High Resolution modelling at IITM

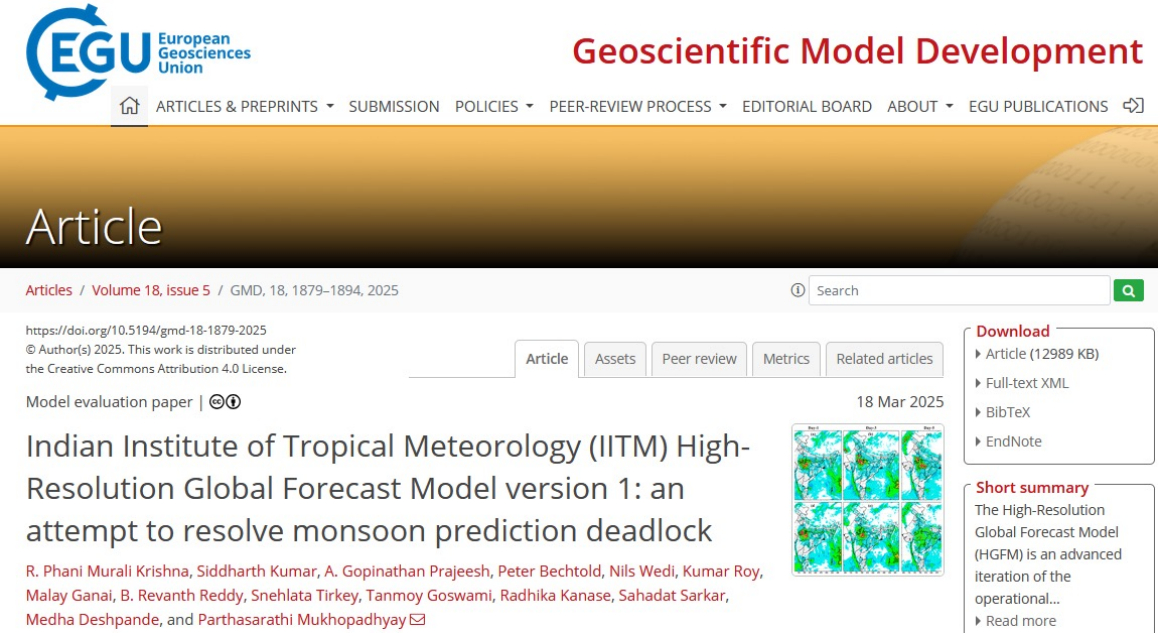
Ankur Srivastava

Indian Institute of Tropical Meteorology

Pune

(with inputs from Dr. Medha Deshpande and colleagues from IITM & MoES)

Bharat Forecast System (BharatFS)



EGU European Geosciences Union

Geoscientific Model Development

ARTICLES & PREPRINTS | SUBMISSION | POLICIES | PEER-REVIEW PROCESS | EDITORIAL BOARD | ABOUT | EGU PUBLICATIONS

Article

Articles / Volume 18, issue 5 / GMD, 18, 1879–1894, 2025

Search

https://doi.org/10.5194/gmd-18-1879-2025

Article | Assets | Peer review | Metrics | Related articles

Download
- Article (12989 KB)
- Full-text XML
- BibTeX
- EndNote

Model evaluation paper | 18 Mar 2025

Indian Institute of Tropical Meteorology (IITM) High-Resolution Global Forecast Model version 1: an attempt to resolve monsoon prediction deadlock

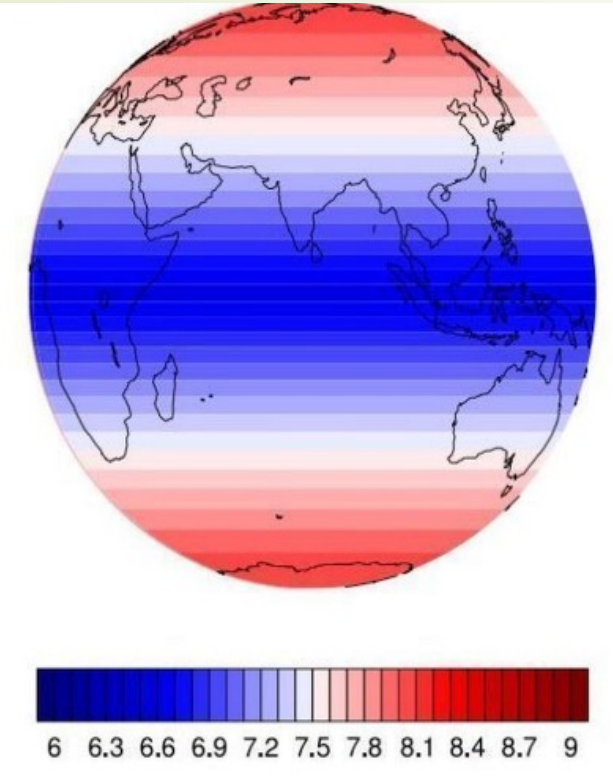
R. Phani Murali Krishna, Siddharth Kumar, A. Gopinathan Prajeesh, Peter Bechtold, Nils Wedi, Kumar Roy, Malay Ganai, B. Revanth Reddy, Snehlata Tirkey, Tanmoy Goswami, Radhika Kanase, Sahadat Sarkar, Medha Deshpande, and Parthasarathi Mukhopadhyay

Short summary

The High-Resolution Global Forecast Model (HGFM) is an advanced iteration of the operational...

Read more

- **BharatFS is based on the Triangular Cubic Octahedral (TCo) Grid.**
- **It provides approx. 6.5 km resolution.**
- Successfully tested in 2022, and then it was running experimentally.
- Performance of the model evaluated for 3 years (2022-2024)
- BharatFS is handed over to IMD for real-time forecast and **running operationally since June 2025.**



Depiction of grid resolution over the globe in TCo grid

Geosci. Model Dev., 18, 1879–1894, 2025
https://doi.org/10.5194/gmd-18-1879-2025

Geoscientific Model Development
EGU

Indian Institute of Tropical Meteorology (IITM) High-Resolution Global Forecast Model version 1: an attempt to resolve monsoon prediction deadlock

R. Phani Murali Krishna[1], Siddharth Kumar[1], A. Gopinathan Prajeesh[2], Peter Bechtold[3], Nils Wedi[3], Kumar Roy[4], Malay Ganai[1], B. Revanth Reddy[1], Snehlata Tirkey[1], Tanmoy Goswami[1], Radhika Kanase[1], Sahadat Sarkar[1], Medha Deshpande[1], and Parthasarathi Mukhopadhyay[1,5]

[1]Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Dr. Homi Bhabha Road, Pune 411008, India
[2]Climate Change Center, King Abdullah University of Science and Technology, Thuwal, Saudi Arabia
[3]European Centre for Medium-Range Weather Forecasts, Bonn, Germany
[4]Department of Mathematics and Statistics, University of Victoria, Victoria, BC, Canada
[5]Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research, Berhampur 760003, Odisha, India

Model Physics Description of BharatFS	
Radiation	Rapid Radiative Transfer Model (RRTM) for both Shortwave and Longwave (Iacono et al., 2000; Clough et al., 2005) with Monte Carlo Independent Column Approximation (McICA)
Microphysics	Formulated grid-scale condensation and precipitation (Sundqvist et al., 1989; Zhao and Carr, 1997)
Convection	Aerosol aware and Scale aware Mass flux based Simplified Arakawa-Schubert (SAS) shallow convection (Pan and Wu, 1995; Han and Pan, 2011; Arakawa and Wu, 2013; Han et al., 2017)
Planetary Boundary Layer	Hybrid Eddy-Diffusivity Mass Flux vertical turbulent mixing scheme (Han and Pan, 2011; Han et al., 2016)
Gravity Wave Drag (GWD)	Mountain blocking (Alpert et al., 1988; Kim and Arakawa, 1995; Lott and Miller, 1997) and stationary convective-forced GWD (Chun and Baik, 1998)

Comparision of forecast skills

(1) BharatFS (GFS-TCo)
(2) IMD-GFS (operational GFS V14) and
(3) NCEP-GFS FV3 (operational GFS V16)

- Rainfall
  Verification is carried out with reference to **IMD Gridded data at 0.25^0x0.25^0** resolution
  Season considered: **JJAS 2022, 2023, 2024**

- Tropical Cyclone cases
  Verification with reference to IMD best track data

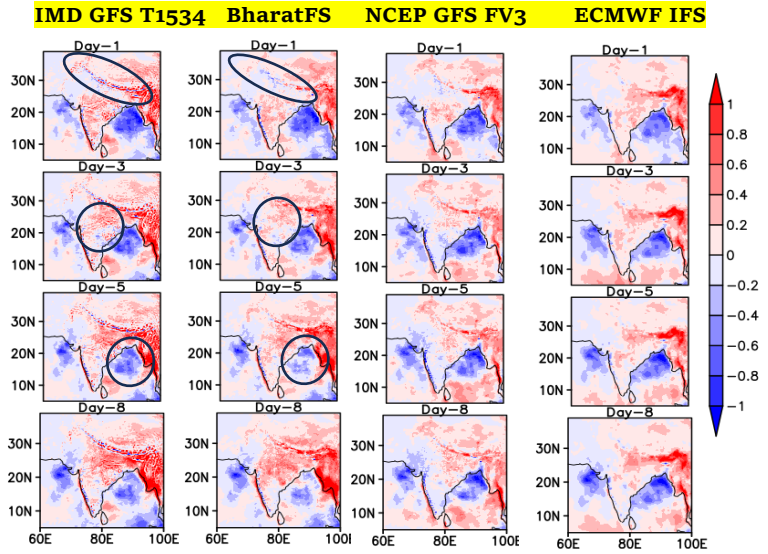
- Extreme rain events
  Verification with reference to IMD gridded data

IITM-GFS-TCo shows better skill than IMD-GFS (operational); NCEP FV3.

