



**Seventh WMO International Workshop on Monsoon (IWM-7)
22-26 March, 2022, IMD, MoES, New Delhi, India**

MEDIUM AND EXTENDED RANGE FORECAST OF MONSOON OVER INDIA : APPLICATION IN AGRICULTURE

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Banik, K. K. Singh and M. Mohapatra**

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Layout of presentations

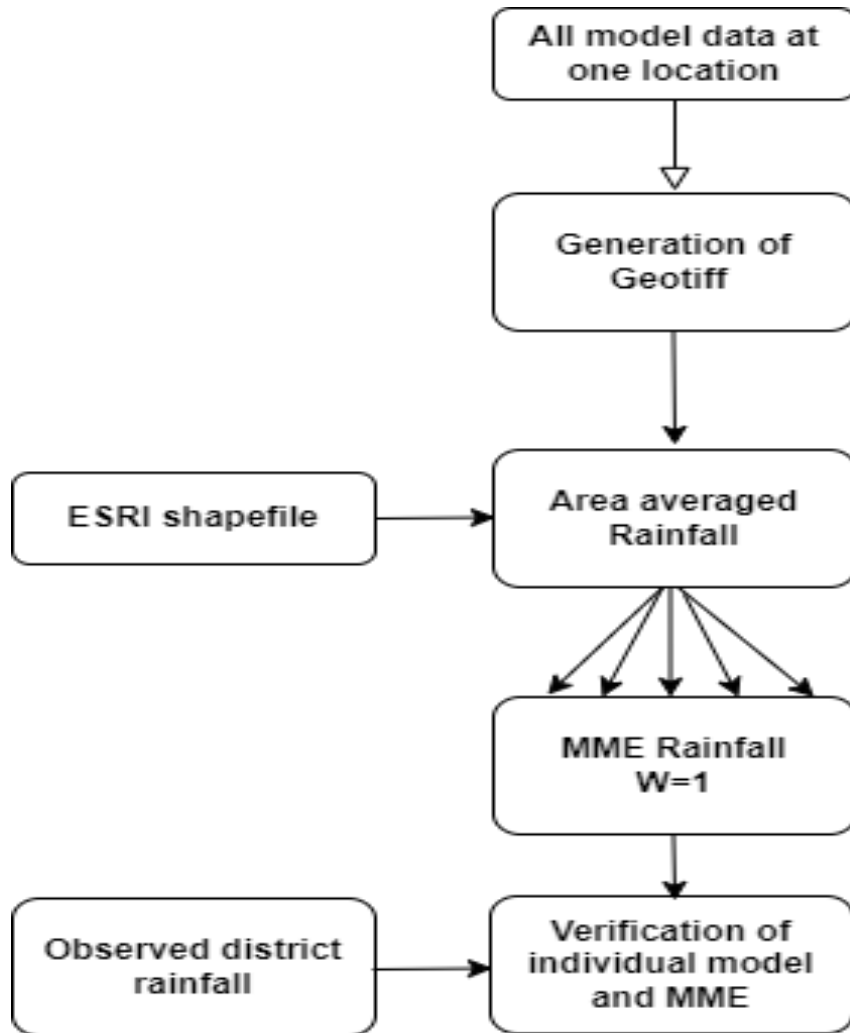
- ❖ **Intra-seasonal variability of monsoon**
- ❖ **IMD's operational MME based district/met subdivision level medium and extended range forecast Performance**
- ❖ **Application in issuing Agro-advisory to farmers**
- ❖ **Economic Benefits**
- ❖ **Summary**

IMD Operational Medium & Extended Range Forecast Models

Temporal scales	Numerical NWP/Climate Models	Resolutions and Frequency of Update
Medium range forecast	<ul style="list-style-type: none"> • Global Forecast System (GFS) atmospheric model • Global Ensemble Forecast System (GEFS) atmospheric model (20 members) 	<ul style="list-style-type: none"> • 12 km (Run four times a day ; 00, 12 UTC) for 10 days and 06 & 18 for 3 days) • 12 km (Run once a day) for 10 days
Extended range forecast (ERF)	<ul style="list-style-type: none"> • Climate Forecast System (CFS) coupled models (16 members) 	<ul style="list-style-type: none"> • 38 km (Run once in a week) for 32 days with 16 years hindcast (2003-2020)



District Level MME Rainfall generation (For 5 days)

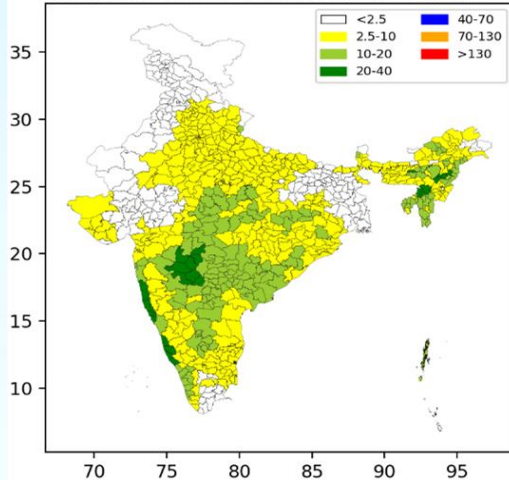


NWP Model data used

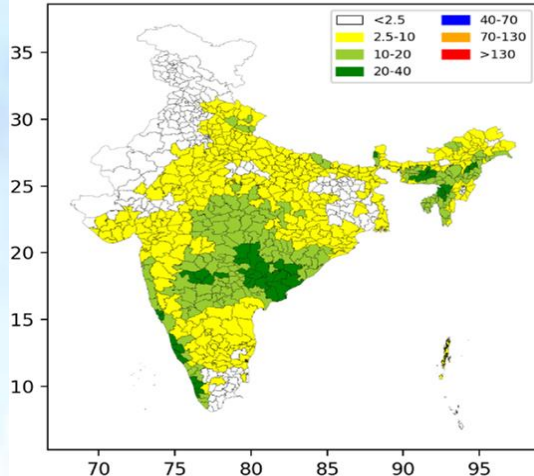
	Model	Agency	Resolution
1	GFS	IMD	12 km
2	GEFS	IMD	12 km
3	GFS	NCEP	25 km
4	UM	NCMRWF	12 km
5	GSM	JMA	25 km

Based on 04 Sep 2021

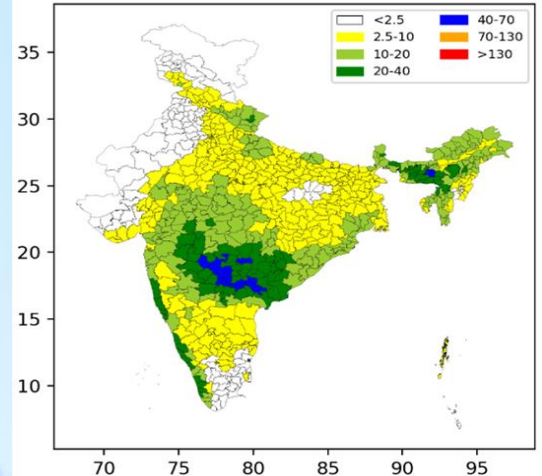
IMD MME Rainfall (mm) Forecast (Day 1)
based on 04-09-2021 valid for 03 UTC of 05-09-2021



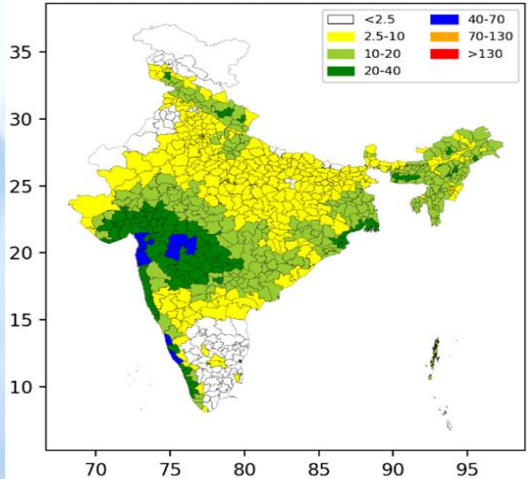
IMD MME Rainfall (mm) Forecast (Day 2)
based on 04-09-2021 valid for 03 UTC of 06-09-2021



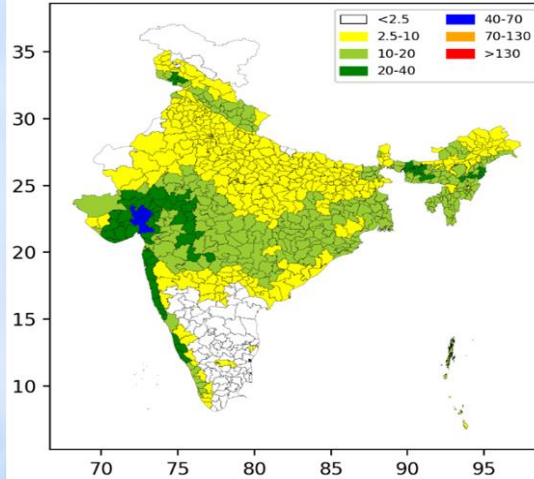
IMD MME Rainfall (mm) Forecast (Day 3)
based on 04-09-2021 valid for 03 UTC of 07-09-2021



IMD MME Rainfall (mm) Forecast (Day 4)
based on 04-09-2021 valid for 03 UTC of 08-09-2021



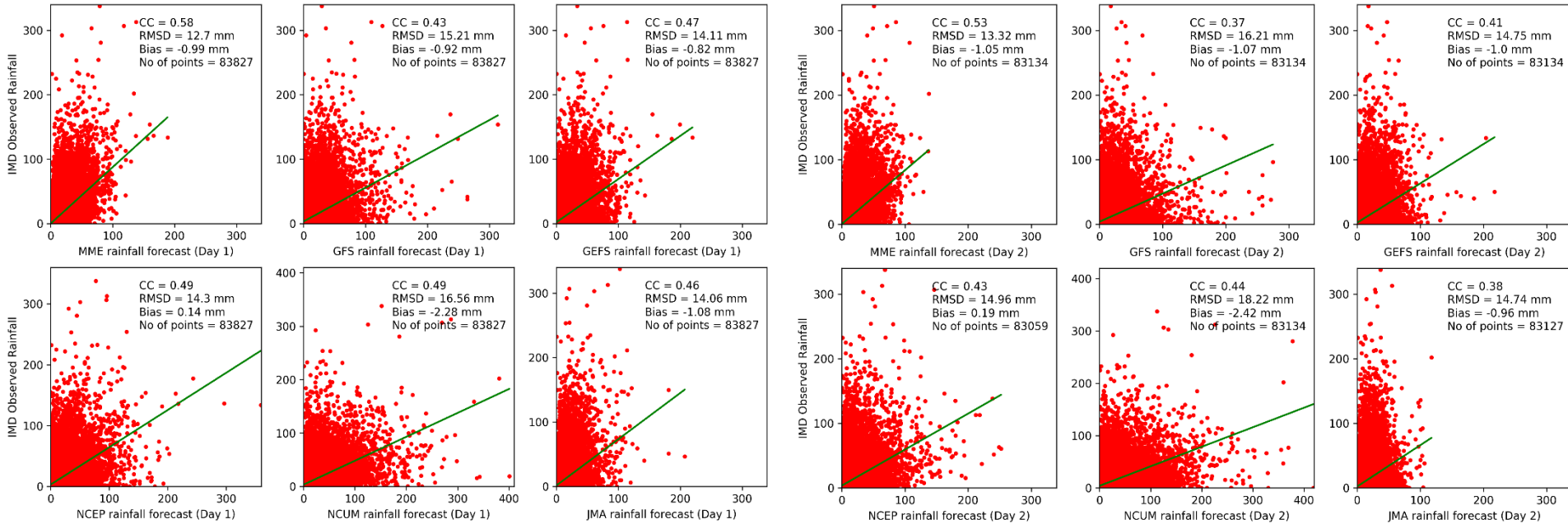
IMD MME Rainfall (mm) Forecast (Day 5)
based on 04-09-2021 valid for 03 UTC of 09-09-2021



