Evaluation of very high-Resolution model performance in capturing the extreme rainfall event over Delhi during July 2023

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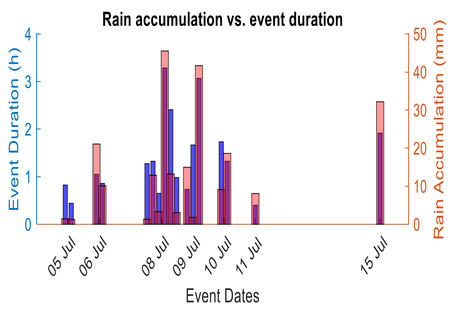
Introduction

In early July 2023, Delhi, the capital city of India, witnessed an extraordinary rainfall event leading to significant disruption. New Delhi received a total monsoon rain accumulation of approximately **543 mm** in this region from June to September from ground-based disdrometer measurements. A significant amount of this total, ~ 241 mm, occurred within **the ten days of July 5-15, 2023**, constituting nearly **45% of the entire monsoon rainfall.** However most of the precipitation occurred within the three days time span from 8-10 July 2023.



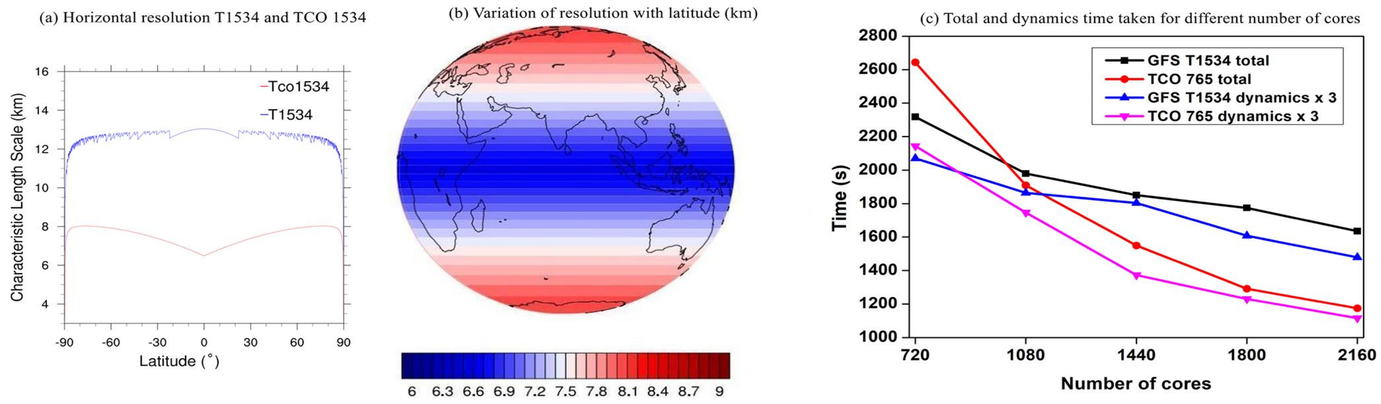
This study seeks to provide an in depth analysis of the convective characteristics of these weather events, alongside the larger atmospheric mechanisms at play. Our primary objective is to assess the accuracy and effectiveness of advanced forecasting models in predicting such extreme weather phenomena.

To achieve this, we have examined two state-of-the-art models: **the 6.5 km High-Resolution Global Forecast Model (HGFM) in TCO grid**, developed by IITM (IITM-HGFM), and the widely recognized ECMWF model. These models were evaluated against real-time observations to better understand the processes that contributed to the event.

About the model

We have used indigenously developed **IITM High resolution Global Forecast Model (HGFM)** running at 6.5 km resolution in triangular–cubic–octahedral (TCO) grid in the global tropics.

- **The model has a higher resolution in the tropics**
- **Reduction in cost of computation**
- **Better filtering & better conservation properties**
- **More Scalable**
- **Better parameterization tuned for the Indian region.**
- **Improved representation of Orography**

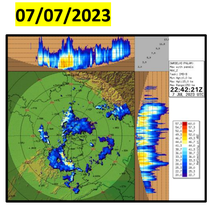


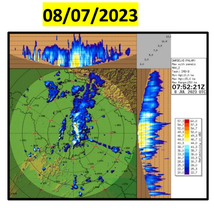
❖ IITM TCO grid model (HGFM) is compared with the ECMWF IFS model in capturing the events.