JJAS (2022-2024) Rainfall forecast skill Comparision

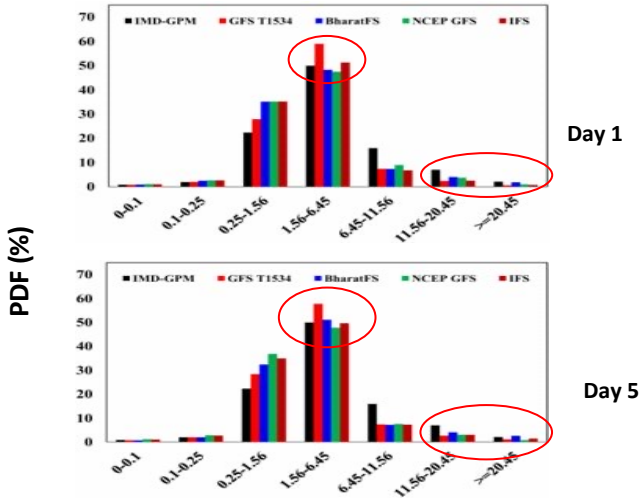
IMD operational (GFS T1534) and BharatFS (GFS TCo1534) models in comparison with GFS FV3 and IFS models

✓ **Prominent wet bias over the Indian mainland region in GFS T1534 is reduced in BharatFS. Improvement in the bias over central India, Bay of Bengal and Himalayan foothills in BharatFS .**



Rainfall bias (Model - Observation) in mm.day^{-1}
+ bias: overprediction ; -ve bias: underprediction

✓ **GFS T1534 overestimates moderate rainfall and underestimates very heavy and extremely heavy category of rainfall. BharatFS improves the forecast of rainfall in these categories. Rainfall forecast with BharatFS is comparable with the observed rainfall in these category.**



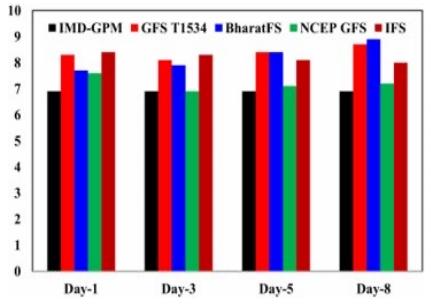
Rain rate in cm.day^{-1}

✓ **BharatFS show better temporal Correlation compared with GFS-1534 and NCEP FV3 (GFS V16)**

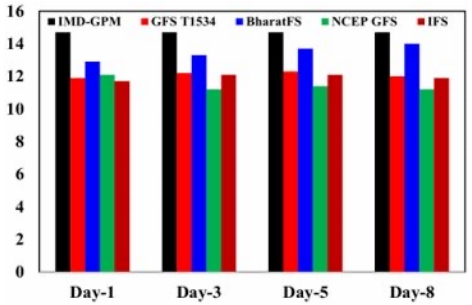
	GFS	BharatFS	NCEP	ECMWF
Day-1	0.87	0.90	0.88	0.93
Day-3	0.80	0.83	0.78	0.85
Day-5	0.68	0.71	0.72	0.77
Day-8	0.59	0.64	0.53	0.69

Temporal correlation (time series of JJAS 2022-2024) for Central India between observation and models

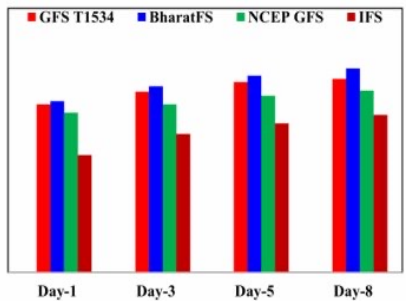
Mean rainfall (mm/day)



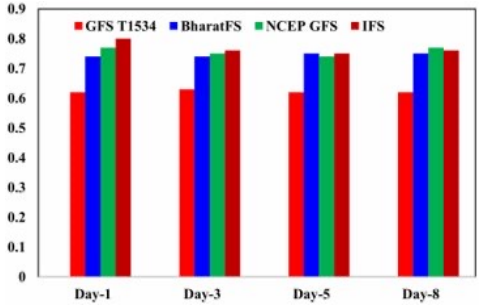
Standard deviation (mm/day)



RMSE (mm/day)



Spatial correlation Coefficient



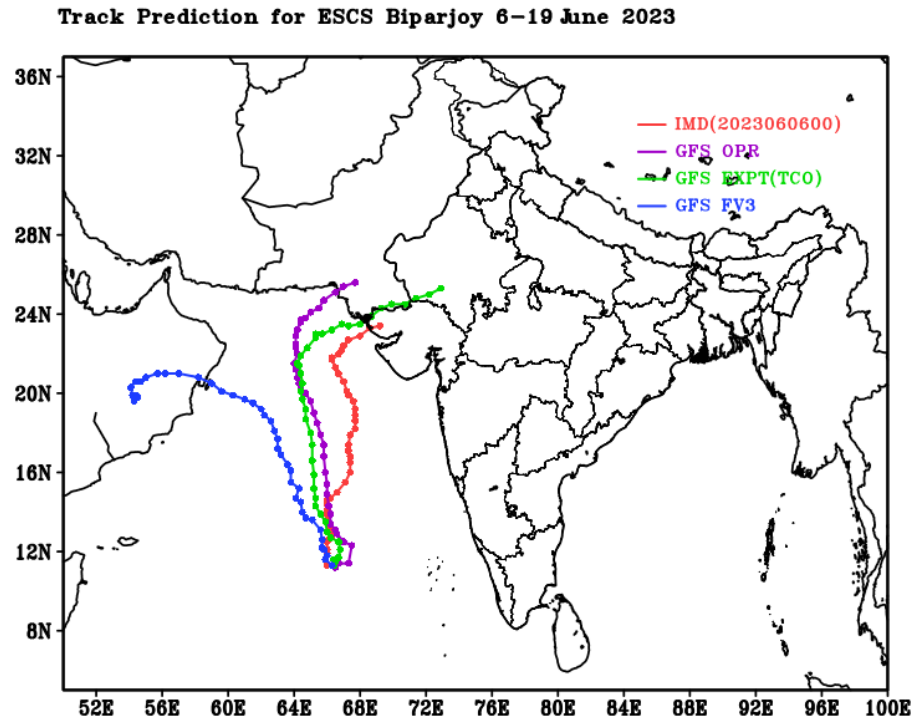
✓ All India mean rainfall slightly improves in BharatFS than GFS T1534

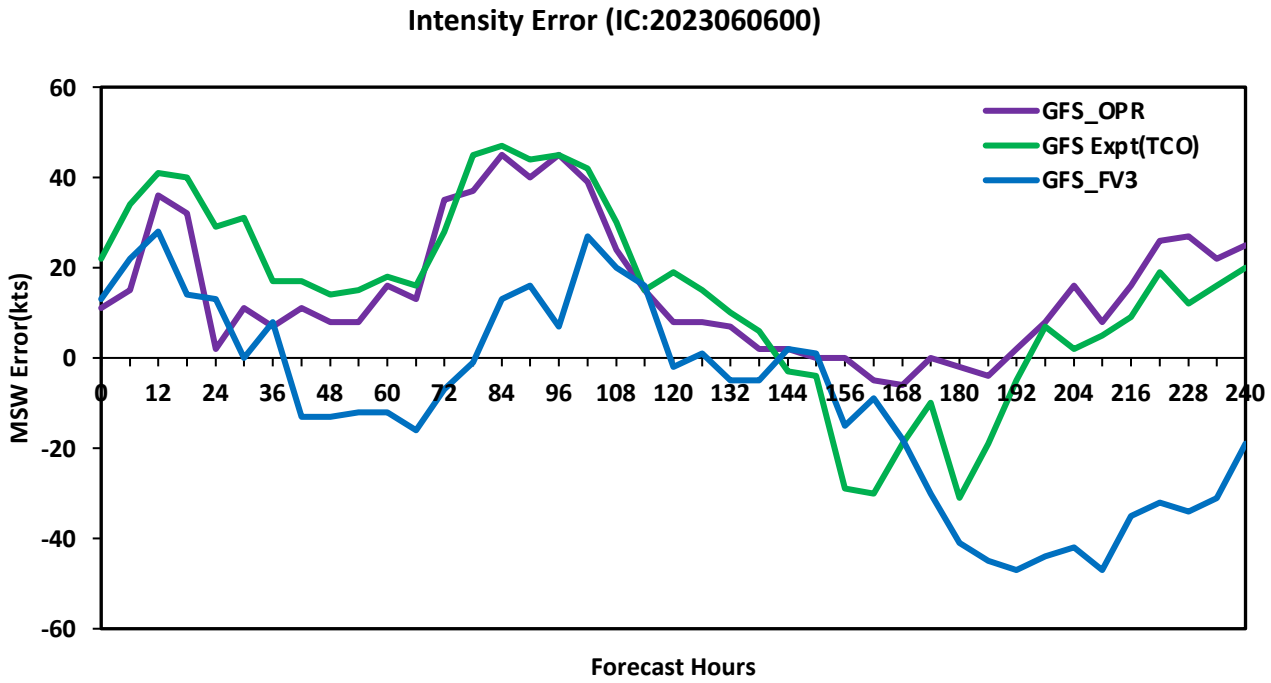
✓ Rainfall variability (Standerd Deviation) better captured in BharatFS than IMD-GFS and also better than ECMWF IFS and NCEP GFS FV3 for all the lead time

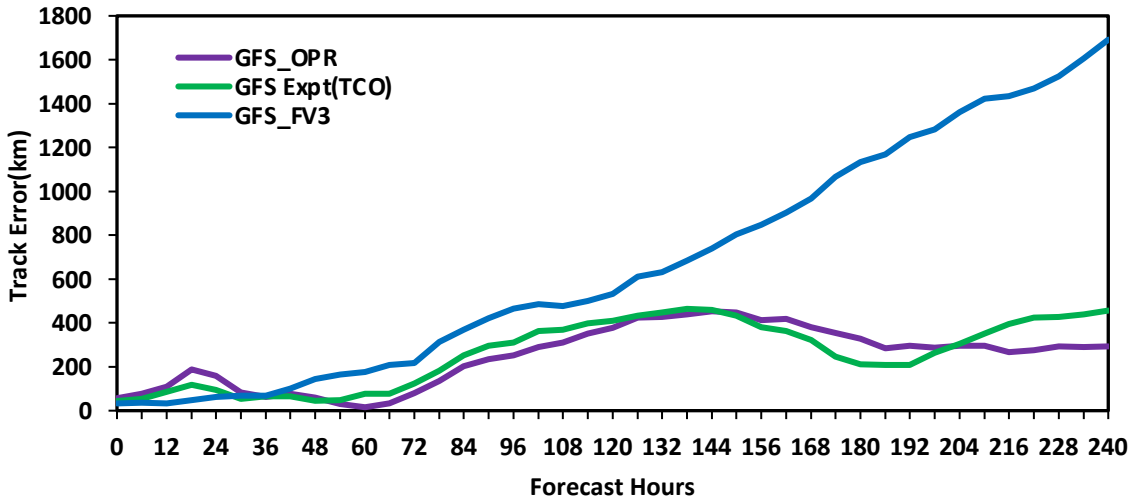
✓ Spatial correlation improves by 20% than operational GFS and comparable with NCEP GFS and IFS