Seasonal (JJAS) rainfall forecast verification

DAY 1

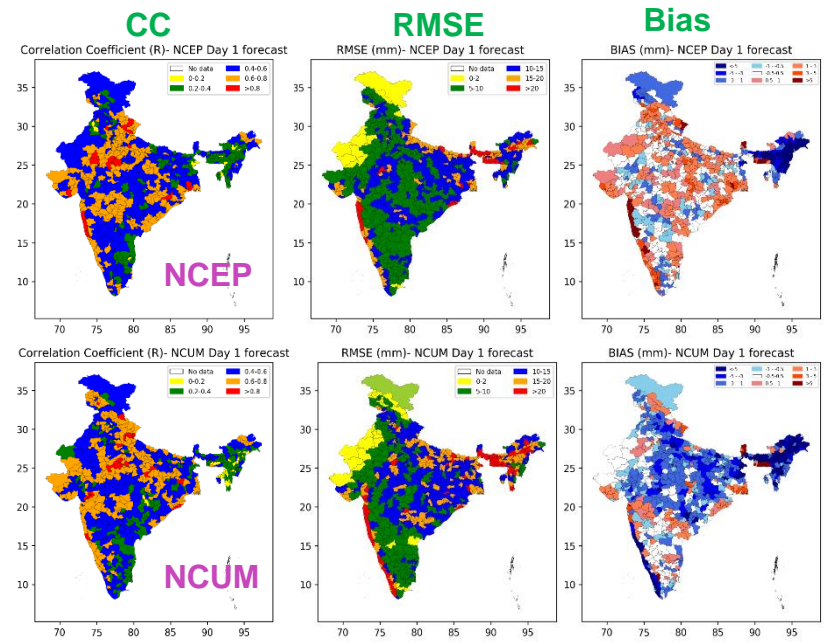
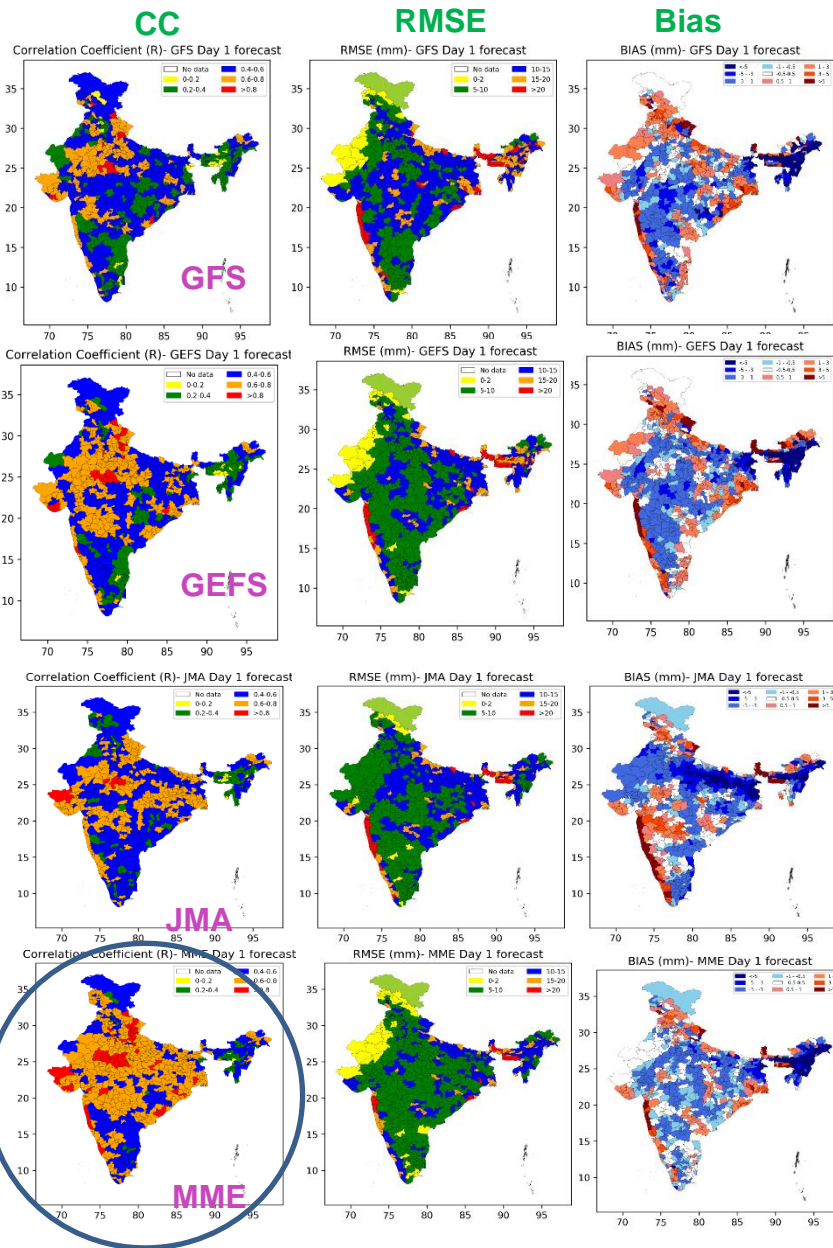
DAY 2



	CC	MME	GFS	GEFS	NCEP	NCUM	JMA
DAY 3	RMSE	0.48	0.34	0.37	0.35	0.4	0.33
		14.22	16.33	14.99	21.39	19.39	15.2
DAY 4		0.43	0.29	0.34	0.32	0.35	0.29
		14.75	16.96	15.35	21.82	20.7	15.6
DAY 5		0.4	0.26	0.3	0.3	0.32	0.26
		15.85	17.52	15.77	29.95	21.21	16.0

- ❑ CC of MME rainfall forecast is high compared to individual rainfall forecast up to day 5.
- ❑ RMSE of MME rainfall is less than individual rainfall forecast up to day 5.
- ❑ Generally under prediction of high rainfall events

Spatial distributions of Correlation, RMSE, and bias



- ❑ The rainfall forecast over Central India is comparatively good in terms of CC and RMSE.
- ❑ CC of MME is marginally high over most of the districts than individual model.
- ❑ RMSE of MME is marginally less over most of the districts than individual model.
- ❑ Still forecasts over Northeastern and part of south peninsular districts needs improvement.

IMD's Operational Extended Range Forecast (ERF) System

Atmospheric ICs
NCMRWF

Current week **Forecast run** for 32 days
based on Wednesday day ICs
*Total 16 ensemble members
(1 control + 3 perturbed) each*
CFSv2_T126 (4 mem)
CFSv2_T382 (4 mem)
GFSv2bc_T126 (4 mem)
GFSv2bc_T382 (4 mem)
(Based on Wednesday ICs)

Ocean ICs - INCOIS

Atmospheric ICs
NCMRWF

¹⁸ years **Hindcast run** for 32 days
(2003 to 2020 based on same date ICs)
*Total 16 ensemble members
(1 control + 3 perturbed) each*
CFSv2_T126 (4 mem)
CFSv2_T382 (4 mem)
GFSv2bc_T126 (4 mem)
GFSv2bc_T382 (4 mem)
(Based on Corresponding Date ICs)

Ocean ICs - INCOIS

**Bias Corrected
Forecasts for 4 weeks**

(Wind, Rainfall, Tmax and Tmin)
and its anomaly
Friday to Thursday

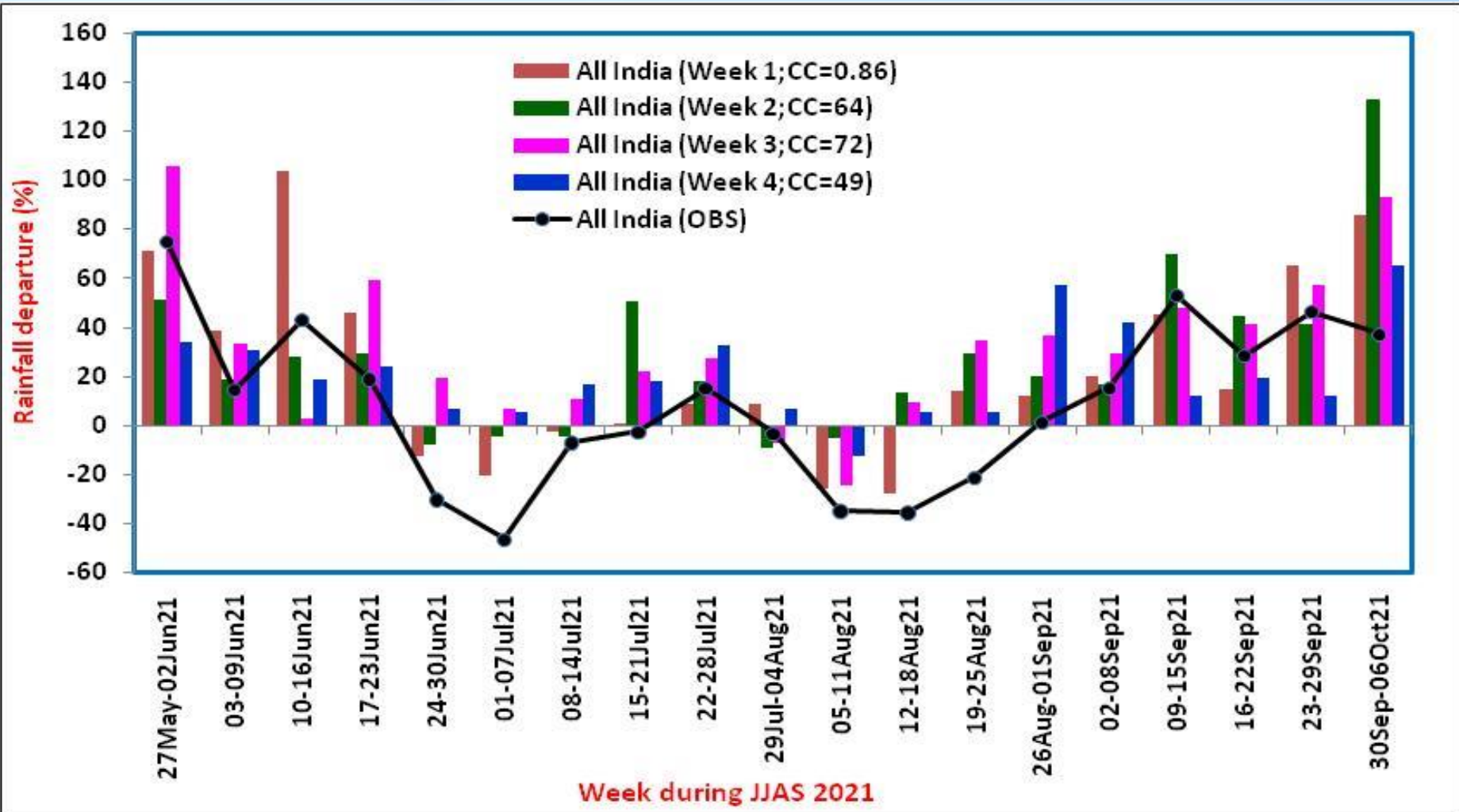
Week 1 : (Days 03-09)

