

High resolution GEFS (T1534) EPS system for prediction of extremes over India

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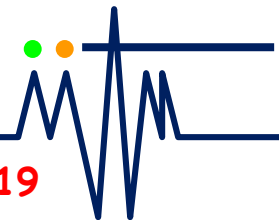
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India Met. Department

Peter Bechtold³ and Nils Wedi⁴

⁴ECMWF, Reading, UK



Outline

- Present status of CFS/GFS based ensemble forecast over India
- Deterministic and Probabilistic skill of GEFS, NEPS and ECMWF for the extremely heavy precipitation over Kerala, India
- Latest Development and future strategies
- Summary

Status of CFS/GFS EPS in India

Seasonal Forecasting (44 member) CFSv2 T382 (~38km)

Extended Range 4 pentad forecast with 44 members, multi model (CFSv2 T126, CFSv2T382, GFS T126, GFST382 with bias corrected SST from CFS)

Weather (up to 10 days)

GEFS and NCUM (12km), 21 members, GFS T1534, L64 since June 2018.

Earlier versions

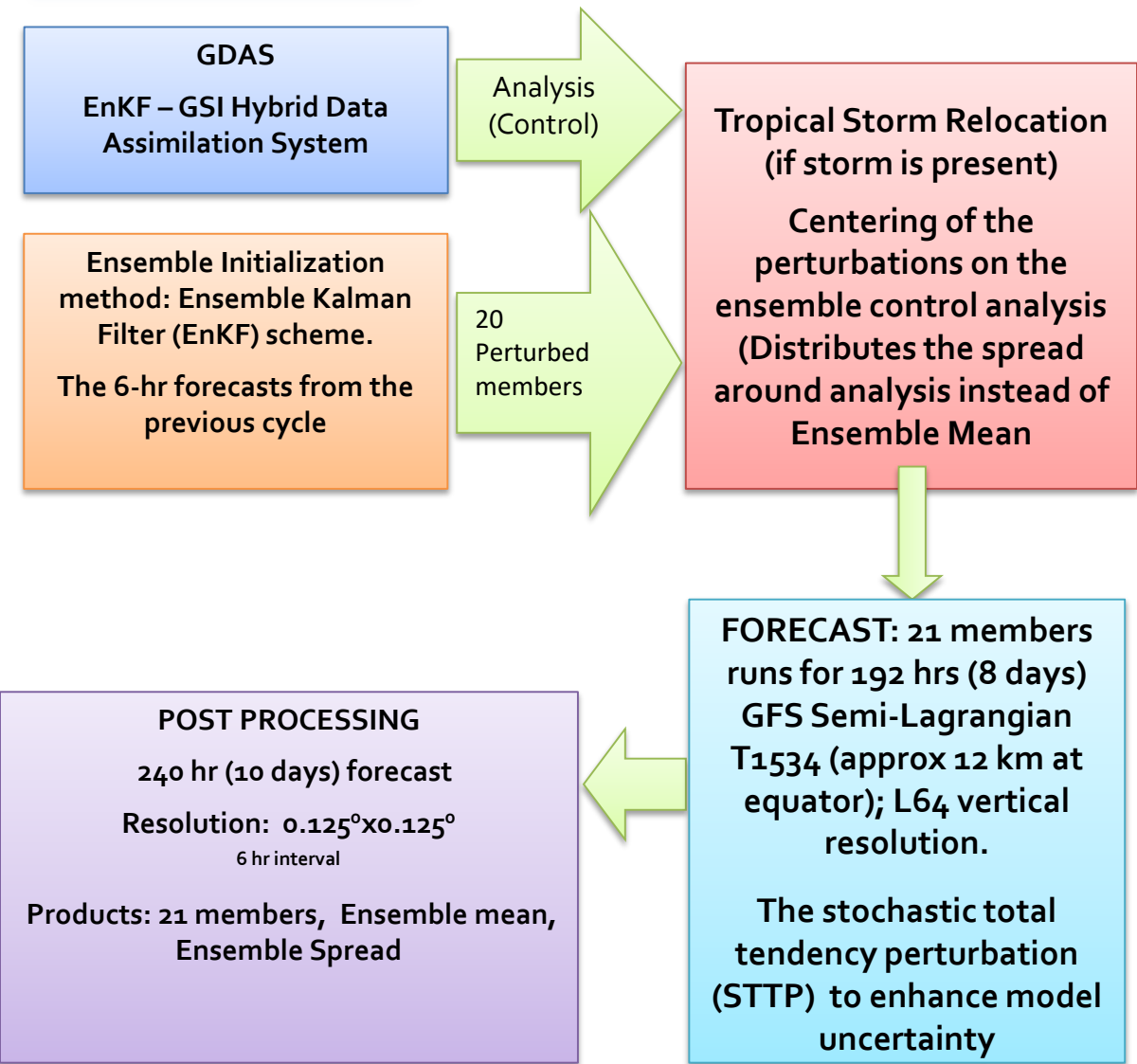
GEFS T574 (Ensemble)

GFS T574 (Deterministic)

GFS T254

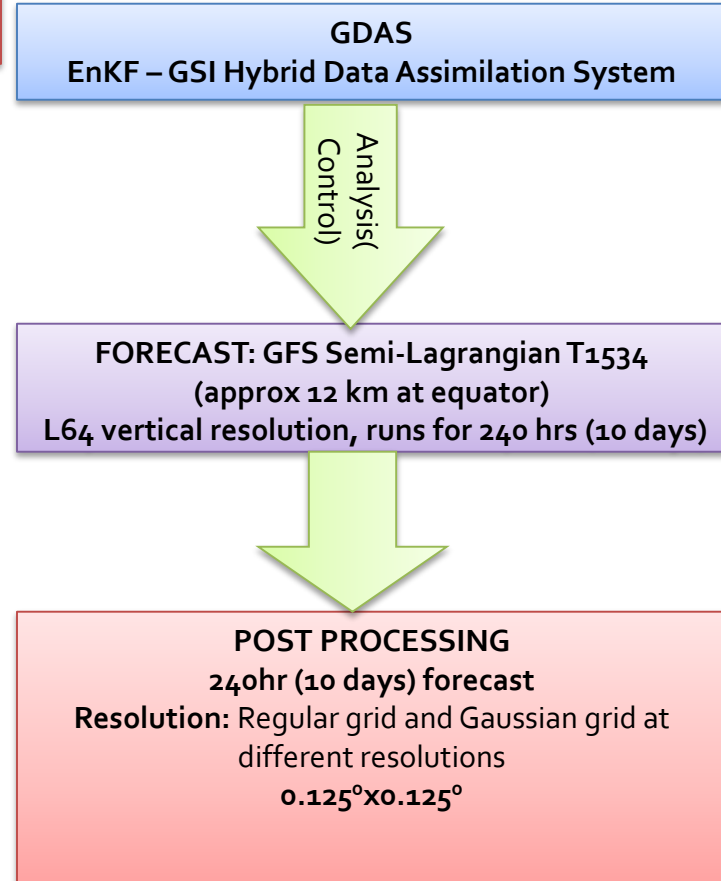
GFS T82

Flowchart of GEFS

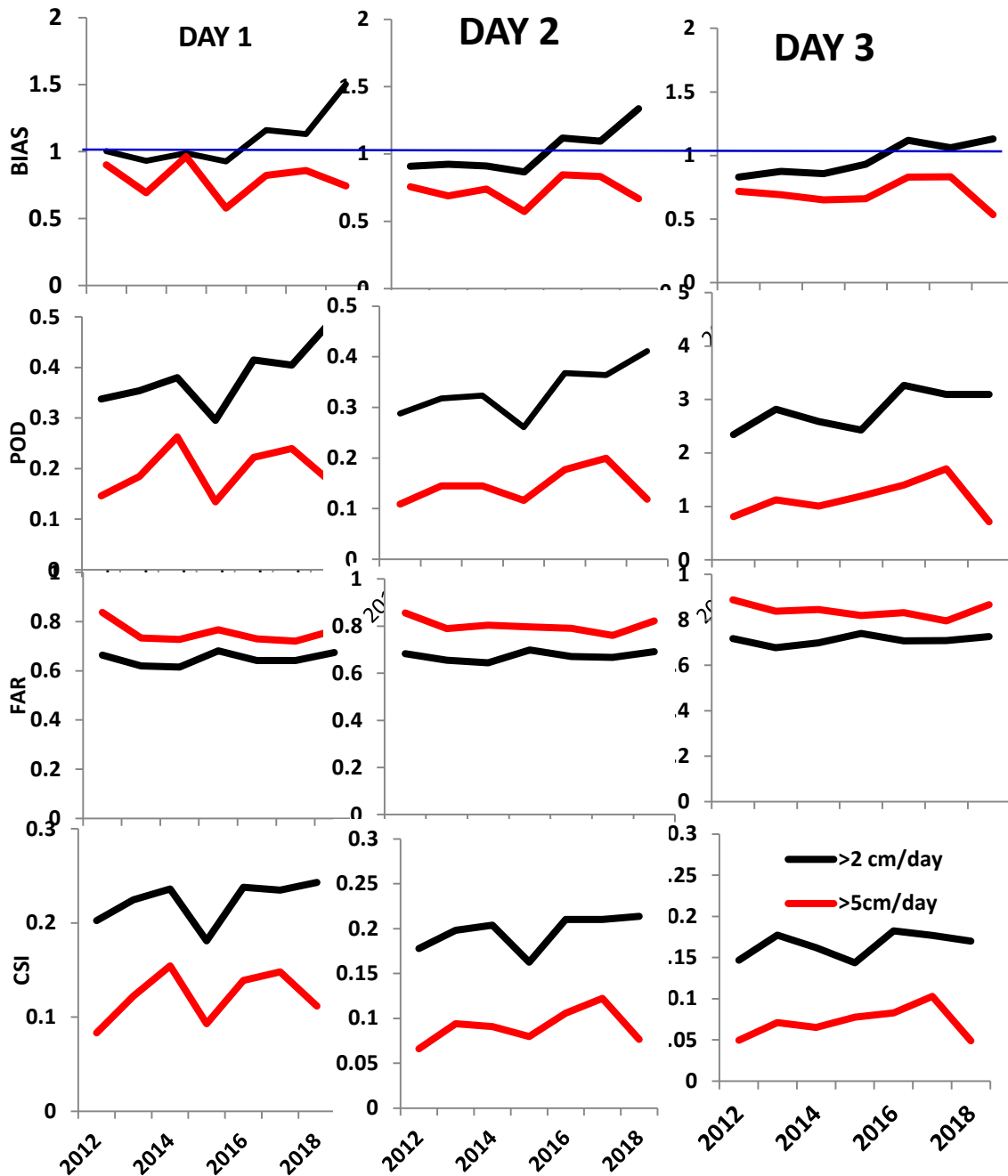


The Global (Ensemble) Forecast Model

Flowchart of deterministic GFS



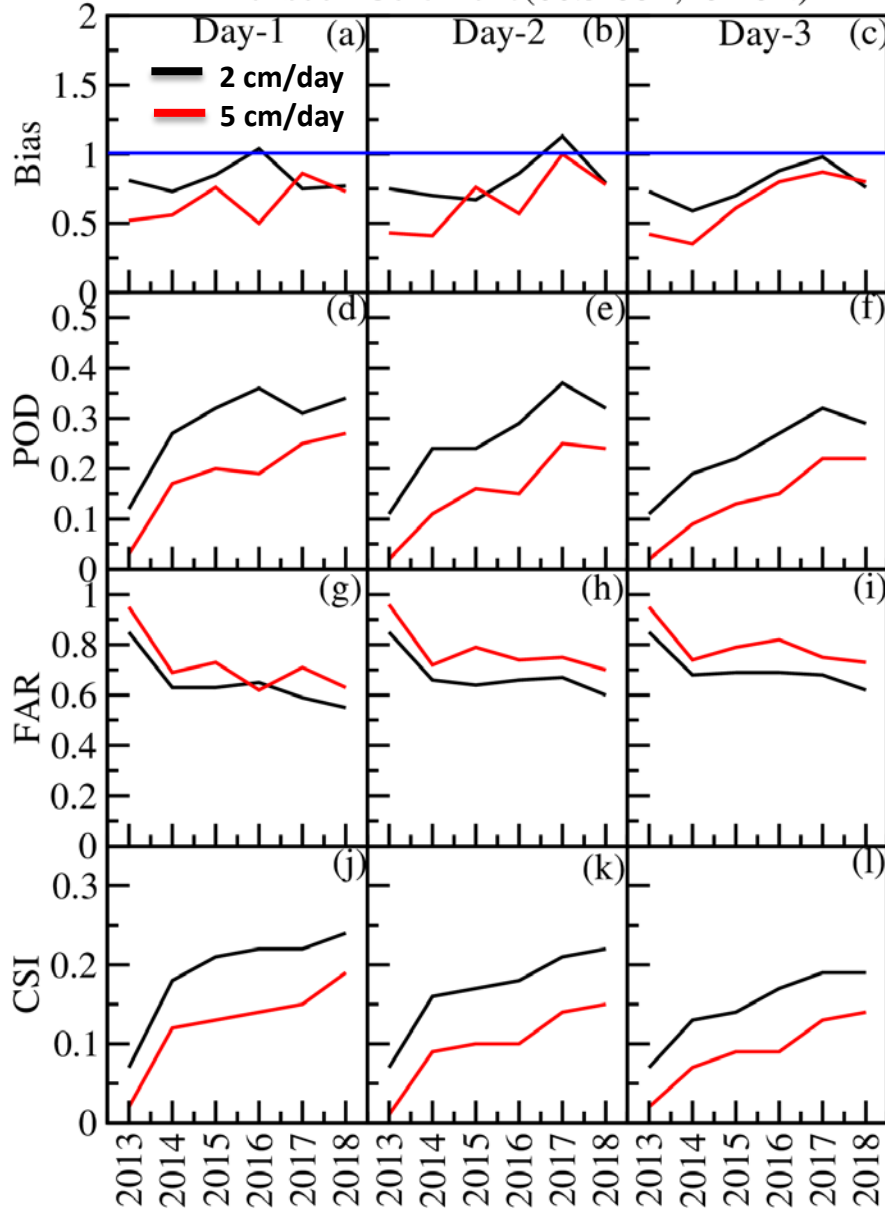
Verification Rainfall forecasts GFS (2012-2018) over India



- **Bias Score: Frequency Bias**
 - >1 implies model overestimates observed rain
 - <1 implies model underestimates observed rain
- **Probability of Detection (POD): Fraction of correct forecasts**
 - 0 No Skill
 - 1 Perfect Score
- **False Alarm Ratio (FAR): Fraction of false alarms**
 - 1 Worst
 - 0 Best
- **Critical Success Index (CSI) : Threat Score**
 - 0 No Skill
 - 1 Perfect Score

Verification of Rainfall forecasts over India

Verification Scores
Monsoon Core Zone(66.5-88E,18-28N)



Bias Score: Frequency Bias

- >1 implies model overestimates observed rain
- <1 implies model underestimates observed rain

Improvement in Bias score in NCUM forecasts

Probability of Detection (POD): Fraction of correct forecasts

- 0 No Skill
- 1 Perfect Score

Increasing trend in POD in NCUM forecasts

False Alarm Ratio (FAR): Fraction of false alarms

- 1 Worst
- 0 Best

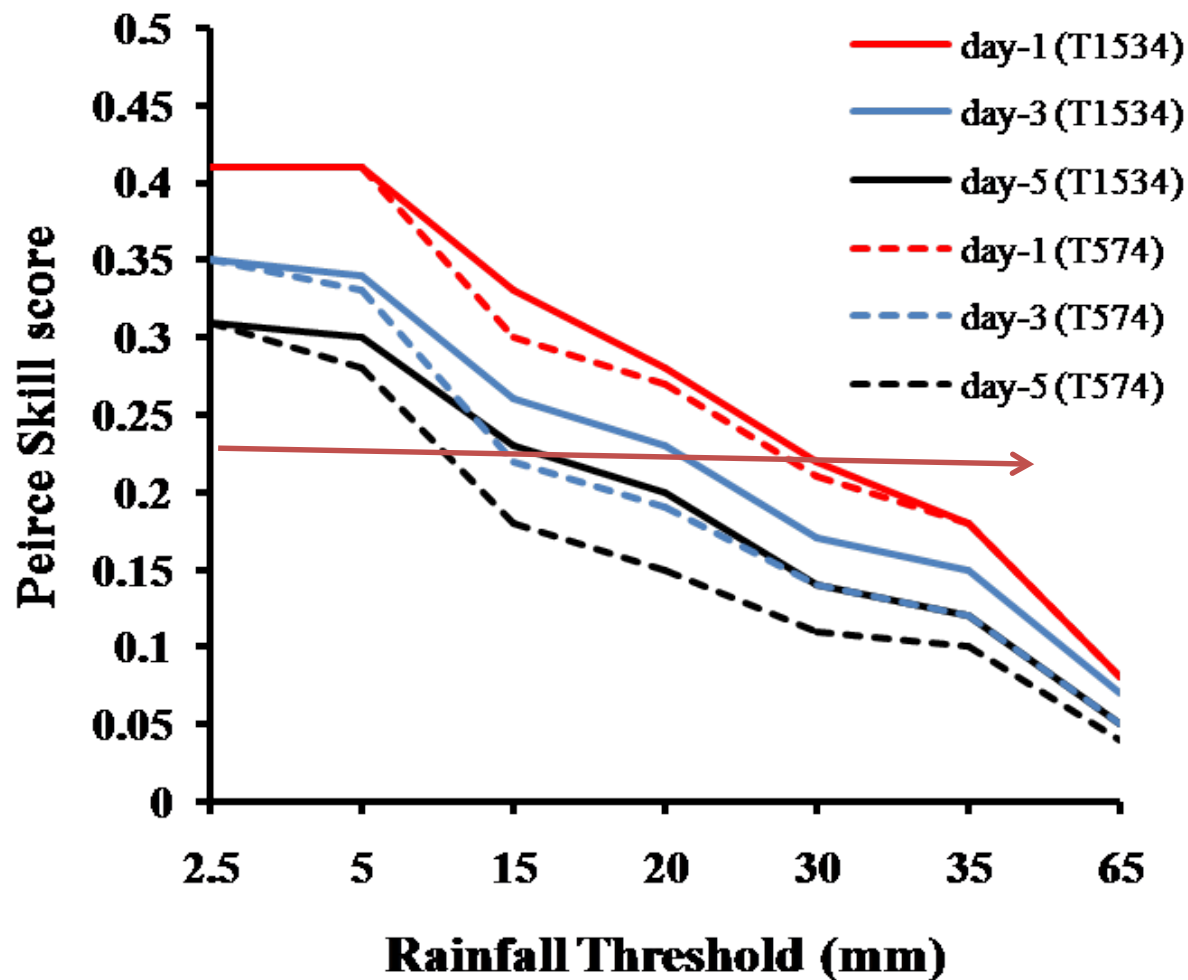
Decreasing trend in FAR in NCUM forecasts

Critical Success Index (CSI) : Threat Score

- 0 No Skill
- 1 Perfect Score

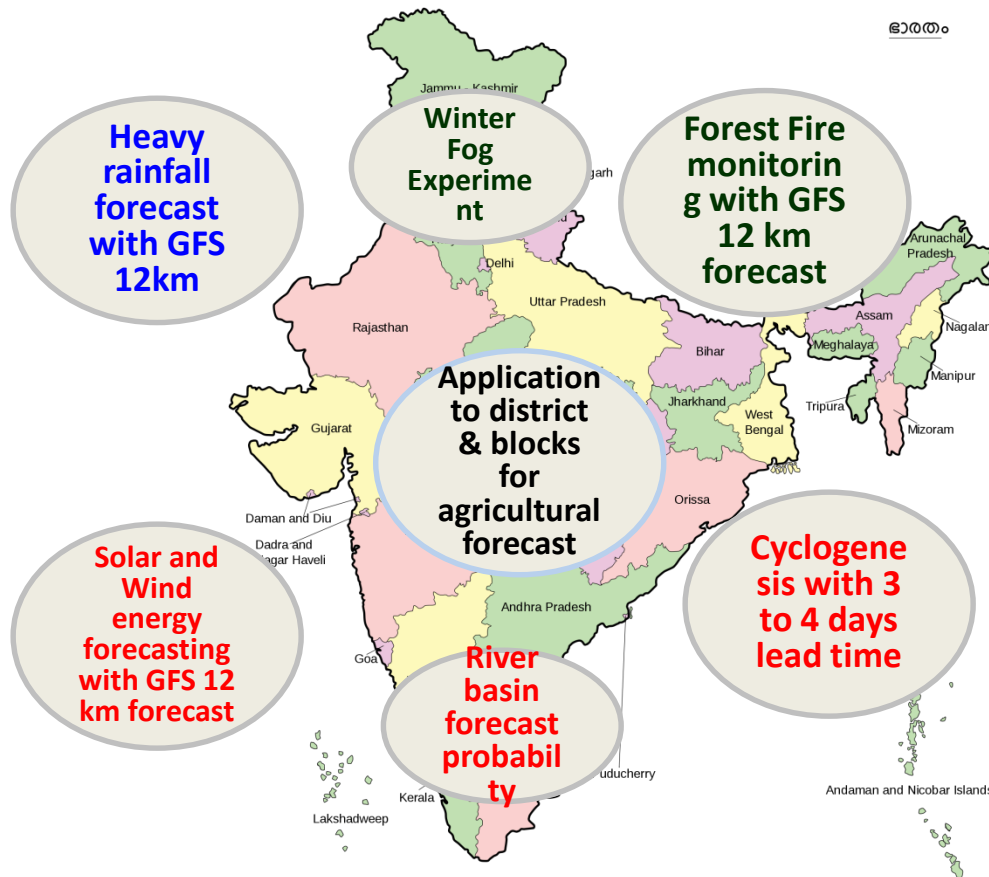
Increasing trend in CSI in NCUM forecasts

Peirce Skill Score (High Resolution global 12.5 km model gives better skill (The skill of GFS T574 with 3 day lead is now extended to 5 days with T1534 ~12.5 km global GFS



High resolution (12Km) Global Ensemble Weather Forecasting System (GEFS)

HIGH RESOLUTION (12 km) GFS MODEL APPLICATION TO THE SOCIETY



THE KERALA DELUGE AUGUST 2018



Ref: CWC Report, Sept, 2018

Synoptic Systems: Monsoon Depressions JJAS 2018

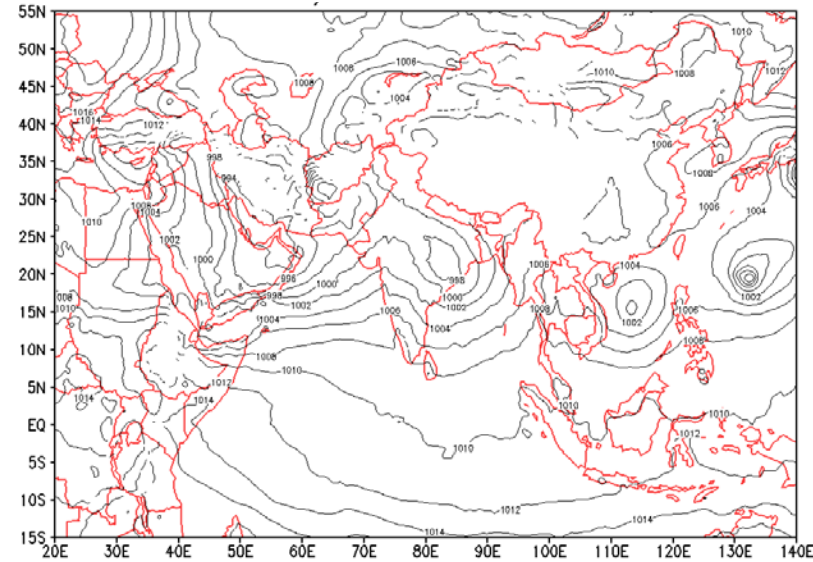
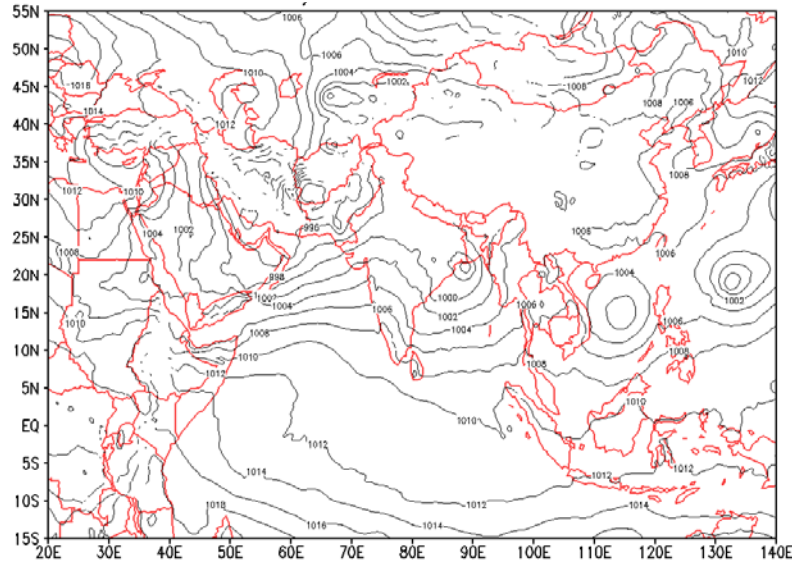
- **10-11 June** Depression over northeast Bay of Bengal and adjoining Bangladesh
- **21-23 July** Depression over northwest Bay of Bengal
- **07-08 August** Depression over northwest Bay of Bengal and neighbourhood.
- **15-17 August** Depression over coastal Odisha
- **06-07 September** Deep Depression over Bay of Bengal
- **19-22 September** Cyclonic Storm Daye over eastcentral Bay of Bengal and adjoining Myanmar