Verification of Tropcal Cyclone Biparjoy (6-18June 2023)

IC:2023060600





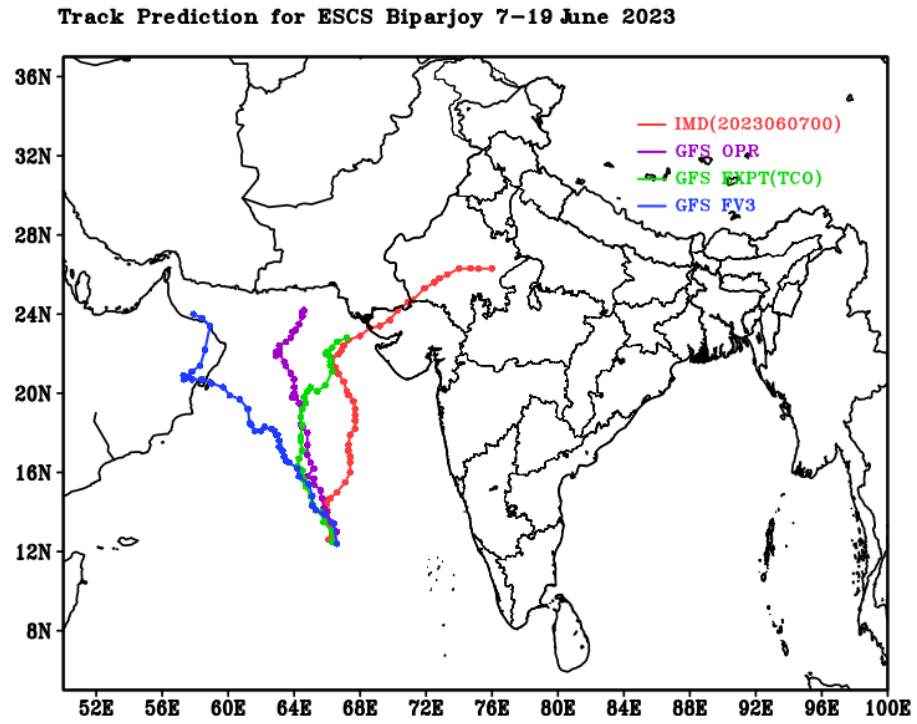


ESCS Biparjoy was a typical difficult to predict Case because of slow moving long track length, long life period and recurving track. It underwent Rapid Intensification phase during genesis and growing stage.

Results are from the run initialized on the day of Depression

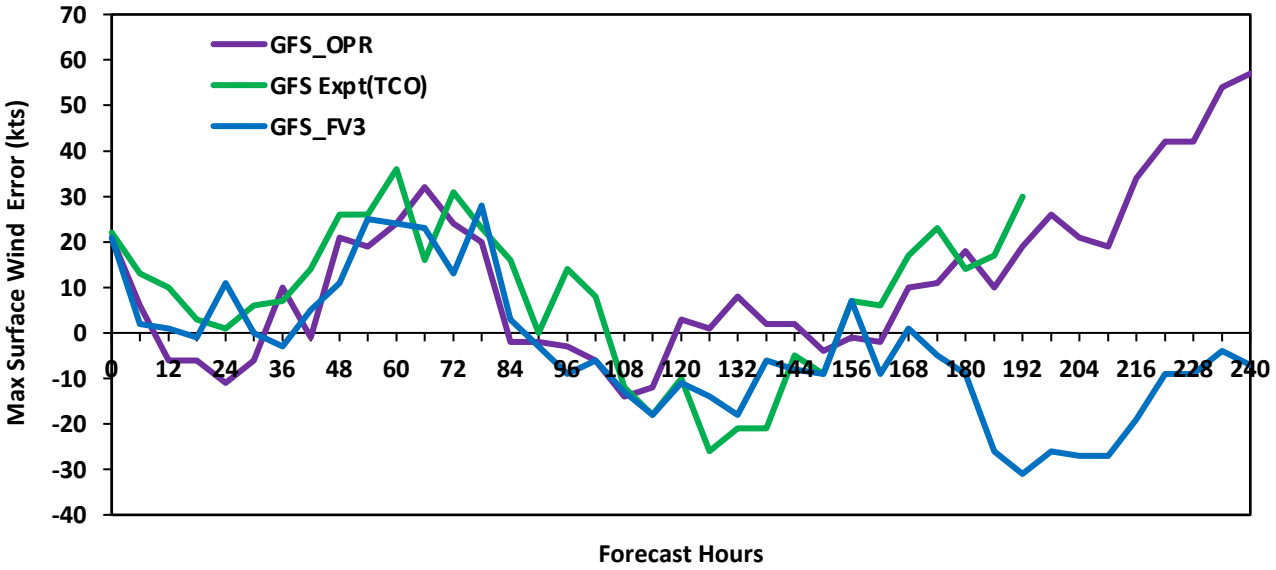
BharatFS (GFS-TCo) did better in predicting recurving track in comparison with IMD GFS and GFS FV3.

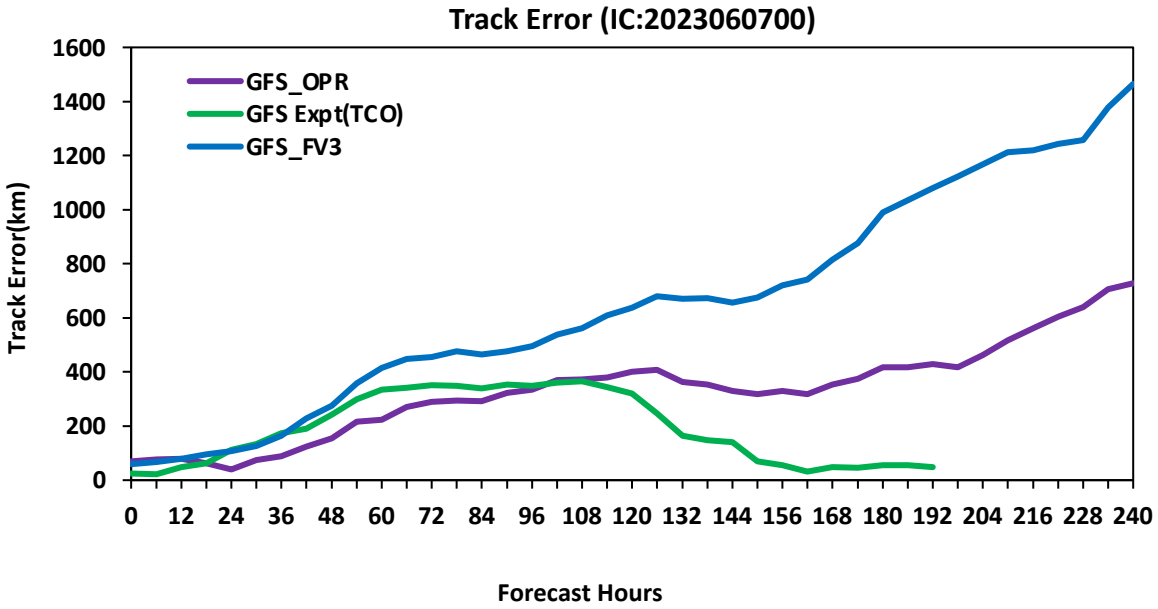
It also indicated an intense storm.



Biparjoy (6-18June 2023)

IC:2023060700





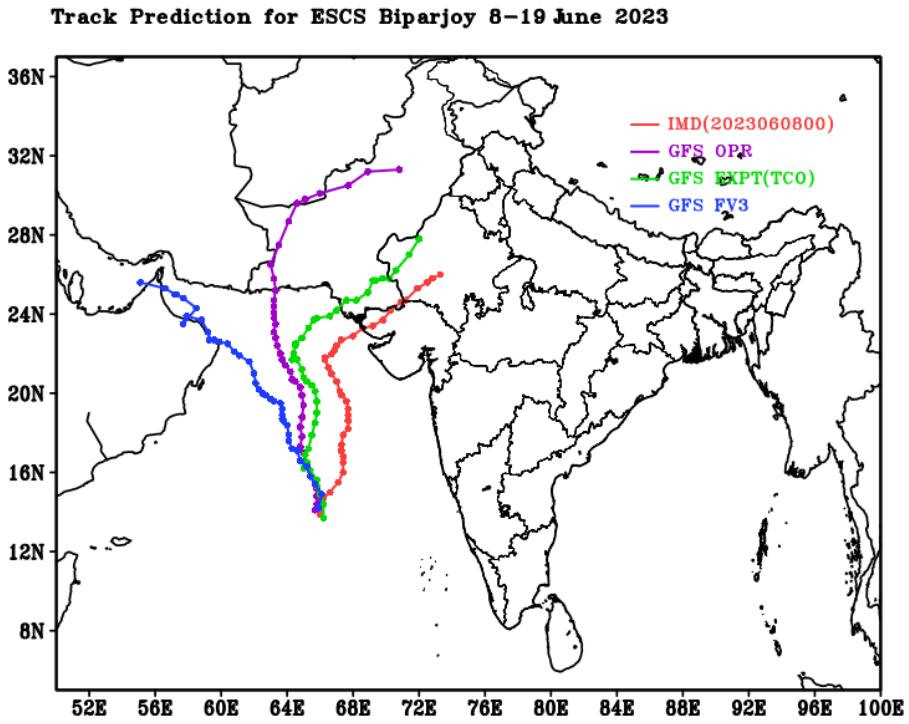
Run initialized on 07 June 2024 (SCS stage)