Week 2 : (Days 10-16)

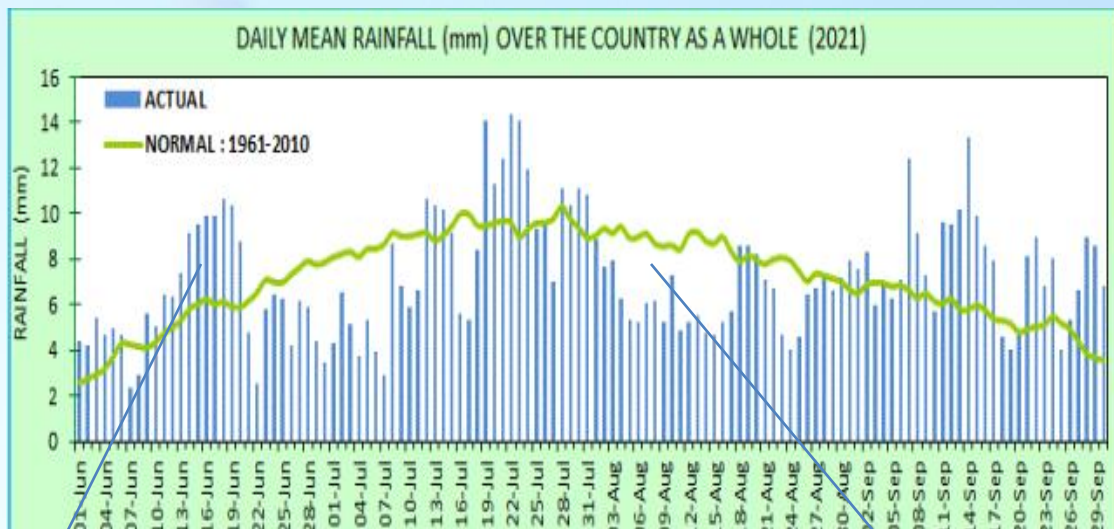
Week 3 : (Days 17-23)

Week 4 : (Days 24-30)

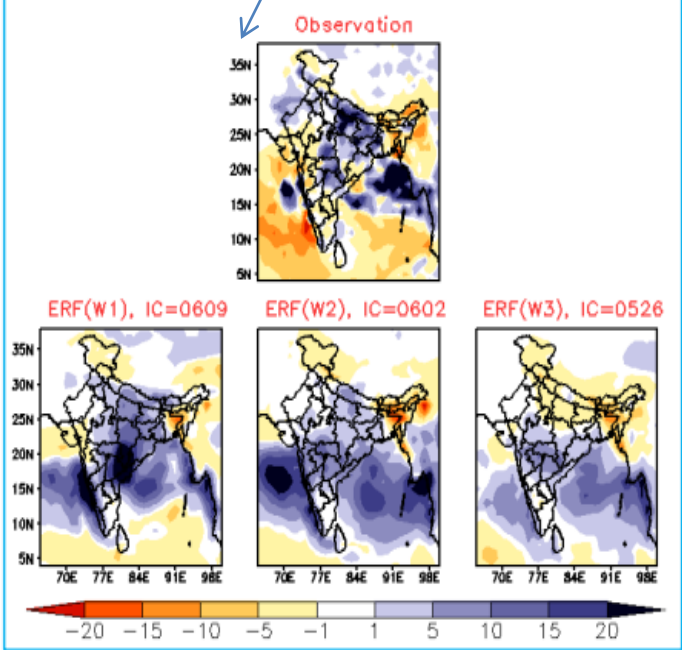
2021 Southwest Monsoon Season



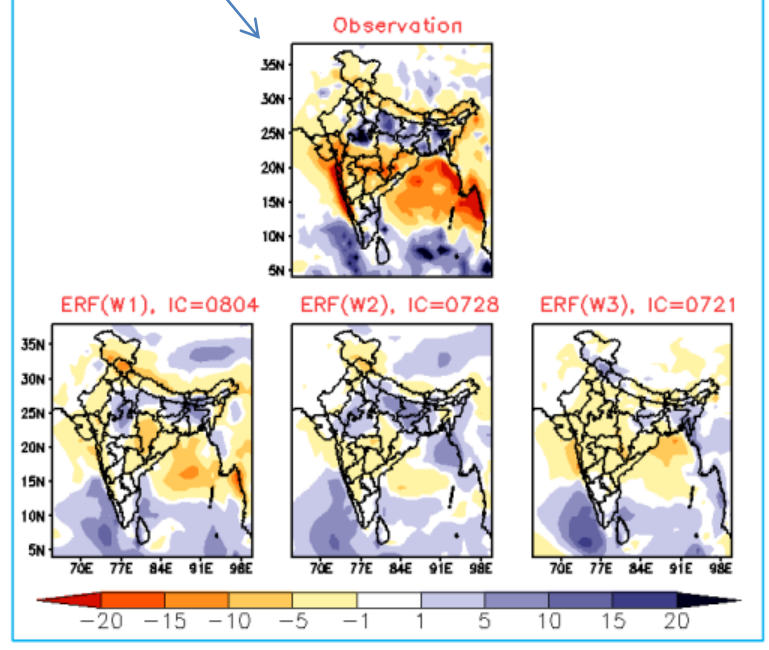
2021 Southwest Monsoon Season



Rainfall Anomaly (mm/day) for the week: 11Jun-17Jun 2021



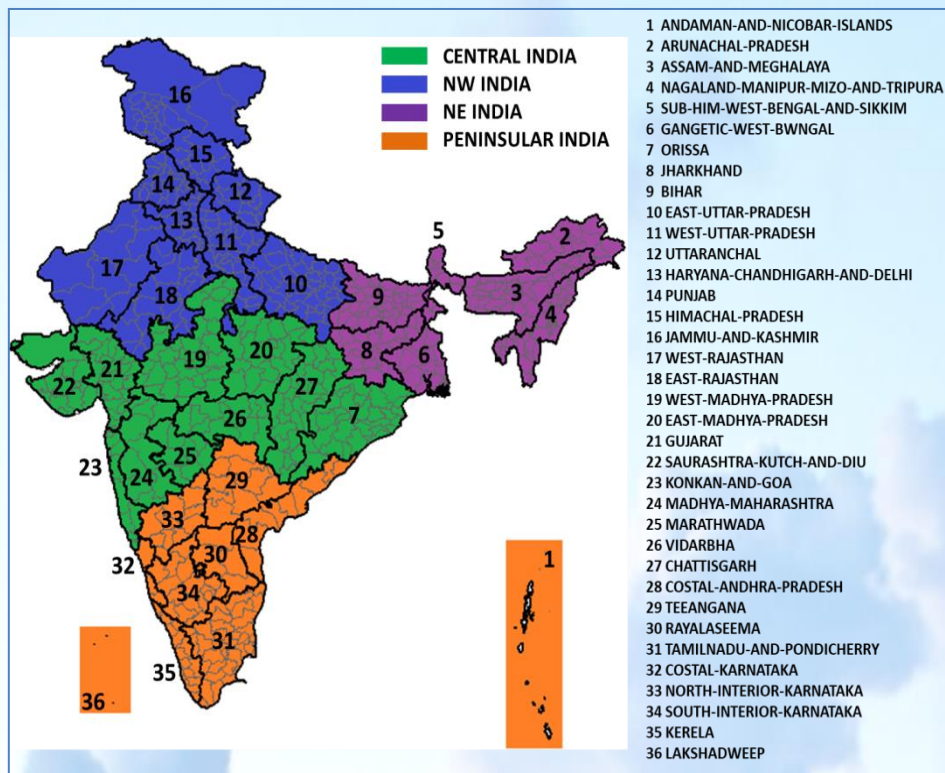
Rainfall Anomaly (mm/day) for the week: 06Aug-12Aug 2021



Observed rainfall anomaly for the target week of 11-17 June 2021 with extended range forecast rainfall with three weeks lead time (ICs of 09 June, 2 June and 26 May, 2021)

Observed rainfall anomaly for the target week of 06-12 August, 2021 with extended range forecast rainfall with three weeks lead time (ICs of 04 Aug, 28 July and 21 July, 2021)

2021 Monsoon – Forecast Skill

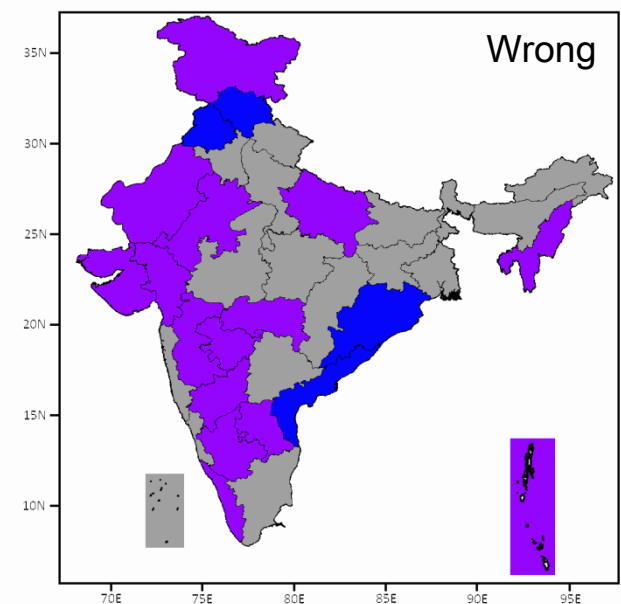
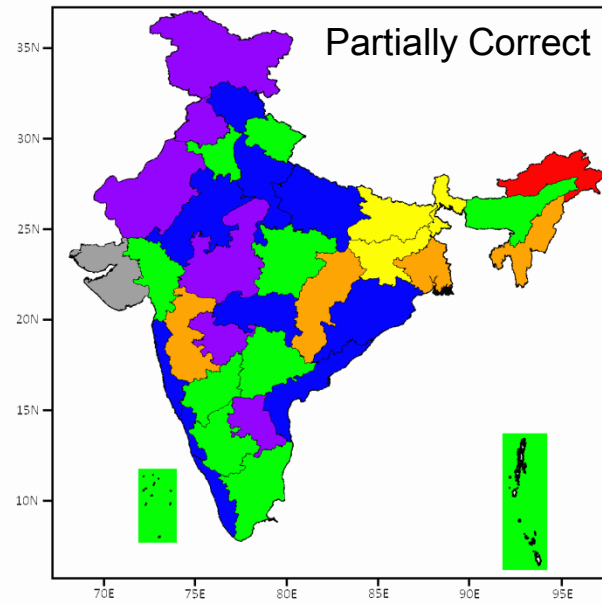
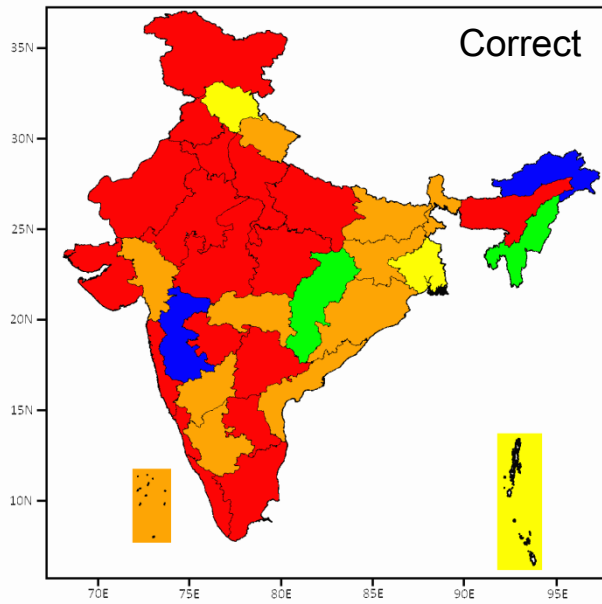


