August 2018

Observed
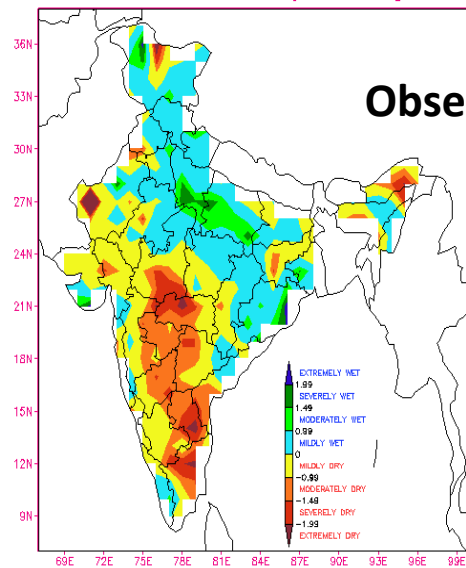
Drought Monitoring

CONTINGENCY TABLE STATISTICS

Criteria	No. Of Grid Points	Percentage Of Grid Points
Total	316	
Same Category	95	30.1 %
1 Category Out	137	43.4 %
2 Category Out	52	16.5 %
3 Category Out	26	8.3 %
4 Category Out	5	1.6 %
5 Category Out	1	0.3 %
6 Category Out	0	0.0 %
7 Category Out	0	0.0 %
Within 1 Category Out	232	73.4 %