Analysis from GFS T1534

Monsoon Depression in August

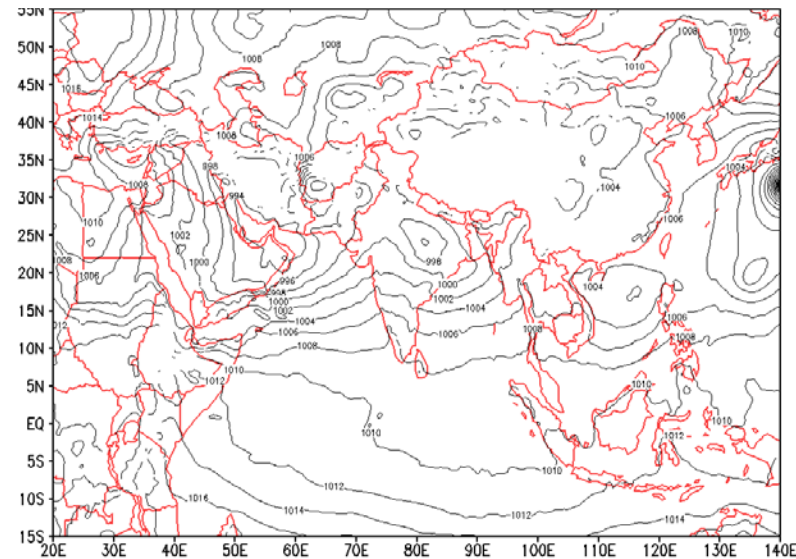
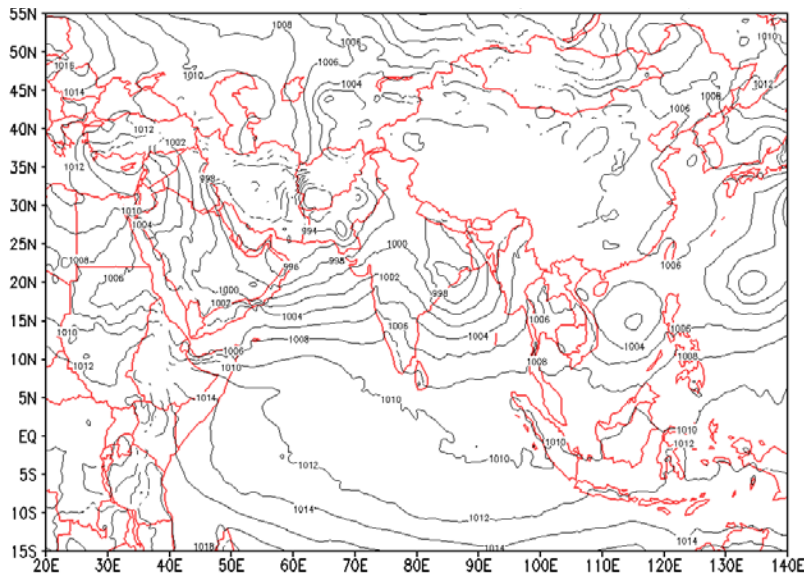
2018080700

2018080800



FCST from 2018080600 IC, valid for
2018080700

2018080800

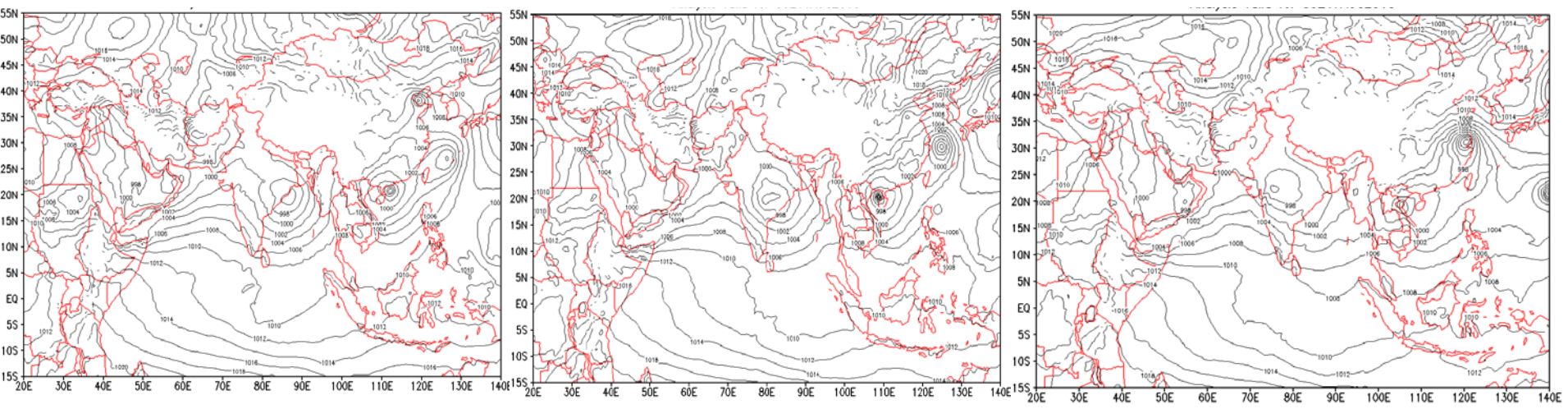


Analysis from GFS T1534

2018081500

2018081600

2018081700

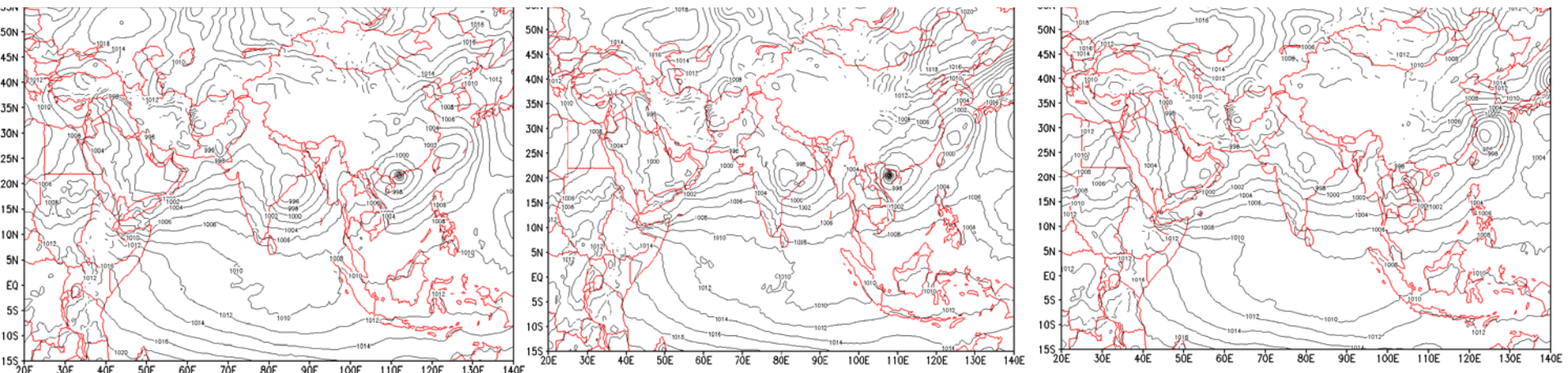


FCST from 2018081400 IC, valid for

2018081500

2018081600

2018081700



Period	Normal Rainfall	Actual Rainfall	Departure from normal
	(mm)	(mm)	(%)
June, 2018	649.8	749.6	15
July, 2018	726.1	857.4	18
1-19, August, 2018	287.6	758.6	164
Total	1649.5	2346.6	42

Districts	Normal Rainfall (mm)	Actual Rainfall (mm)	Departure from Normal (%)	
Kerala State	1701.4	2394.1	41	Excess
Alappuzha	1380.6	1784	29	Excess
Kannur	2333.2	2573.3	10	Normal
Ernakulam	1680.4	2477.8	47	Excess
Idukki	1851.7	3555.5	92	Large Excess
Kasaragode	2609.8	2287.1	-12	Normal
Kollam	1038.9	1579.3	52	Excess
Kottayam	1531.1	2307	51	Excess
Kozhikode	2250.4	2898	29	Excess
Malappuram	1761.9	2637.2	50	Excess
Palakkad	1321.7	2285.6	73	Large Excess
Pathanamthitta	1357.5	1968	45	Excess
Thiruvananthapuram	672.1	966.7	44	Excess
Thrissur	1824.2	2077.6	14	Normal
Wayanad	2281.3	2884.5	26	Excess

INDIA METEOROLOGICAL DEPARTMENT MC THIRUVANANTHAPURAM

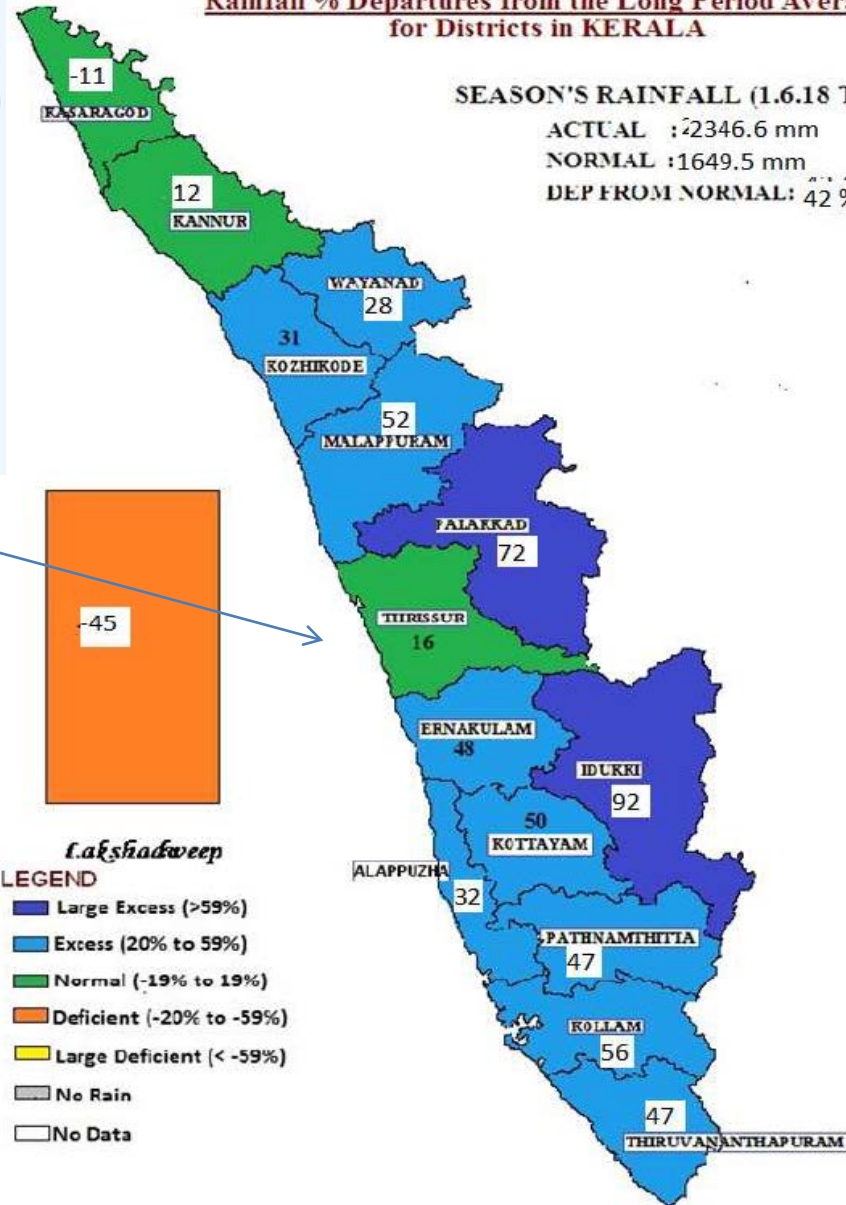
Rainfall % Departures from the Long Period Averages for Districts in KERALA

SEASON'S RAINFALL (1.6.18 TO 19.8.2018)

ACTUAL : 2346.6 mm

NORMAL : 1649.5 mm

DEP FROM NORMAL: 42 %



Lakshadweep

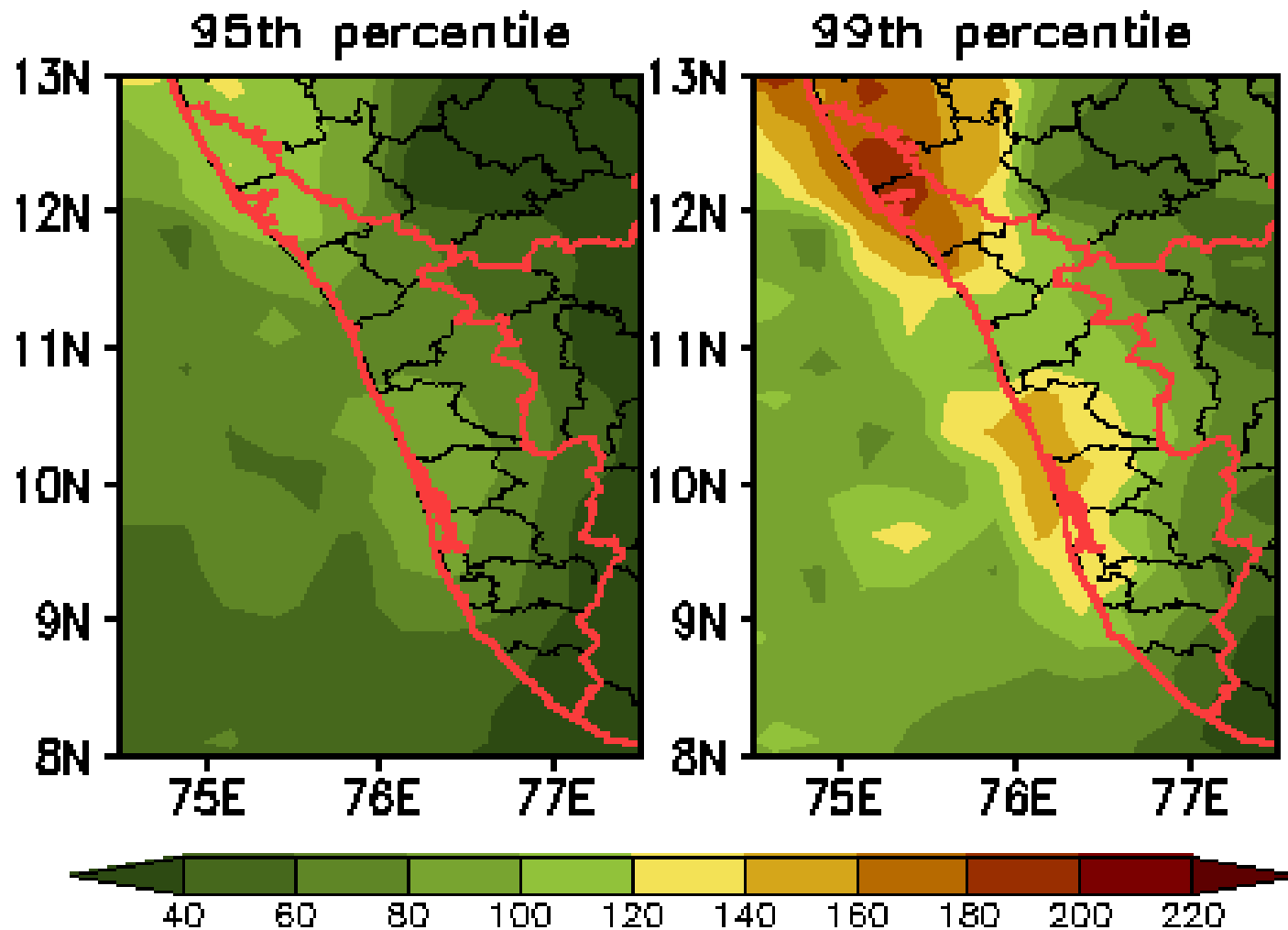
LEGEND

- Large Excess (>59%)
- Excess (20% to 59%)
- Normal (-19% to 19%)
- Deficient (-20% to -59%)
- Large Deficient (< -59%)
- No Rain
- No Data

Districts in Kerala:

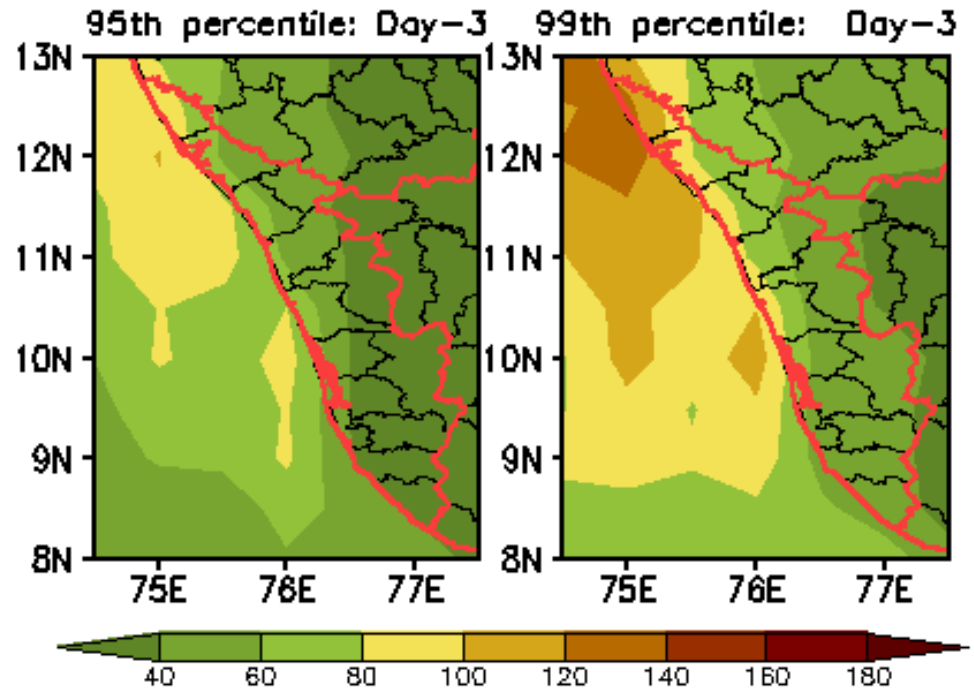
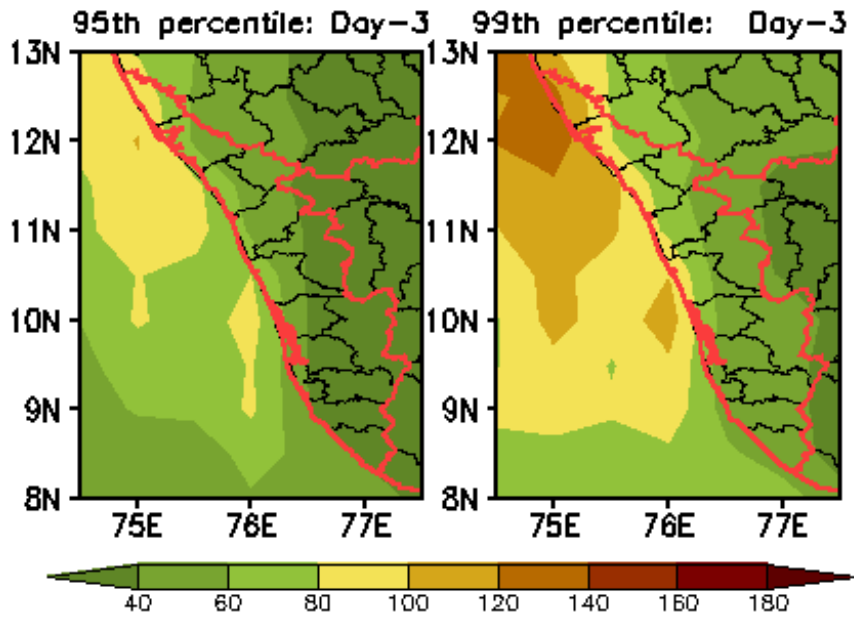
1. Kasargode
2. Kannur
3. Kozhikode
4. Wayanad
5. Malappuram
6. Palakkad
7. Thrissur
8. Ernakulam
9. Idukki
10. Kottayam
11. Alappuzha
12. Pathanamthitta
13. Kollam
14. Thiruvananthapuram

Climatological extreme during August over Kerala (mm day⁻¹) based on Tropical Rainfall Measuring Mission



Extreme from TIGGE forecast CFS

(THORPEX Interactive Grand Global Ensemble is an implementation of ensemble forecasting for global weather forecasting)

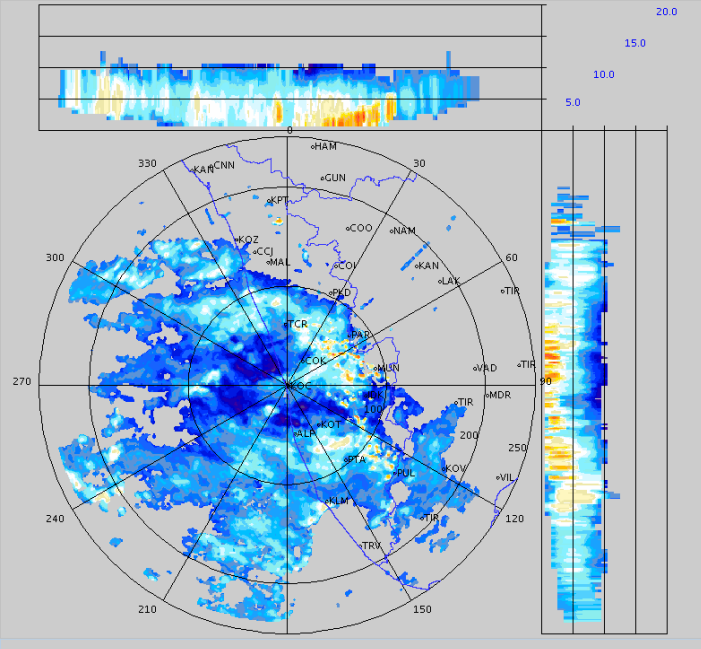


2018/08/15 06:32:10 (UTC)

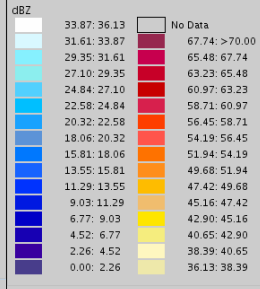
06:32:10 (UTC)

MAX(Z)

DWR KOCHI (9.9263N, 76.2622E, 30.0000 mts)



Height : 20.0 Km
 Layer Spacing : 1.0 Km
 Z (Lo, Hi) : -31.5, 90.0 dBZ
 Grid size : 1 Km
 Display Range : 250 Km
 Display Res : 0.9 Km/Pix
 DDR Enable : Yes
 Scan Elev (Lo, Hi) : 0.0, 20.0 Deg
 PRF (Lo, Hi) : 450, 600 Hz
 Scan Res : 150 mts
 Scan RPM : 1.5
 Log Threshold : 3 dB
 DTP : 57
 Pulse Width : 1.0 micro sec
 Clutter Filter : IIR-HP(36.0 Hz)
 SQI : 0.25
 CSR : 10 dB
 Scan Range : 240 Km
 Preprocessings : NONE
 Filters : NONE



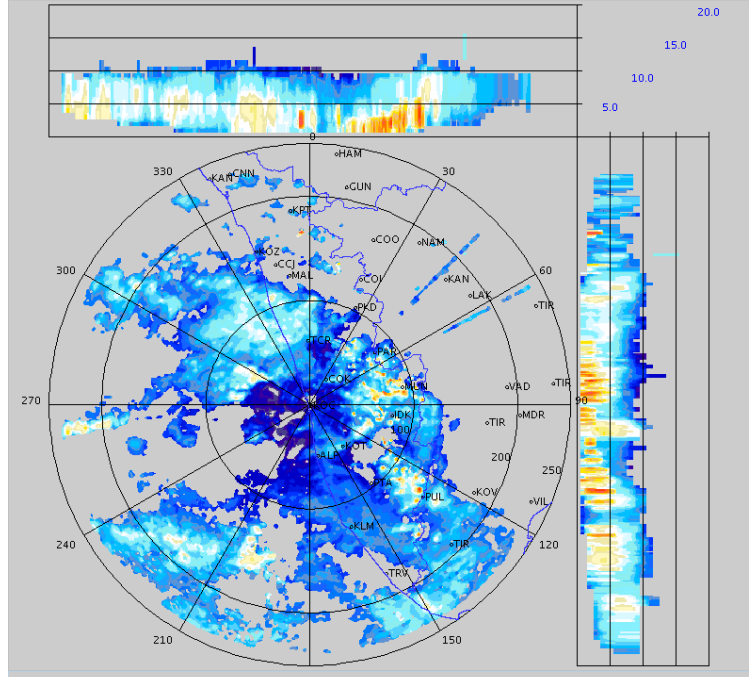
kochi_weather_2018_08_15_08_32_13_dsoimdb_kochi.dwr

2018/08/15

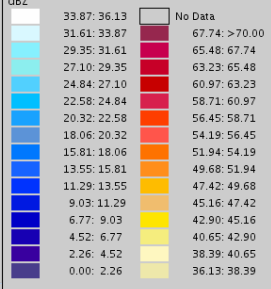
08:32:13 (UTC)

MAX(Z)

DWR KOCHI (9.9263N, 76.2622E, 30.0000 mts)



Height : 20.0 Km
 Layer Spacing : 1.0 Km
 Z (Lo, Hi) : -31.5, 90.0 dBZ
 Grid size : 1 Km
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 Filters : NONE