Categories	Subdivision Rainfall Departure in a week	Classification
Excess (E) Large Excess (LE)	+ 20% or more + 60% or more	Above Normal (AN)
Normal (NN)	-19 % to + 19 %	Normal (NN)
Deficient (D) Large Deficient (LD) No Rain (NR)	- 20% or less - 60% or less -100 %	Below Normal (BN)

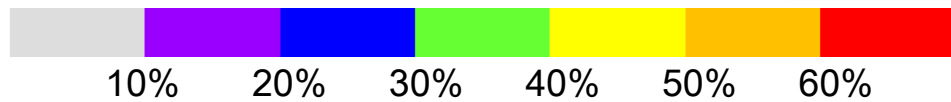
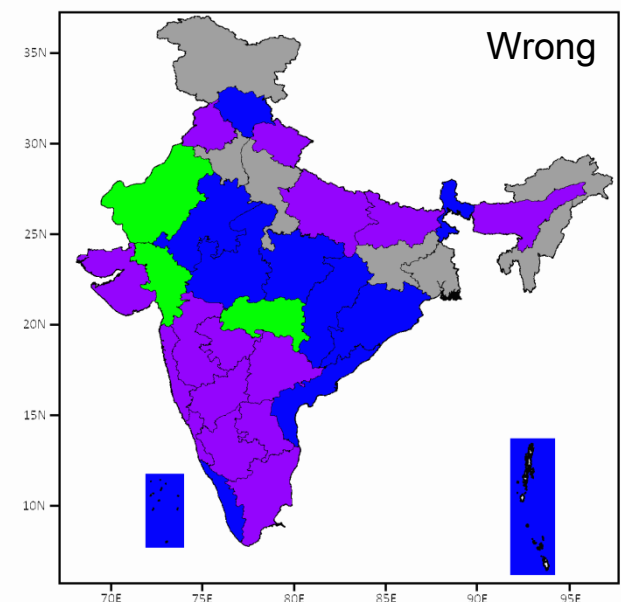
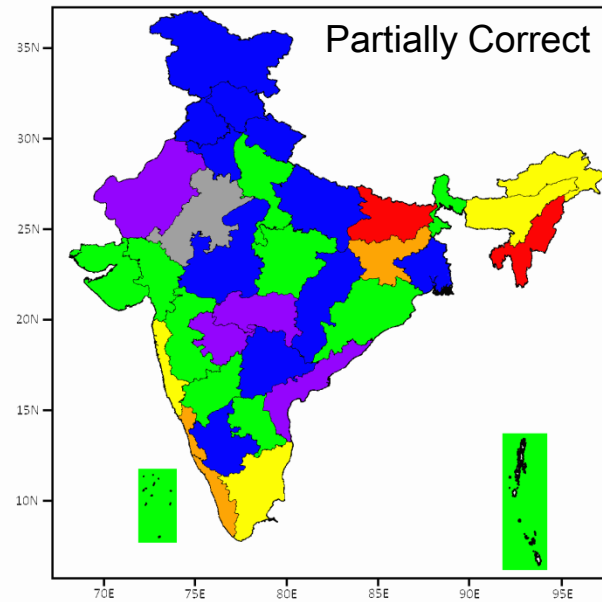
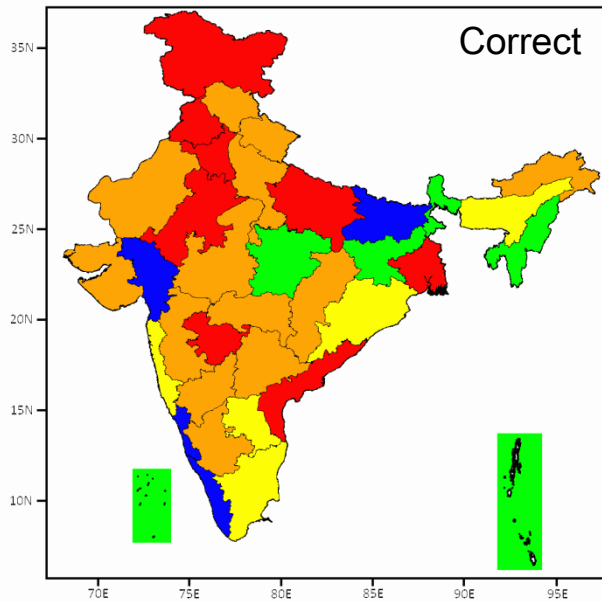
Region	No of Districts
NE India	190
NW India	203
Central India	179
South India	104
Total	676



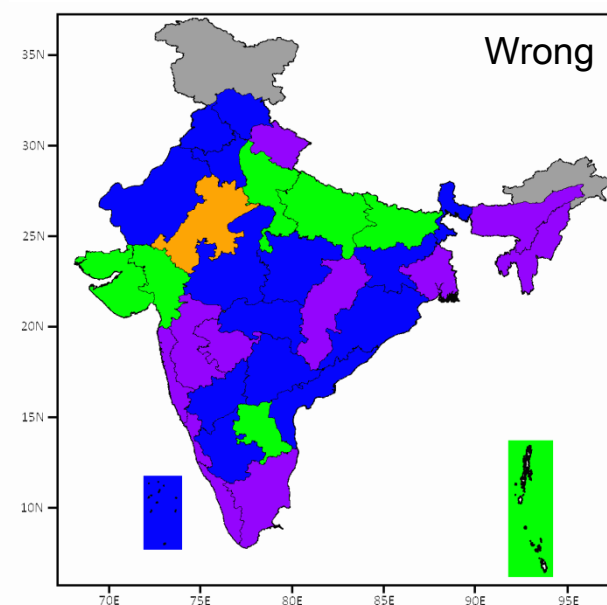
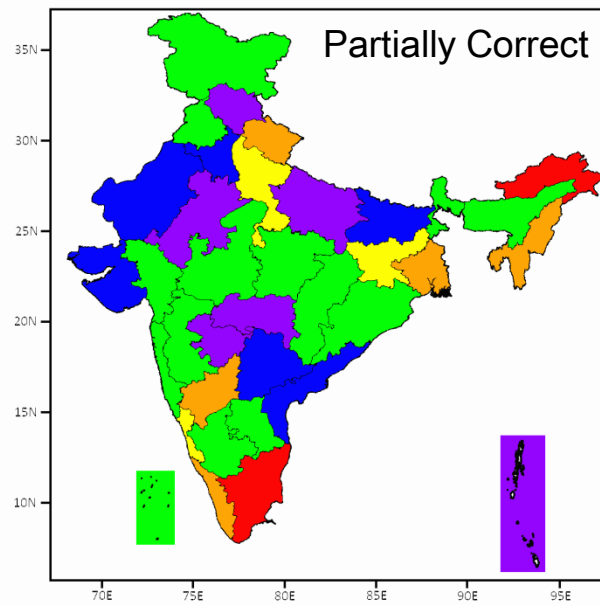
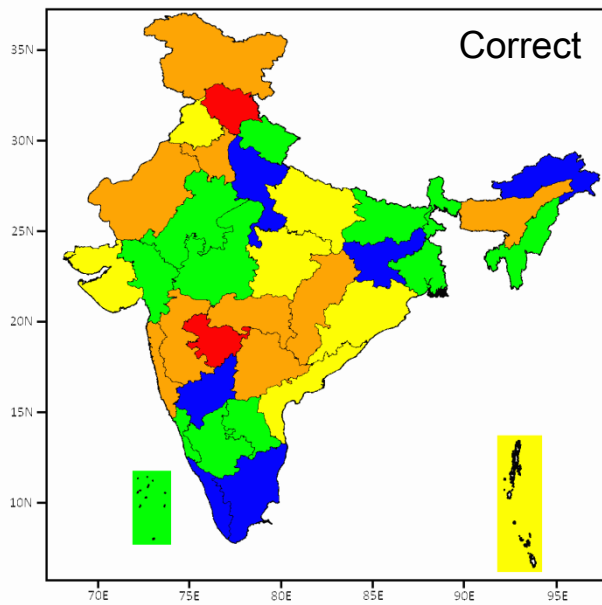
WEEK-1



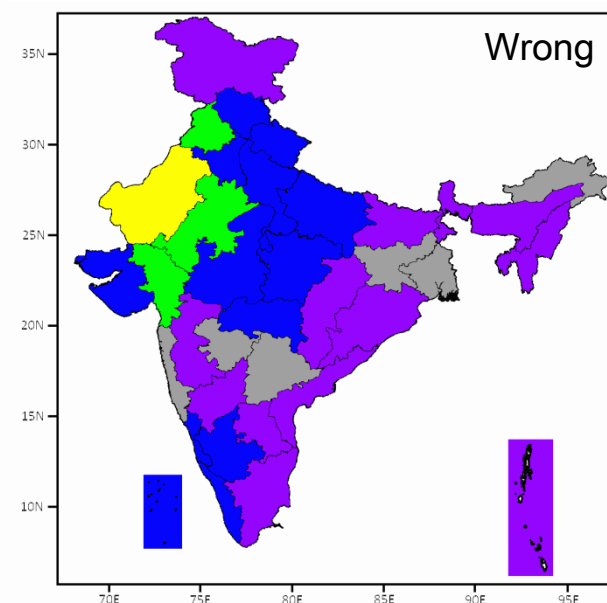
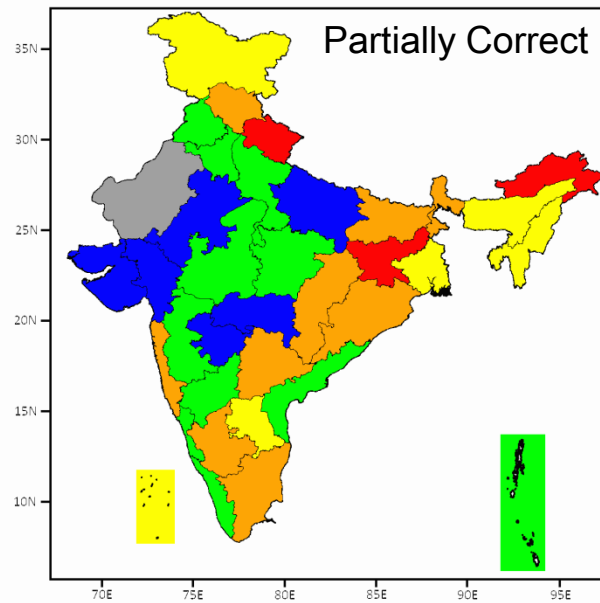
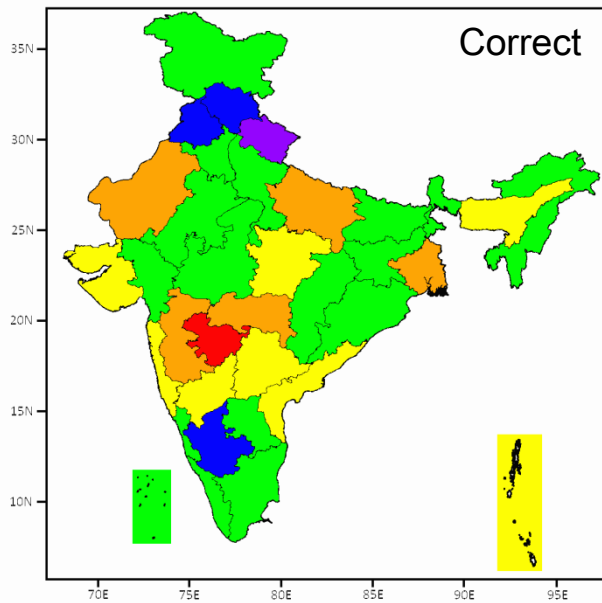
WEEK-2