Predicted anomalies of hydrologic variables for lead 7, 15, 30, and 45 days. (a) Observed (standardized) anomalies in (VIC-simulated) runoff at lead-7 days (b) anomalies in (VIC-simulated) runoff using bias-corrected IITM-ensemble for lead-7 days. (c and d) same as (a and b) but for root-zone soil moisture (e-h), (i-l), (m-p) same as (a and b) for lead 15, 30 and 45 days, respectively.
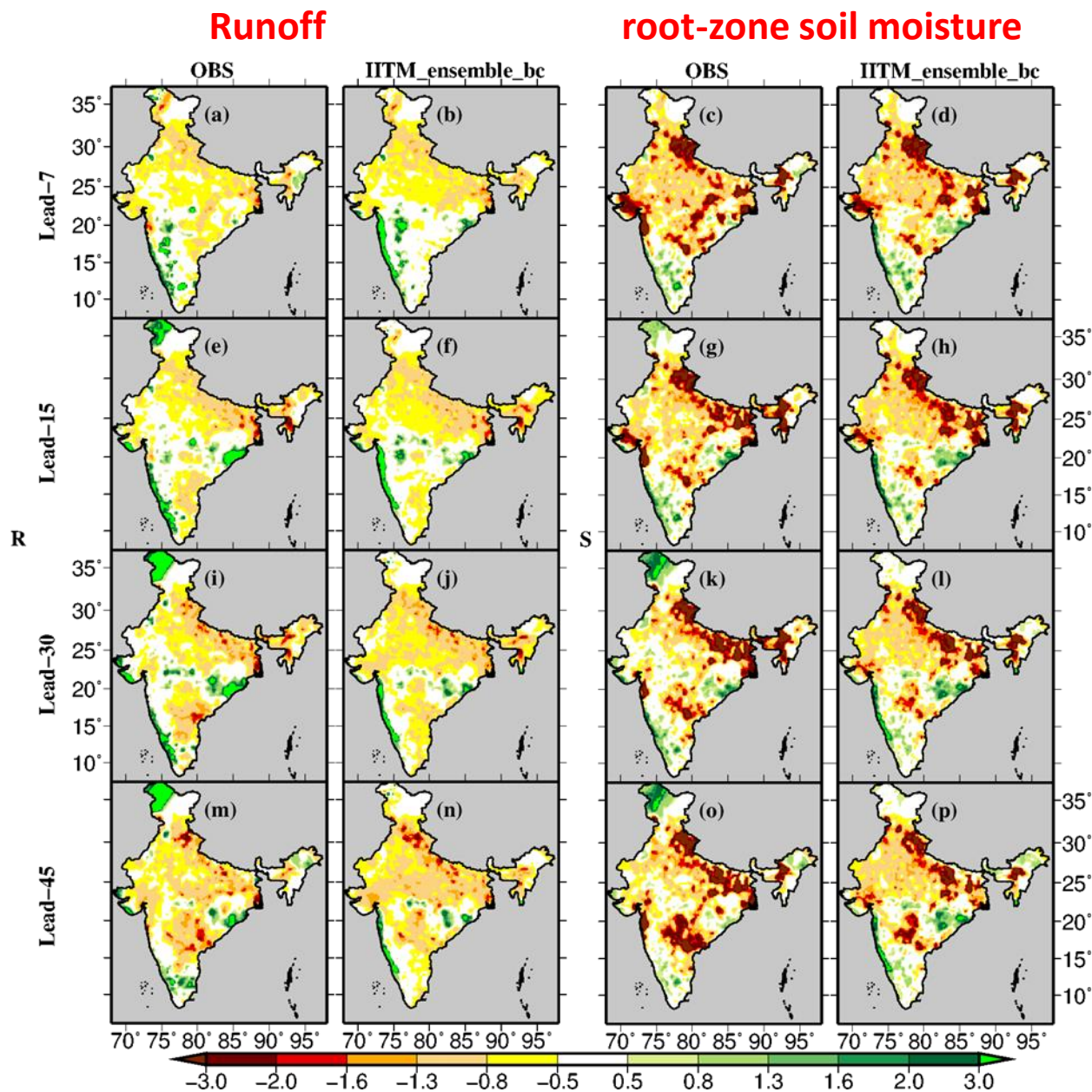
Shah et al. (2017)
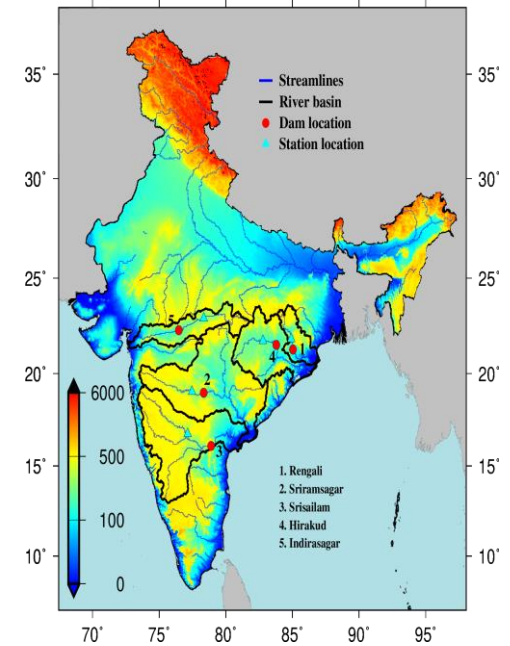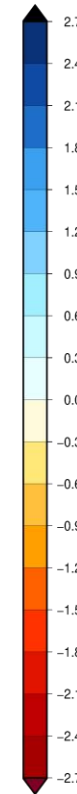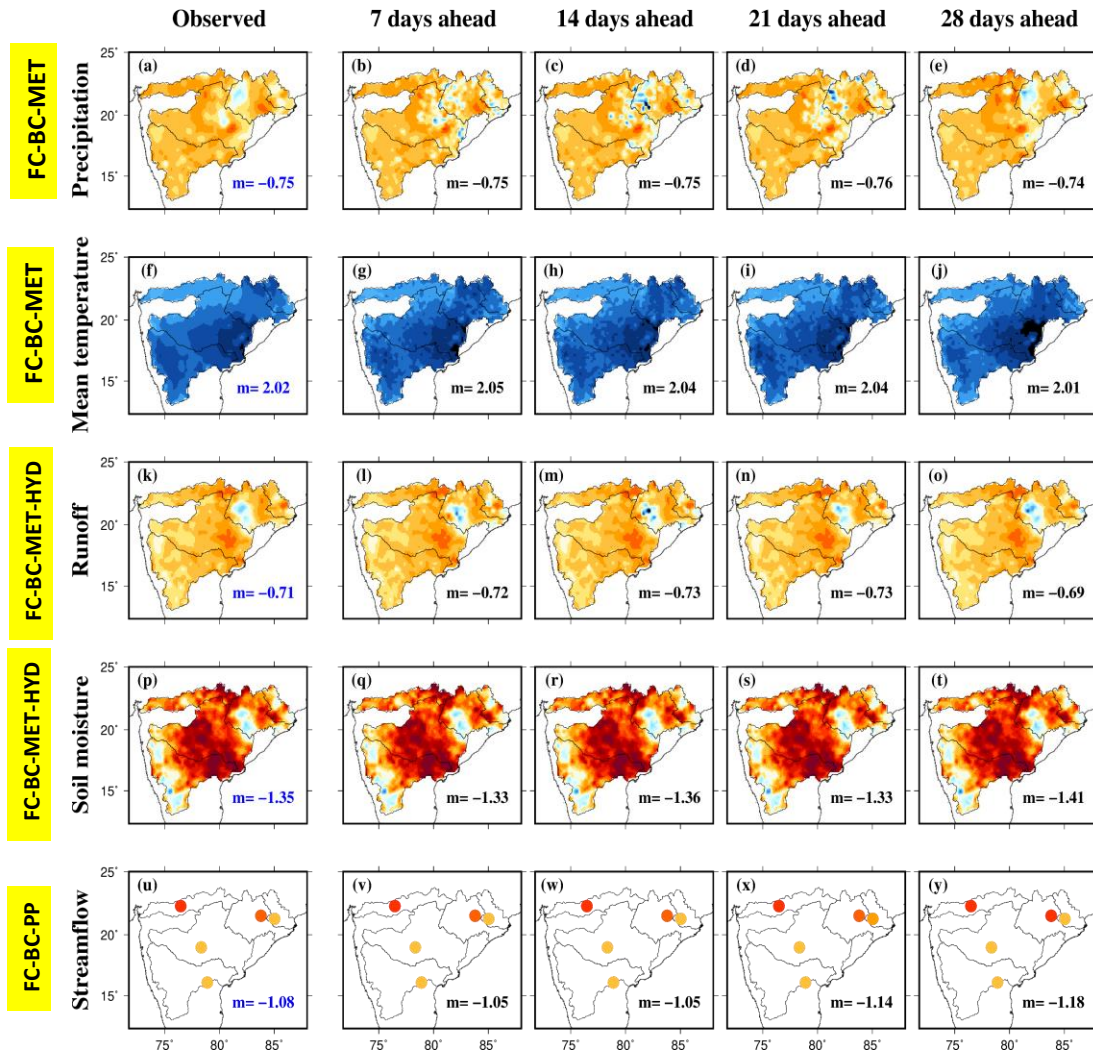
Values shown by m indicate median values for the five river basins.