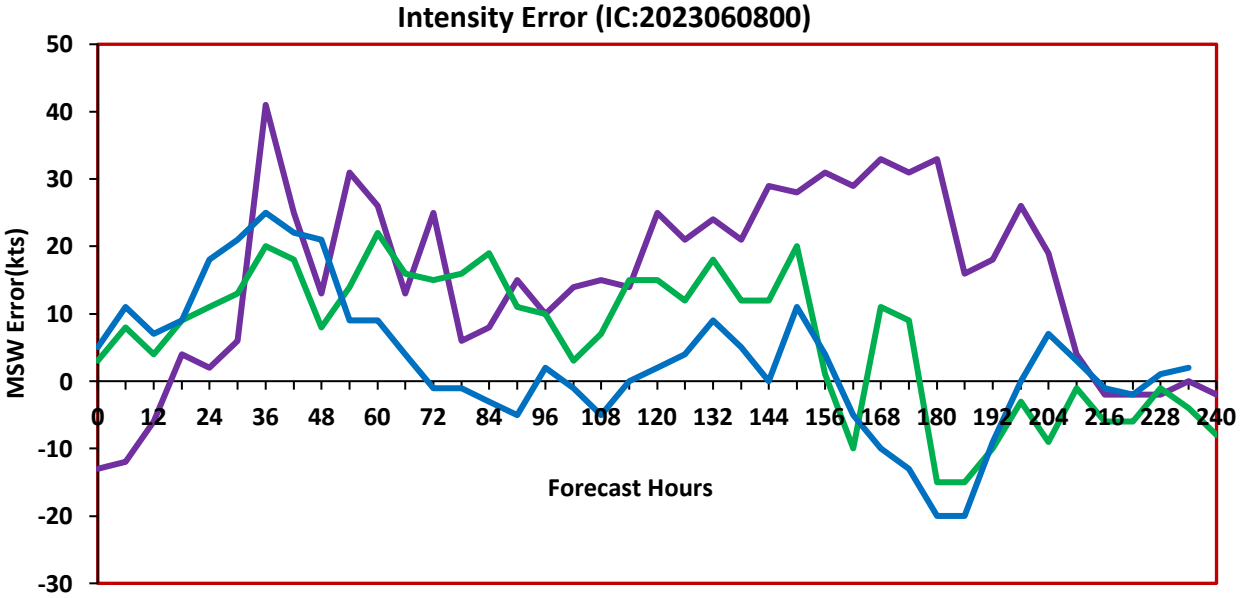
Again **GFS-TCo better predicted recurving track in comparision with IMD GFS and GFS FV3.**

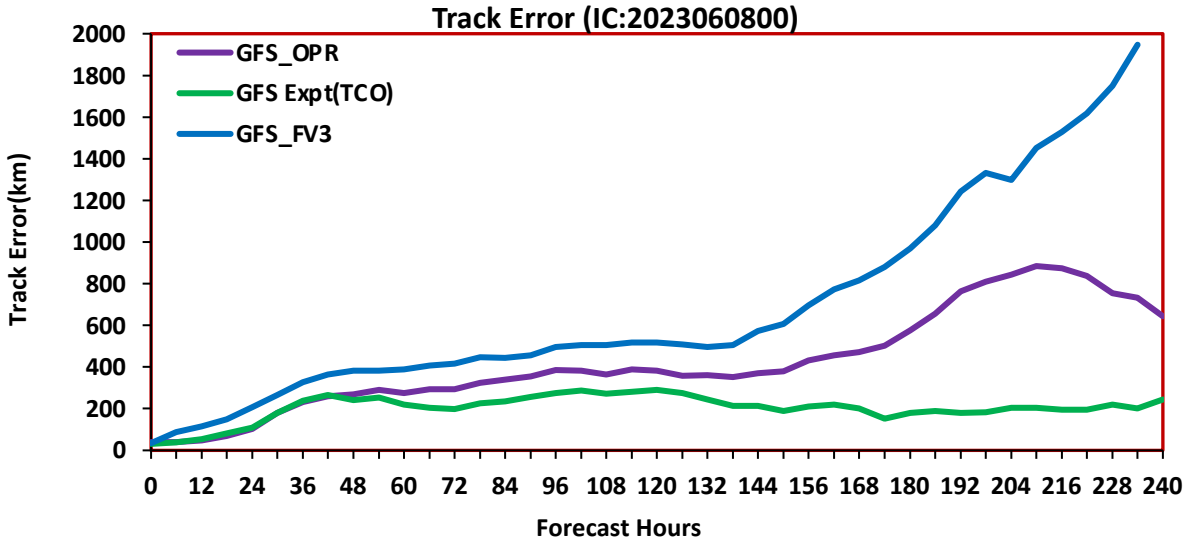
It also indicated an intense storm.

Biparjoy (6-18June 2023)

IC:2023060800







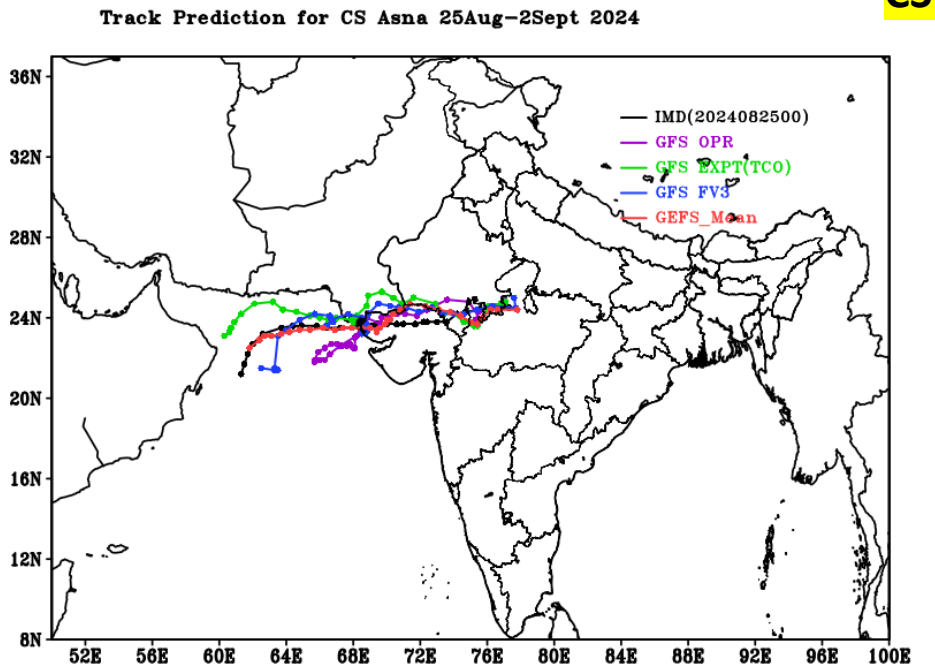
Run initialized on 08 June 2024 (VSCS stage)

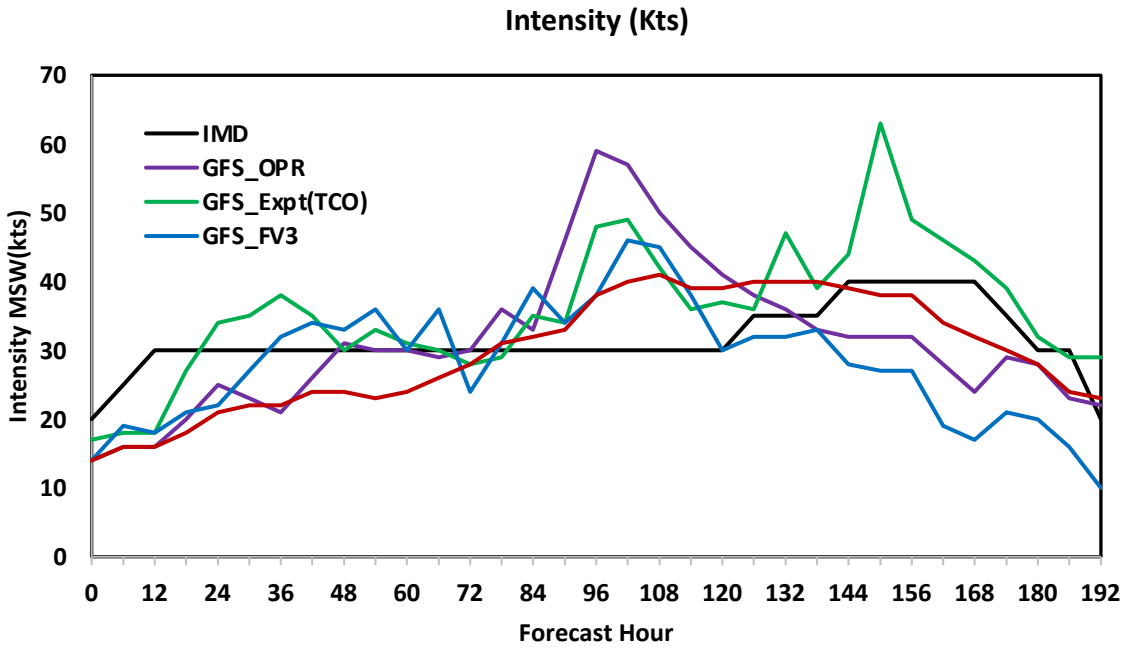
Again **GFS-TCo did better in predicting recurving track in comparision with IMD GFS and GFS FV3.**

Track error is < 200 km and intensity error is less than 20 knots till Day 10.