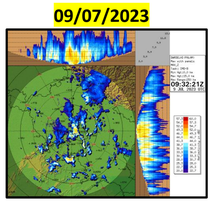
Results

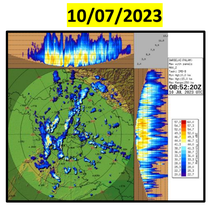
Observation based Hypothesis

Cloud Top Brightness Temperature (CTBT) from INSAT 3D/DR



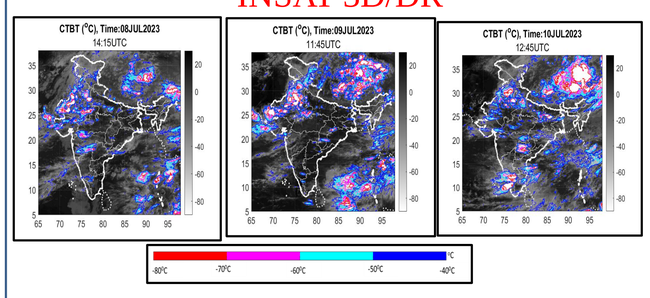




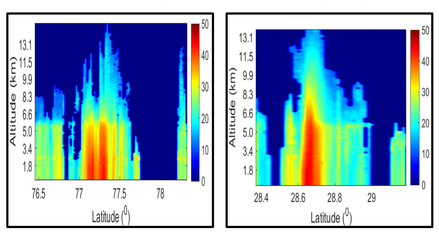


Doppler weather radars (DWR) picture installed at New Delhi (Palam)