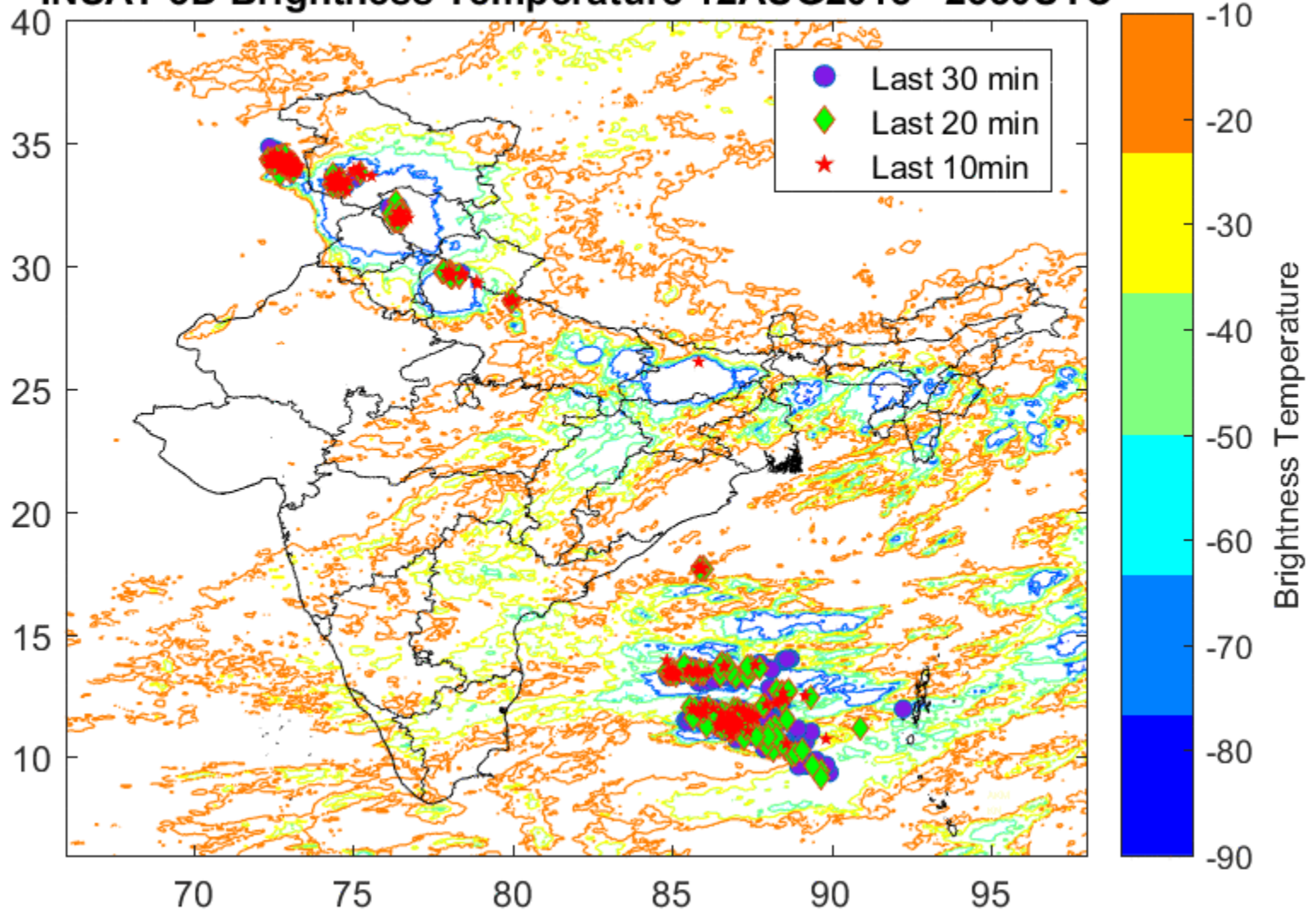
Courtesy: IMD



INDIA METEOROLOGICAL DEPARTMENT

Lightning 2018-08-13 0029UTC

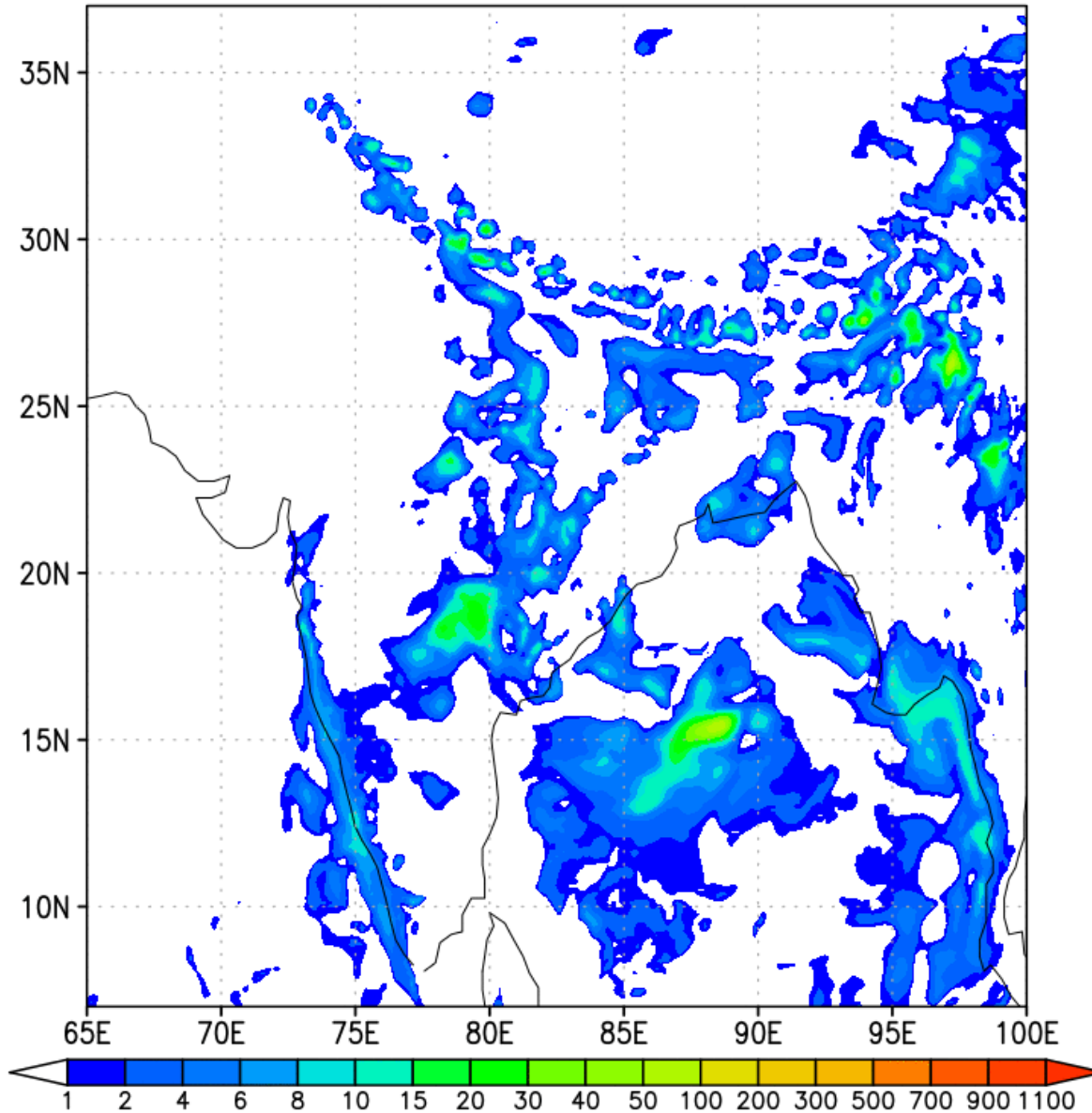
INSAT 3D Brightness Temperature 12AUG2018 2330UTC



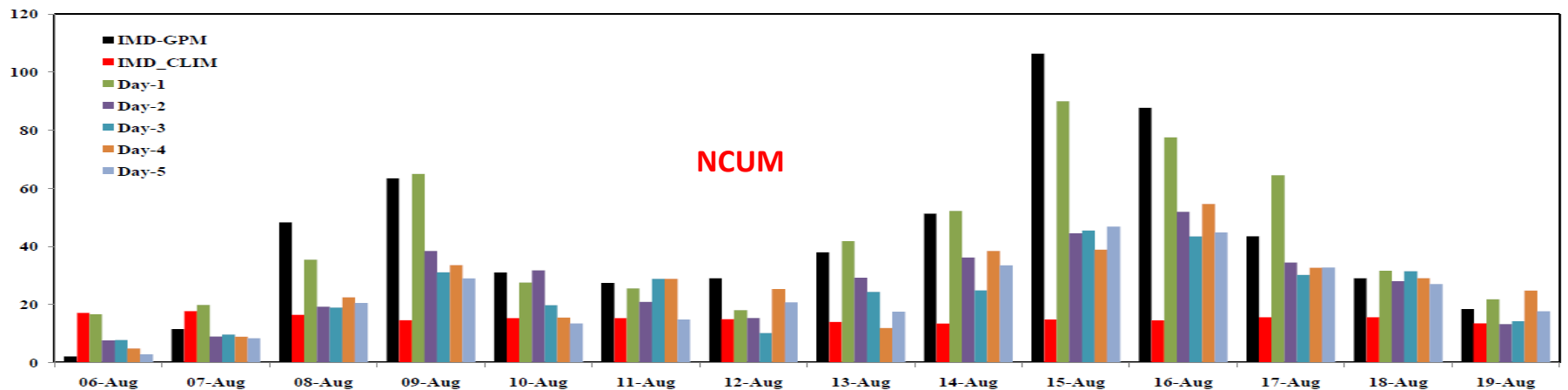
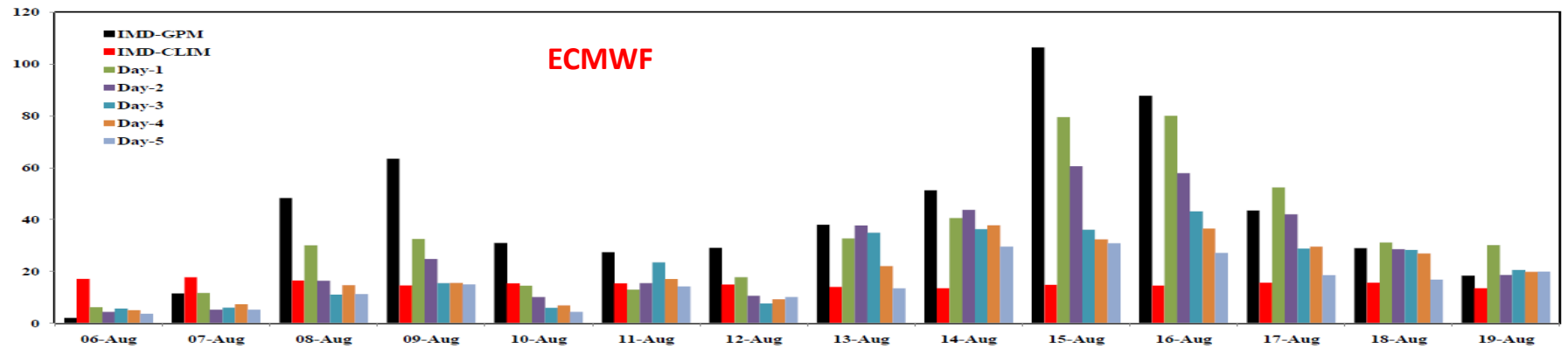
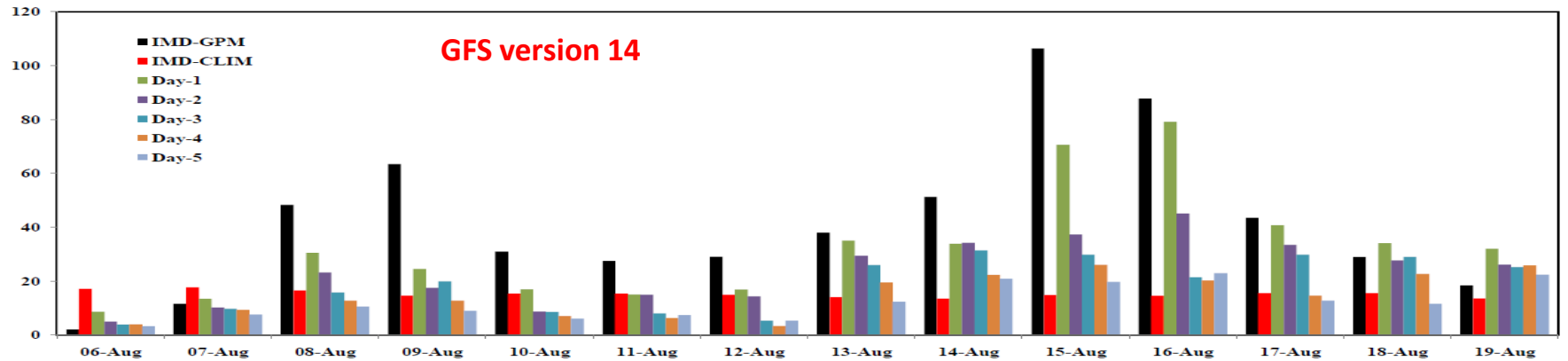
The merged lightning & satellite cloud top temperature operational product is a joint collaboration of IMD, IITM & IAF

IITM GFS T1534 : Rainfall (mm/day)
Forecast valid for 03Z12AUG2018

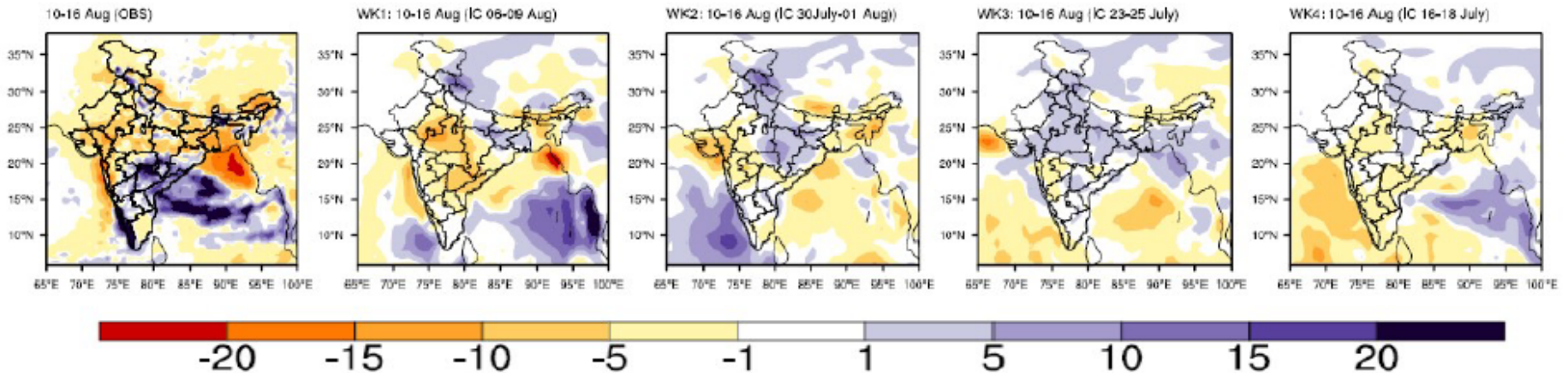
11 Aug IC



Deterministic Forecast Rainfall (mm/day) time series over Kerala



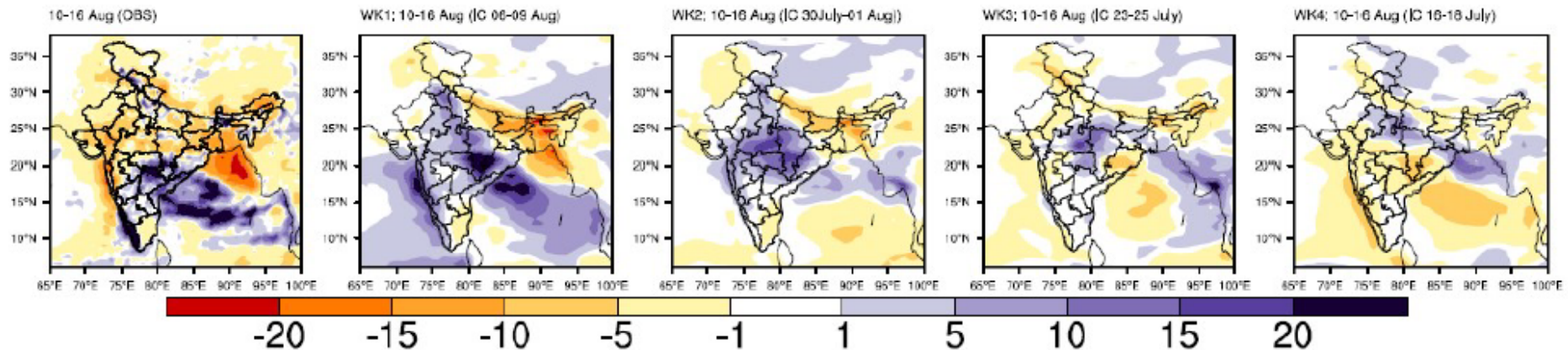
Weekly forecast extended range



Valid period 10-16 Aug 2018

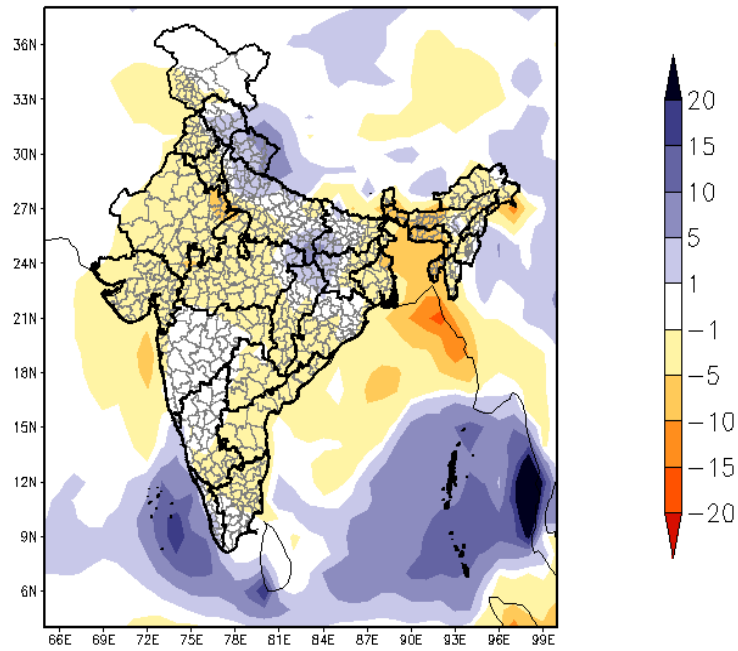
Above Plot: Rainfall anom from NCEP CFS (T126) ~ 100 km

Bottom Plot: rainfall anom from NCMRWF Coupled model ~ 60 km



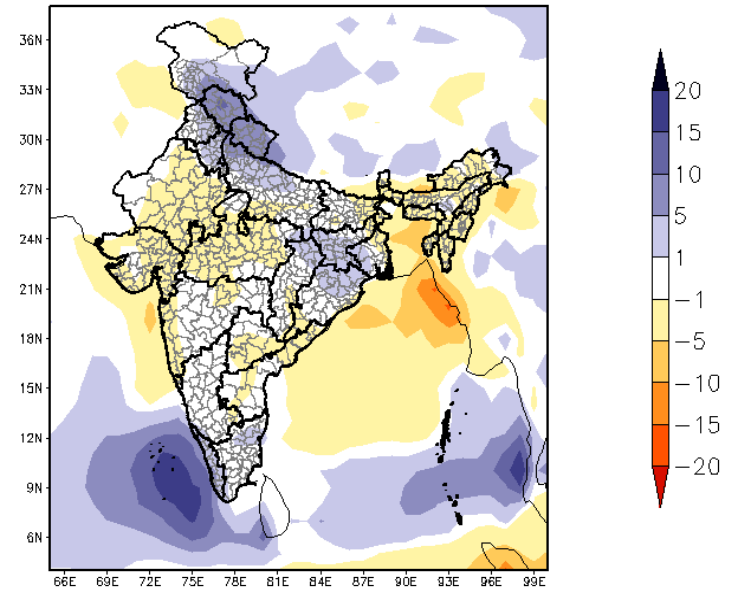
MME Weekly Rainfall Anomaly (mm/day)

(Week1: 10Aug-16Aug)



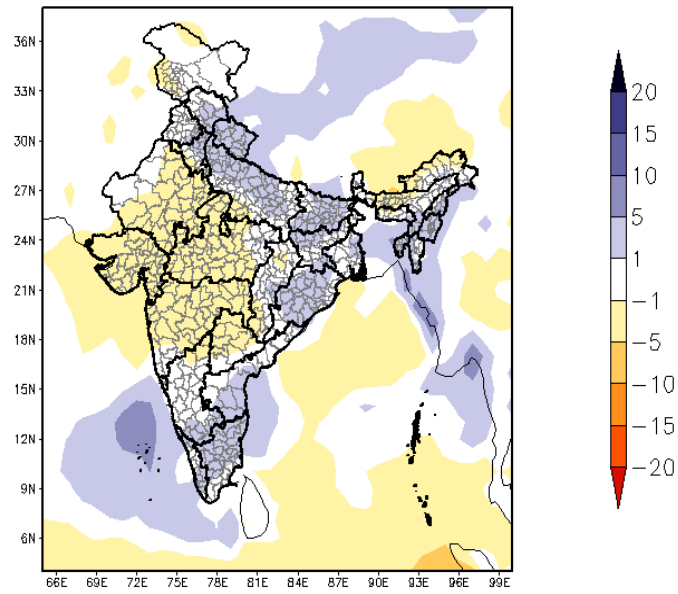
MME Weekly Rainfall Anomaly (mm/day)

(Week2: 10Aug-16Aug)



MME Weekly Rainfall Anomaly (mm/day)

(Week3: 10Aug-16Aug)



**IMD/IITM extended
range forecast based
on CFS/GFS**

ENS weekly TP fc over India for 20180813-0819

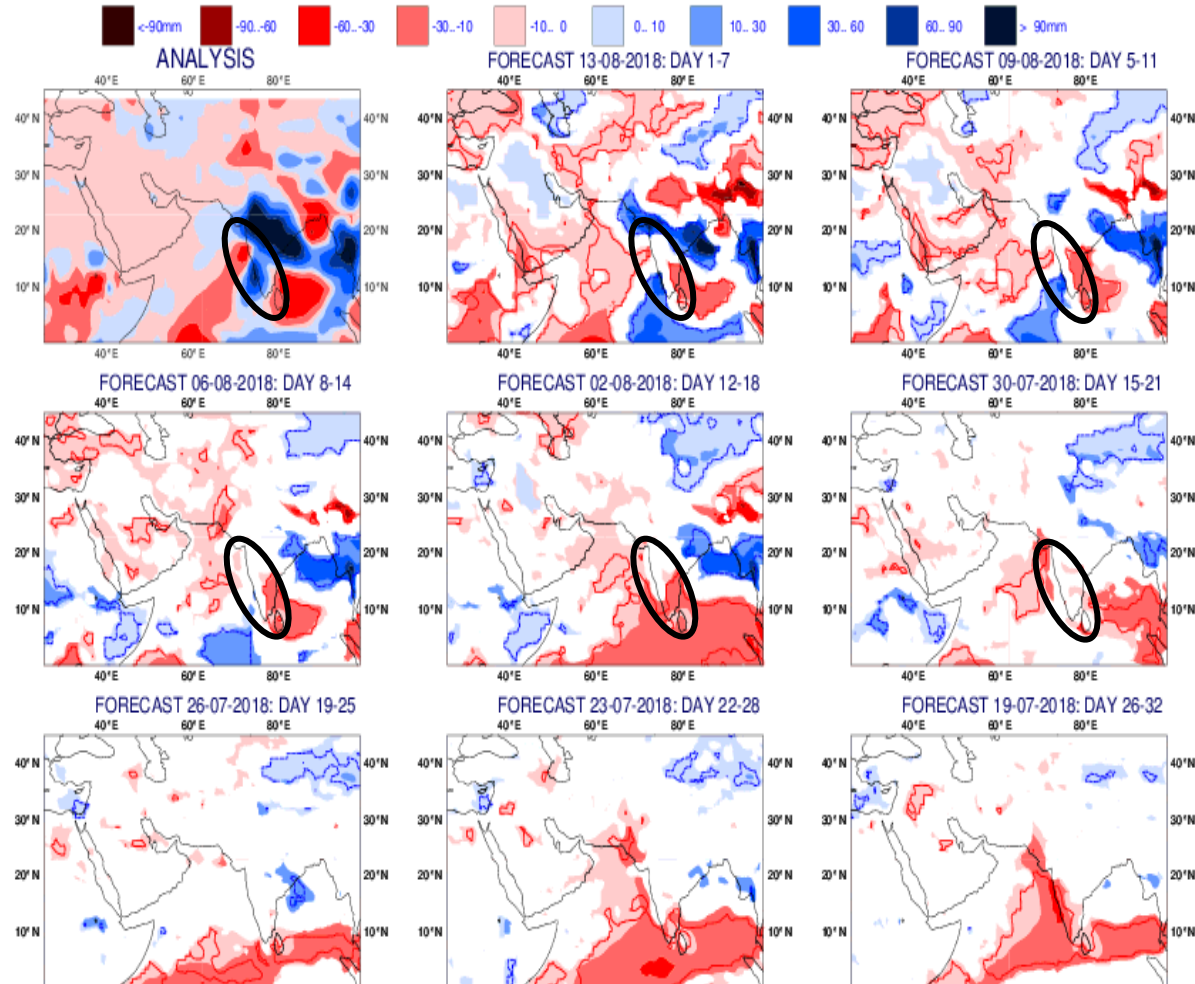
Analysis and ECMWF ENS Forecasting System

