High Resolution Rapid Refresh Data Assimilation System at NCMRWF (India) for Convection Permitting Models

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1. Introduction:

High impact convective weather events evolved with different microphysical and dynamical processes that operate at very small horizontal and time scales. To resolve their properties, the high resolution mesoscale models must be configured with horizontal resolution about 1 to 2 km as well as increase of frequency of assimilation cyclic. In recent years, the high temporal and spatial resolution observational data like Doppler Weather Radar (DWR) are available. Given the need for more accurate prediction of high impact weather systems in short-time scale, the High-Resolution Rapid Refresh (HRRR) Data Assimilation (DA) system for the convection permitting models is required.

The National Centre for Medium Range Weather Forecasting (NCMRWF) has set up a HRRR DA system with regional NCUM-R forecast model. Hourly updating HRRR system for the 1.5 km resolution convection permitting NCUM-R has been configured for three specific domains over the Indian region (Fig-1a; Routray et al. 2022). Indian Doppler Weather Radar (DWR) reflectivity observations from various locations are included in the HRRR data assimilation system. The high resolution four dimensional variational (4DVAR) analyses system is used to assimilate DWR radial velocity and reflectivity along with other observations (Dutta et al. 2019) in HRRR assimilation cyclic. The schematic diagram of the hourly HRRR assimilation cycle is given in Fig-1b. The lateral boundary conditions for the forecast model are obtained from Indian domain 4 km resolution operational NCUM-R. To assess the beneficial impact of 1hrly updated HRRR DA system a case study during convective event (7th June 2021) is presented here (Domain-2 in Fig-1a). Two setup numerical experiments such as CTL (without assimilation) and HRR (1hrly assimilation of DWR observations along with others) are presented. The assimilation cycle is started 6 hrs before from the model integration (Fig-1b).

2. Result of the case study:

The 24 hrs accumulated model simulated (day-1) and observed rainfall are shown in Fig-2(a-e). The observed rainfall clearly shows wide spread heavy rainfall about 8-16 cm around the vicinity of Agartala DWR (Fig-2a). From the CTL simulation (Fig-2d), the simulated heavy rainfall patches are shifted more northeast wards and not able to simulate the heavy rainfall over the eastern part of Agartala. However, the HRR (Fig-2e) is able to reproduce the orientation, pattern and volume of rainfall in better way than the CTL simulation. These features are reasonably well correlated with the observations. From Fig-2f, the ETS values are relatively high in the HRR experiment in all thresholds as compared to the CTL. It is clearly deduced that the high intensity of rainfall is well simulated by the HRR experiment than the CTL experiment. The gain of improvement is comparatively high in the higher threshold of rainfall (> 50mm) in HRR with respect to the CTL. Figure-3 shows various statistical skill scores of rainfall obtained through Contiguous Rain Area (CRA) method. The figure clearly depicts that the statistical skill scores are better represented in the HRR than the CTL experiments.

It can be concluded from the present study that the hourly updated cyclic assimilation in the high resolution modeling approach with assimilation of DWR observations has beneficial impact on the simulation of convective weather systems and these systems can be utilized for nowcasting and short range weather forecasting applications.

References:

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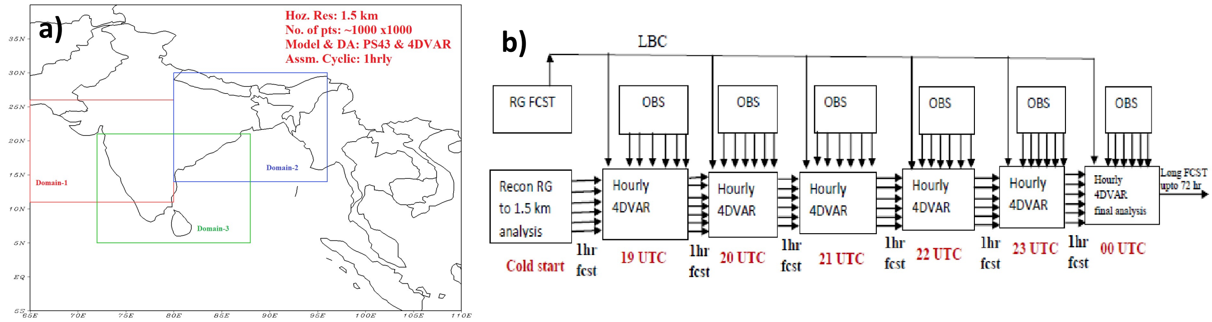

Fig-1: a) Configured different domains for HRRR DA over Indian region and b) Schematic diagram of 1hrly HRRR DA cycle.