Tiwari, Sahai and Mishra (communicated)

Agricultural PRODUCTS Applications

National Agromet Advisory Service Bulletin
Based on
Extended Range Weather Forecast

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

भाकृअनुप
ICAR

REALIZED RAINFALL

12TH TO 18TH OCTOBER, 2017
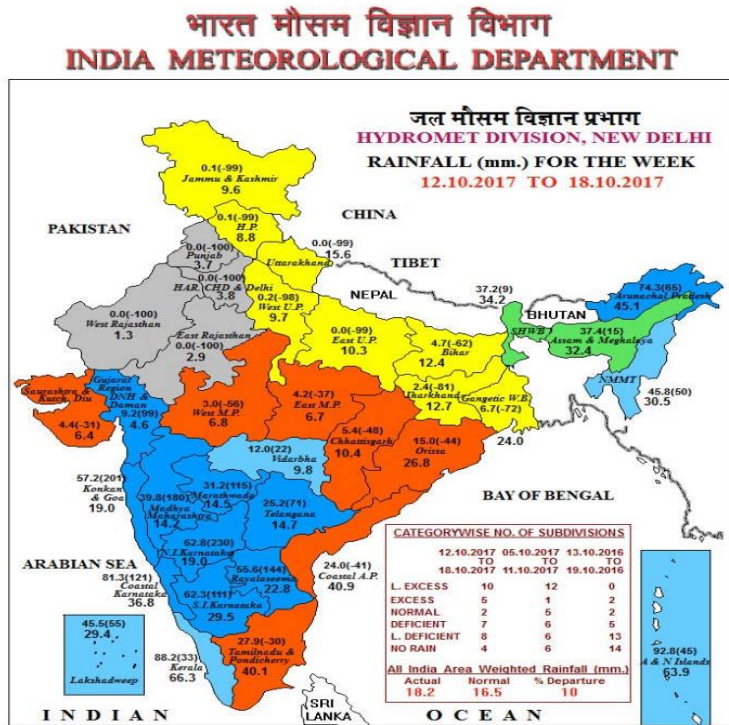
19TH TO 26TH OCTOBER, 2017
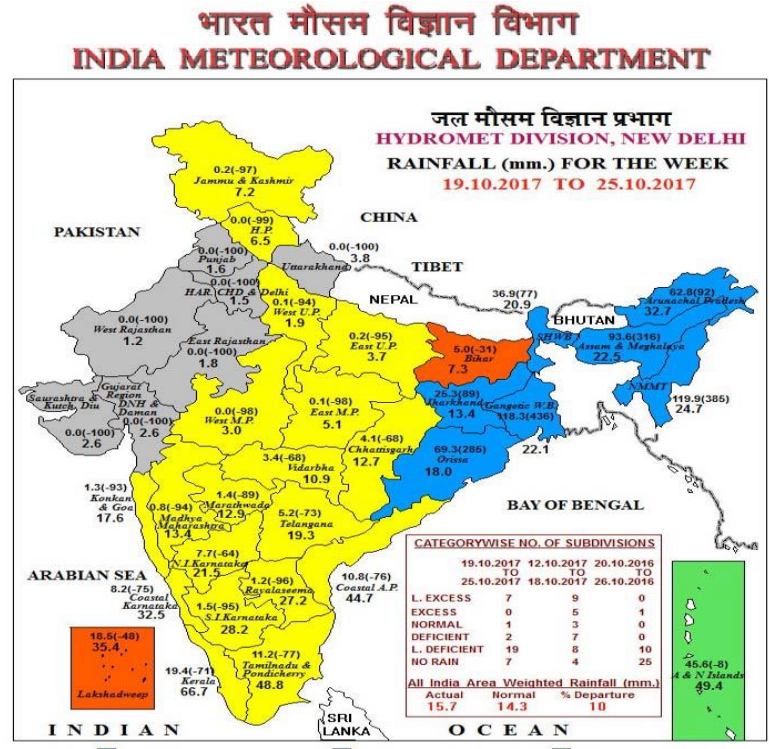
EXTENDED RANGE FORECAST: Sub-division-wise rainfall forecast maps for the next 2 weeks (IC –25 October)