Precipitation anomaly

Verification period: 13-08-2018/TO/19-08-2018

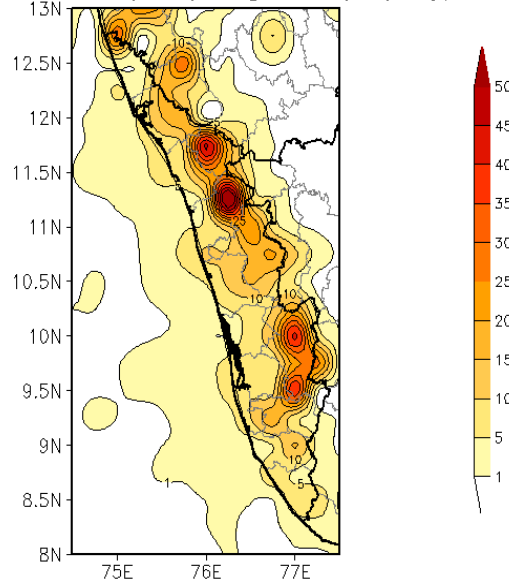
ensemble size = 51 , climate size = 660

Shaded areas significant at 10% level, Contours at 1% level



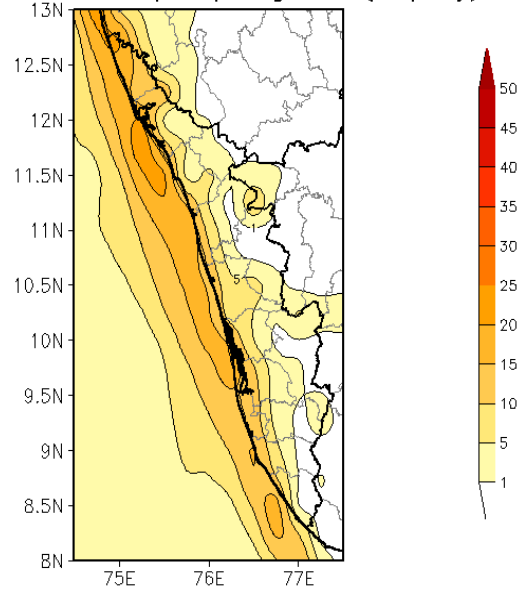
(a)

IMD GPM acc precip Aug 7-9 (cm/day)



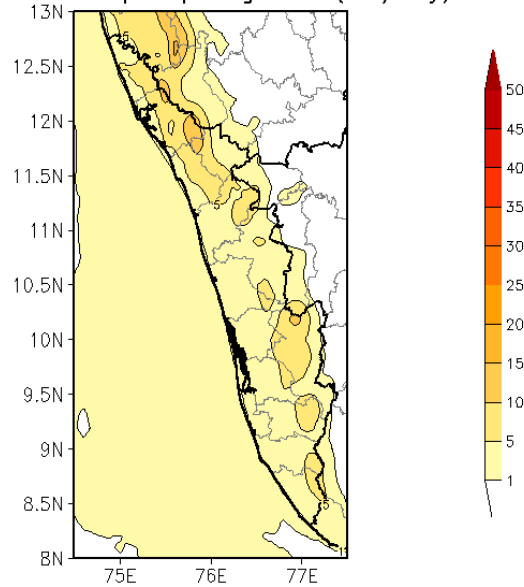
(b)

GEFS T1534 acc precip Aug 7-9 (cm/day)



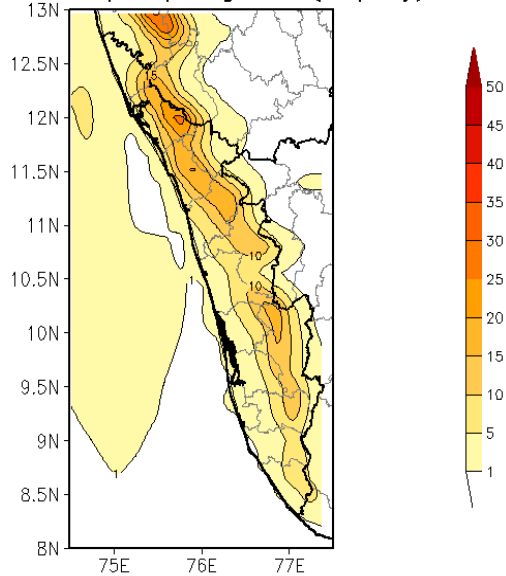
(c)

ECMWF acc precip Aug 7-9 (cm/day)

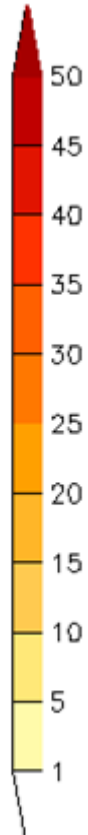
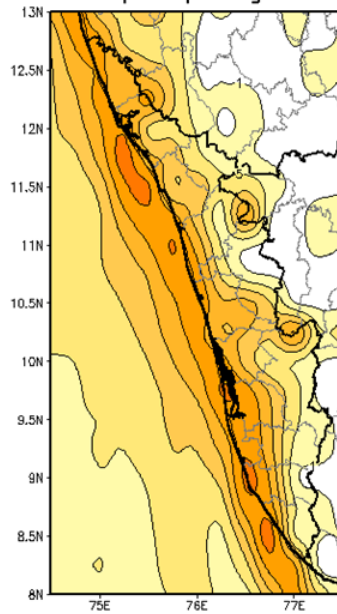
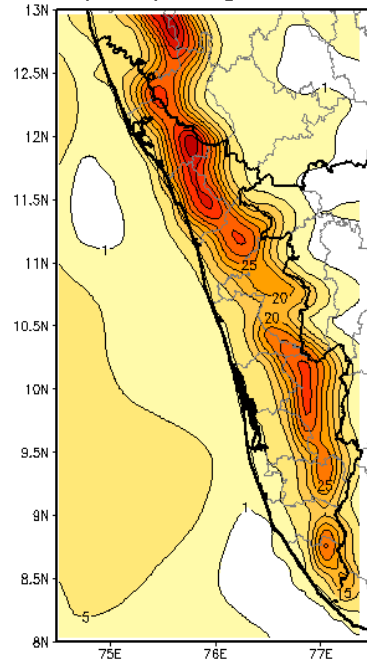


(d)

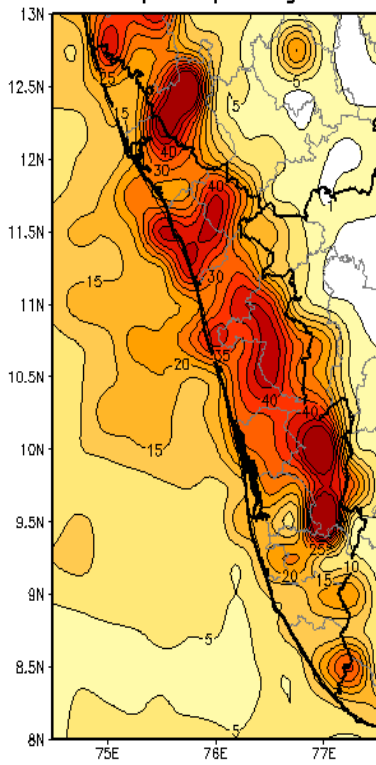
NEPS acc precip Aug 7-9 (cm/day)



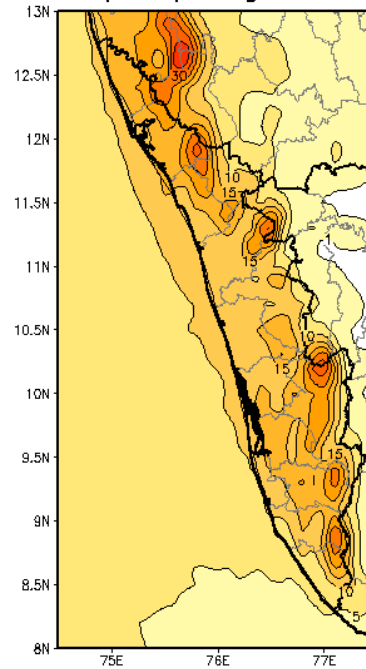
NEPS acc precip Aug 13-16 (cm/day) GEFS T1534 acc precip Aug 13-16 (cm/day)



IMD GPM acc precip Aug 13-16 (cm)

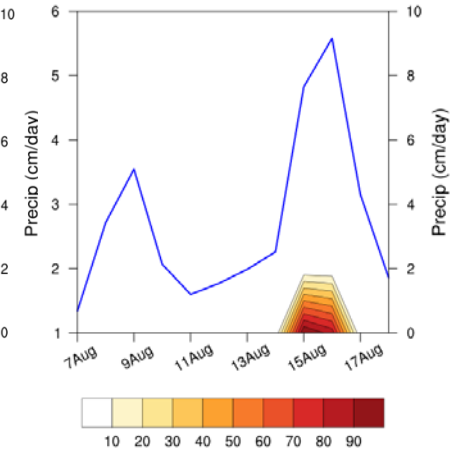
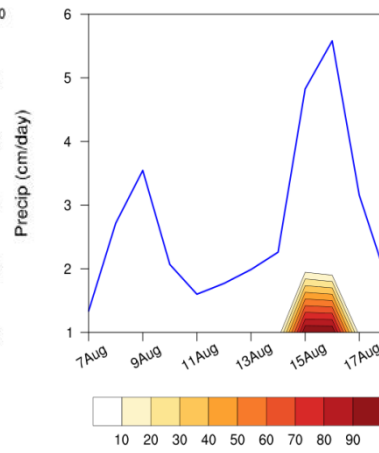
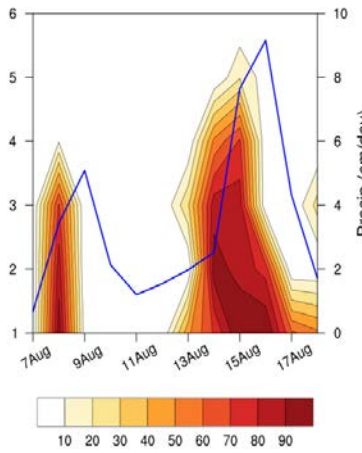


ECMWF acc precip Aug 13-16 (cm/day)

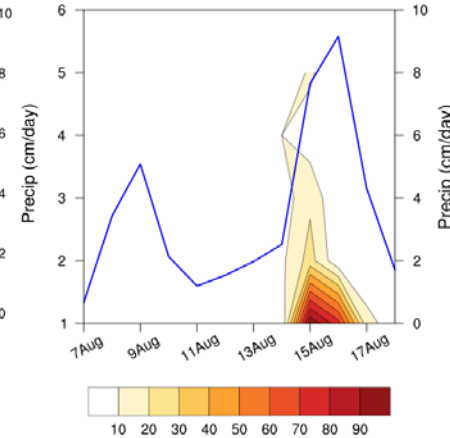
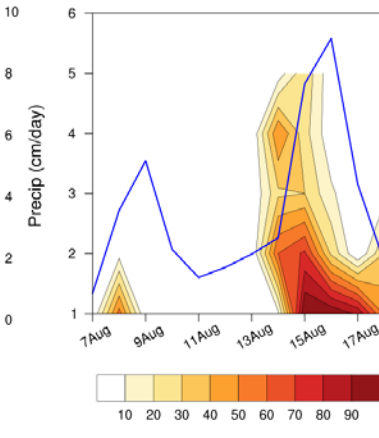
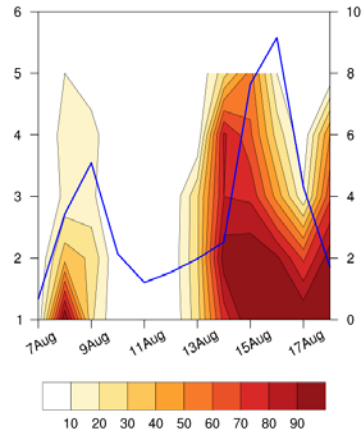


IC 20180812

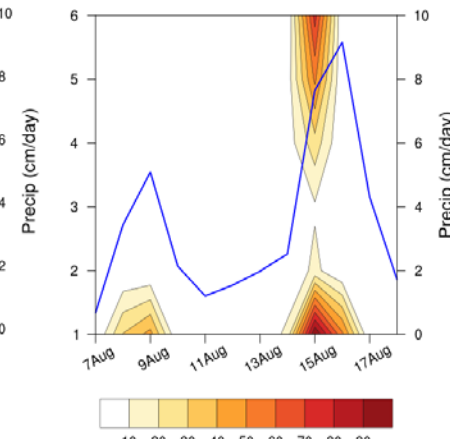
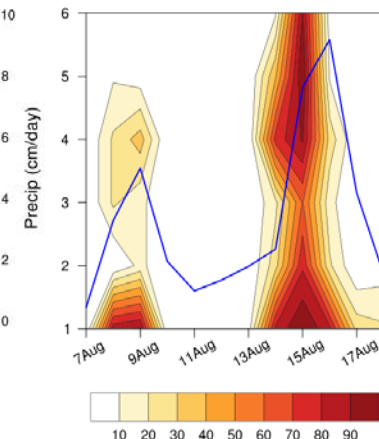
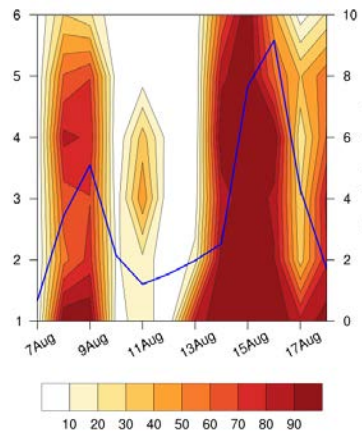
GEFS



ECMWF



NCUM

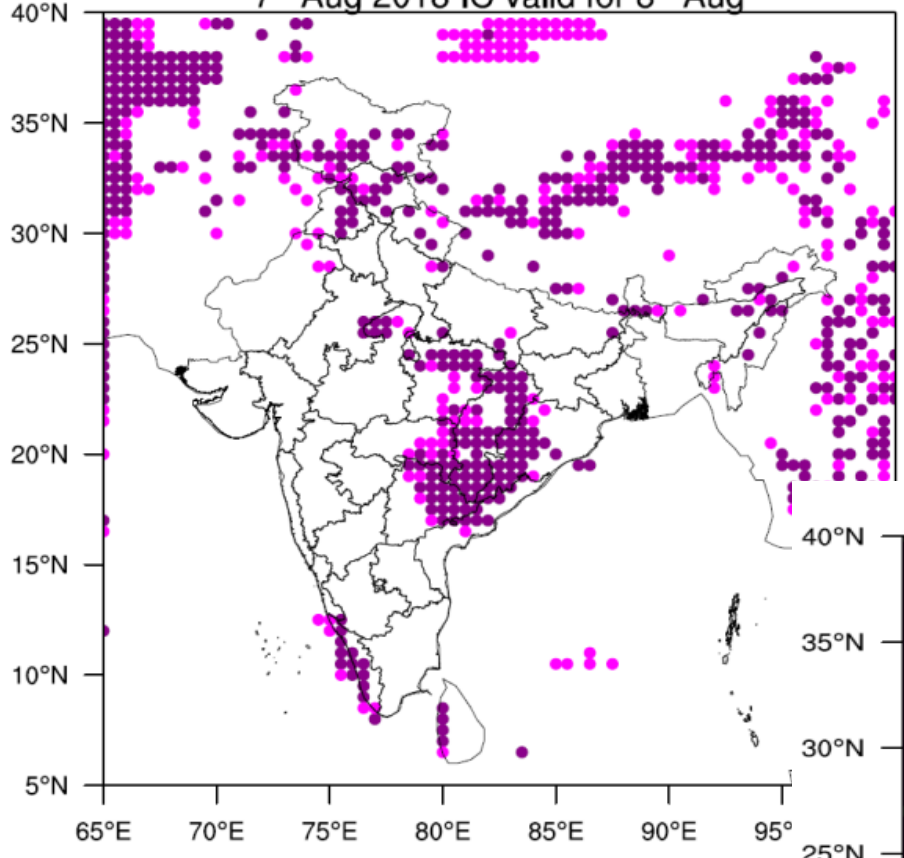


Climatology+1SD

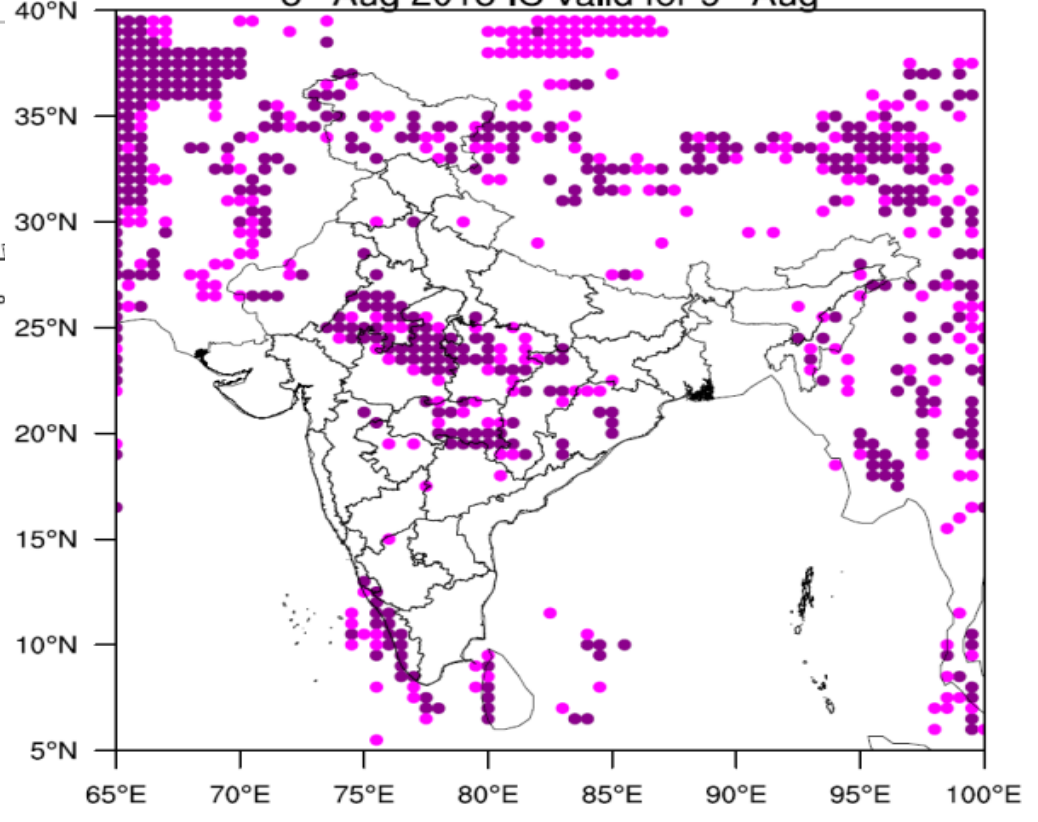
Climatology+2SD

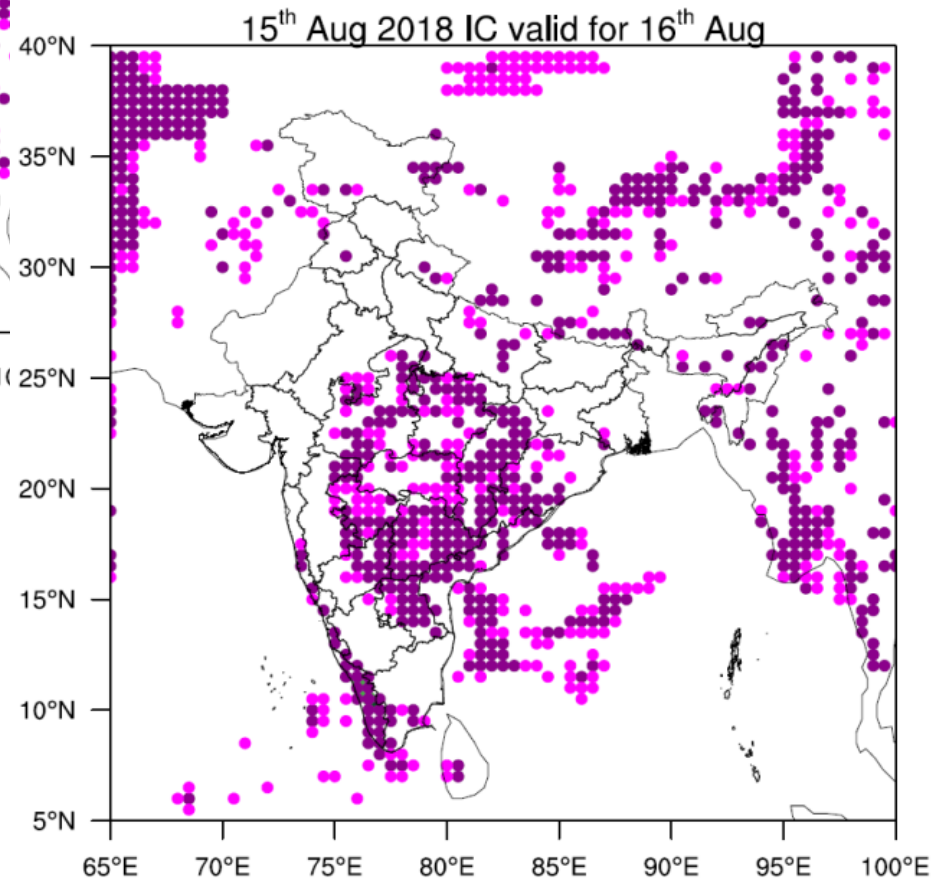
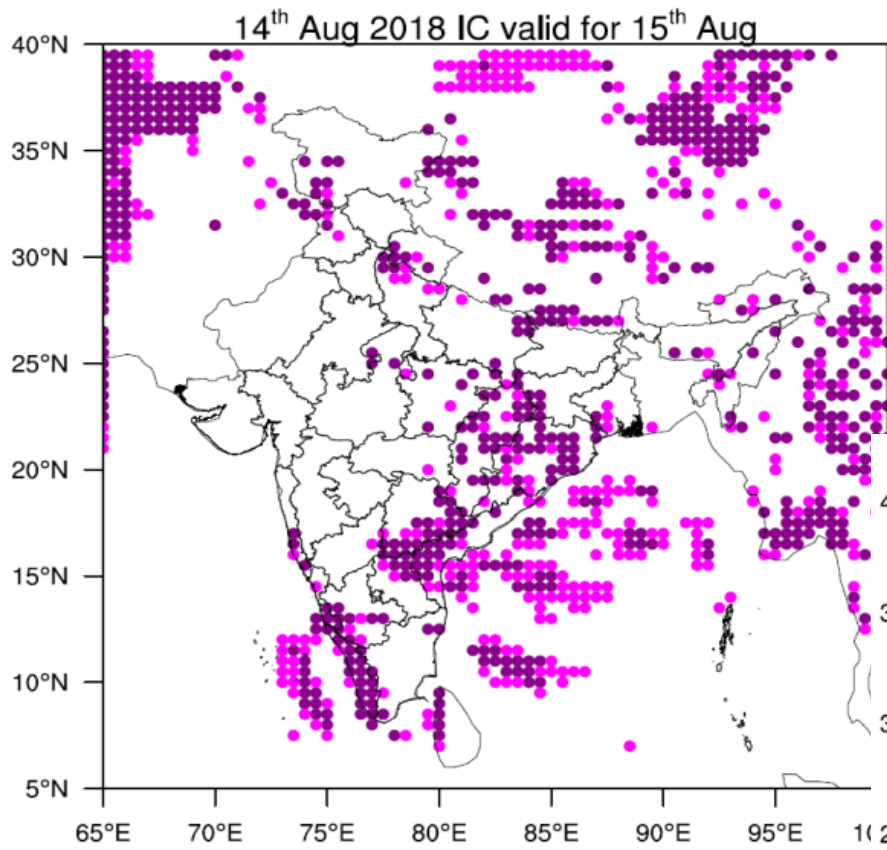
Climatology+3SD

7th Aug 2018 IC valid for 8th Aug



8th Aug 2018 IC valid for 9th Aug





Mumbai during 1-2 July 2019

VSCS VAYU 10-19 June



Chennai: Train arrives with 2.5 million lt water



Indian Express 2 July 2019

Rain pounds Mumbai

Airport Ltd said. The main runway was shut down. "Airport to Mumbai Spicet flight 502/27 slips on runway while landing. All passengers safe," a passenger aboard the flight, Praveen Betad, tweeted. MAL said flight operations at CSIA were continuing after the incident with the secondary runway in use. All schools and colleges will remain closed on Tuesday, as per directives of the municipal commissioner.

According to rainfall data released by the India Meteorological Department, the suburb of Malad West had received 301 mm of rain from 8:30 am until 7:30 pm on Monday. Late at night, residents of Malad, Andheri, Borivli, Chhatkopar, Kurla, Chembur and other suburbs said the rain was coming down in thick sheets in their neighbourhoods.

"Suburban rainfall values are very high. Take care," tweeted IMD Deputy Director General K S Hoslaikar in the evening.

In another tweet, he said: "Mumbai almost non stop heavy rains since Friday. Vigorous activity. Now laser speckles are continuing and cumulative rainfall figure tomorrow morning would be very interesting figure."

As the downpour continued without let-up at night, concerns rose for shanties and settlements on riverbanks and along nullahs. Social media buzzed with photographs of water logging at various places, including train tracks.

In Malad, where the highest rainfall was recorded, residents said it had been raining non-stop in their area. "It has been raining heavily since last night. I managed to get to work in Andheri in the morning but it took me over two hours just to travel from Malad (east) to Malad (west) to each home, which normally takes 20 minutes," said Khadija Shaikh.

Other residents of Malad also said that the Western Express highway south-bound traffic was at a standstill in the evening. "It had been raining non-stop since morning with barely a few breaks of no showers. In some areas water had accumulated knee-deep," said Anur Das, a Malad resident.

Mumbai police commissioner Sanjay Barve tweeted warning of "heavy to very heavy rains" in the city and Mumbai Metropolitan Region over the next three days.

"I request Mumbaiikars to check weather updates and plan the day accordingly," he tweeted.