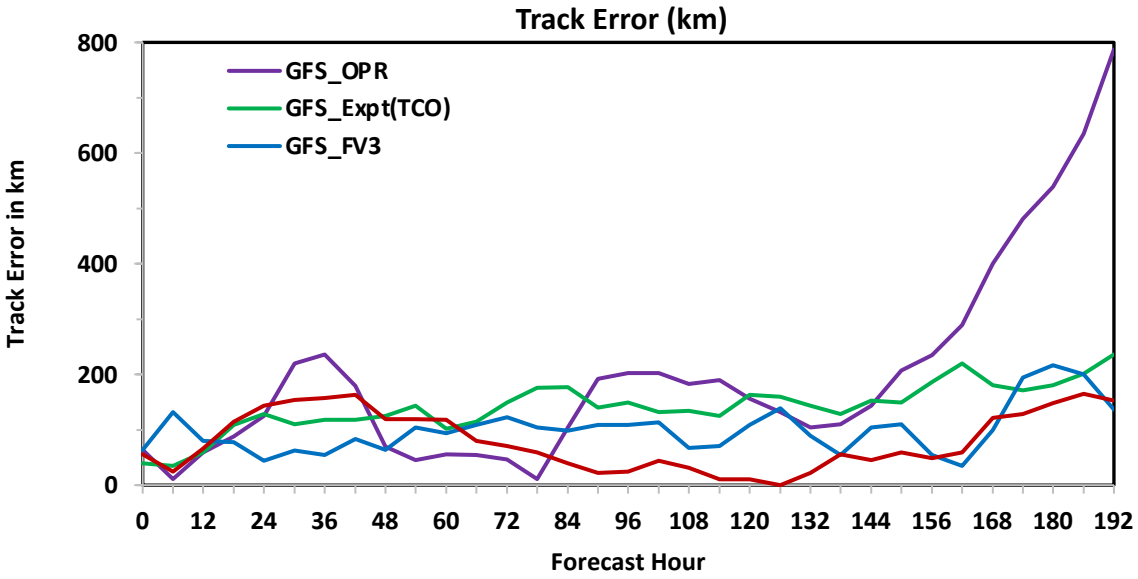
CS Asna (25Aug -02 Sept 2024)

IC:2024082500





With GEFS Mean



CS ASNA was another typical difficult to predict Case because of Genesis over land during the month of August (monsoon season) and moved to Arabian Sea to become a CS.

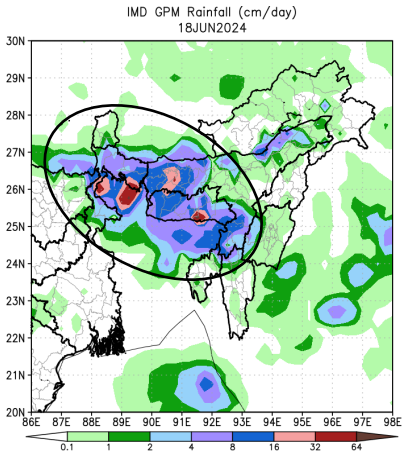
Results are from the run initialized on the day of Depression on 25 Aug 2024

GFS-TCo and GFS-FV3 show less track error in comparision with IMD GFS.

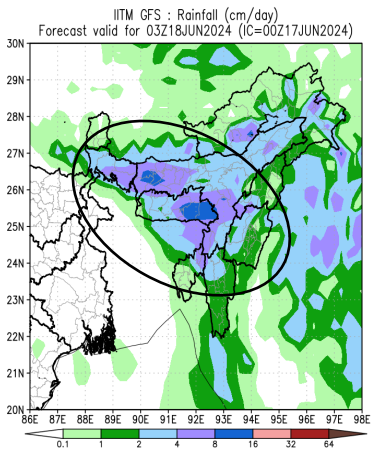
18-June-2024

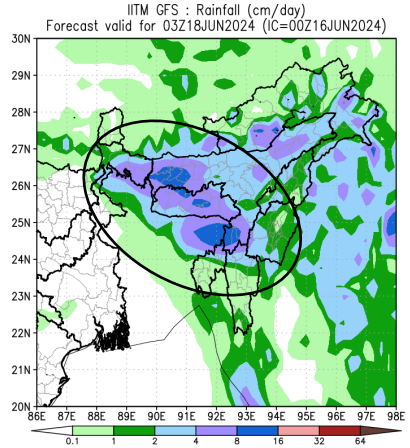
Day-1 Day-2 Day-3 Day-4 Day-5

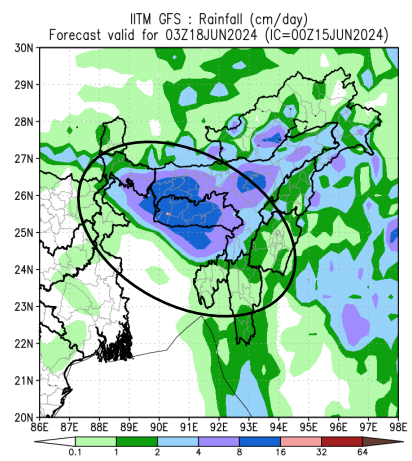
IMD

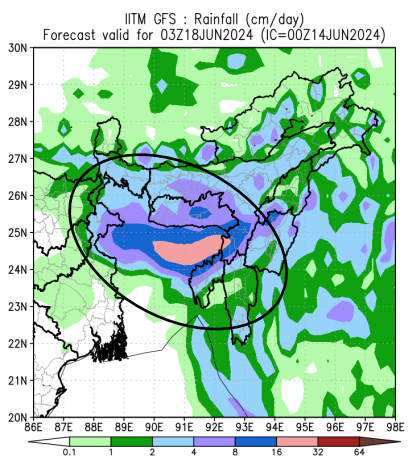


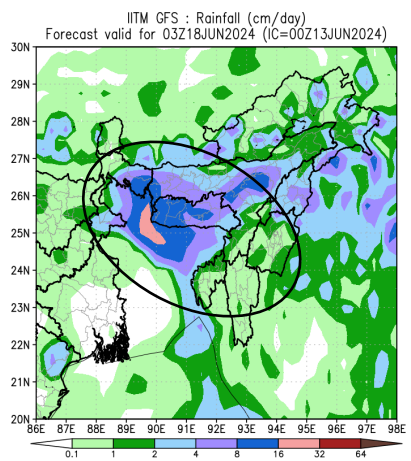
GFS



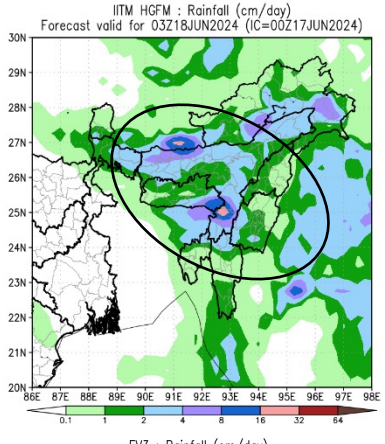


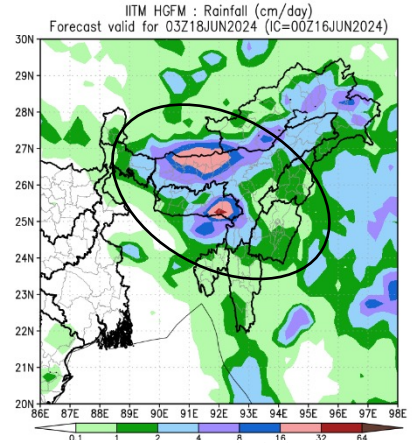


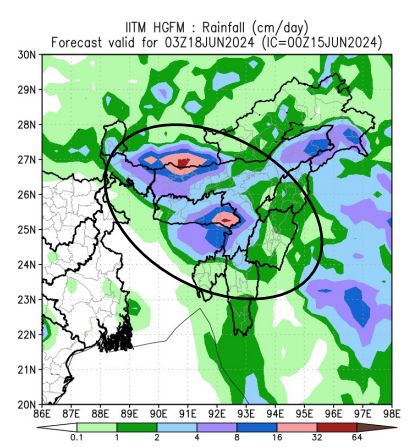


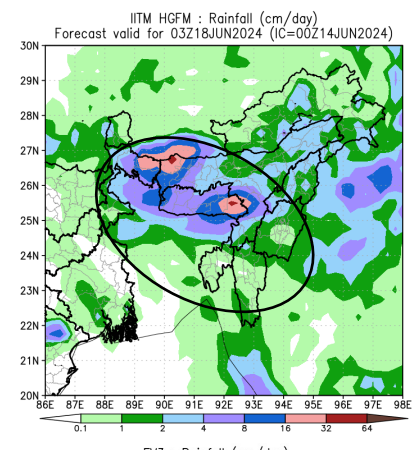


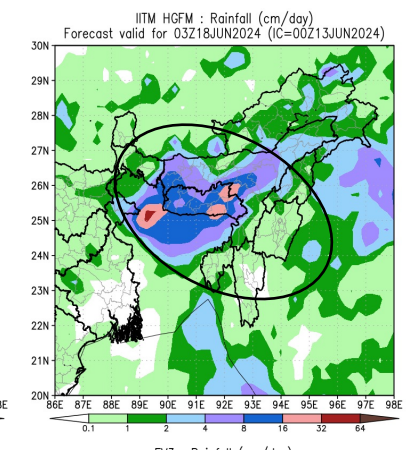
BharatFS







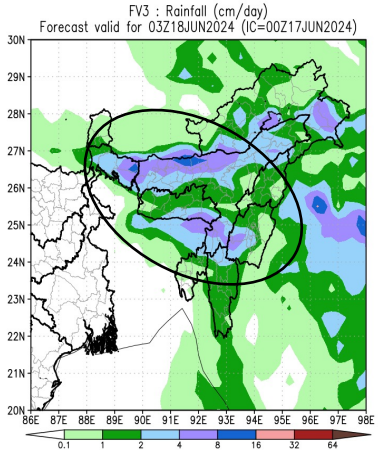


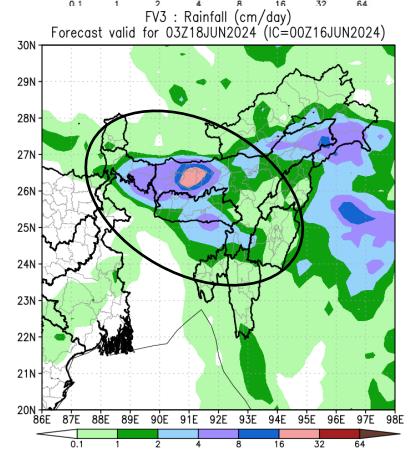


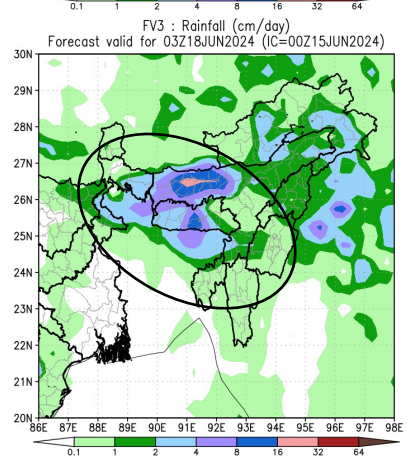
EXTREME RAIN EVENT
North East India

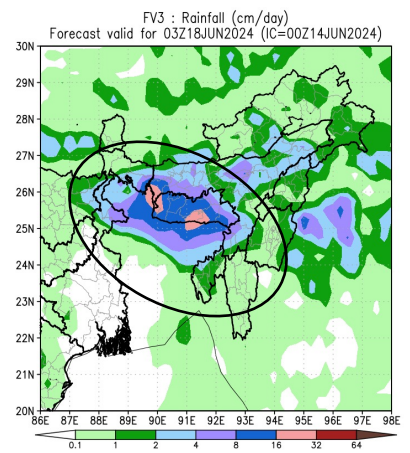
BharatFS better captures the extremely heavy rainfall amount consistently till Day 5.