WEEK-3



WEEK-4



10%

20%

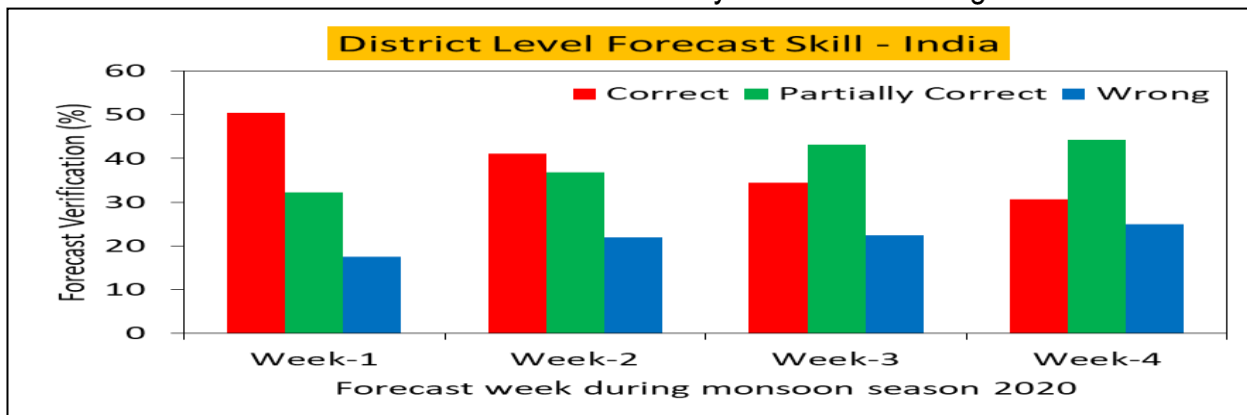
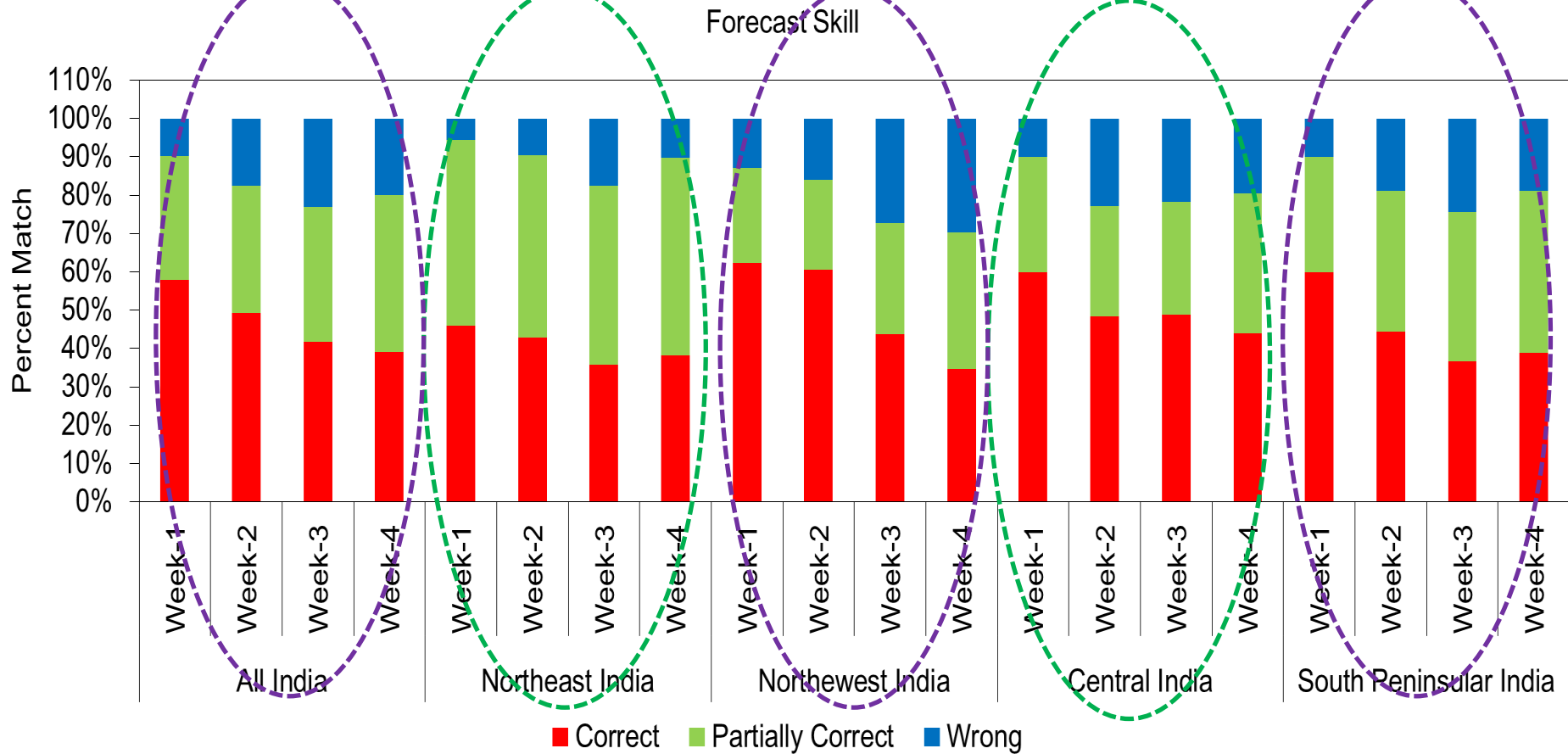
30%

40%

50%

60%

Met-subdivision forecast skill; 2021 Monsoon season



Extended Forecast Over District level During Monsoon- 2021

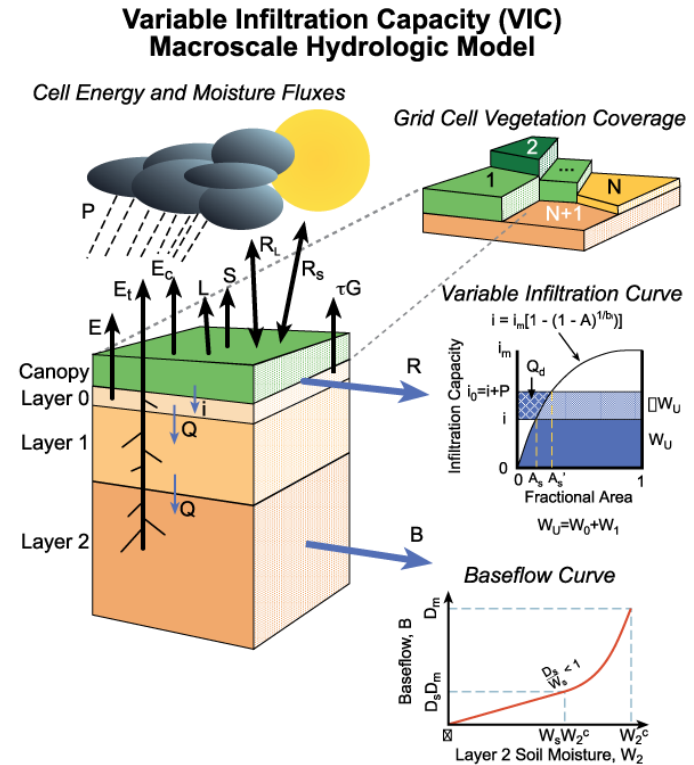
- ❖ Operational ERF based on CFSv2 coupled modeling system has been evaluated at different spatial scales starting from All India to 36 met-subdivision levels for the 2020 & 2021 monsoon season.
- ❖ The ERF also captured different intra-seasonal episodes of monsoon
- ❖ The spatial distribution of the met-subdivision level mean forecast skill of predicting above normal, normal and below normal categories in terms of correct forecasts (forecast and observed category matching) for the 36 subdivisions
- ❖ The ERF captured very well the transitions from normal to weaker phase of monsoon



Land surface products using VIC model

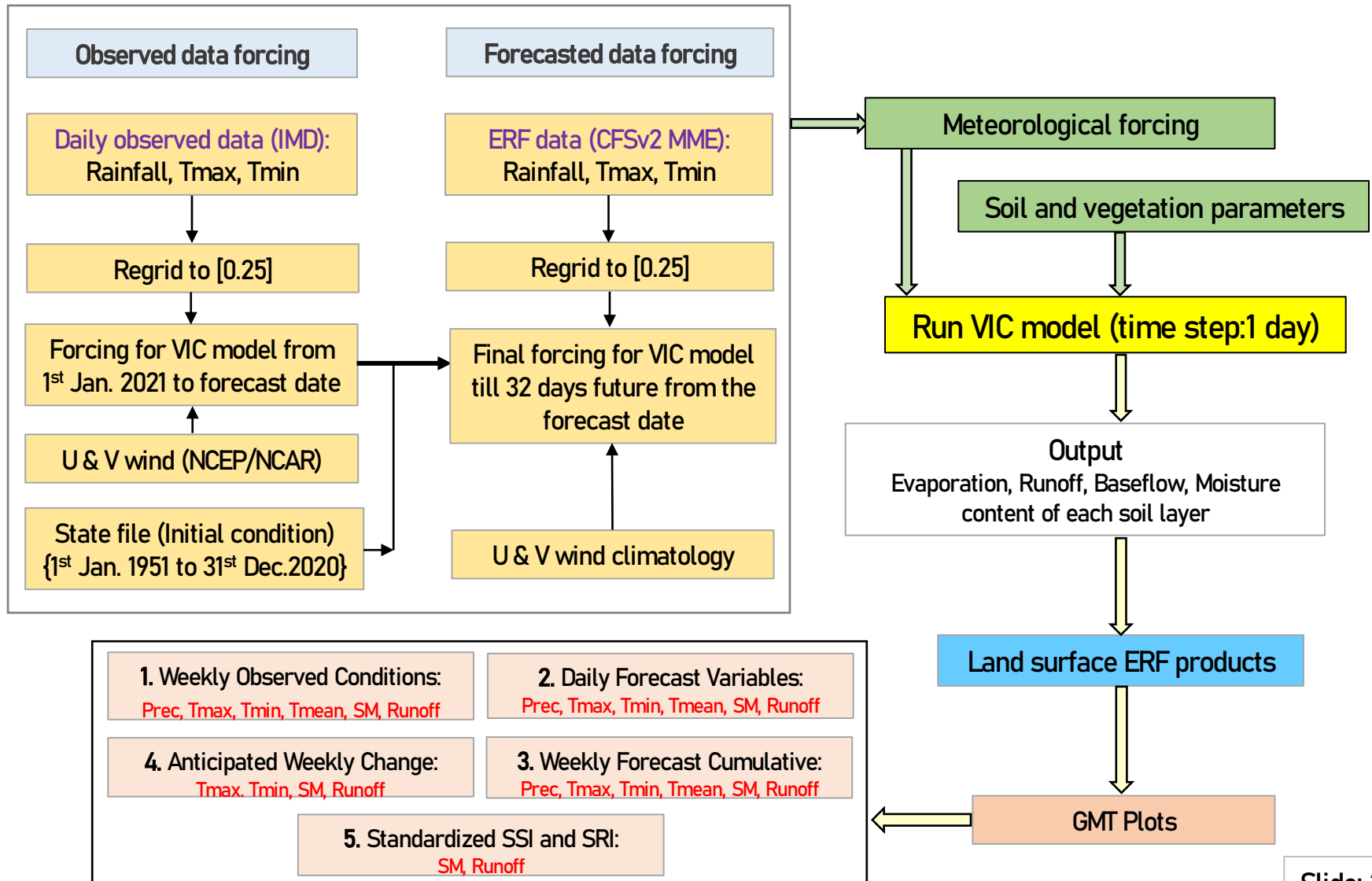
[in collaboration with IIT Gandhinagar]

- ❖ A large-scale hydrologic model developed at the University of Washington (Liang et al. 1994).
- ❖ Simulates water and energy fluxes in each grid cell considering soil and vegetation parameters, and meteorological forcing as input.
- ❖ Sub-grid heterogeneity (e.g. elevation, land cover) is handled via statistical distributions.
- ❖ The VIC model has three soil layers and water can only enter a grid cell via the atmosphere
- ❖ Infiltration is estimated using a variable infiltration capacity curve (REF).
- ❖ The VIC model has been widely used in India for hydrologic assessment (Mishra et al. 2014).