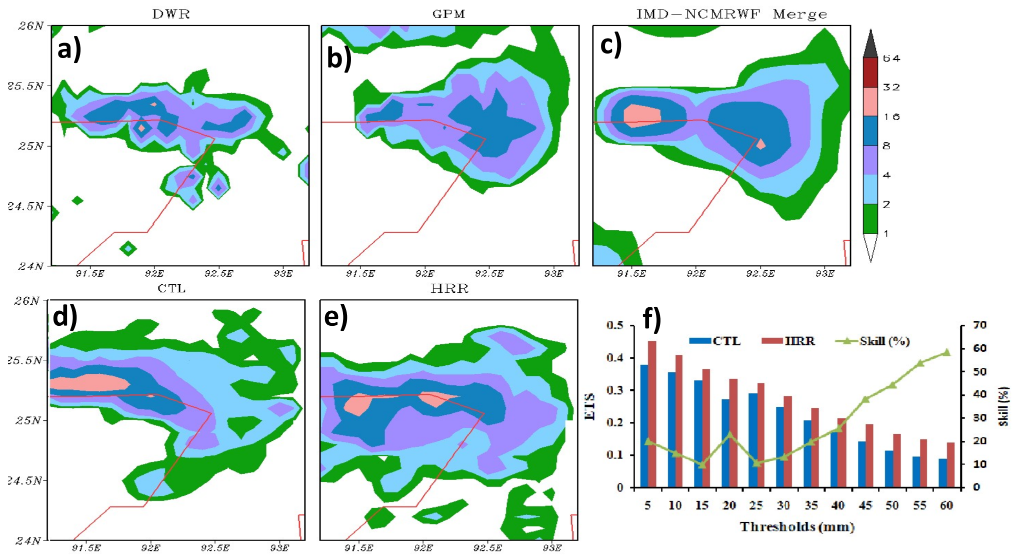

Fig-2: 24 hrs accumulated rainfall from (a) Agartala DWR; (b) GPM satellite; (c) merged satellite-rain gauge analysis (NCMRWF-IMD); (d) CTL; (e) HRR experiment valid at 03 UTC 8 June 2021 and f) ETS along with skill (%; line) of HRR over CTL of day 1 for different thresholds of rainfall (mm).

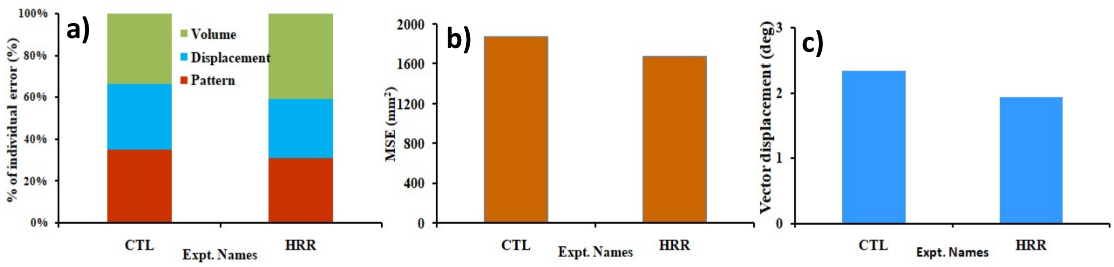

Fig-3: CRA verification of rainfall for threshold 10 mm a) % of contribution of volume, displacement and pattern errors; b) Total Mean Square Error (MSE) and c) vector displacement error (deg.) valid at 00 UTC 08th June 2021.