27th October to 2nd November 2017

3rd to 9th November 2017
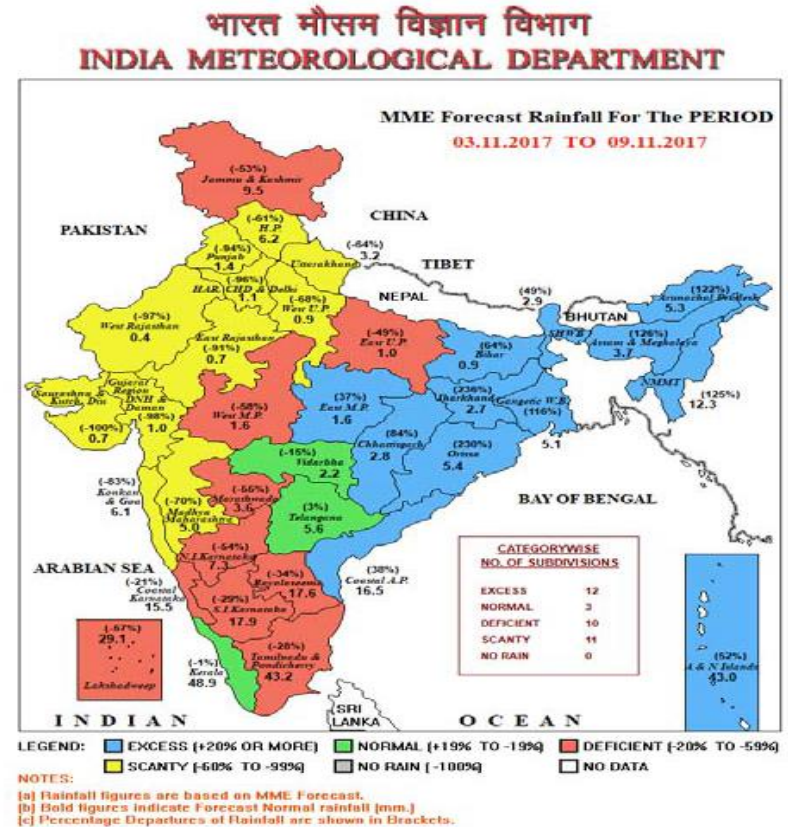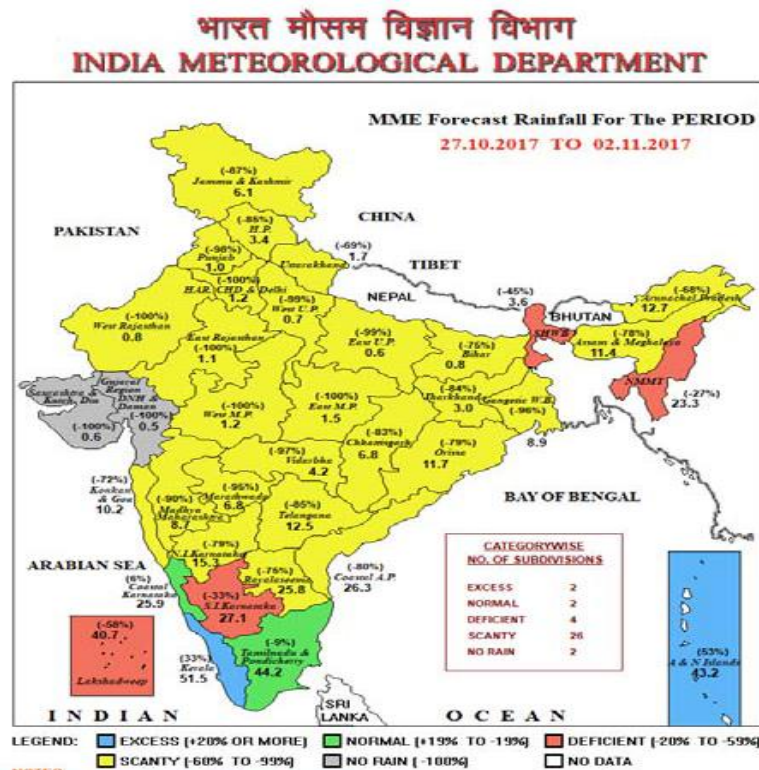
Strategic Agricultural Planning based on rainfall during next two weeks till 09th November 2017

Agromet Advisories

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

Agromet Advisories

Odisha : Rainfall received during 1-26 October 2017 over Odisha is 161.0 mm (58% surplus) .**The extended range weather forecast provided for next two weeks is** Scanty and Excess, **respectively.**