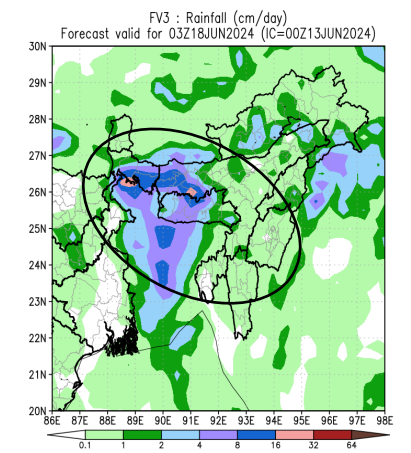
FV3





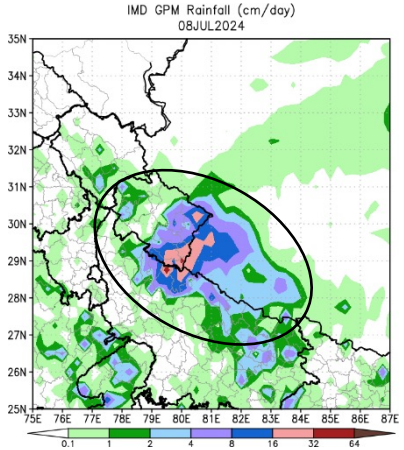


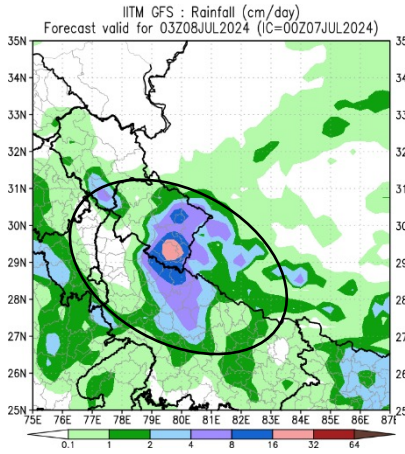


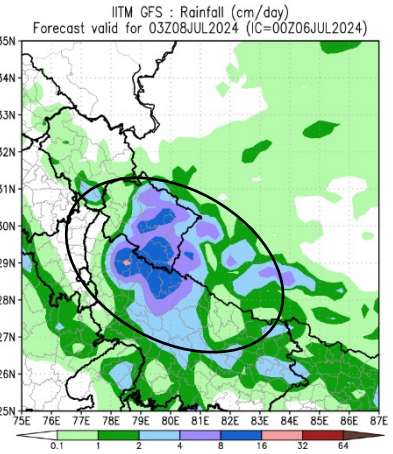


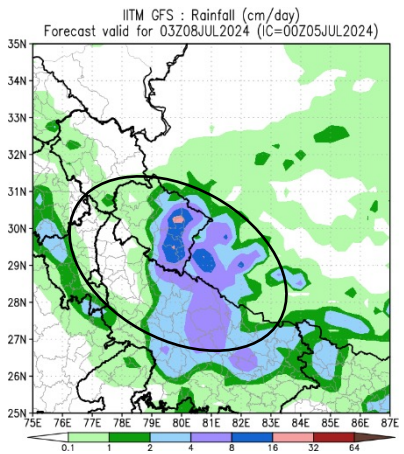
08-July-2024

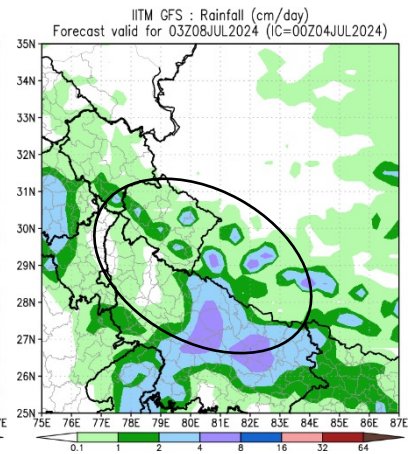
	Day-1	Day-2	Day-3	Day-4	Day-5
IMD					
GFS					
BharatFS					
FV3					

