**Development of a High-Resolution Global Forecast System Model with a Triangular Cubic Octahedral Grid**

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1. Introduction:

The number of small-scale weather extremes has risen exponentially in the past few years. Since the prevalent Global Forecast System (GFS) has an inherent limitation of horizontal resolution, a dire need was felt to have a forecast model capable of providing increased horizontal resolution to forecast extreme weather events much ahead of time. However, directly increasing the resolution poses computational and other challenges. Hence to overcome these issues in the existing model, a new reduced Gaussian grid called Triangular Cubic Octahedral (TCO) grid was adopted (following Malardel, Sylvie, et al. "A new grid for the IFS." ECMWF newsletter 146.23-28 (2016): 321.). In the original reduced Gaussian Grid, the number of longitude points per latitude remains fixed in different blocks of latitudes, whereas in the TCO Grid, the latitude circle closest to the pole consists of 20 longitude points, and the number of longitude points increases by four at each latitude circle, moving from poles towards the equator. Moreover, unlike the original-reduced Gaussian Grid, the number of longitude points in the TCO grid jumps from one latitude circle to the other by a constant number. Therefore, the horizontal resolution varies smoothly with latitudes. This configuration is obtained by the projection of a sphere on an octahedron. The TCO grid provides a horizontal resolution of near 6kms in the tropics which gives a much finer resolution than the near 12kms of the GFS.

The TCO grid uses cubic truncation in which each wave is represented by four grid points instead of two - as in the linear truncation of GFS.Using a TCO grid over a conventional reduced Gaussian Grid has various advantages. To name a few:

a. Orography is represented in a better way
b. Conservation of mass, momentum, and energy is well-captured
c. Computation of local derivatives is more efficient
d. Model is more scalable
e. Less diffusion is needed to reduce noise.

While the 12 km GFS model helps generate block-level forecasts, IITM's High-Resolution Global Forecast Model (HGFM) model will help reach forecasts on a spatial scale smaller than a block level. Currently, the development of the model is being accomplished by following steps:

i. A basic version of the model involving only the dynamical core is developed first.
ii. All the necessary input files are prepared on the new TCO grid
iii. Individual pieces like dynamical core, necessary input files and model physics are put together to build the full fledge model completely indigenously.
iv. Numerical diffusion is modified

2. Preliminary Results:

The HGFM model (GFS TCO) considerably improves the probability density function of rain over Indian landmass as depicted in Fig. 1. In a case study of an extreme rain event on 22nd August 2022; the HGFM model outperformed the existing GFS model (Fig. 2)