ADVISORIES : • **Sowing of rabi groundnut is recommended. Choose high yielding varieties like Smruti, TAG- 27, TAG – 24 and JL-24. Use 60 kg pods /acre. Treat the seeds with 1.5 g Carbendazim or 3 g Thiram/kg of seeds one week before sowing.**

• **Optimum time for sowing mustard under rainfed condition. Choose high yielding varieties like Parbhati, Anuradha, and TS-29 & M-27. Use 3 to 4 kg seeds/acre. Treat the seeds with 1.5 g Carbendazim or Thiram 3g/kg of seeds one week before sowing.**

Assam : Rainfall received during 1-26 October 2017 over Assam is 190.2 mm (36% surplus). **The extended range weather forecast provided for next two weeks is** scanty and excess, **respectively.**

ADVISORIES :

• **Spray Malathion 5% dust @ 20 kg/ha as weather is congenial for rice Gundhi bug infestation.**

• **Farmers are advised to prepare land for sowing of rapeseed, and mustard crop. Apply lime @ 65.5 kg/bigha at least 15 days prior to sowing of seeds. The recommended varieties of rapeseed and mustard are M-27, TS-36, TS-38 etc.**

• **Farmers are also advised to prepare the field for potato cultivation.**

Rainfall forecast maps for the next 2 weeks
(IC – 6th June) (8th to 28th June 2018)

An Example of Extended Range Forecast application in Agriculture

Date	Realized Rainfall for month											Vidarbha
	01-Jun	02-Jun	03-Jun	04-Jun	05-Jun	06-Jun	07-Jun	08-Jun	09-Jun	10-Jun	11-Jun	
Rainfall (mm)	50	5	65	0	0	75	0	45	0	0	0	

↑ **Pre-monsoon shower**

Date	Rainfall Forecast				
	12-Jun	13-Jun	14-Jun	15-Jun	16-Jun
Rainfall (mm)	1	0	0	0	1

Advisory for sowing operation

Even though there was sufficient realized rainfall during first 10 days of June fulfilling the criteria for sowing, based on Extended range forecast, farmers were advised to wait for sufficient rainfall to undertake sowing.

Realization

- Farmers followed the advisory as there was wide publicity by the State Department of Agriculture, Maharashtra.
- Only 8% area was sown by 25th June 2018, as compared to 45% area during previous year.
- As the forecast was correct and sowing was not undertaken, there was no report of crop loss.

Districtwise forecast of Rainfall over Maharashtra (IC 5Aug 2020)
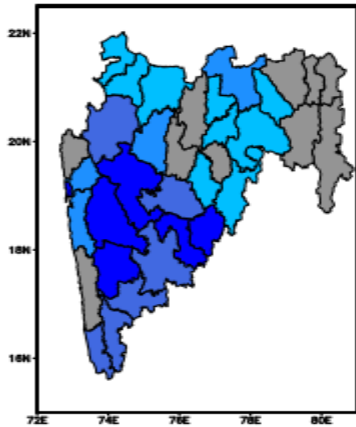
AUG06—AUG12(WK01) AUG13—AUG19(WK02) AUG20—AUG26(WK03) AUG27—SEP02(WK04)