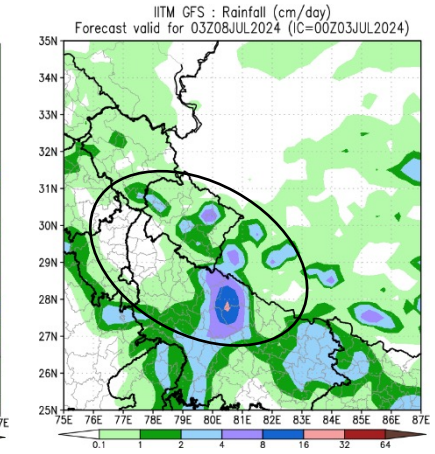


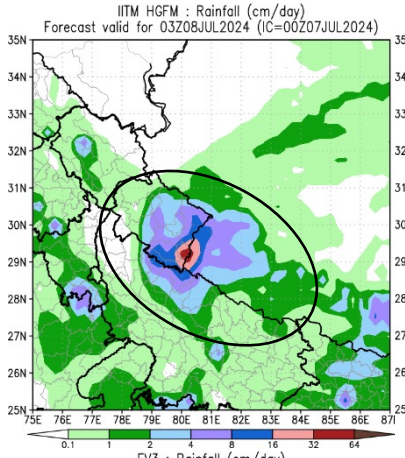


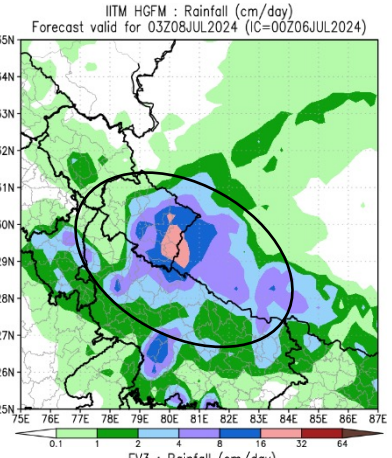


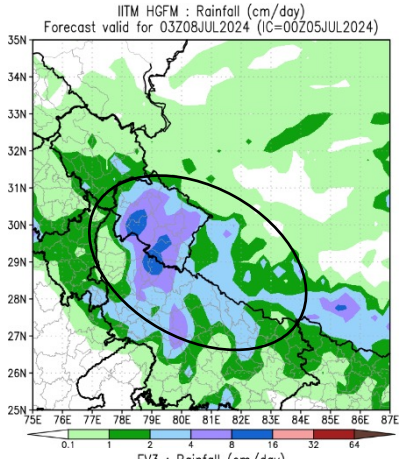


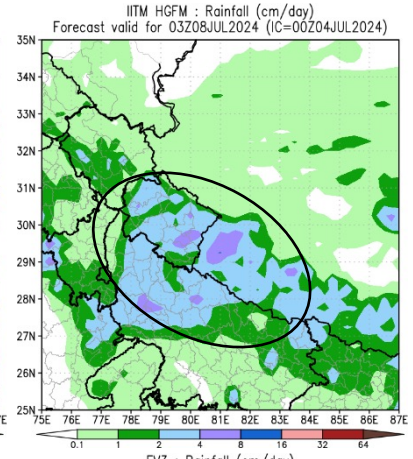


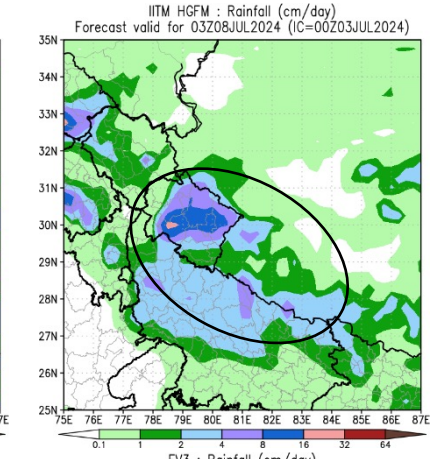


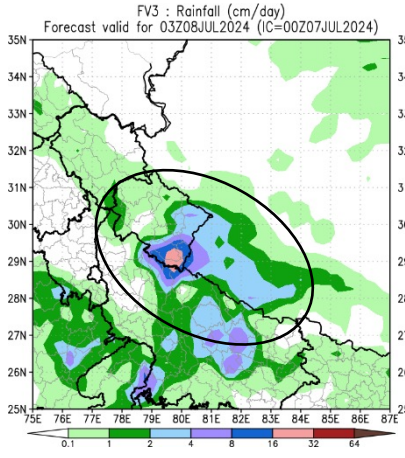


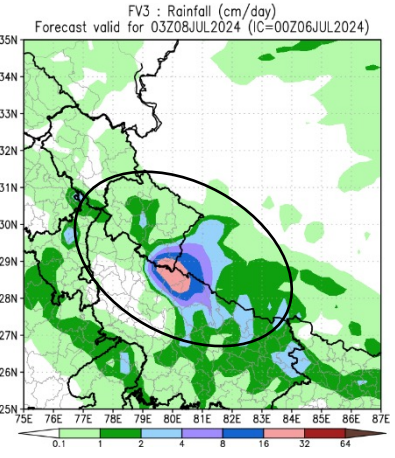


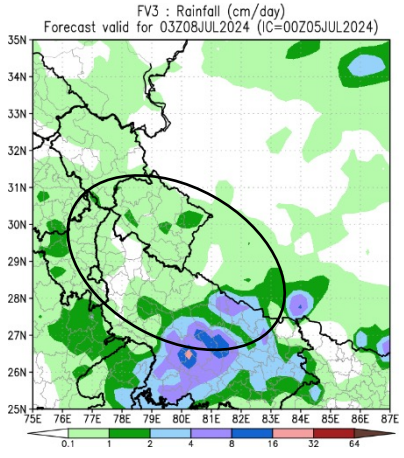


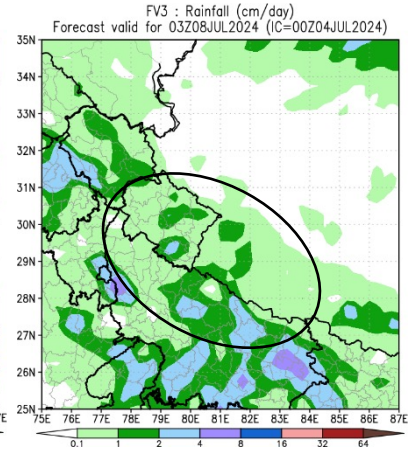


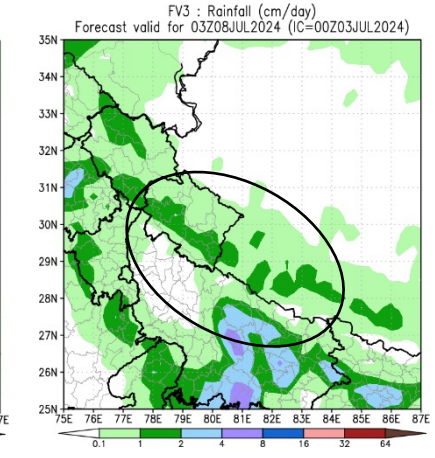




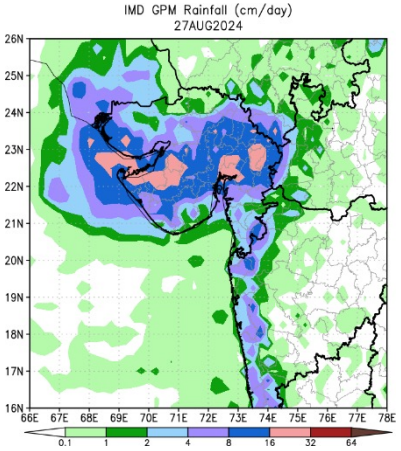
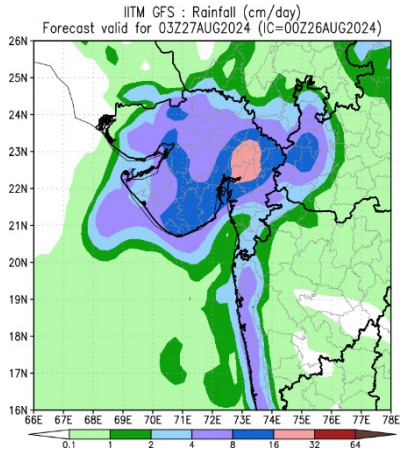
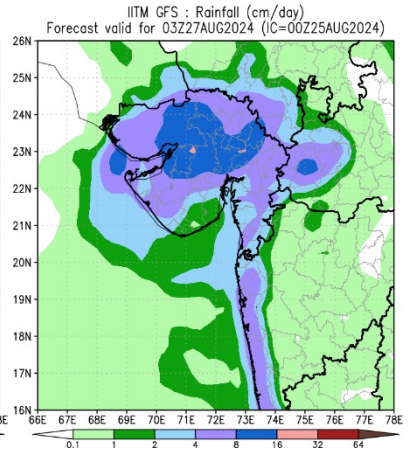
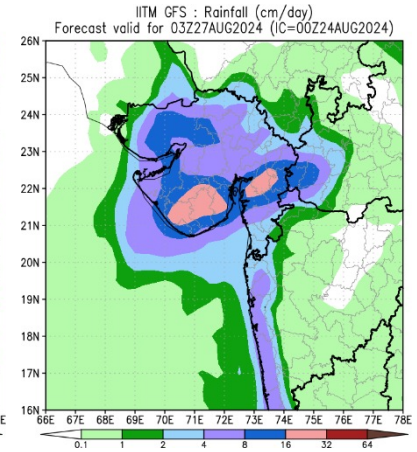
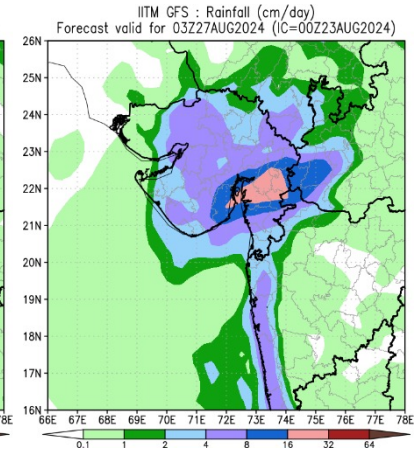
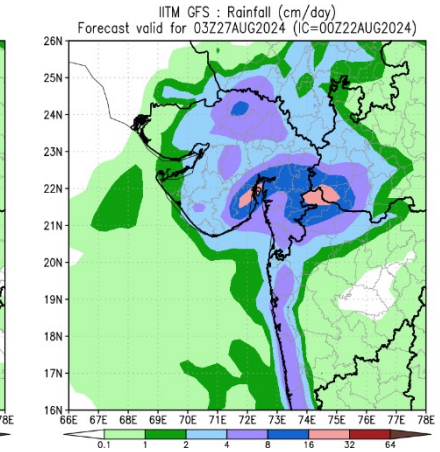
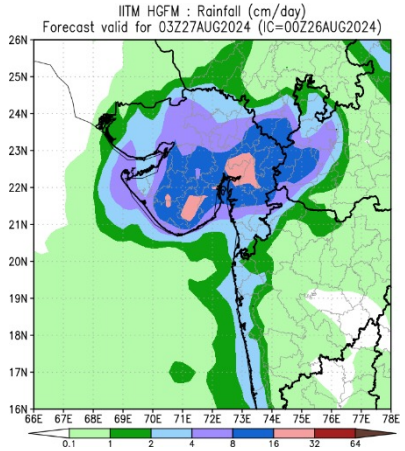
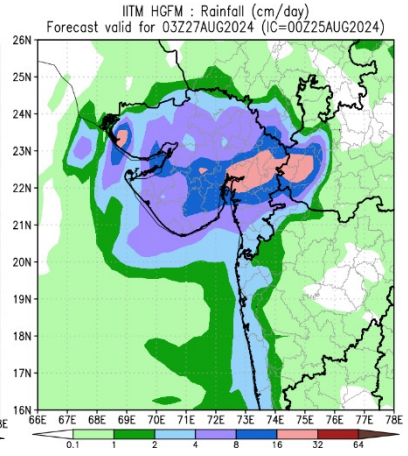
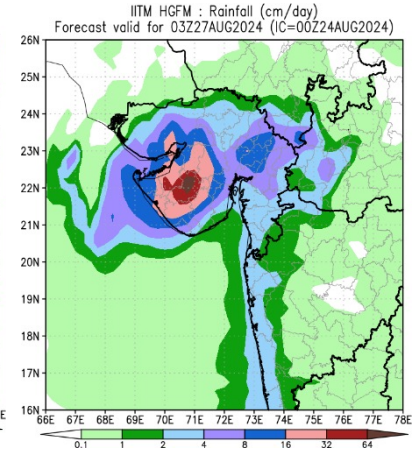
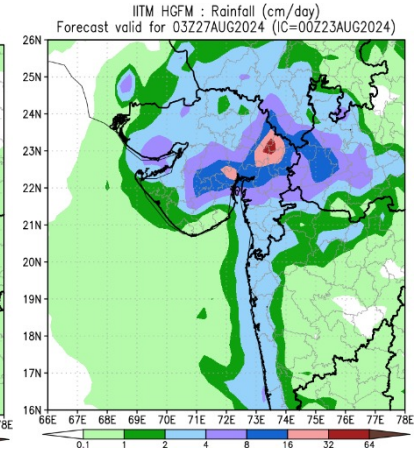
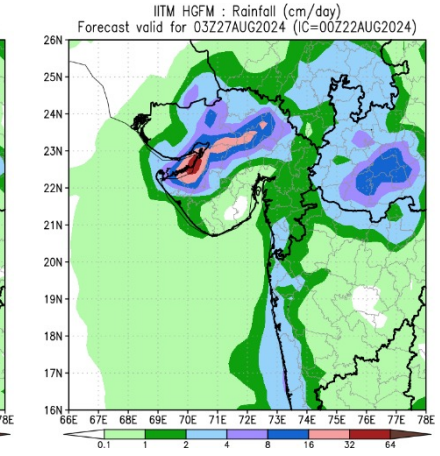
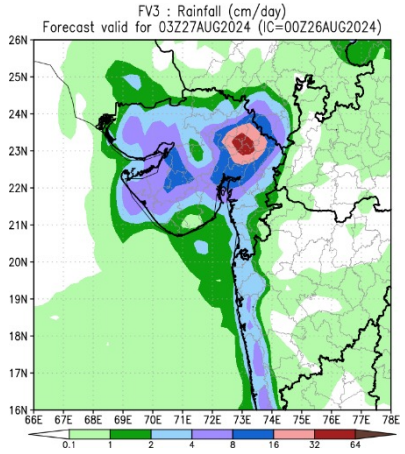
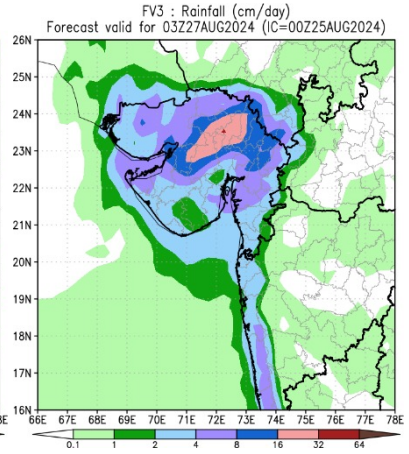
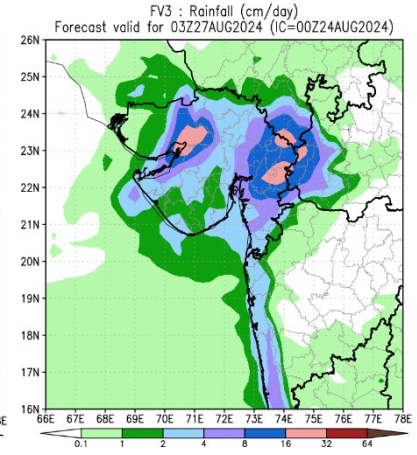
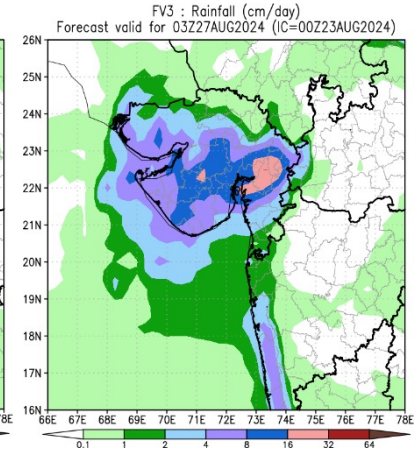
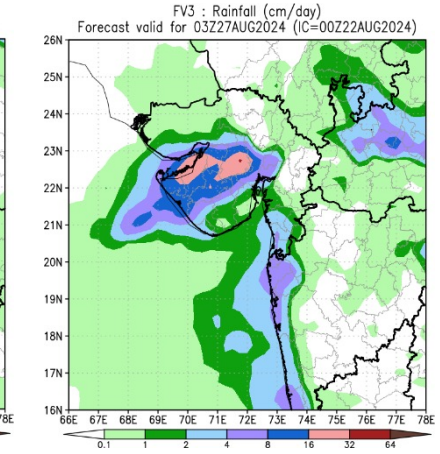