MONDAY DOWNPOUR (8.30AM-8.30PM)

Malad	301.0
Gopagan	215
Andheri	187.0
Malad West	181.1
Kandoli	142.1
BKC	142.0
Andheri	141.5
Vikhroli	138.5
Baroli	127.27
Worli	117.6
Wandrup	116.6
Lower Parel	112.4
Worli	86.7
Haji Ali	81.2
Borivli	80.7
Dadar	80.7
Mahabaleshwar	64.5

Very heavy rain forecast between July 3-5

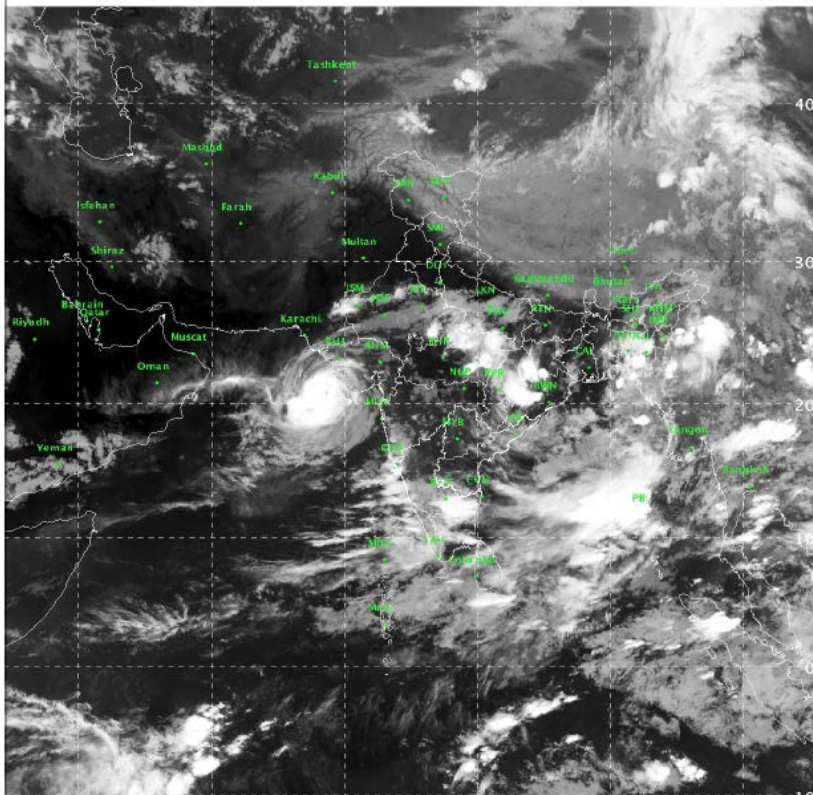
Weather forecasting agency SkyMet said the rain intensity may dip slightly on Tuesday. "However, by July 3 we expect rains to revive with heavy rainfall around July 4-5 for the city. This is owing to a low pressure area over Bay of Bengal which will gradually move towards the interior parts of Maharashtra," said Mahesh Palawat, vice president, meteorology and climate change, SkyMet. BMC's twitter handle @bmcmet tweeted "As per IMD updates, close to 200mm or more rain per day is likely between July 3 and 5." The IMD has put districts like Palghar, Thane, Mumbai, Raigad, Ratnagiri and Sindhudurg in Konkan on alert from July 2 to July 5. "A week will witness a high tide. The intense rain over Mumbai will continue till July 5."



Floods ravage north-east India & Bihar, IMD declares red color warning for Assam 14-17 July

SAT :INSAT-3D IMG
IMG_TIR1 10.8 um
LIC Mercator (LINEAR STRETCH: 1.0%)

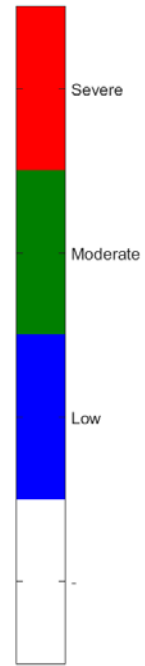
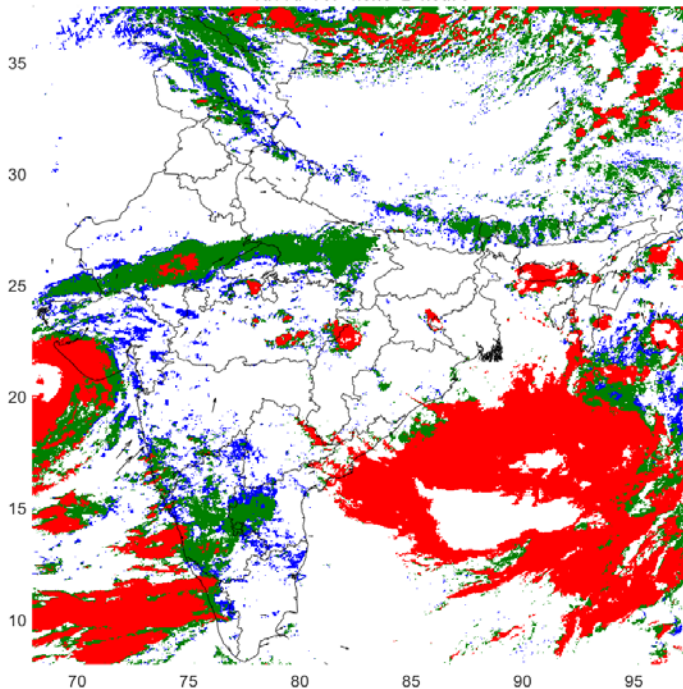
13-06-2019/16:00 GMT
13-06-2019/21:30 IST



VSCS TC VAYU 13 June



INSAT-3D CONVECTIVE INDEX
based on 13JUN2019-0930UTC
valid for next 2 hours

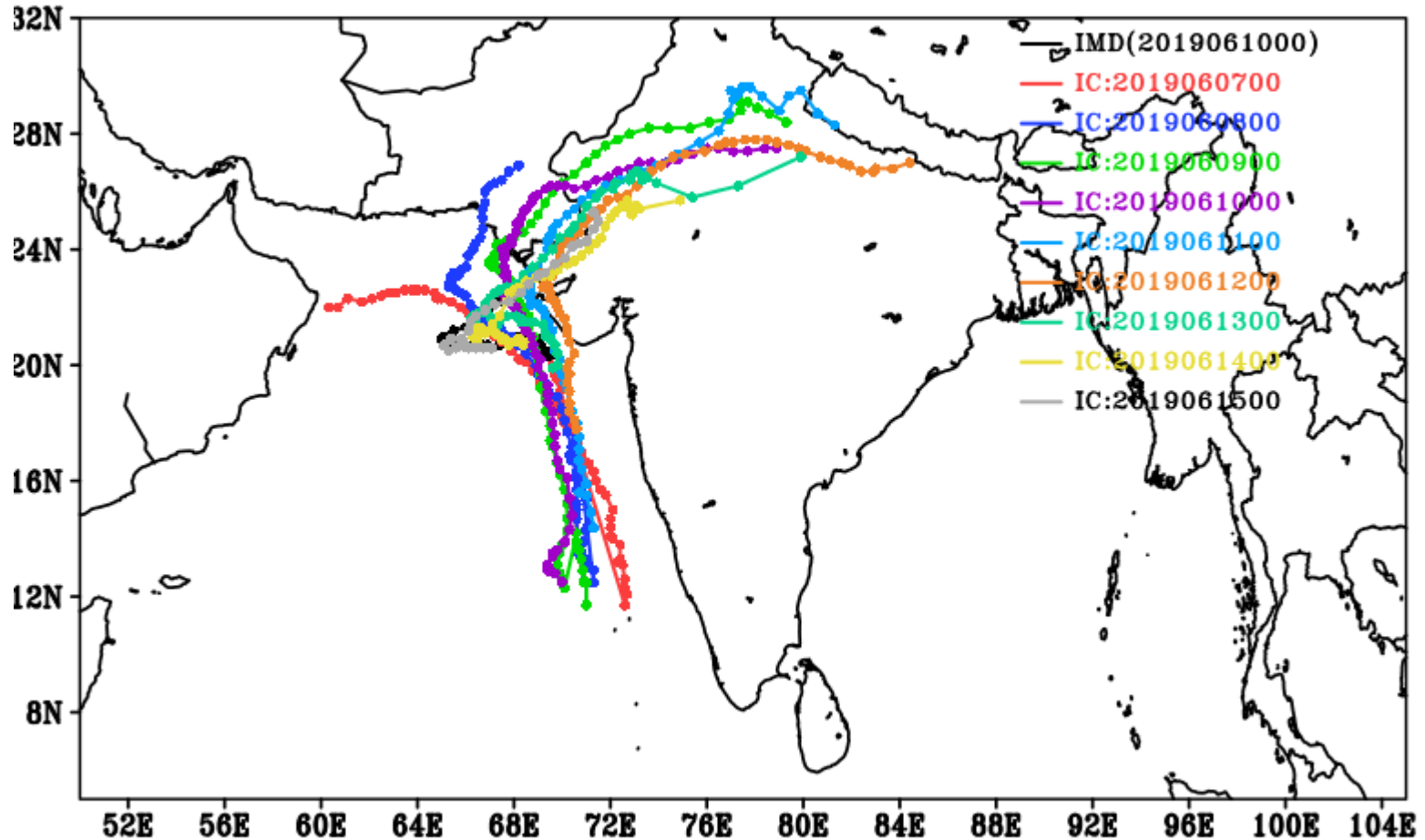


(DMP - Based on IR/VIS/SWIR composite)

GFST1534 Model Verification with IMD

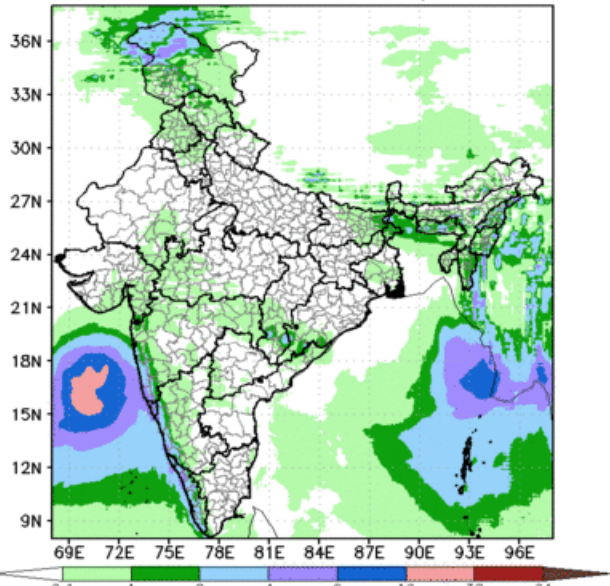
ICs From 7June-15June 2019

TRACK PREDICTIONS FOR VAYU

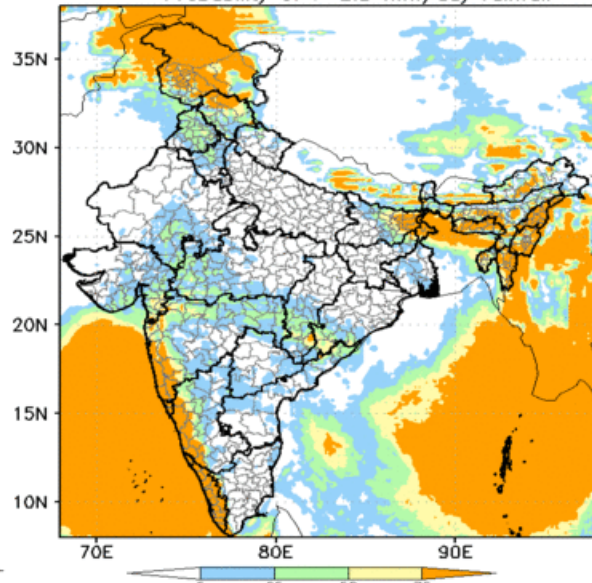


Probabilistic rainfall forecast from GEF5 T1534

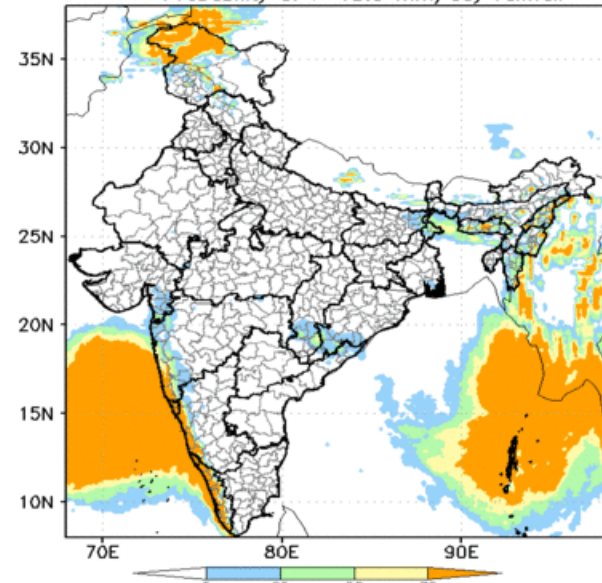
GEF5 T1534 : Rainfall (cm/day), Ens Mean (20 Ens)
24-hr Forecast valid for 03Z12JUN2019 (IC=00Z11JUN2019)



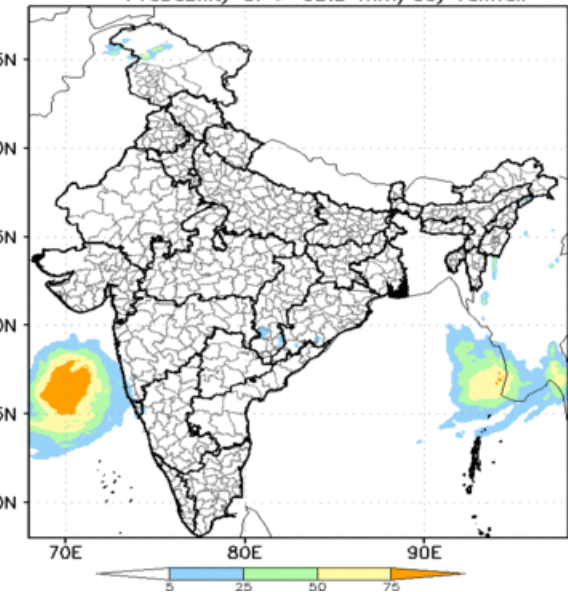
GEF5 SL T1534 Probabilistic of Exceedance Precipitation
IC:2019061100 Day-1 Forecast Valid for 03Z12JUN2019
Probability of > 2.5 mm/day rainfall



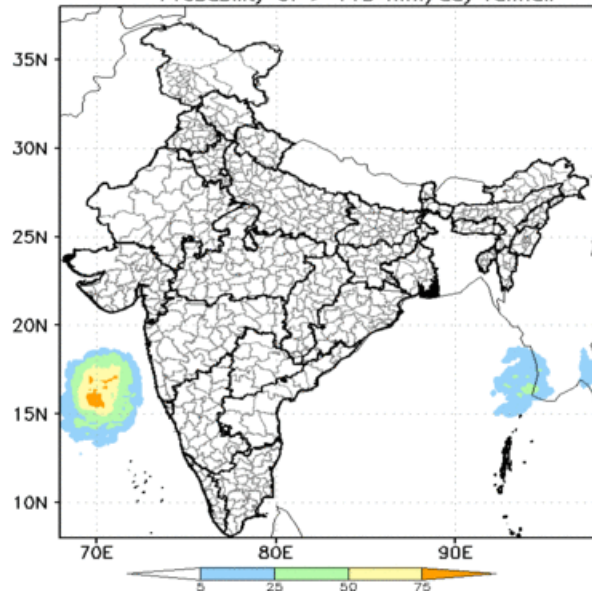
GEF5 SL T1534 Probabilistic of Exceedance Precipitation
IC:2019061100 Day-1 Forecast Valid for 03Z12JUN2019
Probability of > 15.6 mm/day rainfall



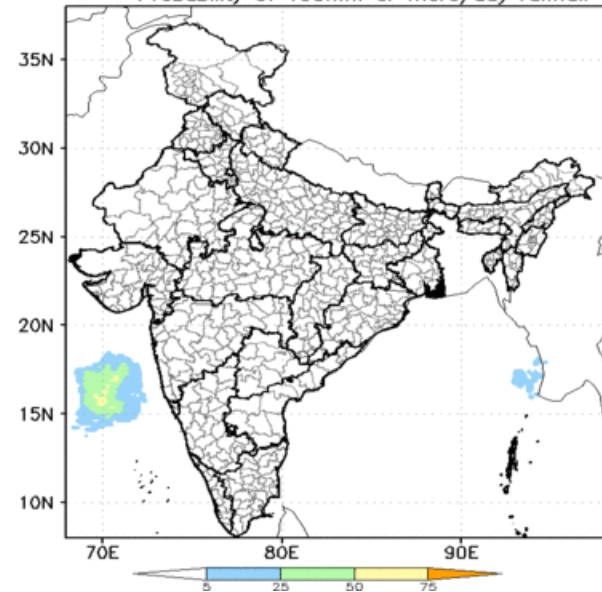
GEF5 SL T1534 Probabilistic of Exceedance Precipitation
IC:2019061100 Day-1 Forecast Valid for 03Z12JUN2019
Probability of > 65.5 mm/day rainfall

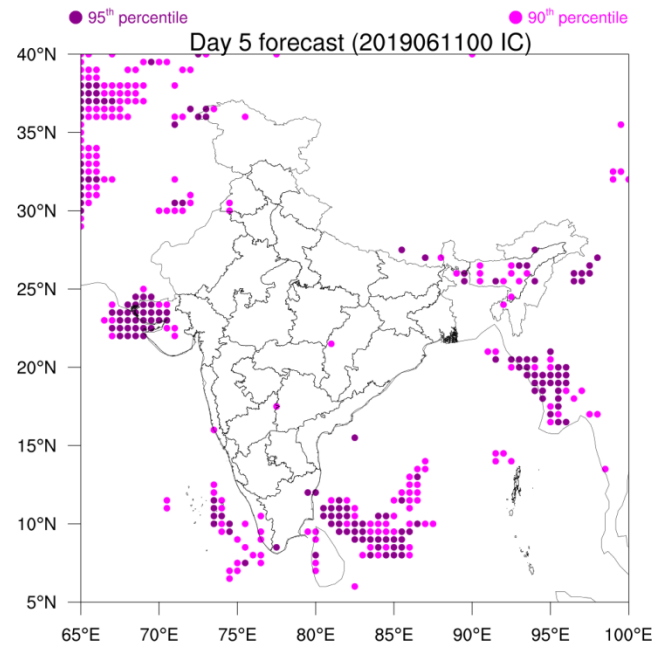
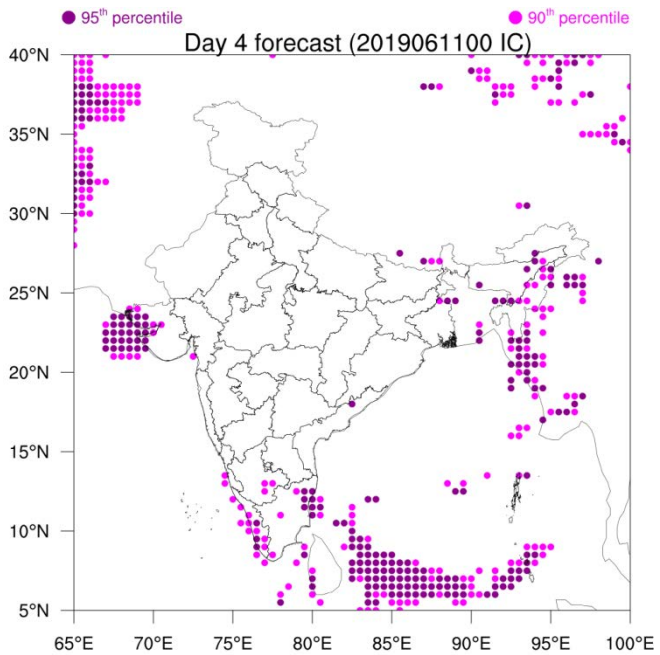
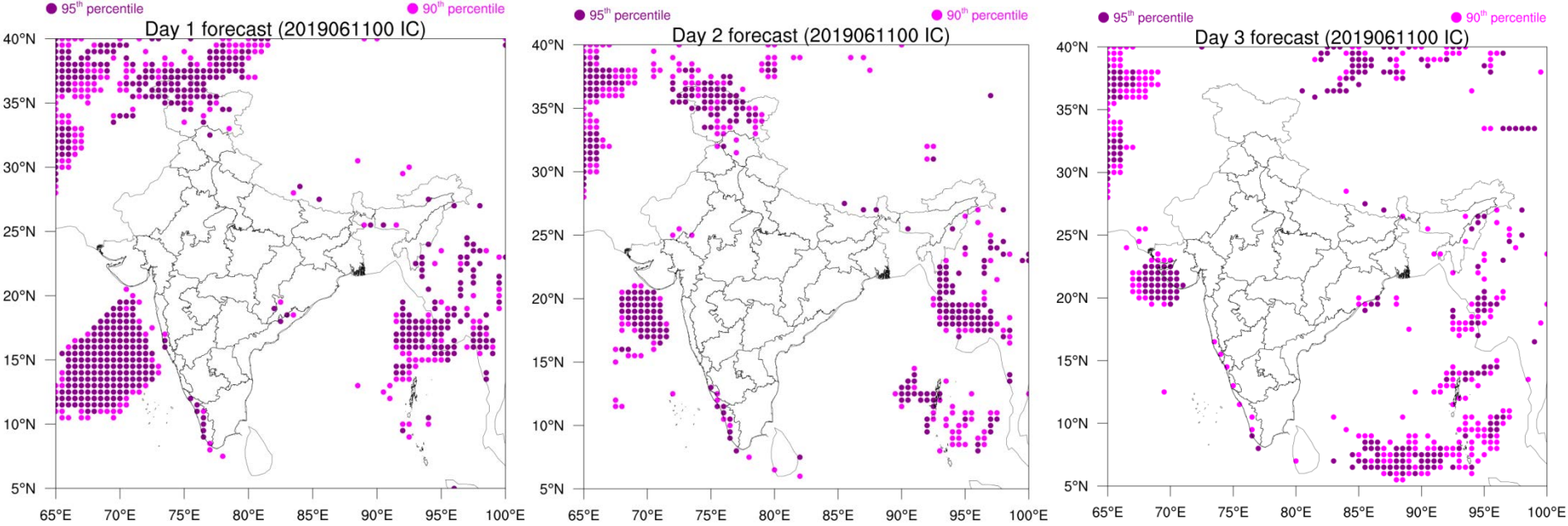


GEF5 SL T1534 Probabilistic of Exceedance Precipitation
IC:2019061100 Day-1 Forecast Valid for 03Z12JUN2019
Probability of > 115 mm/day rainfall



GEF5 SL T1534 Probabilistic of Exceedance Precipitation
IC:2019061100 Day-1 Forecast Valid for 03Z12JUN2019
Probability of 195mm or more/day rainfall

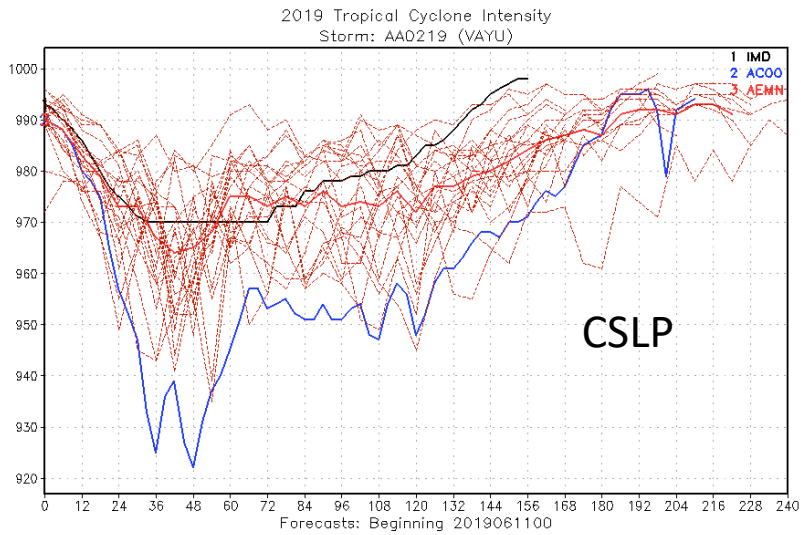
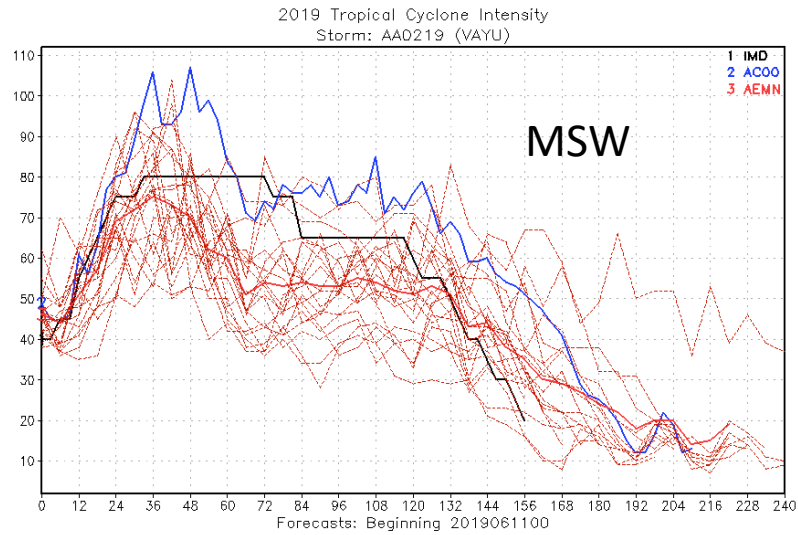