Anantpur District

Health PRODUCTS Applications

Climate information for Health
(Experimental basis)
Based on Extended Range Weather Forecast
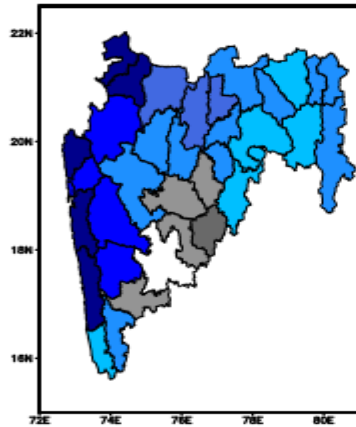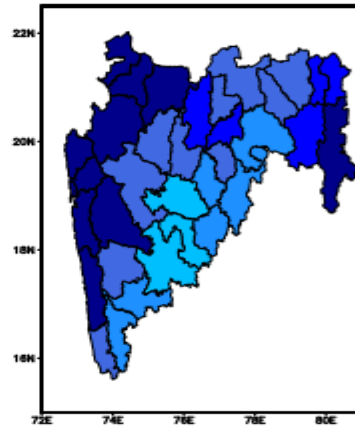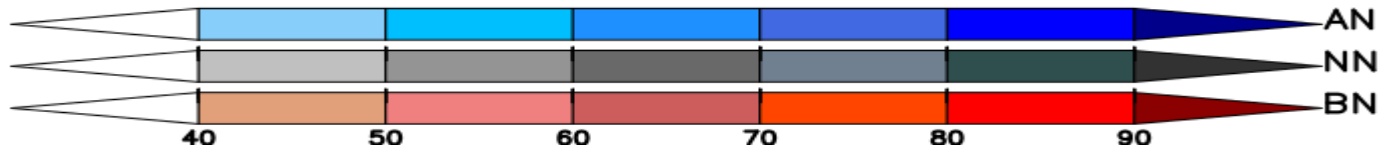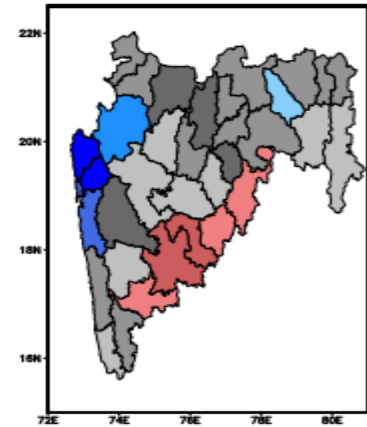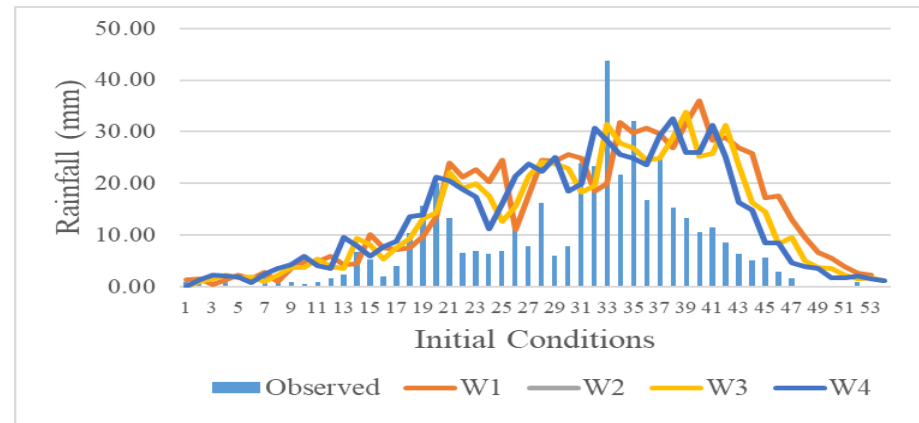**(Valid from 15th to 28th March, 2019)**
Issued on 15th March, 2019
Office of Climate Research and Services, India Meteorological Department, Pune

Realised Weather during 01st Mar to 14th Mar 2019

- Major parts of the country experienced maximum temperature below 35°C except some places in Maharashtra, Telangana, Karnataka, Kerala, Tamil Nadu and major parts of the country experienced minimum temperature below 20°C except some places in Maharashtra, Goa, Karnataka, Telangana, Chhattisgarh, West Bengal, Odisha, Andhra Pradesh, Kerala, Tamil Nadu during 01st to 07th Mar 2019.
- Major parts of the country experienced maximum temperature below 35°C except some places in Maharashtra, Chhattisgarh, Odisha, Telangana, Karnataka, Kerala, Tamil Nadu and major parts of the country experienced minimum temperature below 20°C except some places in Maharashtra, Goa, Karnataka, Telangana, Chhattisgarh, West Bengal, Odisha, Andhra Pradesh, Kerala, Tamil Nadu during 08th to 14th Mar 2019.

Weekly Prediction of maximum and minimum temperature
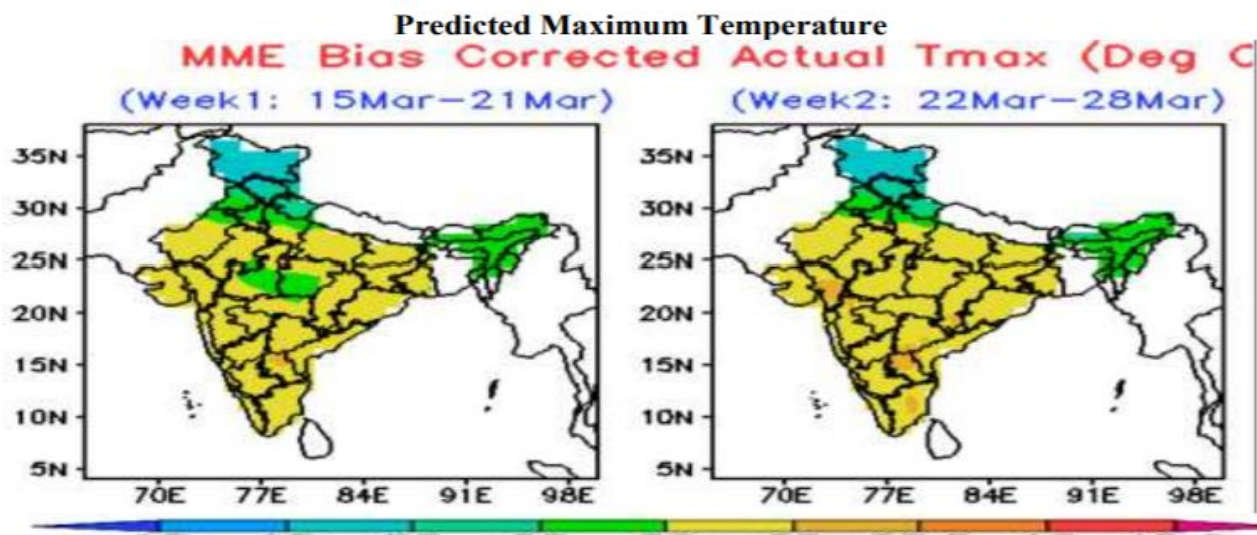
Predicted Maximum Temperature