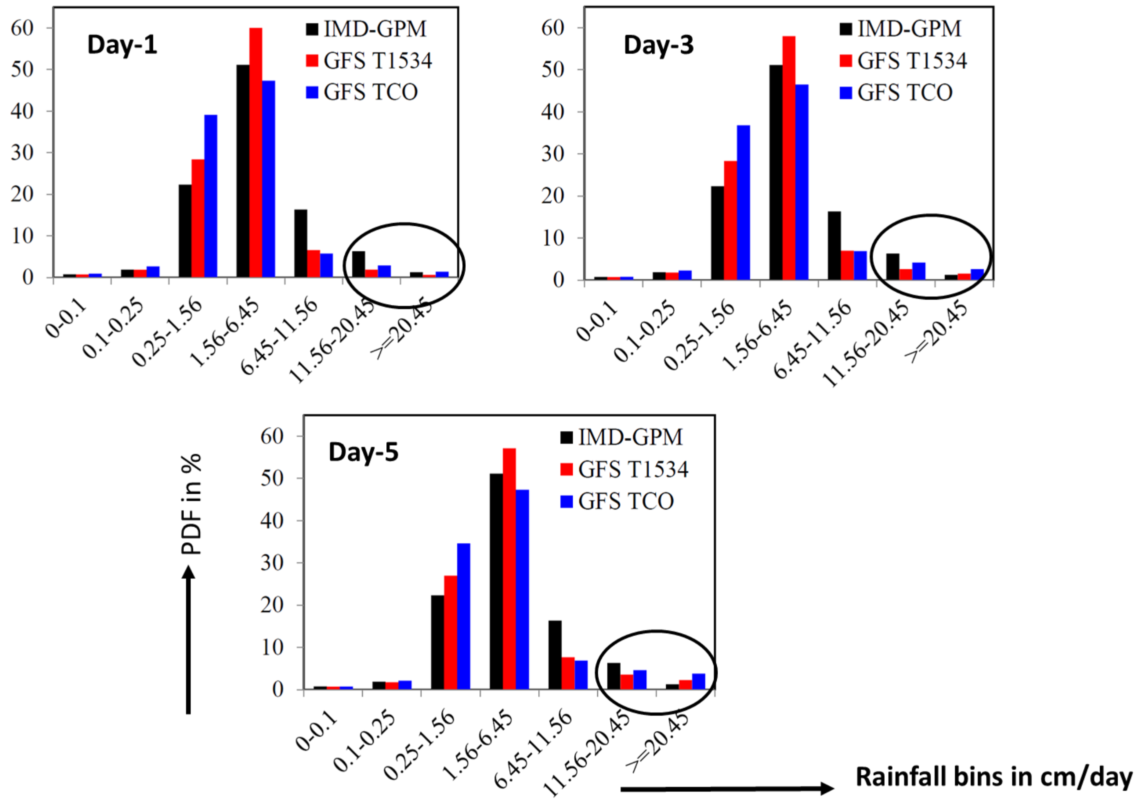


Fig. 1. Rainfall PDF (%) over ALL India landmass

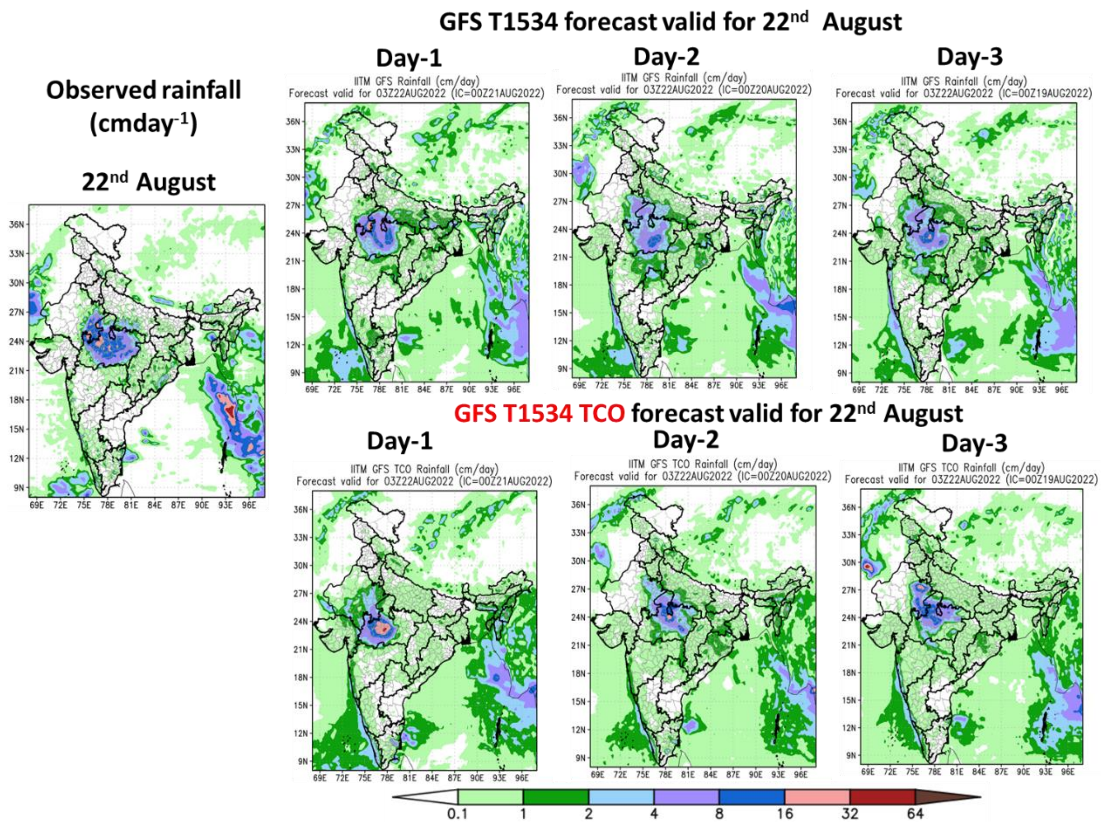


Fig. 2. Extreme rainfall event on 22nd August 2022