Percentile based extreme rainfall forecast from GFS T1534

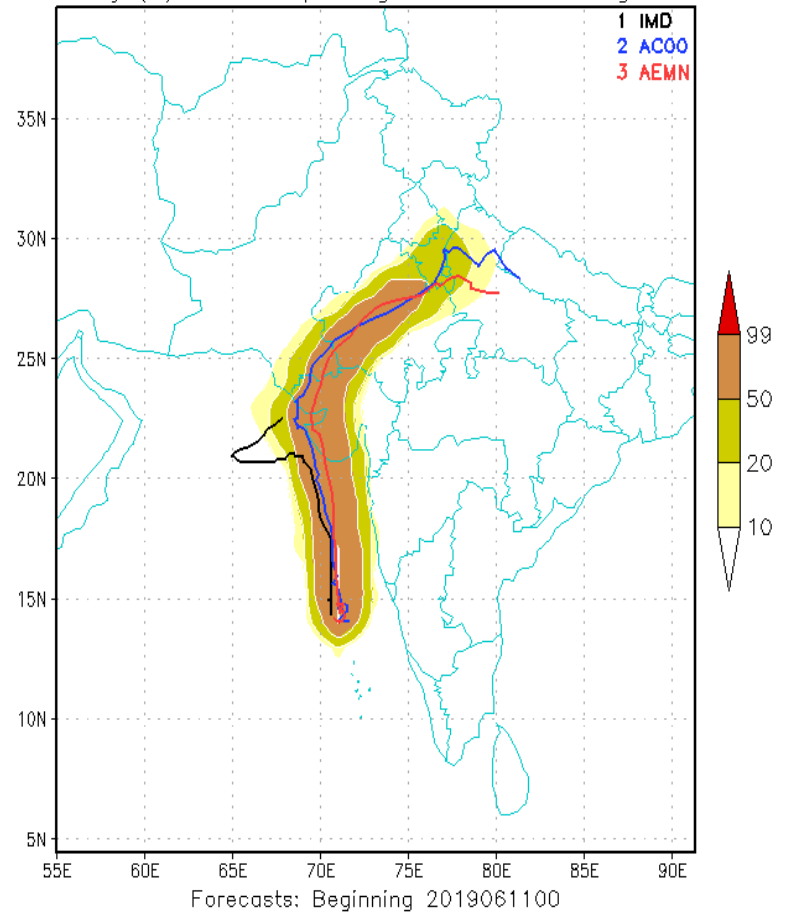
GEFS verification with IMD observations

IC:2019061100



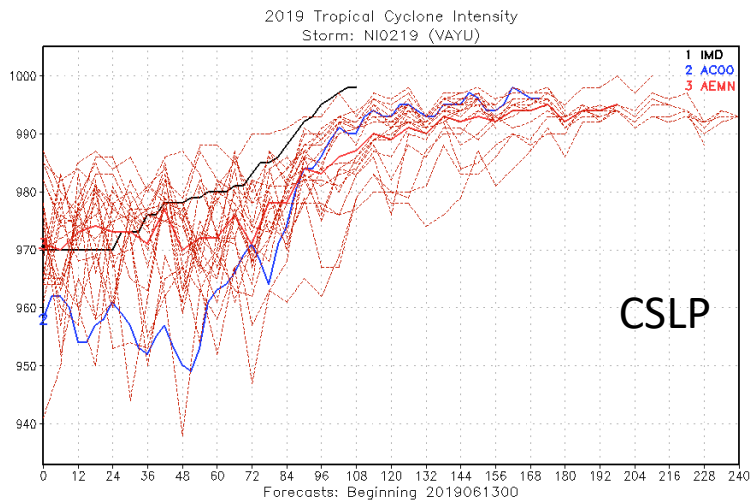
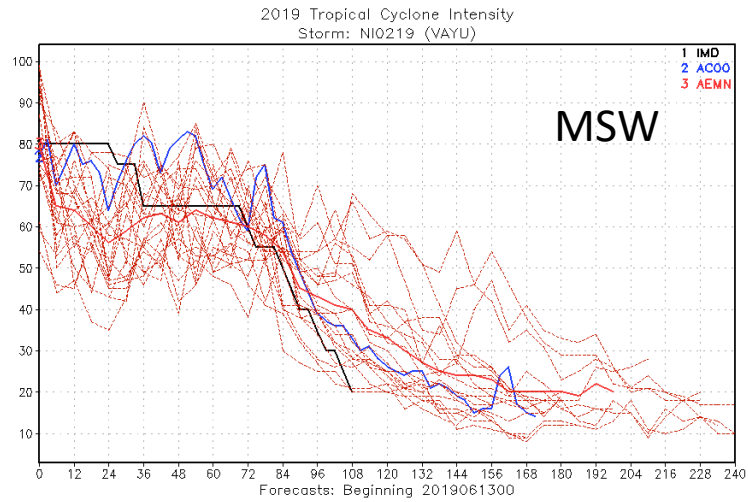
Strike Probability

2019 Tropical Cyclone Tracks
Storm: NIO219 (VAYU)
Probability (%) of storm passing within 65nm during next 72h

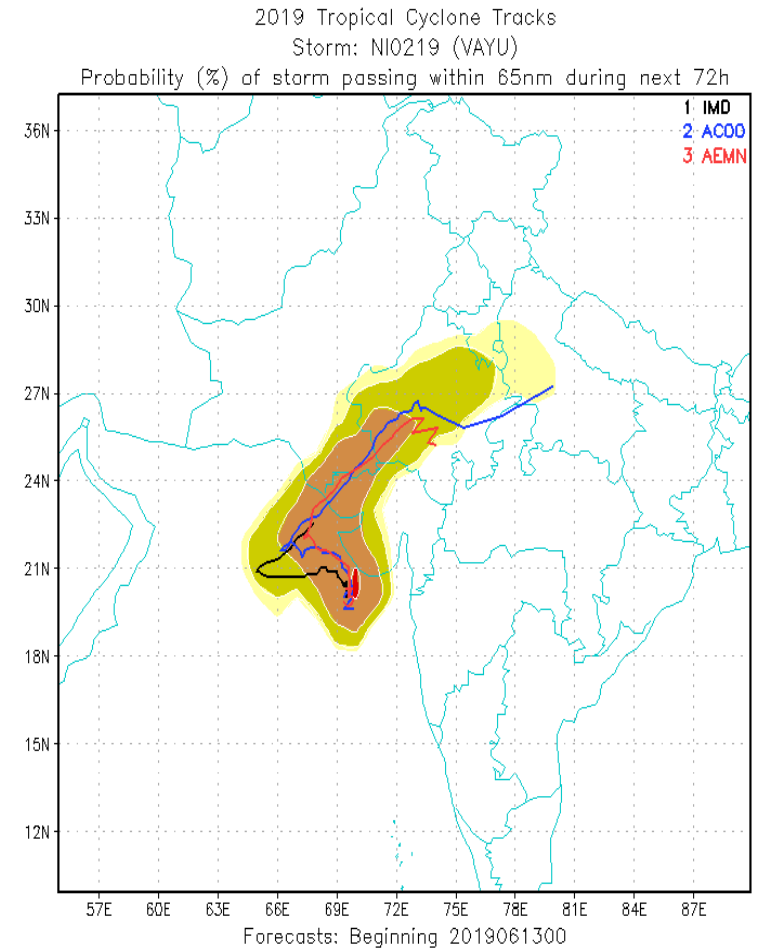


GEFS verification with IMD observations

IC:2019061300

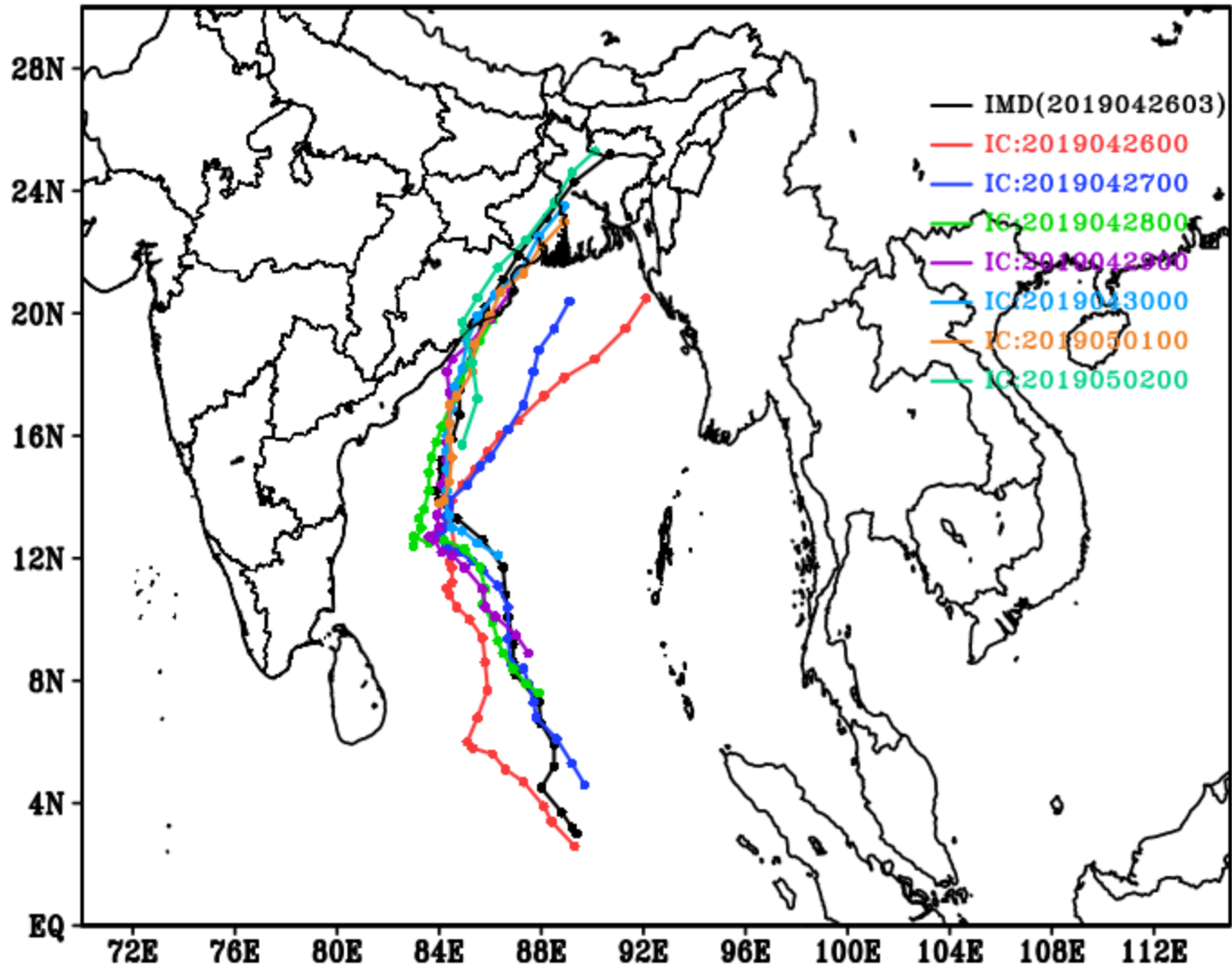


Strike Probability



FANI Cyclone Apr-2019 (26 Apr- 2 May)

TRACK PREDICTIONS FOR FANI



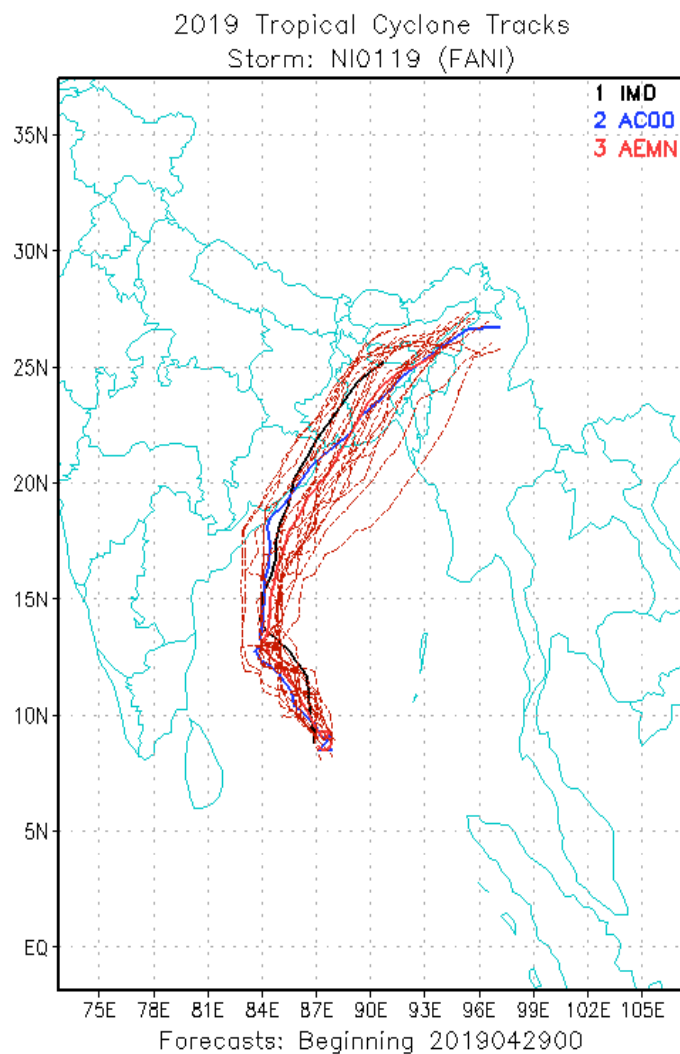
Cyclone 'FANI' over Bay of Bengal

IMD - Observation

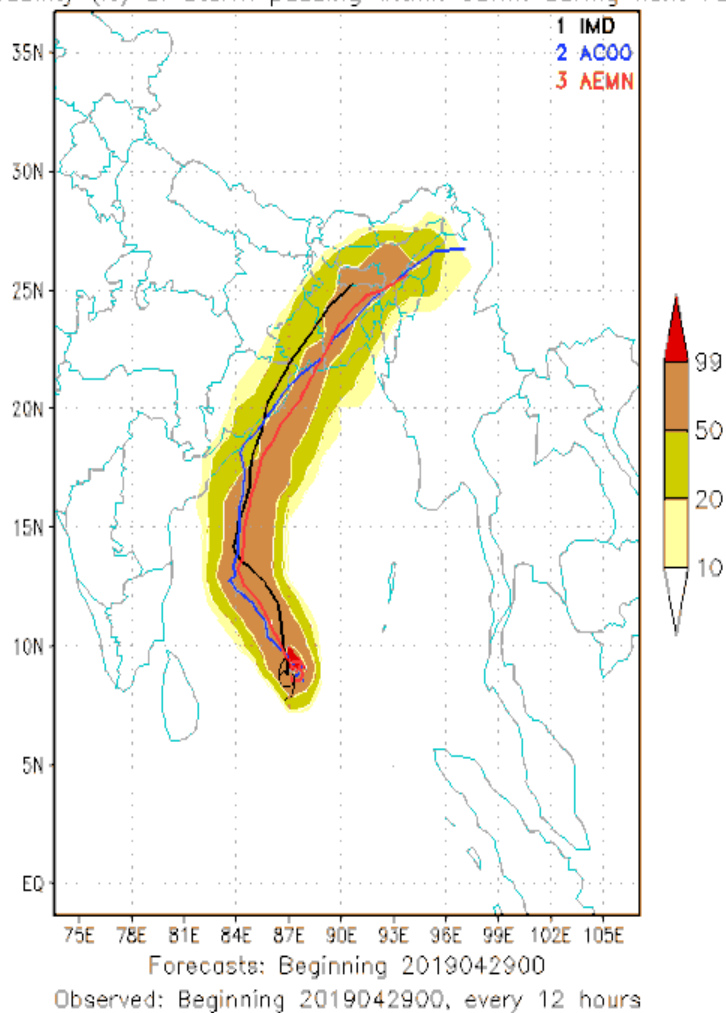
AC00 - control run

AEMN-Ensemble Mean

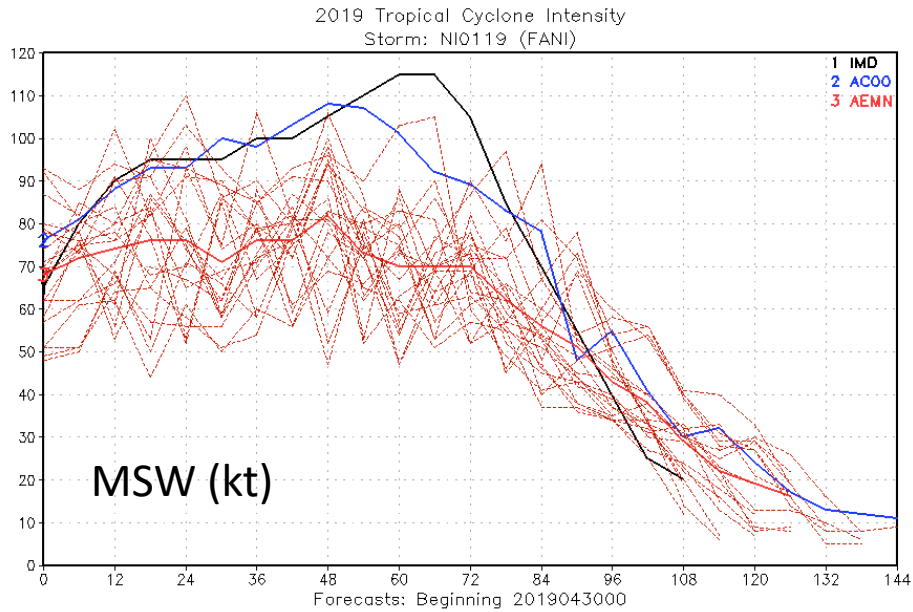
---- Ensemble members



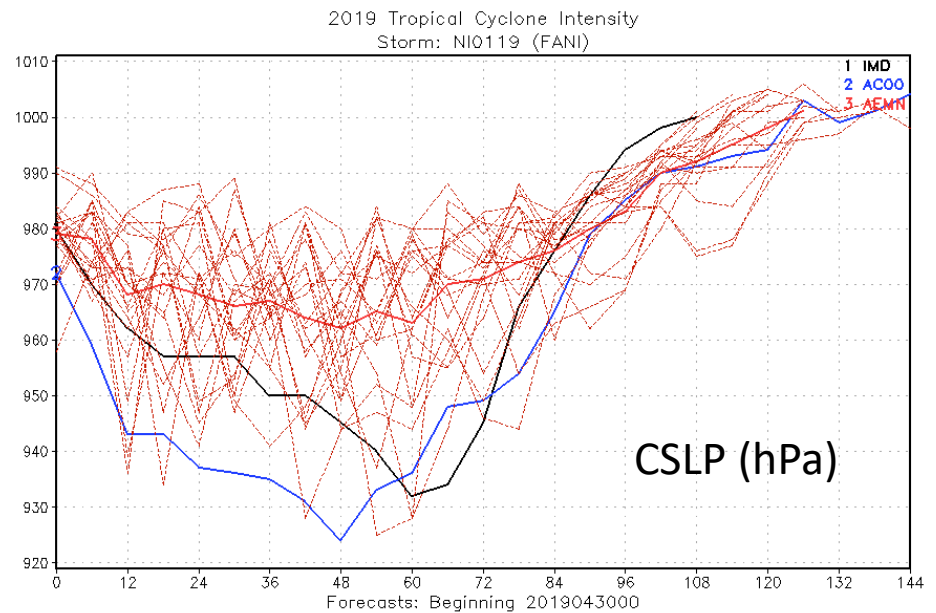
2019 Tropical Cyclone Tracks
Storm: NI9119 (FANI)
Probability (%) of storm passing within 65nm during next 72h



GEFS based track Prediction for IC:2019043000

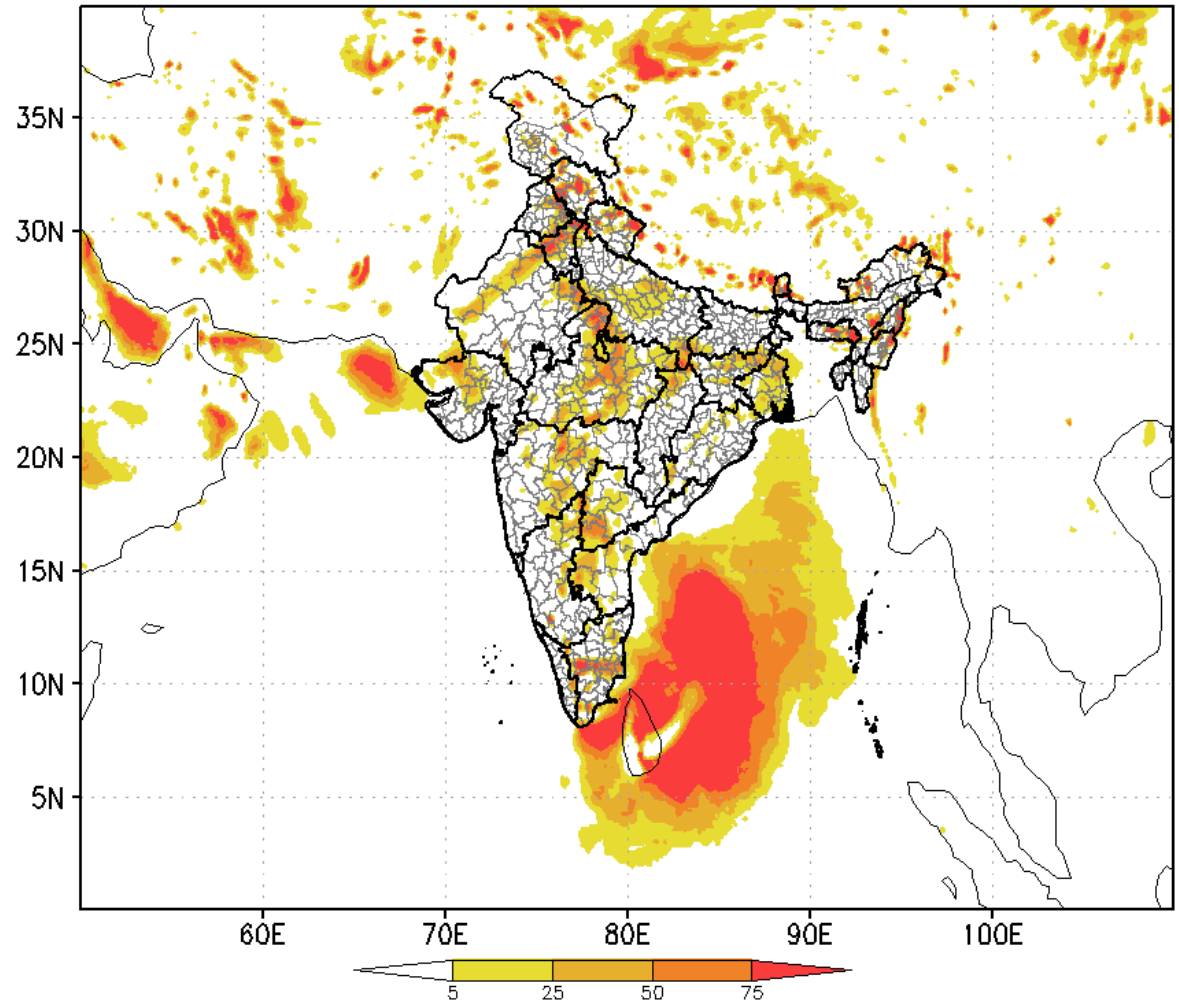


IMD - Observation
AC00 - control run
AEMN-Ensemble Mean
---- Ensemble members



GEFS T1534: Probability of wind gust >25kt
Forecast Valid for 00Z01MAY2019 (IC : 00Z01MAY2019)

IC: 2019050100
Probability of Gust
associated with TC FANI



Landfall Error : Cyclone Fani

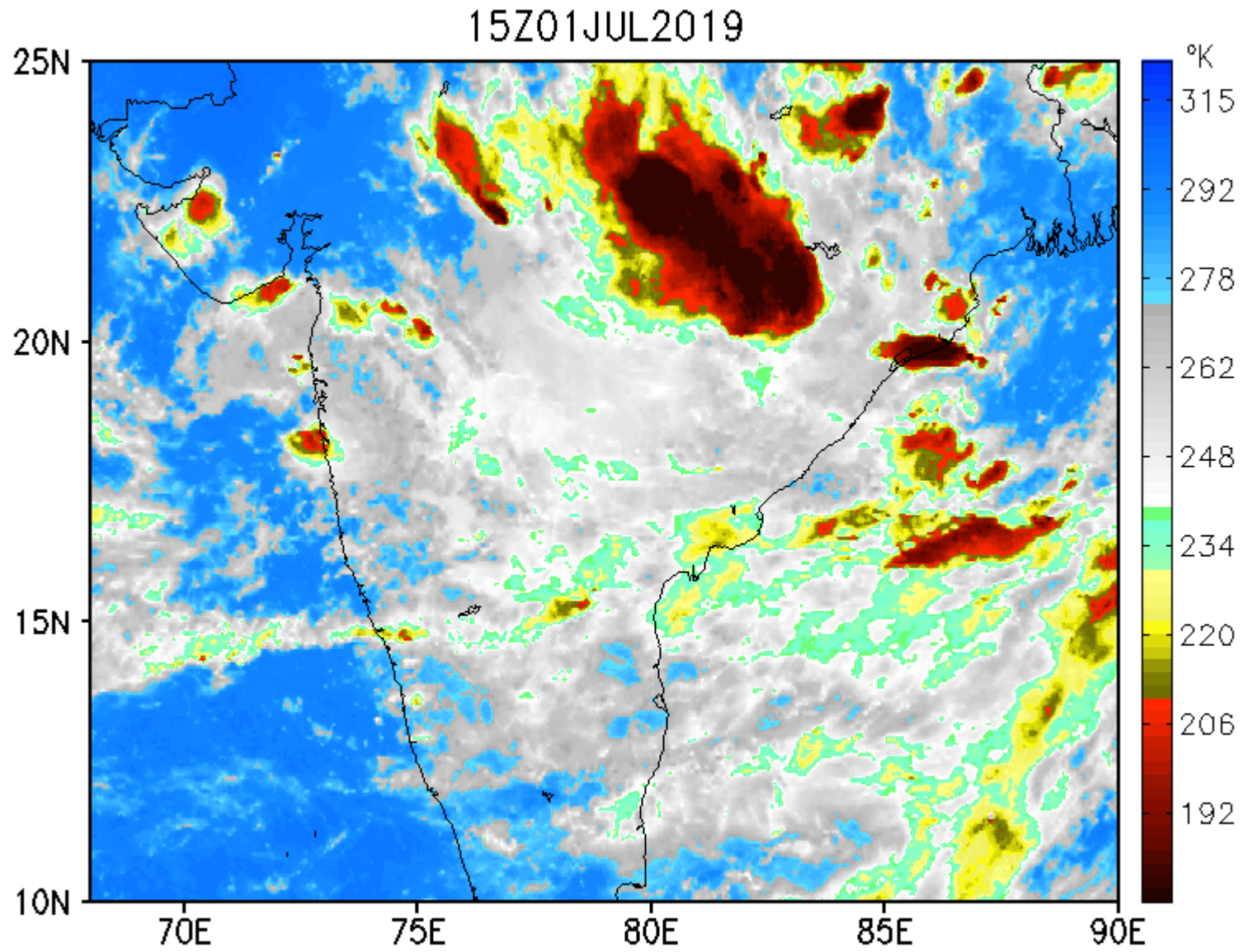
Initial Condition	Landfall Point		Landfall Error (km)	Landfall Time
	Lat	lon		
2019042600	20.8995 ⁰ N	92.3808 ⁰ E	746	bet 12Z-15Z 04MAY2019
2019042700	21.8801 ⁰ N	90.1575 ⁰ E	543	at 00Z 05May2019
2019042800	19.8126 ⁰ N	86.1251 ⁰ E	47	bet 12-15Z 04MAY2019
2019042900	19.8126 ⁰ N	85.9901 ⁰ E	33	at 06Z 04May2019
2019043000	19.5503 ⁰ N	85.27 ⁰ E	52	at 09Z 03May2019
2019050100	19.8876 ⁰ N	86.0351 ⁰ E	40	bet 09-12Z 03May2019
2019050200	19.4003 ⁰ N	85.09 ⁰ E	77	at 18Z 02May2019