Land surface products using VIC model

[in collaboration with IIT Gandhinagar]

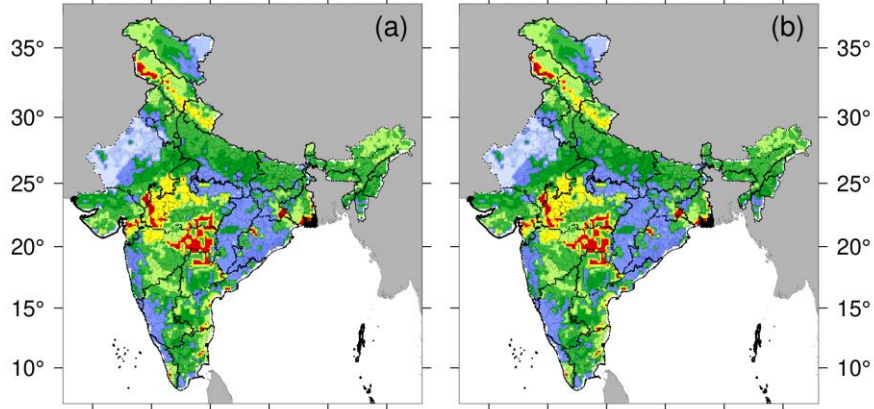


③ Weekly Forecast Cumulative

Weekly soil moisture (%)

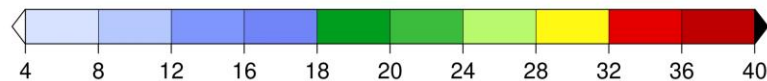
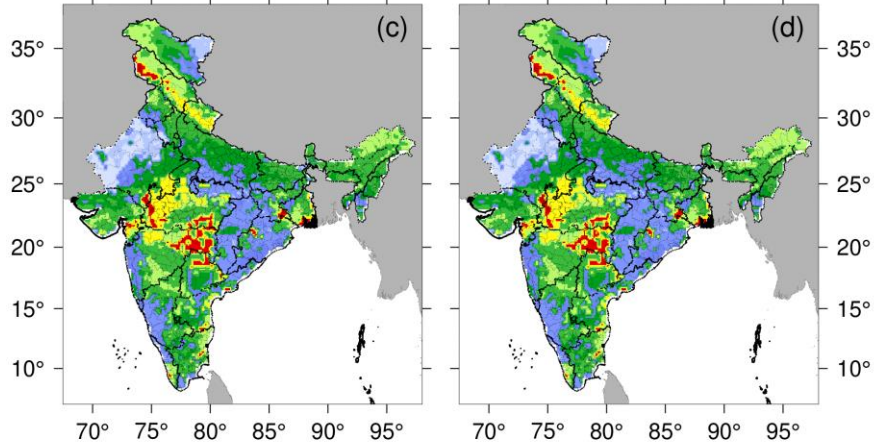
Week 1, 04.03.2022-10.03.2022

Week 2, 11.03.2022-17.03.2022



Week 3, 18.03.2022-24.03.2022

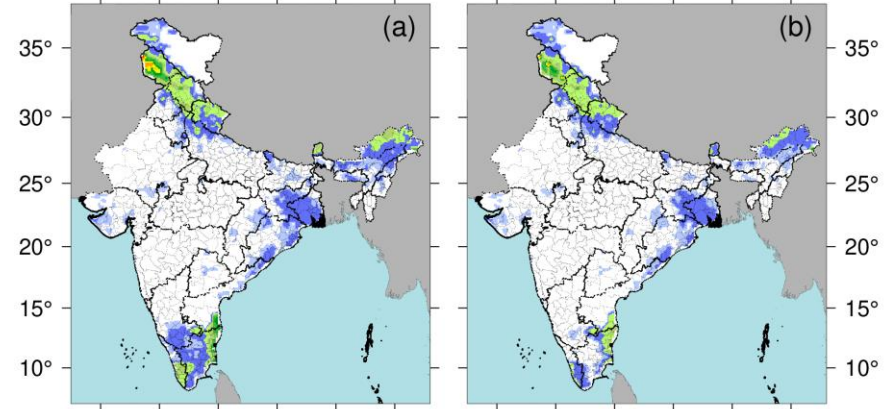
Week 4, 25.03.2022-31.03.2022



Weekly Runoff (mm)

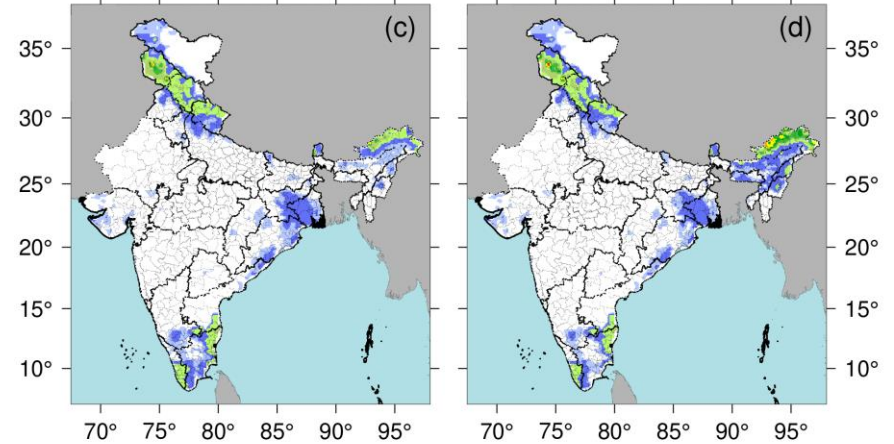
Week 1, 04.03.2022-10.03.2022

Week 2, 11.03.2022-17.03.2022



Week 3, 18.03.2022-24.03.2022

Week 4, 25.03.2022-31.03.2022



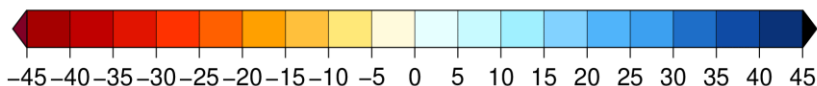
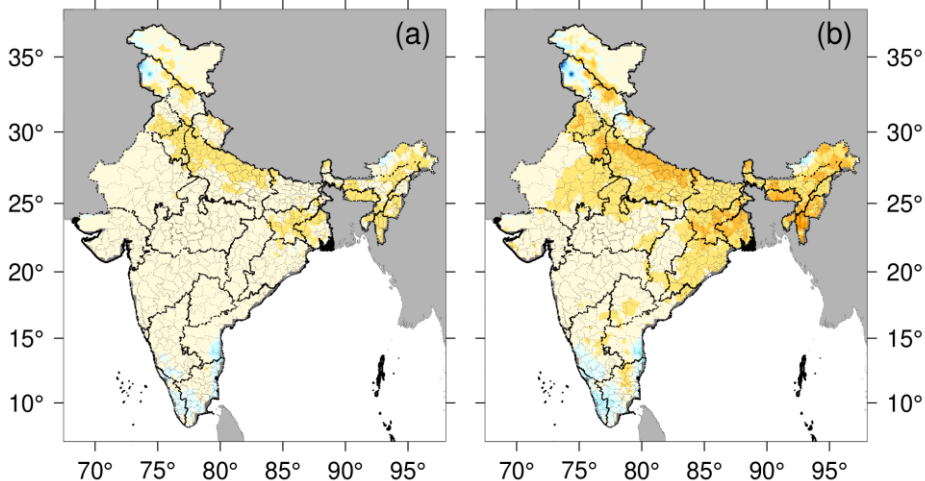
④ Anticipated Weekly Change

Anticipated weekly soil moisture change (mm)

w.r.t. previous week, 25.2.2022-3.3.2022

Week 1, 04.03.2022-10.03.2022

Week 2, 11.03.2022-17.03.2022

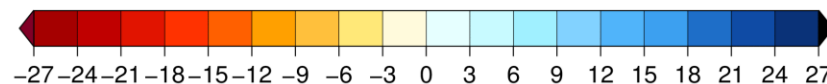
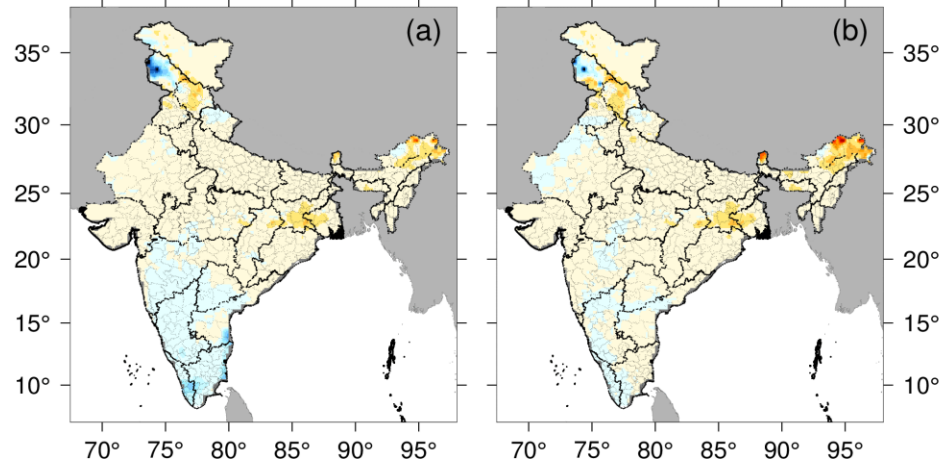


Anticipated weekly runoff change (mm)

w.r.t. previous week, 25.2.2022-3.3.2022

Week 1, 04.03.2022-10.03.2022

Week 2, 11.03.2022-17.03.2022



Inputs for Preparation of Agromet Advisories

Past Weather

Agro-met Advisory Service bulletin for the District



South 24 Parganas

(Period to 31st July to 4th August, 2019)

Issued jointly by GKMS, Kakdwip, BCKV and IMD

From RRS, Kakdwip, Bidhan Chandra Krishi Viswavidyalaya

Email: askakdwip@rediffmail.com, shibani.bckv@gmail.com

Bulletin No.:60

Date: 30th July, 2019

Weather for last four days (26th July to 29th July, 2019)

	26.07.19	27.07.19	28.07.19	29.07.19
Rainfall (mm)	0.0	48.0	0.0	17.0
Maximum Temperature (°C)	30.0	30.0	32.0	32.5
Minimum Temperature (°C)	24.0	23.5	25.0	24.0
Relative Humidity (%)	89	92	88	95
Wind Speed (Km ph)	1	1	1	1

Quantitative medium range

weather Forecast for next Five days

Weather forecast for next five days 31st July to 4th August, 2019)

