Operational Convective-Scale Numerical weather prediction model and high resolution city scale model at NCMRWF

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India recently witnessed severe weather episodes such as flash floods, thunderstorm, dust storm, pollution episodes etc under a warming climate. A reliable forecast for the variables associated to aforementioned dynamic tropical systems is one of the mandates of the NCMRWF. Subsequently, the seamless prediction system of Unified Model (UM) at a range of scales is employed for a step-change in the severe weather prediction.

Convective-Scale model : A convective scale model covering Indian domain with a gridded length of 4km is setup for generating 75hour forecast based on 00 UTC and 12 UTC initial conditions. The model employs NASA Shuttle Radar Topographic Mission (SRTM) 90m digital elevation map orography. It has a rotated latitude-longitude horizontal grid with Arakawa-C staggering and a terrain-following hybrid vertical coordinate with Charney-Philips staggering. The domain covers (62ºE-106 ºE; 6 ºS 41 ºN) with 1200x1200 grid points horizontally and 90 hybrid levels in the vertical with a top at 40km. Lateral boundary and initial conditions are downscaled from the operational NCMRWF Unified model at 12 km resolution.

The science configuration of this model is based on UK Met Office science version "Regional Atmosphere and Land version 3" (RAL3), operationalised from 1 October, 2022. The model explicitly represents deep convective processes within the resolved dynamics, and a comprehensive set of parameterization schemes from the earlier version includes a double moment cloud microphysics scheme (CASIM: Cloud-Aerosol Interactive Microphysics) and Bi-modal cloud generation scheme (BM) (Field et al., 2023). Five hydrometeor species such as cloud, liquid, rain, ice, snow and graupel are represented within a cloud by CASIM, while a sub-grid cloudiness and cloud water content are diagnosed by BM, allowing for two modes of variability in the entrainment zones. Other physical schemes used here follow the one defined in the earlier operational models at NCMRWF (Jayakumar et al., 2021a).

Figure 1 is one of the example prepared during, 'Mocha', severe cyclonic storm of the decade, where the snap shot of the real time forecast (t+48hour) of total lightning flashes, wind gust maxima, Dust AOD, mean surface dust and winds made available as a severe weather warning for India Meteorology Department (IMD), and other users. Here lighting flash is diagnosed from blended electric scheme depends on ice hydrometeor distribution and the dust forecast is from a prognostic mineral dust six bin scheme.

City-scale model : The DM-Chem is the city scale modeling system for every winter seasons to provide fog and visibility predictions, and also targeting air quality forecast from this year onwards. Physics change details are of the latest configuration of the DM-Chem (based on the RAL3) from the first release of this model (Jayakumar et al., 2021b). The emissions are prescribed by EDGAAR inventory in the outer 1.5 km nest and high-resolution IITM SAFAR inventory for the inner 330 m domain. The 24-hr forecasts of the previous day from the 1.5 km and 330 m models are used to initialize the chemistry and aerosols at the start of each cycle, whereas other fields are initialized and laterally mixed similar to the setup of a limited area Convective-Scale model.

Prognostic aerosol number and mass from United Kingdom Chemistry and Aerosols (UKCA) are coupled to CASIM for predicting number concentration of cloud and ice. A detailed urban canopy parameterisation, the Met Office Reading Urban Surface Exchange Scheme (MORUSES) is developed based on the local urban morphology (Anurose et al., 2022). The Delhi urban morphology data is derived

in collaboration with Indian Institute of Remote Sensing (IIRS) and is used for generating the empirical relationships between the urban morphological parameters and urban land-use fraction. Diurnally varying anthropogenic heat flux (QF) is estimated in the MORUSES scheme using a top-down, energy-consumption inventory method, which was derived based on socio economic statistics and energy consumption data for Delhi. Flexible interactive dry deposition scheme, treating 6 chemical species, is introduced in the land surface model of DM-Chem. The scheme considered three 'resistance' analogies to calculate deposition velocity such as Aerodynamic resistance (depends on the surface types), boundary layer resistance (depends on the species diffusion coefficient) and canopy resistance. The real-time daily biomass emissions datasets are initiated using Global Fire Assimilation System (GFAS) with one-day delayed.

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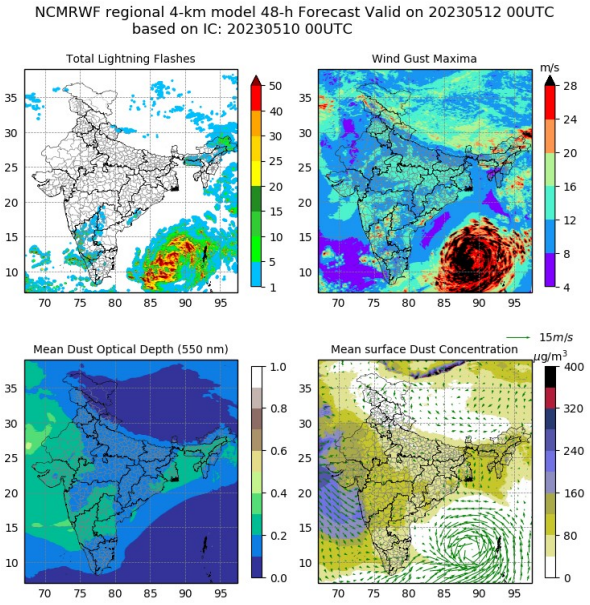

Figure 1. t+48 hour forecast from 4km model based on 20230510 00UTC initial condition.