MME Bias Corrected Actual Tmax (Deg C

(Week1: 15Mar−21Mar)　　　(Week2: 22Mar−28Mar)

ERFS based weekly evolution of transmission window for Malaria					
Week	VBD	Threshold minimum temp (Th-Tm)	Region(s) with Predicted Tmin within range of Th-Tmin	Threshold maximum temp	Region(s) with Predicted Tmax within range of
15th to 21st Mar 2019	Malaria (*Plasmodium falciparum*)	16-19			
	Malaria (*Plasmodium vivax*)	14-15			
22nd to 28th Mar 2019	Malaria (*Plasmodium falciparum*)	16-19			
	Malaria (*Plasmodium vivax*)	14-15			

ERFS based weekly evolution of transmission window for Dengue					
Week	VBD	Threshold minimum temp (Th-Tmin)	Region(s) with Predicted Tmin within range of Th-Tmin	Threshold maximum temp (Th-Tmax)	Region(s) with Predicted Tmax within range of Th-Tmax
15th to 21st Mar 2019	Dengue virus	11.9°C	Haryana, major parts of Rajasthan, Punjab, some parts of Uttar Pradesh, Madhya Pradesh, few parts of North-eastern states.	Not known	-
22nd to 28th Mar 2019	Dengue virus	11.9°C	Punjab, Haryana, some parts of Rajasthan, Uttar Pradesh, few parts of Uttarakhand and North-eastern states.	Not known	-

Glossary:

SN	Malaria **VBD**	Threshold minimum temp (Th-Tmin)	Threshold maximum temp (Th-Tmax)
1	*Plasmodium falciparum*	16-19°C	33-39°C
2	*Plasmodium vivax*	14-15°C	

		Probabilistic weekly evolution of transmission window for Malaria (*Plasmodium falciparum*)		
		First week (15th to 21st Mar 2019):		
1		**75** probability level	🟥	

First week (15th to 21st Mar 2019):

2	1	**75** probability level	🟥	Nil.	ka, Kerala
	2	**55-75** probability level	🟧	Nil.	Gujarat , ngana and
3	3	**35-55** probability level	🟨	Few districts of Rajasthan, Punjab and Haryana.	and, West
	4	**Less than 35** probability level	🟩	Major districts in rest of states.	h, Odisha,
4					

Second week (22nd to 28th Mar 2019):

1	1	**75** probability level	🟥	Nil.	
	2	**55-75** probability level	🟧	Nil.	Karnataka
2	3	**35-55** probability level	🟨	Few districts of Punjab.	f Gujarat, ka, Kerala
3	4	**Less than 35** probability level	🟩	All states	hattisgarh, f Odisha,

Glossary:

SN	VBD	Threshold minimum temp (Th-Tmin)	Threshold maximum temp (Th-Tmax)
1	Dengue virus	11.9ºC	Not known

Malaria Week-1 Forecast Verification for Patna District (April to Sep 2019)

Yes : Means Satisfy WMO Criteria (33°C< Tmax <39°C and 14°C <Tmin <19°C) for both P. Vivax and P.Falciperum parasite

OBS FCST	YES	NO
YES	7	15*
NO	Nil	2

(Malaria>=6)
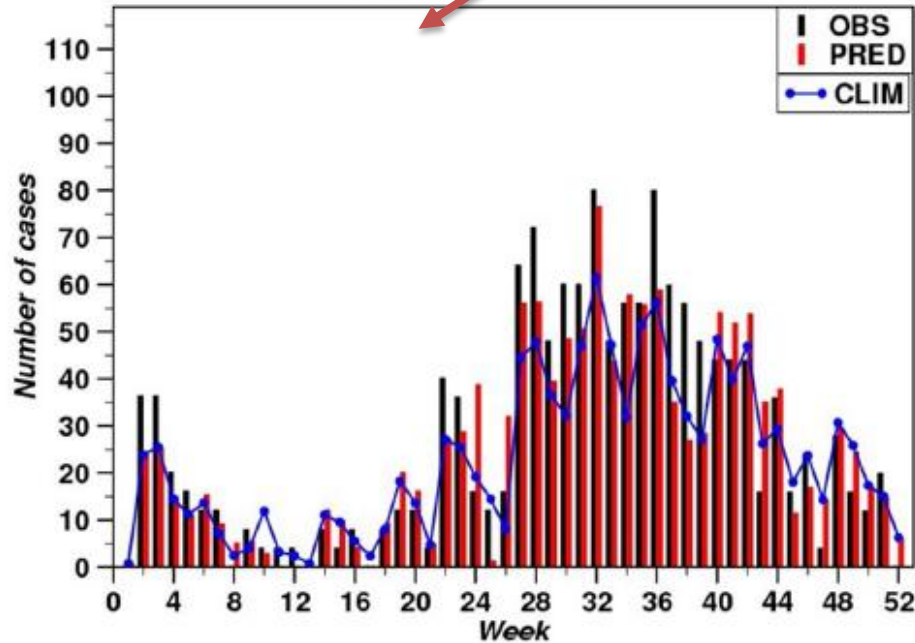
Contingency table is prepared for Weekly Malaria Cases and Week 1 Forecast using ERPS of Patna District from Bihar.