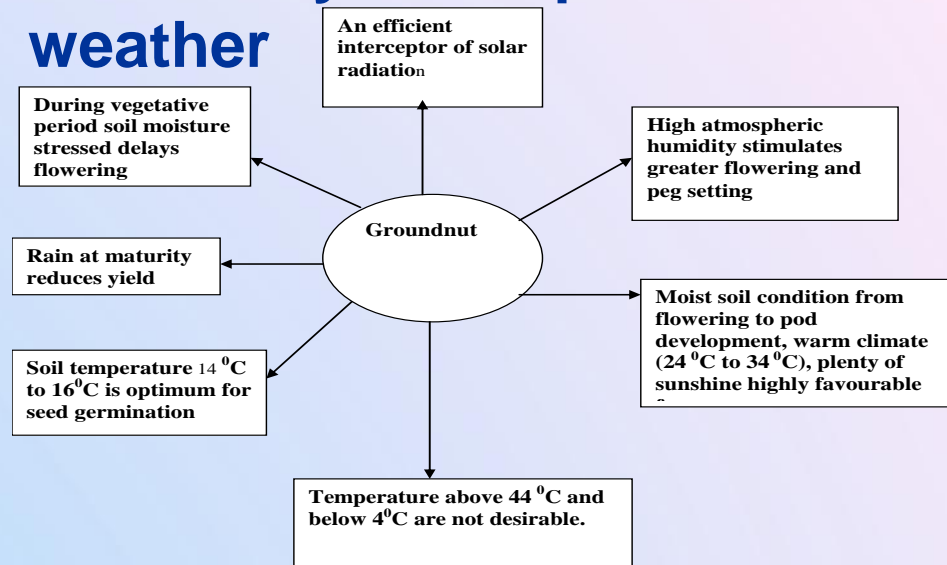
- Light rainfall is predicted in next five days .
- Sky will mainly cloudy in the next five days.
- Wind speed will be 13.7-26.5 km/hr and the predominant wind direction will be Southerly to Westerly.
- Maximum temperature is expected to be around 33.0°C-36.0°C and minimum temperature is likely to be around 27.0°C- 29.0°C.
- Maximum and minimum relative humidity will be in the range of 75%-80% and 53% -61%.

Diagnose weather related stresses

Moisture, weather based pest & disease occurrence, excessive Heating & desiccation, cold injury and frost, soil born biotic stress, soil health & nutrient related issues, extreme weather related issues.


AND ADVISE MITIGATION

Sensitivity of Crop to weather



Crop stage & state and

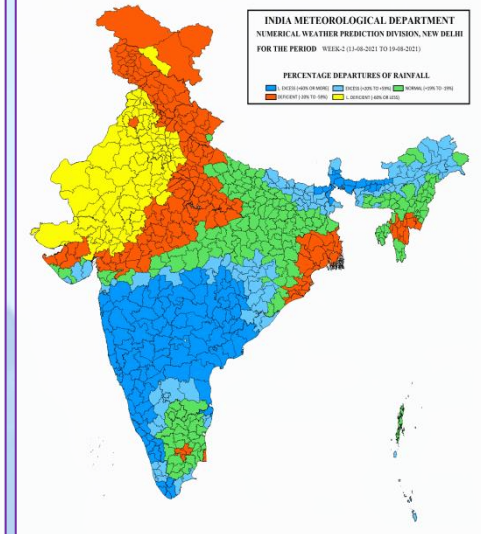
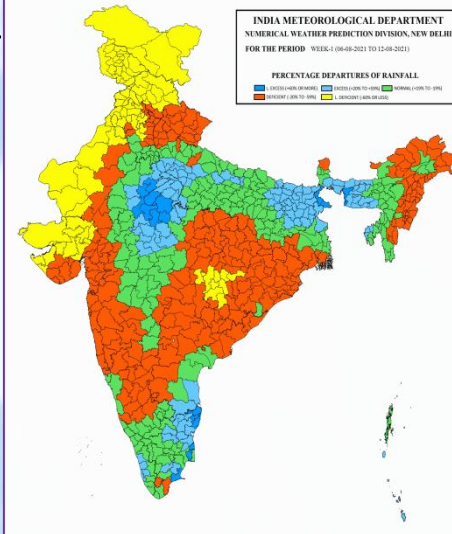
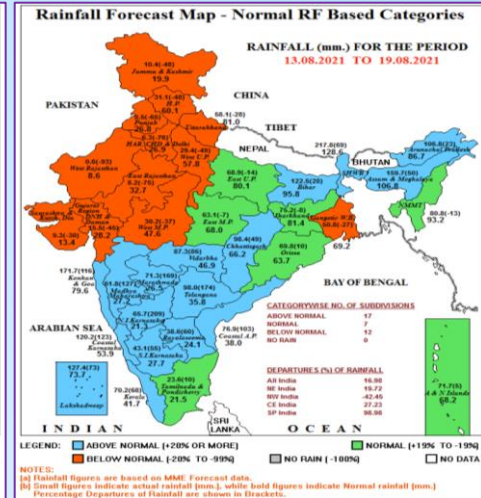
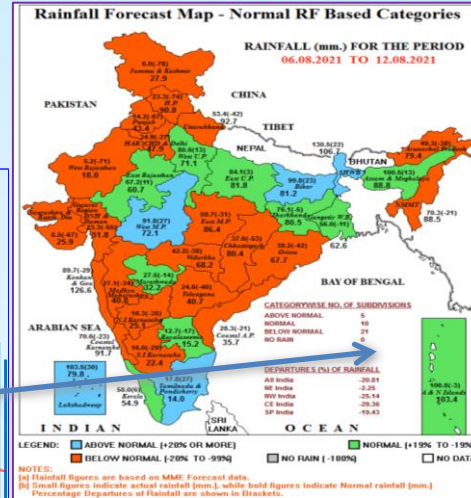
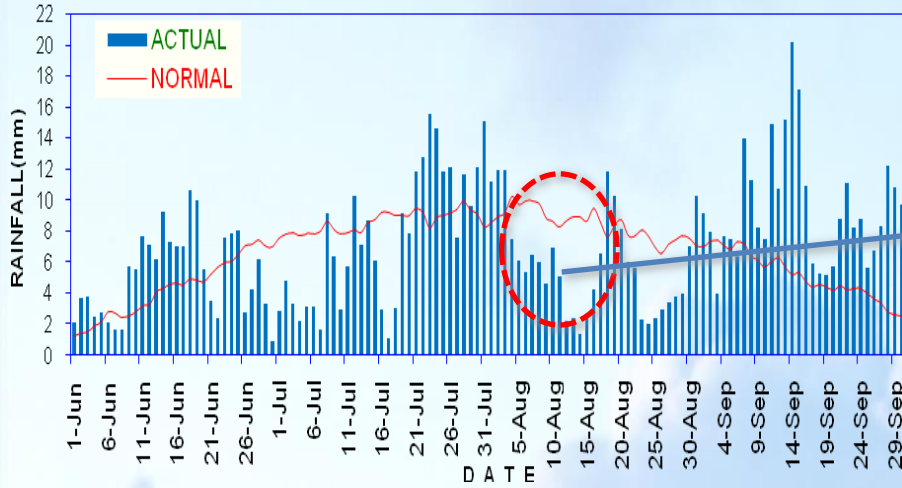
Weather based Agro-Advisories

Crop	Stage	Disease pest	Advisory
Aman wet seeded paddy	seedling		--Moderate rainfall is received so in seed bed where seedlings are not ready still now use rain water for irrigation and arrange bunding for restricting run off of rain water --Before uprooting the seedlings from seed bed apply Carbofuran@3g/m ² for preventing stem borer
Aman wet seeded paddy	Transplanting		-- Prepare area with low land for transplanting by ploughing at a depth of 12-15 cm and puddle the field --Apply 7quintal organic manure per bigha in main field --Check the bund around the field --In low land area where seedlings are ready start transplanting
Betel vine	Green leaf		--Keep the drainage channel clean --No irrigation required for next five days
Tomato, chilli, brinjal			--Complete sowing of tomato, chilli, brinjal seeds, in upland area for transplanting at the end of August on comparatively upland area with proper drainage channel. --Select some hybrid variety of tomato for sowing like Avinash-2, 448 etc.
Poultry	At all stages	Fungal attack due to wet weather	--Change the litter --Mix lime and old news paper in the litter --Apply proper warming in case of new born chicks

Location wise Contingency action

Met-subdivision wise forecast for two weeks based on 04 August 2021 IC and forecast for (a) 06-12 August, 2021 and (b) 13-19 August 2021.

DAILY AVERAGE RAINFALL (mm) OVER THE CORE MONSOON ZONE REGION



Applications in Agriculture



National Agromet Advisory Service Bulletin

based on

Extended Range Weather Forecast (ERFS)

Validity: 14 - 27 August 2020

Date of issue: 14 August 2020

Issued by

AICRP on Agro-Meteorology (AICRPAM),
Central Research Institute for Dryland Agriculture (CRIDA),
Indian Council of Agricultural Research (ICAR)
&
India Meteorological Department (IMD)
Earth System Science Organization

Marathwada

- Due to cloudy and humid weather condition, there is a chance of infestation of sucking pest in cotton crop. For management, spray of 5 % NSKE or Thiamethoxam 25 % @ 40 g and Clothianidin 50 % @ 30 g per acre during clear weather condition is advised.
- Due to excess rainfall, fruit drop in citrus orchard is noticed. For management, it is advised to remove excess amount of water from orchard and spray of Trifloxystrobin 25 % + Tebuconazole 50% @ 2.5 g/ litre of water.

Vidharbha

- Under prevailing weather condition, there is a chance of pink boll worm larvae in cotton crop flowers. To control, it is advised to spray Quinolphos 25% AF @ 25 ml or Chlorpyriphos 20% EC @ 25 ml per 10 litres of water. It is also advised to collect and destroy rosette flowers/buds.

Hisar

Amount of rainfall received over Hisar is 272.1 mm (-2% deficit) during 01 June 2020 - 13 August 2020. The extended range rainfall forecast provided for next two weeks (14 - 20 August and 21 - 27 August 2020) over Hisar is below normal for week-1 and above normal for week-2.

- Under prevailing weather conditions, farmers are advised to withhold irrigation in vegetables and fruits crops.
- Farmers are also advised to go for sowing of sorghum, maize and lobia as fodder crops.
- Provide 50 g iodized salt and 50 - 100 g mineral mixture daily with animal feed/fodder to keep animals healthy.

Karnataka

Rainfall received during 01 June 2020 - 13 August 2020 over South Interior Karnataka is 526.1 mm (19% excess) and North Interior Karnataka is 415.7 mm (45% excess). The extended range weather forecast for next two weeks (14 - 20 August and 21 - 27 August 2020) over South Interior Karnataka is normal and North Interior Karnataka is above normal for week-1 and normal over South Interior Karnataka and North Interior Karnataka for week-2.

South Interior Karnataka

- Under prevailing weather condition, there is a chance of wilt diseases in redgram. It is advised for drenching with Carbendazim 50 WP @ 2 g/litre of water. Remove and burn the infected plants in the field itself.
- Due to high wind speed, it is advised to provide staking support to banana and vegetable crop to protect from uprooting of crops.