IMD Observation: Crossed Odisha coast close to Puri (near lat. 19.75⁰N and Long. 85.7⁰E) between 0230 to 0430 UTC of 3rd May 2019

Date	Time (IST)	Santacruz (mm)	Colaba (mm)
1-07-2019	8.30-09.30	5.5	12.0
	09.30-10.30	4.7	1.5
	10.30-11.30	2.0	1.5
	11.30-12.30	7.0	12.0
	12.30-13.30	3.0	20
	13.30-14.30	13.0	10
	14.30-15.30	15.5	5.0
	15.30-16.30	13.5	9.6
	16.30-17.30	17.6	0.0
	17.30-18.30	13	0.5
	18.30-19.30	2.4	0.5
	19.30-20.30	2.6	0.2
	20.30-21.30	1.7	6.5
	21.30-22.30	6.0	16.0
	22.30-23.30	26.7	4.0
	23.30-00.30	56.5	0.0
2-07-2019	00.30-1.30	60	0.0
	01.30-02.30	48.1	2.0
	02.30-03.30	26.3	3.5
	03.30-04.30	20	1.0
	04.30-05.30	11.5	6.0
	05.30-06.30	3.1	4.0
	06.30-07.30	10.5	8.0
	07.30-08.30	5.0	14.0

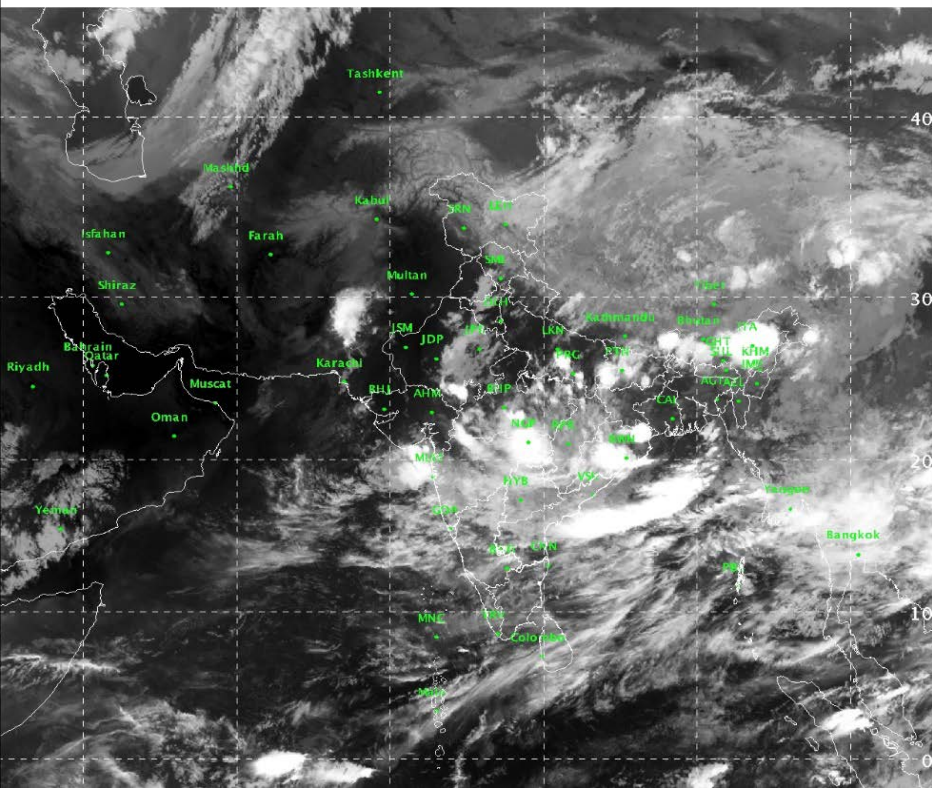
**Extreme
Precipitation
over Mumbai
city 1-2 July
2019**

The Satellite brightness temp says



SAT :INSAT-3D IMG
IMG_TIR1 10.8 um
LIC Mercator (LINEAR STRETCH: 1.0%)

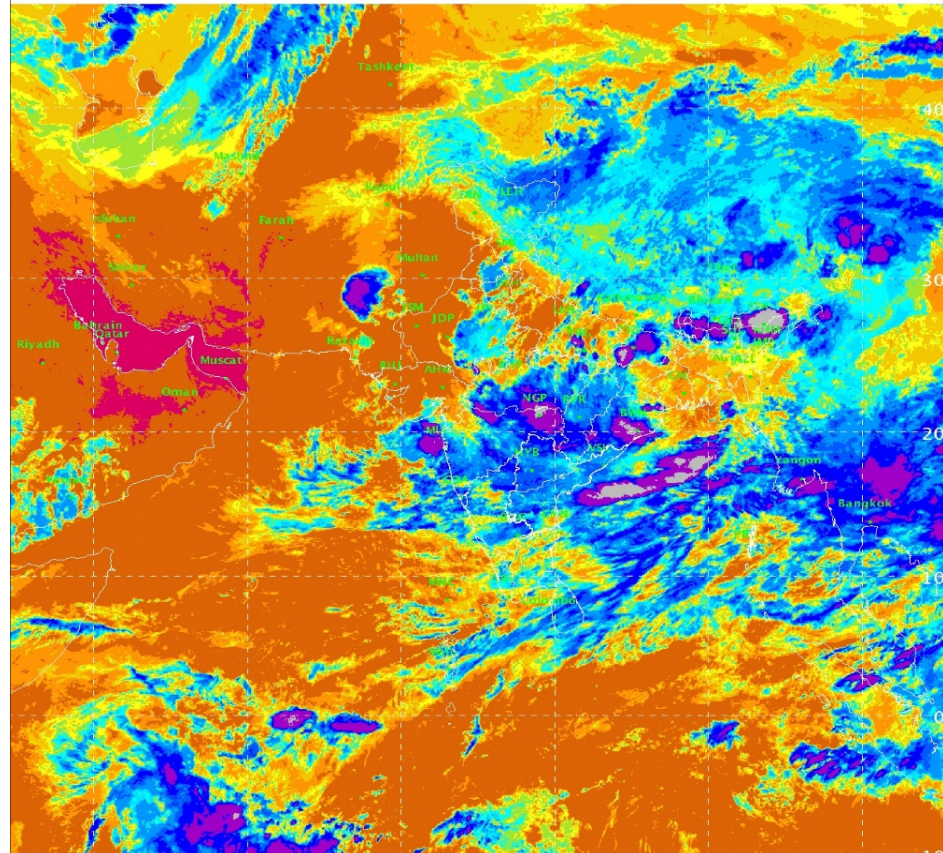
01-07-2019/21:00 GMT
02-07-2019/02:30 IST



and the Satellite says

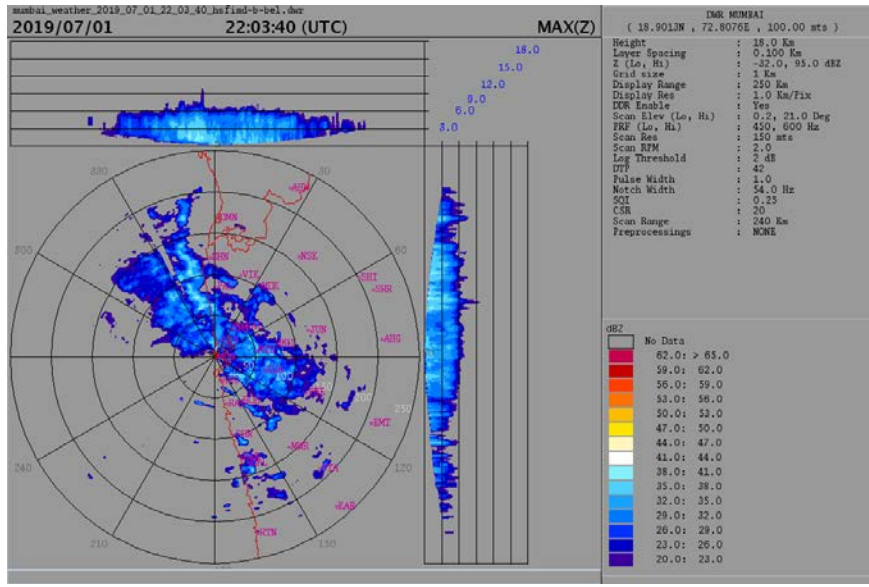
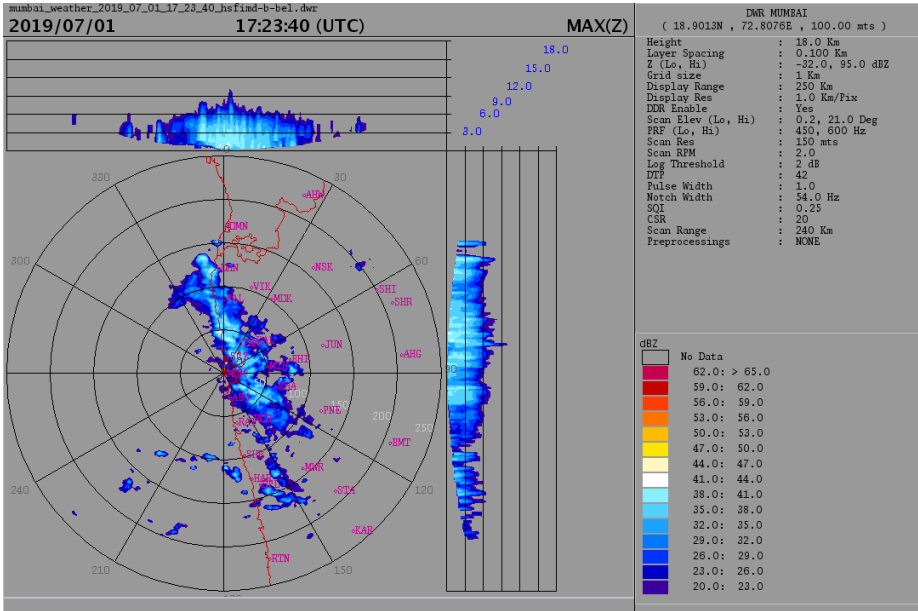
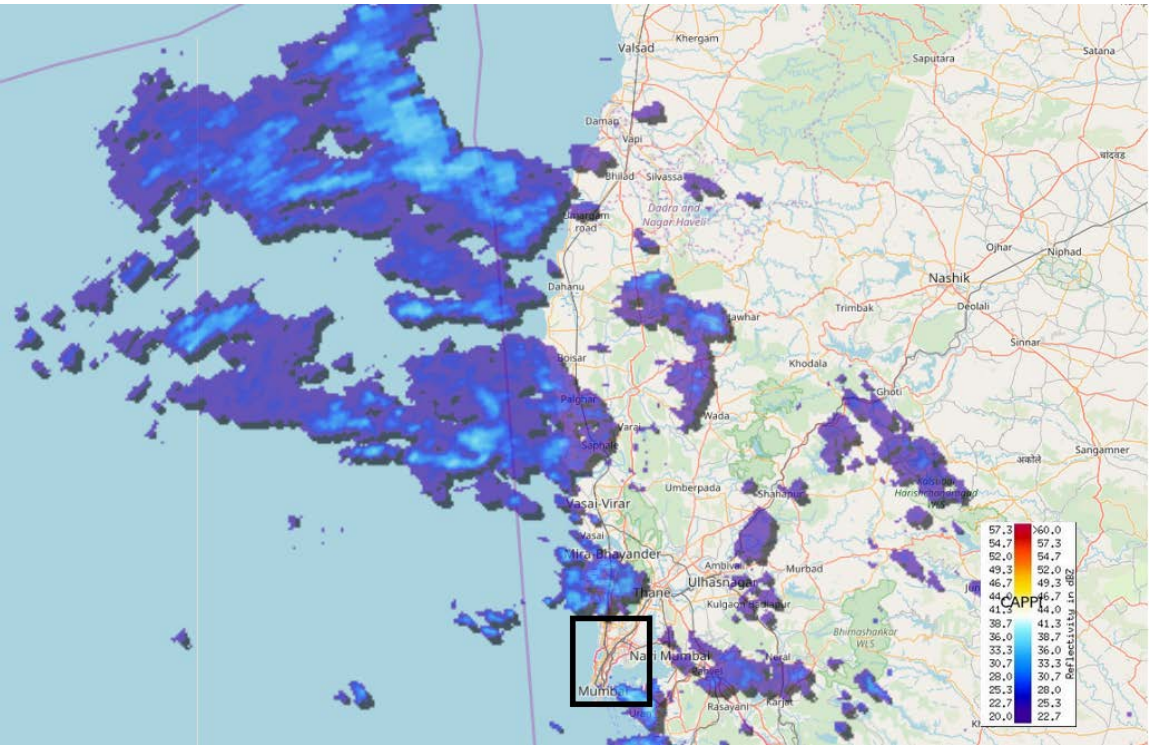
SAT :INSAT-3D IMG
IMG_TIR1_TEMP 10.8 um
LIC Mercator

01-07-2019/20:00 GMT
02-07-2019/01:30 IST



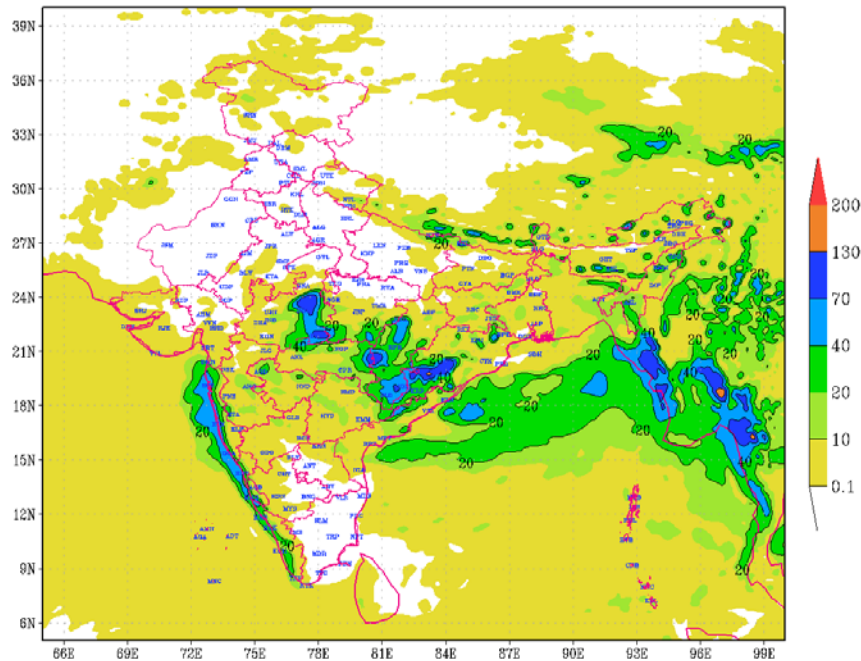
IMD/Delhi

What the RADAR says



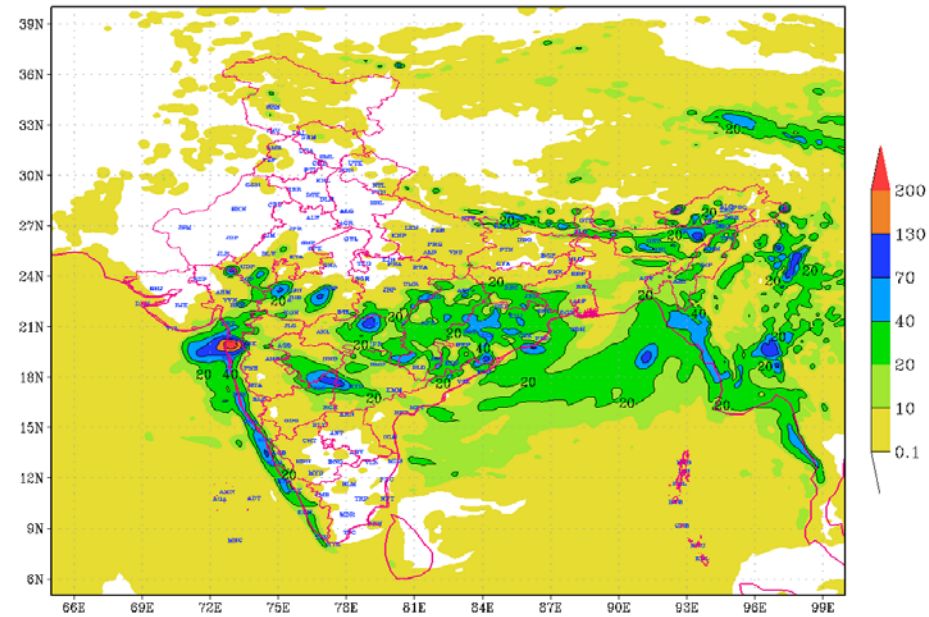
GFS (12 km) forecast of rainfall valid for 03UTC of 2 July

IMD :GFS MODEL(12 Km) RAINFALL (mm) FORECAST (72 HR)
based on 00 UTC of 29-06-2019 valid for 03 UTC of 02-07-2019



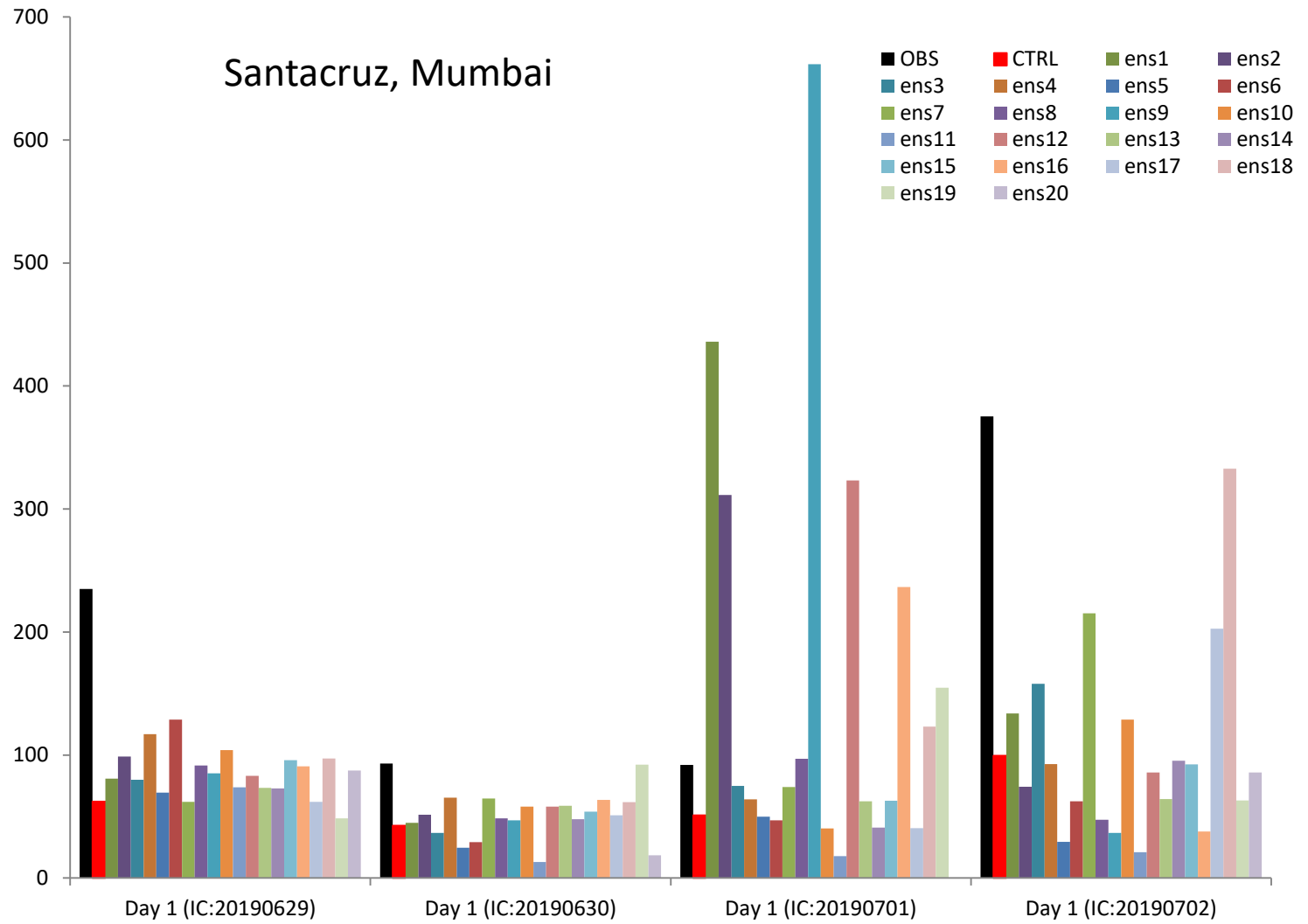
(Background does not depict political boundary)

IMD :GFS MODEL(12 Km) RAINFALL (mm) FORECAST (24 HR)
based on 00 UTC of 01-07-2019 valid for 03 UTC of 02-07-2019

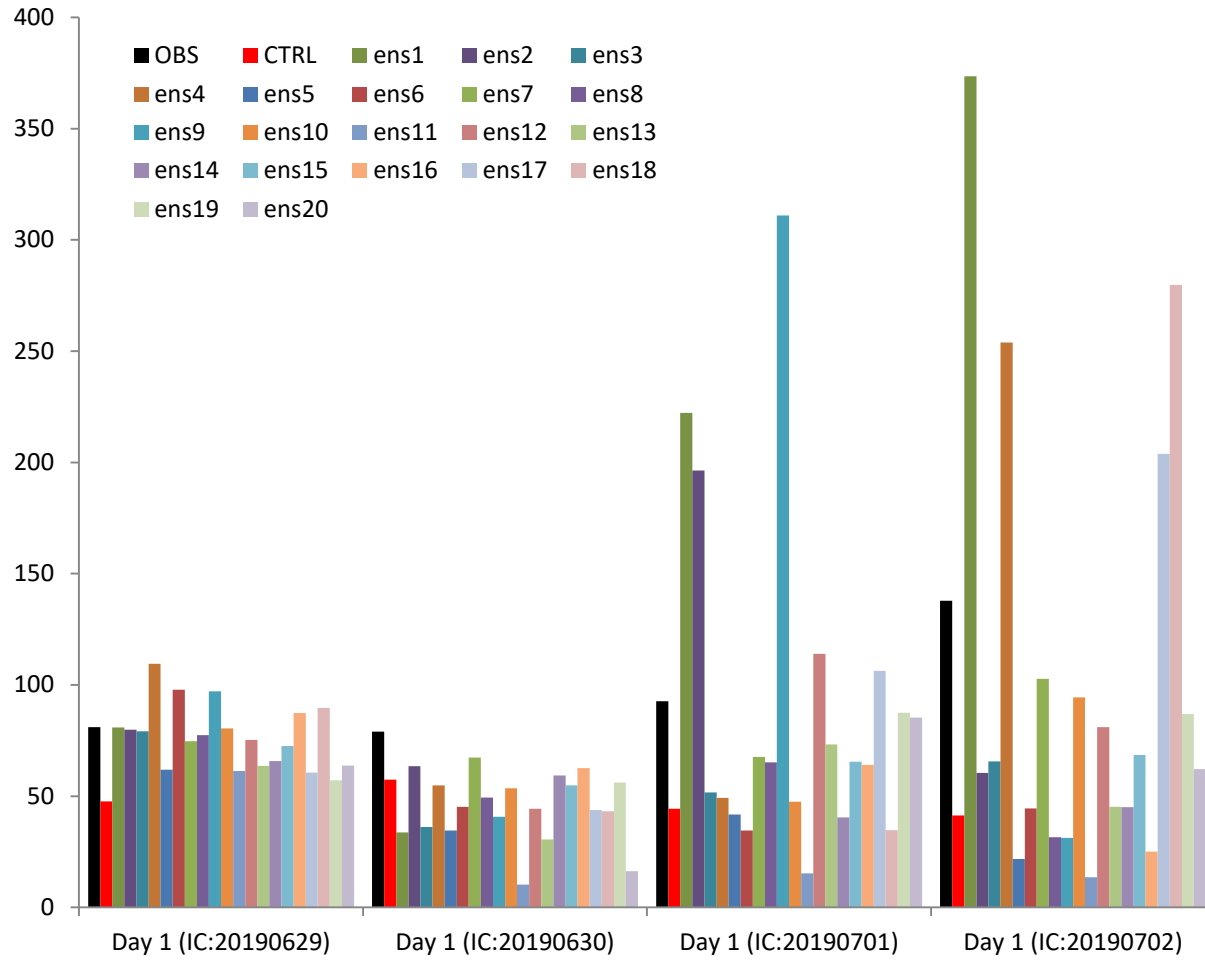


(Background does not depict political boundary)