*More False alarm is seen during April and May, while correct Week 1 Forecast is seen during June to September IC. WMO criteria does not include rainfall while there is a clear link with rainfall season and malaria season. This could be a reason for large false alarm.

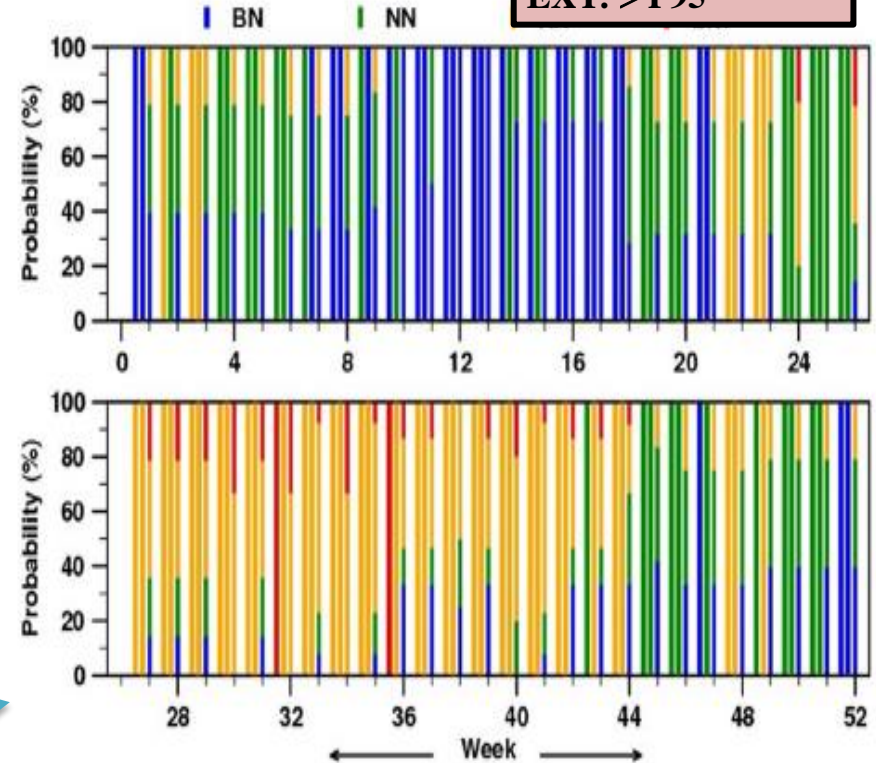# Nagpur 2013 Malaria
Forecast is based on climatic data only

Deterministic Forecast

Q1= lower tercile
Q3= upper tercile
P95= 95th percentile

BN: < Q1
NN: ≥ Q1 and ≤ Q3
AN: > Q3 and ≤ P95
EXT: > P95

Probabilisticistic Forecast
% Probability of Below Normal, Near Normal, Above Normal and Extreme occurences.
For Observation and clim forecast any of the above probabilities is 100%

Development of a probabilistic early health warning system based on meteorological parameters

A. K. Sahai[ ], Raju Mandal[1,2], Susmitha Joseph[1], Shubhayu Saha[3], Pradip Awate[4], Somenath Dutta[5], Avijit Dey[1], Rajib Chattopadhyay[1], R. Phani[1], D. R. Pattanaik[6] & Sunil Despande[5]

Sahai et. al (2020) Sci. Rep.

Type of events	CC	RMSE	BSS		
			BN	NN	AN
Nagpur MAL	0.74	15.4	0.21	0.15	0.29

Summary

- There are spatio-temporal errors in most of the extreme cases.

- Improvement has seen up to three weeks for multi-physics multi-model strategy over current operational system.

- Experiments with increased vertical resolution are going on.

- Fully coupled data assimilation is being attempted under MM.

- Efforts are underway to improve the skill and downscale to higher resolution using AI/ML.

However, for better services in various sectors, a strong collaboration between weather/climate scientists and stake holders (research and data exchange) and co-production is very much needed. Also the disaster managers have to be very active to take full benefit of the forcasts/warnings/advisories.

Thank You!!!