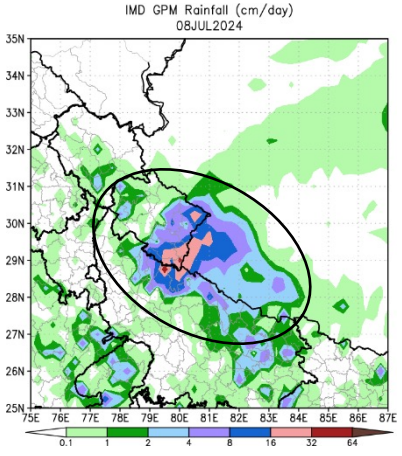
27-Aug-2024

	Day-1	Day-2	Day-3	Day-4	Day-5
IMD					
GFS					
BharatFS					
FV3					

8th July 2024

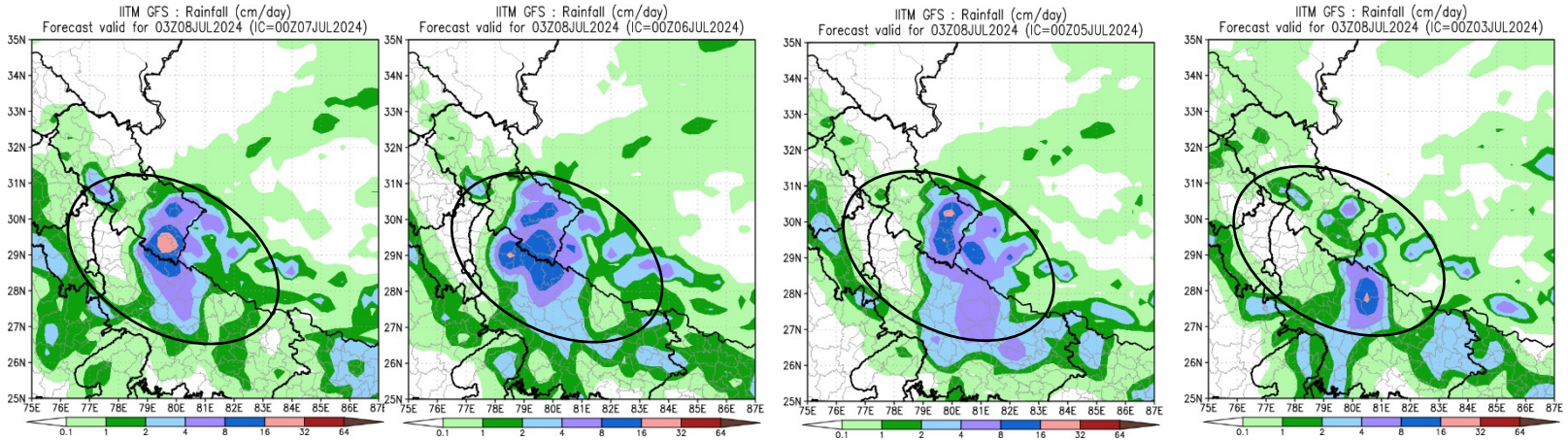
Exceptionally heavy rainfall Event caused major flash floods West Uttar Pradesh and Uttarakhand

IMD Gridded Data

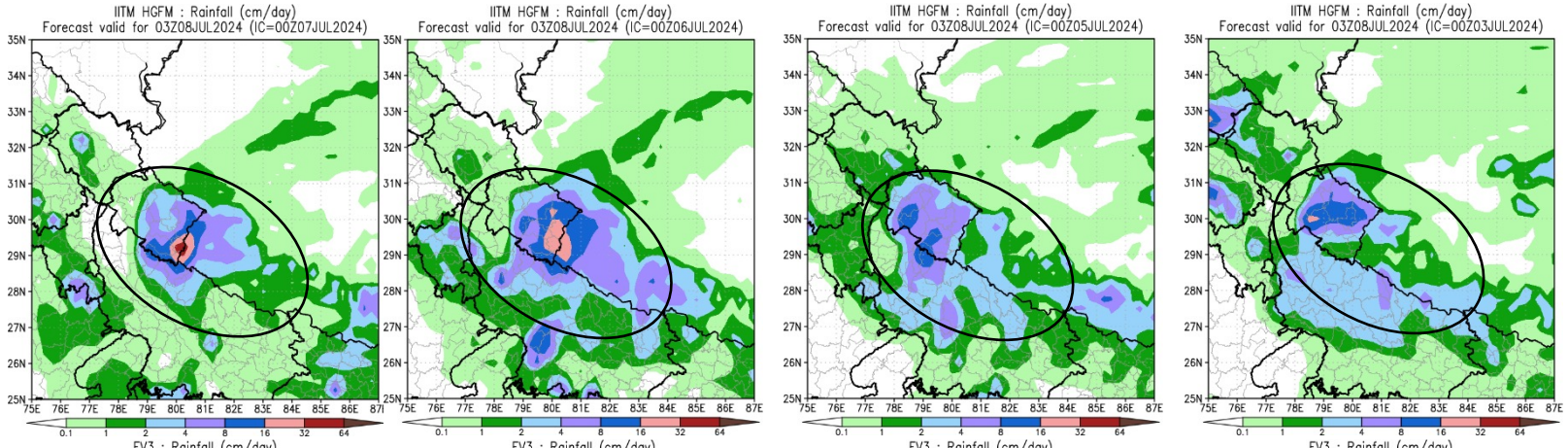


BharatFS Exceptionally well predicted the rainfall amount and location

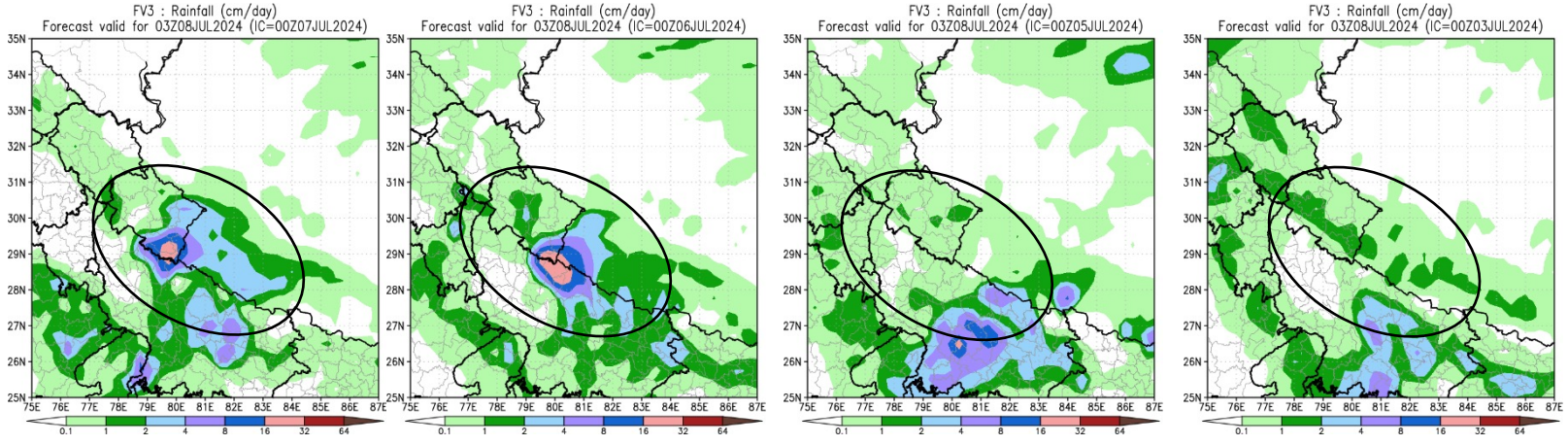
Day-1 Day-2 Day-3 Day-5



IMD GFS
12 km resolution



BharatFS
6 km resolution



NCEP GFS (FV3)
13 km resolution

Thankyou!