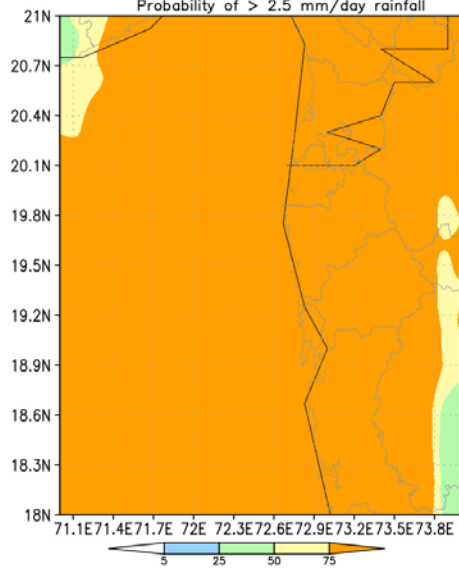
Santacruz, Mumbai



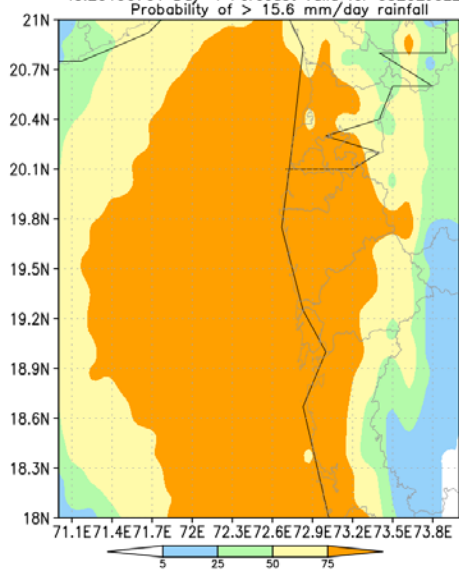
Colaba, Mumbai



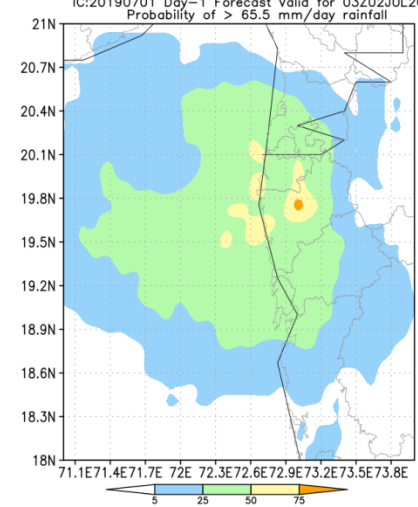
GEFS SL T1534 Probabilistic of Exceedance Precipitation
IC:20190701 Day-1 Forecast Valid for 03Z02JUL2019
Probability of > 2.5 mm/day rainfall



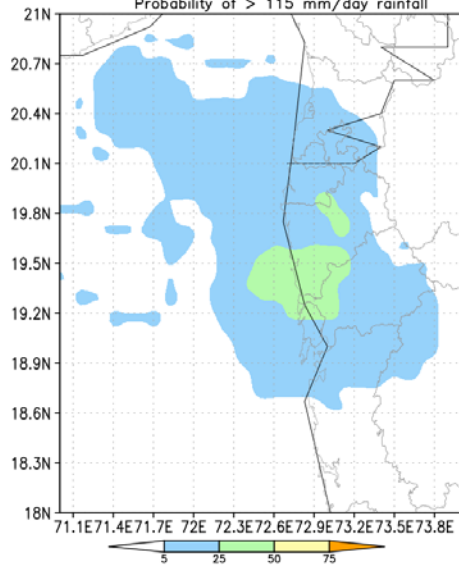
GEFS SL T1534 Probabilistic of Exceedance Precipitation
IC:20190701 Day-1 Forecast Valid for 03Z02JUL2019
Probability of > 15.6 mm/day rainfall



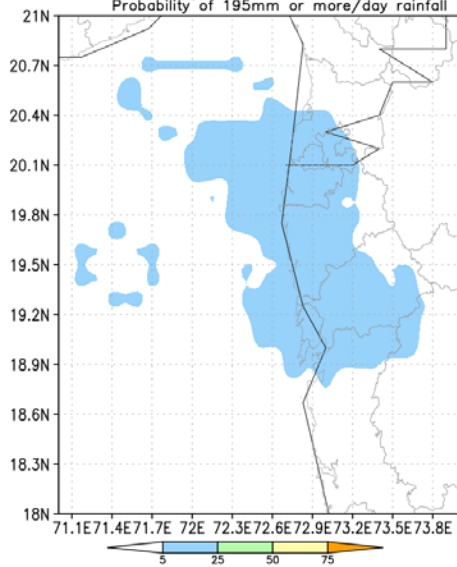
GEFS SL T1534 Probabilistic of Exceedance Precipitation
IC:20190701 Day-1 Forecast Valid for 03Z02JUL2019
Probability of > 65.5 mm/day rainfall



GEFS SL T1534 Probabilistic of Exceedance Precipitation
IC:20190701 Day-1 Forecast Valid for 03Z02JUL2019
Probability of > 115 mm/day rainfall



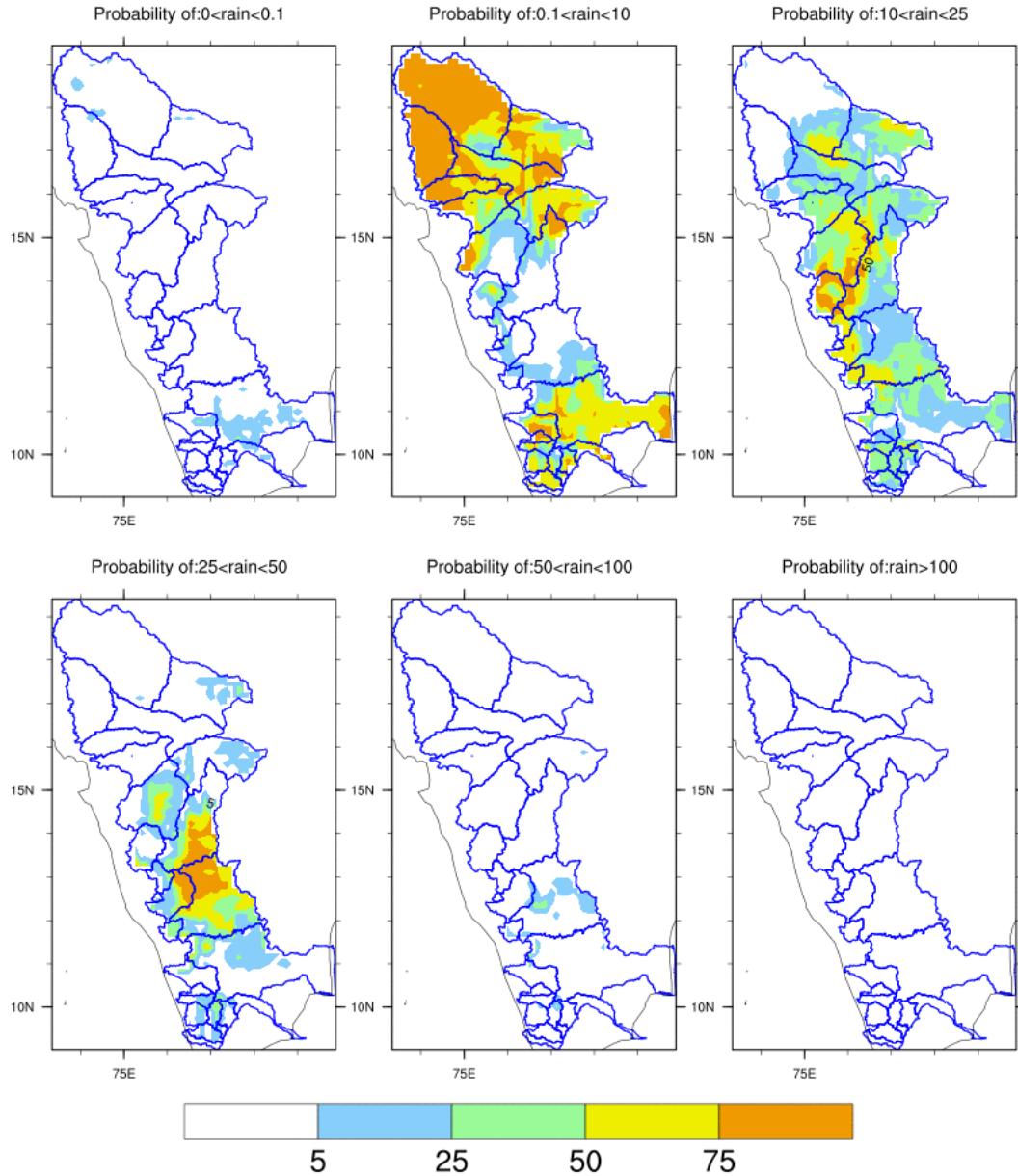
GEFS SL T1534 Probabilistic of Exceedance Precipitation
IC:20190701 Day-1 Forecast Valid for 03Z02JUL2019
Probability of 195mm or more/day rainfall



IC:2019070100

GEFS SL T1534 Probability of Excedance Precipitation for FMO bengaluru_kerala

IC:2019081800 - Forecast Valid for 24 hrs

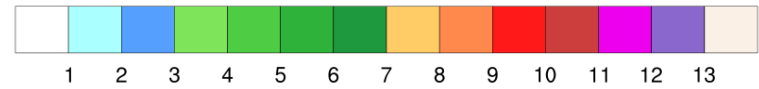
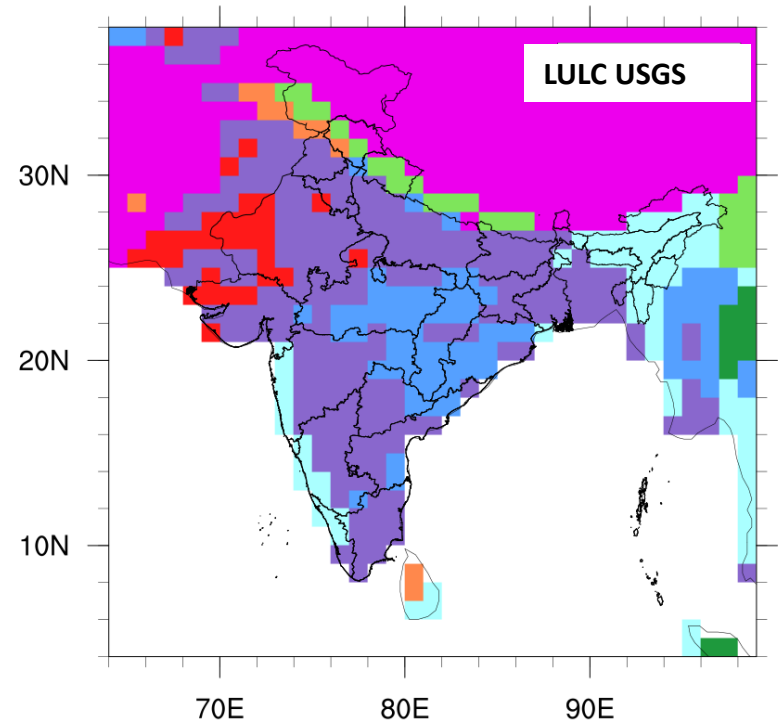
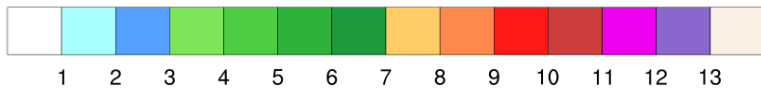
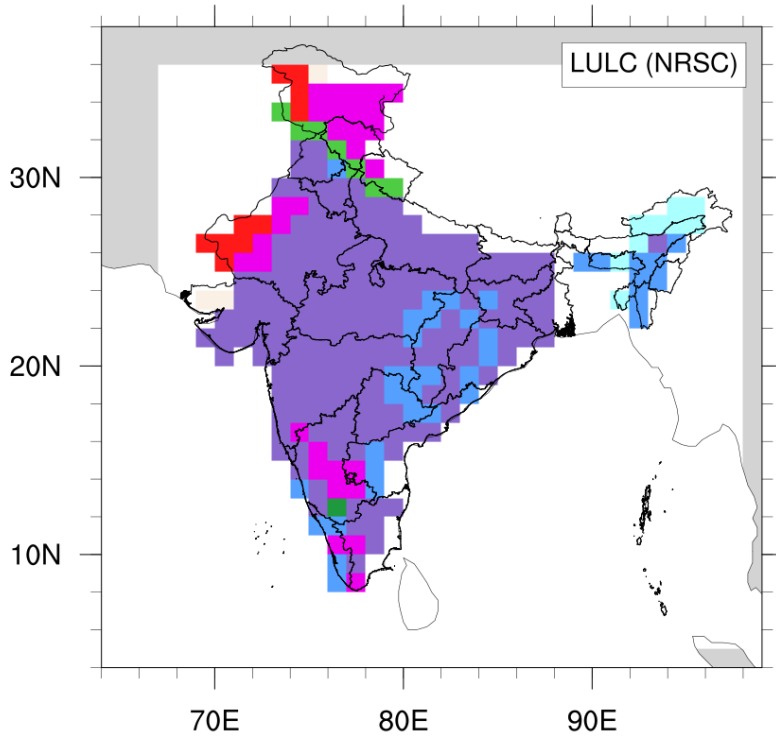




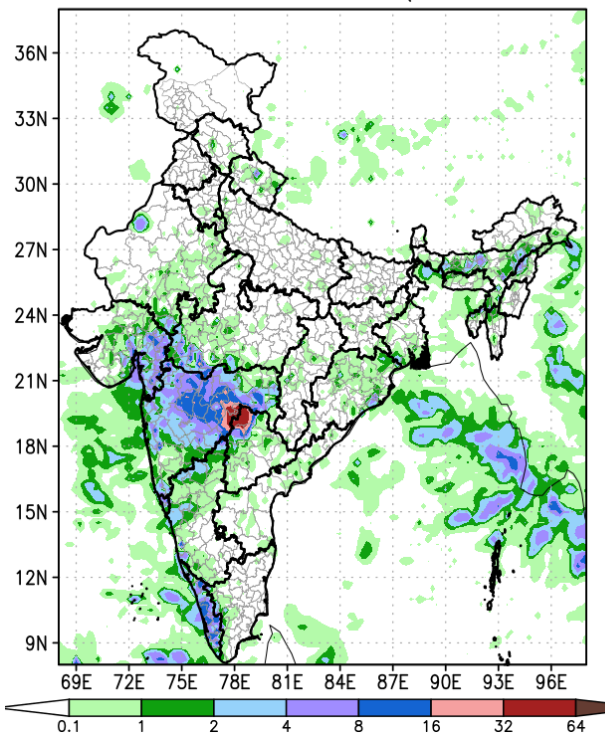
**Strategy for
Operational forecast
improvement**

**Strategy Model
Development**

Land Use Land Cover data

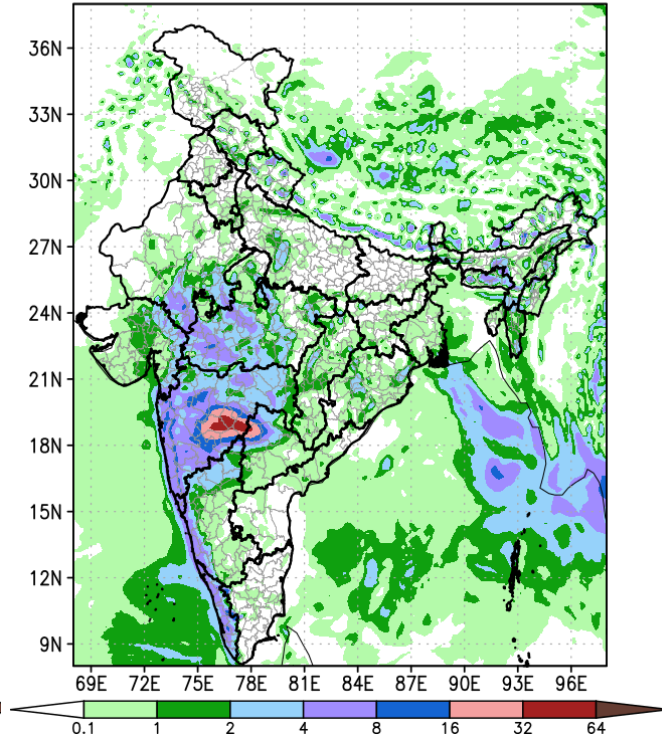


IMD : Rainfall (cm/day)
Forecast valid for 03Z17AUG2018 (IC=00Z16AUG2018)



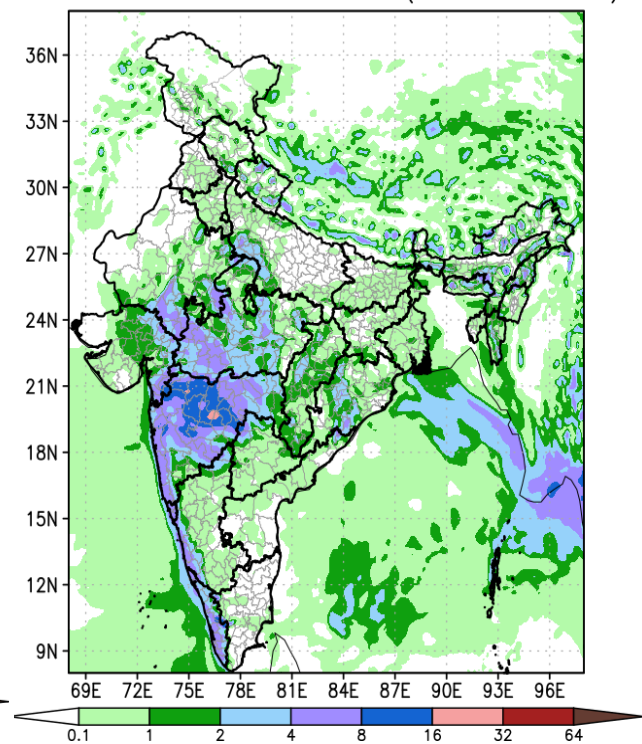
IMD OBS

IITM GFS T1534 (LULC) : Rainfall (cm/day)
Forecast valid for 03Z17AUG2018 (IC=00Z16AUG2018)



GFS with Modified
LULC NRSC

IITM GFS T1534 : Rainfall (cm/day)
Forecast valid for 03Z17AUG2018 (IC=00Z16AUG2018)



GFS with default
LULC

Major Future Update in Dynamic Core: Spectral Cubic Octahedral grid T1534 => Tco765 => Tco1534

Conventional Spectral grid:

- Not scalable
- I/O
- Artificial diffusi damping
- Negative tracer

- Improved representation of orography
- Global mass conservation improves
- Computationally more efficient
- Local derivative calculation is more accurate
- Works well with scale aware physics

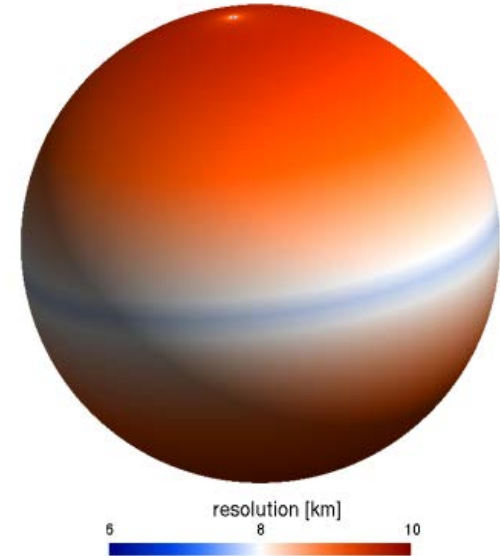
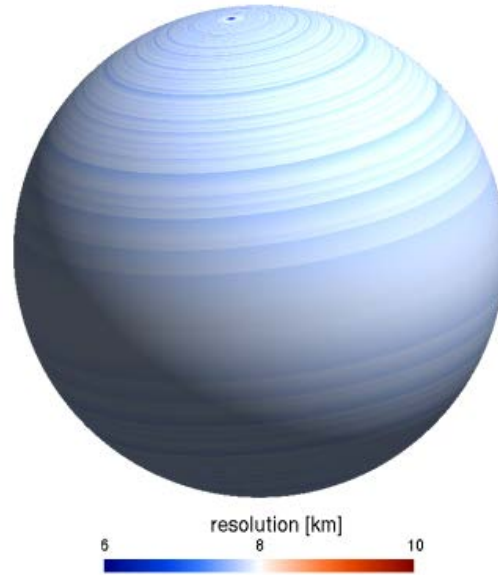


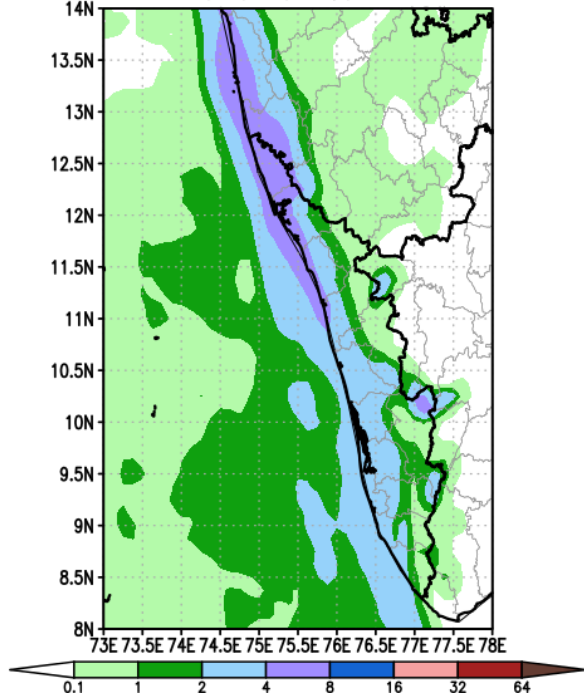
Figure (adopted from ECMWF News Letter 146) demonstrates that the octahedral mesh (right) has a locally more uniform dual-mesh resolution than the mesh (left).

Numerical simulation of an idealised baroclinic instability, conducted using IFS model on both the mesh showed the octahedral grid results in higher accuracy and substantially reduced unphysical flow distortions accuracy mainly as the approach depends on the underlying mesh which defines the shape of the elementary volumes around which the computations are made (ECMWF New Letter, No. 146, 2015).

Forecast comparison with GFS T1534 and GFS Tco 764 with Initial condition of 2018081000

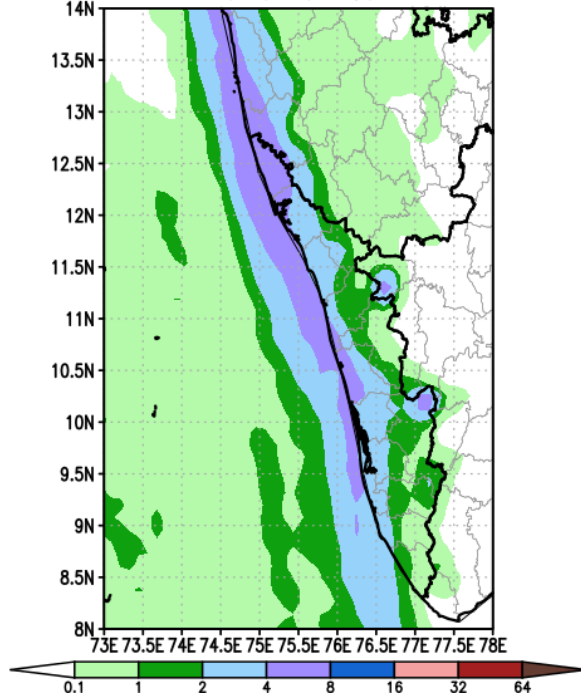
GFS T1534

GFS T1534 : Precip (cm/day) for 03Z13AUG2018



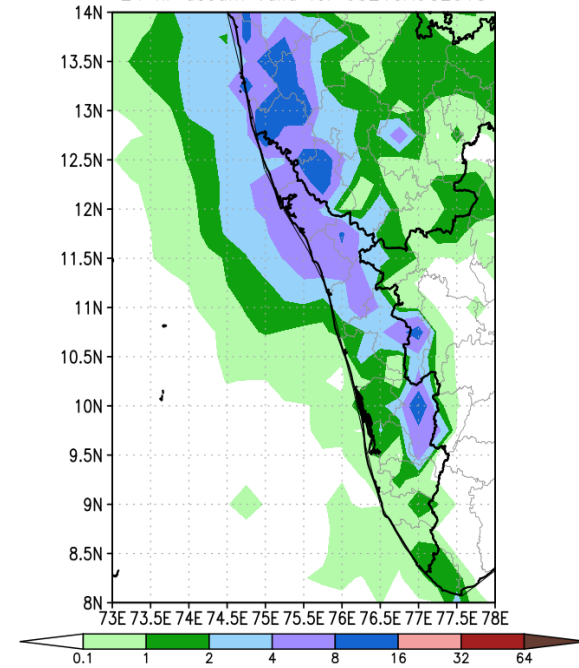
GFS Tco764

GFS Tco T764 : Precip (cm/day) for 03Z13AUG2018



IMD Merged data

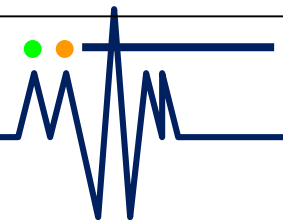
IMD GPM Rainfall (cm/day)
24 hr accum valid for 03Z13AUG2018



GFS Tco 764 shows better precipitation distribution and too much rain over ocean also appears to be reduced.

Summary

- The way forward is the probabilistic forecast of extremes.
- In India, currently operational is the globally high resolution EPS (12.5km) for 10 days forecast and made operational since June 2018
- A Suite of societal application initiated e. g. forest fire forecasting, block level rainfall forecasting, cyclogenesis forecasting, solar and wind energy forecasting etc.
- New Dycore, stochastic convection and Cloud microphysics and stochastic multcloud parameterization constrained by ~Indian RADAR data, new LULC data is attempted in improving the systematic bias of GFS/GEF.
- Remaining is Impact based forecast



Thank You !