North Interior Karnataka

- Under prevailing rainy weather condition, sowing of *kharif* crops like bajra, redgram, groundnut (spreading type), navane, and horsegram is recommended.
- Farmers are also advised to sow the crops in rows across the slope to facilitate better soil

Medium range forecast (District) & Subsequent 1 week (ERF) outlook

Day & Date : Friday, 04.06.2021

Weather Parameters	Weather Forecast (Valid for 05 th to 09 th June 2021)					
	Beed	Hingoli	Jalna	Latur	Nanded	Parbhani
Districts						
Rainfall (mm)	90.0	39.0	33.0	55.0	90.0	48.0
T _{max} (°C)	31.0-32.0	35.0-38.0	34.0-37.0	34.0-36.0	36.0-38.0	34.0-38.0
T _{min} (°C)	23.0-26.0	24.0-27.0	21.0-23.0	23.0-24.0	24.0-26.0	23.0-27.0
Cloud Cover	Partially Cloudy to Cloudy	Partially Cloudy to Cloudy	Partially Cloudy to Cloudy	Clear to Cloudy	Clear to Cloudy	Clear to Cloudy
RH-I (%)	69-75	57-71	61-67	66-74	58-72	61-71
RH-II (%)	36-51	31-44	30-44	32-48	31-41	29-43
Wind Speed (km/hr)	11-19	5-19	6-19	13-20	7-20	8-19
Wind Direction	WSW-W	SW-WNW	W-WNW	SSW-WNW	SW-WNW	SSW-W

As per ERF products maximum temperature may be moderately below normal, minimum temperature may be below normal and rainfall may be above normal in Marathwada region during 09th June to 15th June 2021.

Plantation of citrus crop should not be done until sufficient amount of rainfall is received. Intercultural operation should be done in citrus orchard. for uniform flowering in Citrus take a spray of 13:00:45 @ 15 gram per litre along with sticker during clear weather condition.



Subsequent week forecast is used in AAB



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Agromet Advisory Bulletin No. 31/2020-21

Day & Date : Friday, 17.07.2020

DISTRICT WISE WEATHER FORECAST OF MARATHWADA (Valid for 18 th to 22 nd July, 2020)								
Weather Parameters	Districts							
	A'bad	Beed	Hingoli	Jalna	Latur	Nanded	O'bad	Parbhani
Rainfall (mm)	51.0	52.0	36.0	60.0	50.0	76.0	46.0	55.0
T _{max} (°C)	30.0-32.0	30.0-33.0	30.0-32.0	30.0-32.0	29.0-33.0	32.0-33.0	27.0-31.0	29.0-33.0
T _{min} (°C)	22.0-24.0	21.0-24.0	23.0-24.0	23.0-24.0	22.0-24.0	24.0-25.0	22.0-24.0	23.0-25.0
Cloud Cover	Clear to cloudy	Partially cloudy to cloudy	Clear to cloudy	Clear to cloudy	Cloudy	Partially cloudy to cloudy	Cloudy	Partially cloudy to cloudy
RH-I (%)	82 – 85	79 – 86	80 – 85	83 – 86	81 – 89	79 – 85	80 – 90	79 – 84
RH-II (%)	49 – 62	49 – 70	51 – 60	52 – 61	53 – 74	52 – 63	51 – 76	49 – 63
Wind Speed (km/hr)	10 – 15	12 – 18	10 – 15	10 – 15	11 – 16	09 – 15	12 – 15	10 – 16
Wind Direction	SW to W	SW to W	SW to NW	SW to NW	SW to NW	SW to W	SW to NW	SW to NW

During next five days weather will be cloudy light rainfall may occur at isolated places in Marathwada region. The places in Marathwada where sowing was not yet completed sowing of cotton, soybean, pigeonpea, pearl millet, sunflower, castor, sesamum should be done after receipt of sufficient amount of rainfall in adequate soil moisture and wapsa condition. Sowing of black gram, green gram, sorghum, groundnut should not be done.

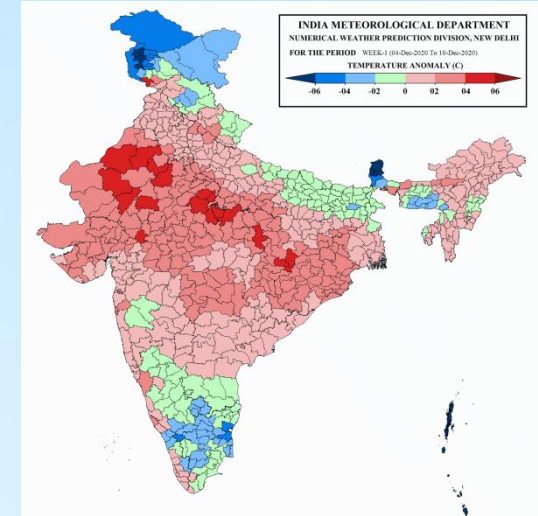
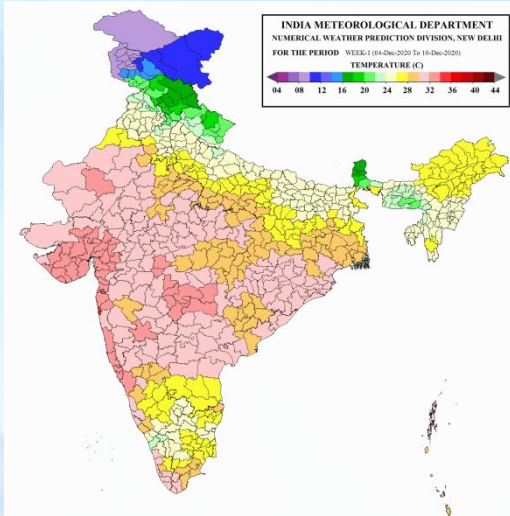
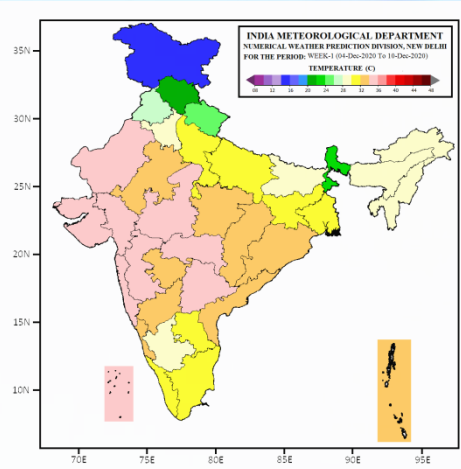
As per ERFs products above normal rainfall may occur in Marathwada region during 22nd to 28th July 2020.

ERF based agromet advisory (RF was above normal):

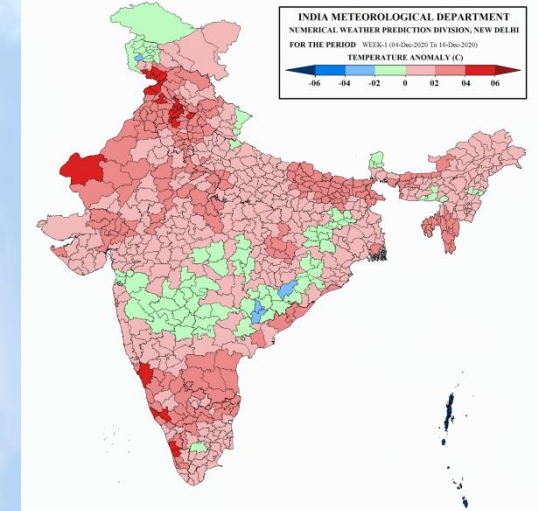
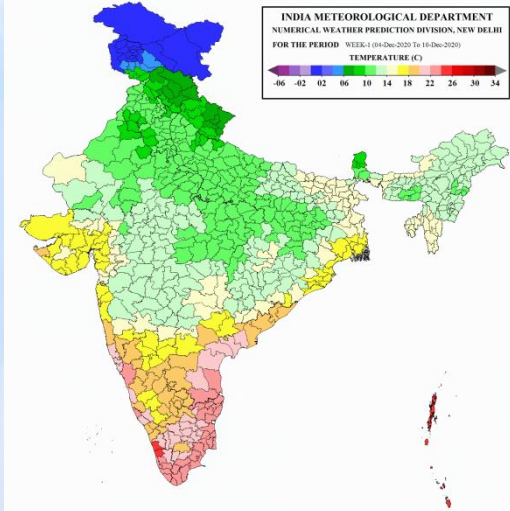
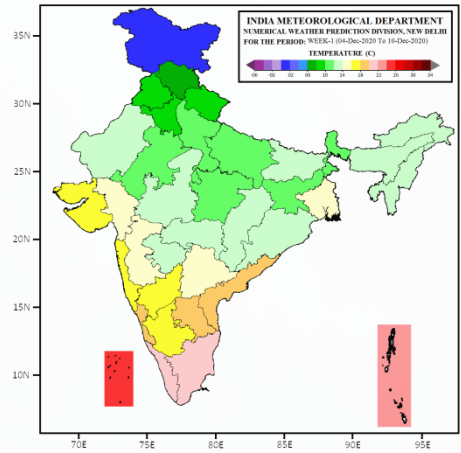
Management practices should be done to drain out excess amount of water from Soybean, Sorghum, Sugarcane, pearl millet, turmeric and orchards like pomegranate, sapota, citrus as well as vegetable crops etc.

Temperature Forecast: (Met Sub-Division and District level)

Maximum Temperature



Minimum Temperature



Actual Temperature (C)
Sub-Division Level

Actual Temperature (C)
District Level

Temperature Anomaly (C)
District Level



Medium range forecast (District)&Subsequent 1 week (ERFS) outlook

Weather Parameters		Weather Forecast (Valid for 17 th to 21 st April 2021)				
		17/04	18/04	19/04	20/04	21/04
Date		17/04	18/04	19/04	20/04	21/04
Rainfall (mm)		0.0	0.0	0.0	0.0	0.0
T _{max} (°C)		37.0	37.0	38.0	38.0	38.0
T _{min} (°C)		22.0	23.0	24.0	22.0	23.0
AM	Cloud cover	Clear	Clear	Partially Cloudy	Clear	Partially Cloudy
PM						
RH-I (%)		47	44	37	38	41
RH-II (%)		18	19	15	15	14
Wind Speed (km/hr)		8	11	7	12	15
AM	Wind direction	SSE	NNW	WSW	WNW	NW
PM						

As per ERF products, max. temperature may be moderately below normal and min. temperature may be below normal in Marathwada during 21-27 April 2021.

ERF

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Precaution should be taken so that water stress may not occur in Summer groundnut crop. Irrigation management should be done as per requirement of crop during early in the morning or at evening. If infestation of sucking pests (Thrips, Aphids, Jassids) is observed in groundnut crop, take a spray of *imidacloprid* 17.8% @ 2 ml or *Thiamethoxam* 12.6 % + *Lambda Cyhalothrin* 9.5 % @ 3 ml per 10 liter of water. Spraying should not be taken during noon time.

Economic impact study of Gramin Krishi Mausam Seva

Study by **National Centre for Applied Economic Research (NCAER), New Delhi** conducted in year 2019 by. **Salient findings-**
(interviewed 3,965 farmers across 121 districts of 11 states of India)

- 98% of surveyed farmers made modifications to at least one of nine practices based on weather advisories-
- 80% of farmers receiving information on high resolution weather events reported to have reduced losses.
- An estimated additional annual income of Rs. 12,500 per agricultural household belonging to Below Poverty Line category in rain-fed areas.
- Total income gain is estimated at Rs. 13,331 crore per annum in rain-fed districts.



Summary

- ❖ MME based district level forecast provides useful skill up to 5 days.
- ❖ Implementation and operationalization of coupled modelling system at IMD has led to the improvement of Extended Range Forecasting to provide services to various users.
- ❖ The ERF provides useful skill up to 2 to 3 weeks and the products are being prepared routinely for applications in Agriculture and for providing advisories to the farmers.
- ❖ The advisory to farmers issued based on medium and extended range forecast has large economic benefits.