INSAT 3D/DR



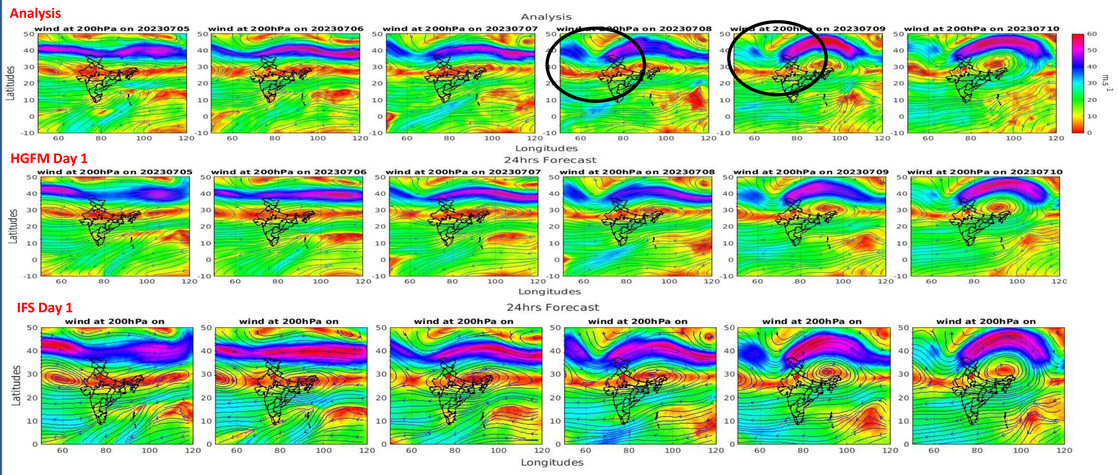
GPM 2ADPR Product



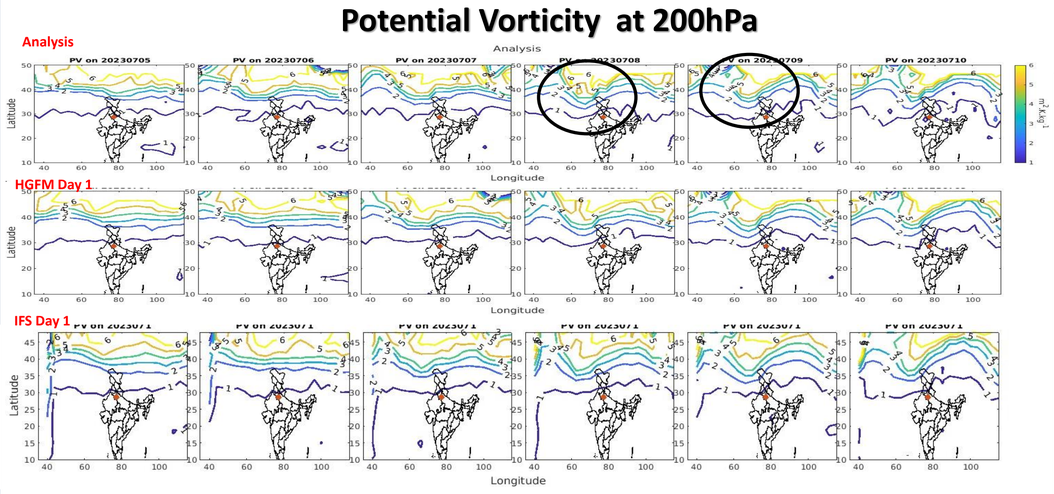
❖ The DWR's MaxZ data reveals that the storm cell heights reached up to approximately 12 km, indicating deep convective activity. Reflectivity values in the core of these cells exceeded 45 dBZ, which is characteristic of intense convective rainfall.

❖ GPM pass also indicates that the storm is characterized by deep convective clouds, which contributed to the intense and sustained rainfall over the region. It is also confirmed by INSAT 3D CTBT.

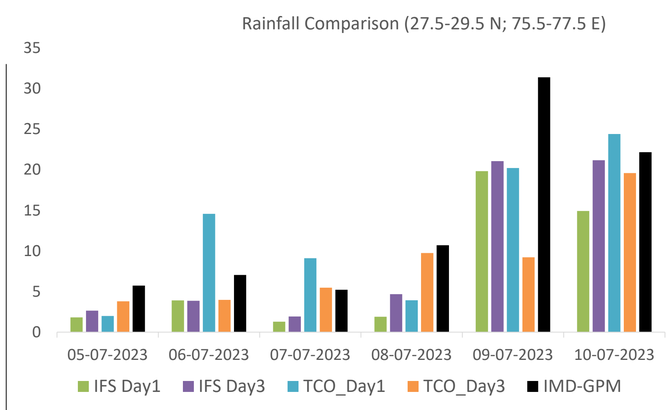
Wind at 200hPa

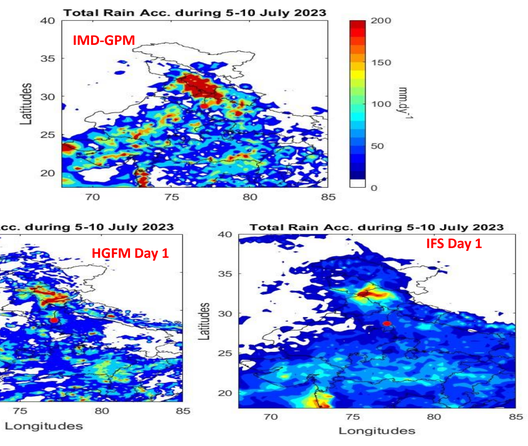


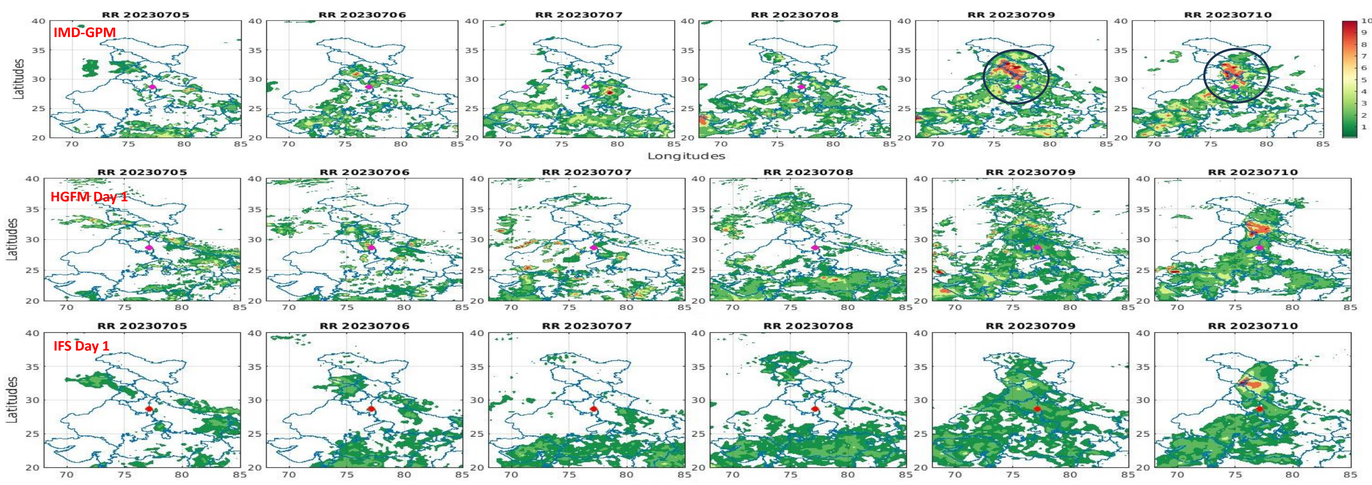
Potential Vorticity at 200hPa



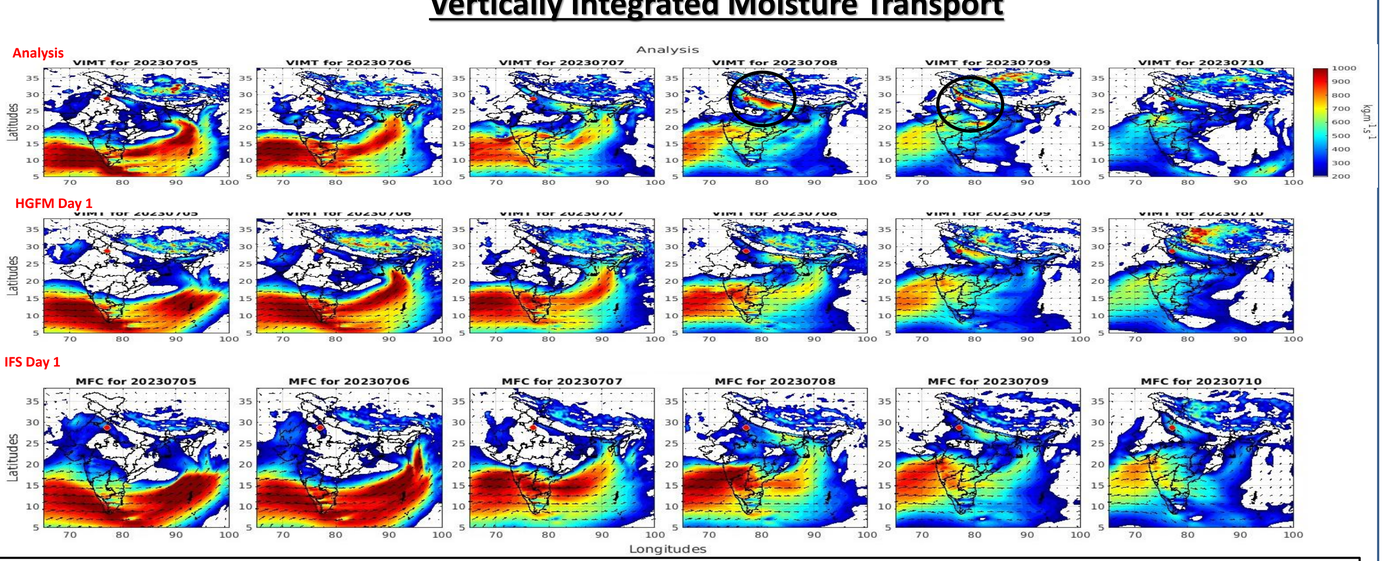
Rainfall Comparison (27.5-29.5 N; 75.5-77.5 E)







Vertically Integrated Moisture Transport



CONCLUSIONS

❖ IITM HGFM model shows very good fidelity in capturing the overall rainfall structure in day-1 and with increased lead time. The IFS model has slightly under-estimated the rainfall on 9th July but has predicted well the rainfall on 10th July.

❖ The vertically integrated moisture transport shows that the build up of moisture over the events location before the events. Both models slightly under-estimated the VIMT.

❖ The potential vorticity deepening over the region might be associated with the Rossby wave breaking phenomenon. It coincide with the event dates. Both the models capture the potential vorticity structure quite well but the gradient is more for IITM-HGFM model.

Thank you…