Assimilation of Indian DWR Radial Velocity in Regional NCUM-R Model

Devajyoti Dutta*, Ashish Routray, John P. George and V. S. Prasad
National Centre for Medium Range Weather Forecasting (NCMRWF), Ministry of Earth Sciences (MoES),
A-50, Sector-62, Noida UP-201309, India
*E-mail address: djyoti@ncmrwf.gov.in

1. Introduction:

The need for precise forecasting of severe weather events over the Indian region is on the rise. Over the past years, significant enhancements have been made in improving the predictability of high-impact weather events through the implementation of higher model resolutions (Dutta et al., 2018 & 2019). Prior research conducted by many authors has provided evidence of the beneficial impact of assimilating Doppler Weather Radar (DWR) data in the high-resolution Numerical Weather Prediction (NWP) systems, particularly of convective-permitting scales. These studies have shown positive outcomes in terms of influencing structural fields, which in turn have the potential to enhance the accuracy of convection evolution and precipitation forecasts. Here we are presenting a case study which represents some of the efforts of National Centre for Medium Range Weather Forecasting (NCMRWF, India) for improving the high resolution NWP forecast by including the Indian DWR datasets in its high-resolution regional NWP system.

The NCMRWF Unified Model (NCUM-R) is currently in operational at NCMRWF with a horizontal grid spacing of approximately 4 km, encompassing 1200 x 1200 grid points and 80 vertical level within the domain. In this study, the regional data assimilation system utilizes the 4DVAR (Four-Dimensional Variational) method to generate the initial conditions for the NCUM-R forecast model (Courtier et al. 1994). To assess the beneficial impact of DWR radial velocity assimilation, a case study (26–29 July 2016) is presented. This period represents an active period of south-west monsoon season, with heavy to very heavy rainfall occurred over many parts of India. Two numerical experiments are carried out viz. CNTL (assimilation of convectional and non-conventional observations) and RAD (assimilation of observations in CNTL plus DWR radial velocity).

2. Results:

The Quality Control (QC) procedures are developed for DWR radial velocity which involves analyzing the standard deviation and non-meteorological echoes in the DWR radial velocity data to identify and eliminate low-quality data. To ensure data accuracy, an Observation Processing System (OPS) is employed for further quality control. Following the OPS procedure, Super Observations are generated by combing the nearby observations. Figure 1a–c illustrates the raw observations obtained from the Chennai DWR station, including the deviation of the observation from the background (O – B), as well as the super-observations utilized in the assimilation cycle respectively. In the assimilation cycle, DWR observations from 12 stations in India operating in varying frequency bands (S-band, C-band, and X-band) were considered. The details of the DWR stations over Indian region are shown in Figure 1d. Figure 2a–c presents the merged data from Global Precipitation Measurement (GPM) satellite-rain gauges and 24-hour accumulated rainfall from both simulations. The RAD experiment (Figure 2c) effectively simulates the rainfall amount and spatial distribution across all regions compared to the CNTL experiment (Figure 2b). Figure 2d displays the time series of 1-hourly accumulated model-simulated rainfall from the CNTL and RAD analyses, along with observations from the GPM satellite. It is evident from the figure that the RAD simulation closely matches with the rainfall pattern observed by GPM throughout the forecast hours in all cases. In summary, the RAD experiment demonstrates better performance in simulating rainfall patterns and closely aligning with observations, offering valuable insights into analysis forecast system and understanding precipitating system in the studied regions.

References:

Courtier, P., The´paut, J. N., & Hollingsworth, A. (1994). A strategy for operational implementation of 4D-Var, using an incremental approach. Quarterly Journal of the Royal Meteorological Society, 120(519), 1367–1387.

Dutta, D., Routray, A., Preveen Kumar, D., George, John P., & Singh, V. (2018). Simulation of a heavy rainfall event during southwest monsoon using high-resolution NCUM-modeling system: A case study. Meteorology and Atmospheric Physics. 131, pages1035–1054 (2019).

Dutta D, Routray A, Preveen Kumar D, George JP (2019) Regional data assimilation with the NCMRWF unified model (NCUM): impact of doppler weather radar radial wind. Pure Appl Geophys 176:4575–4597.

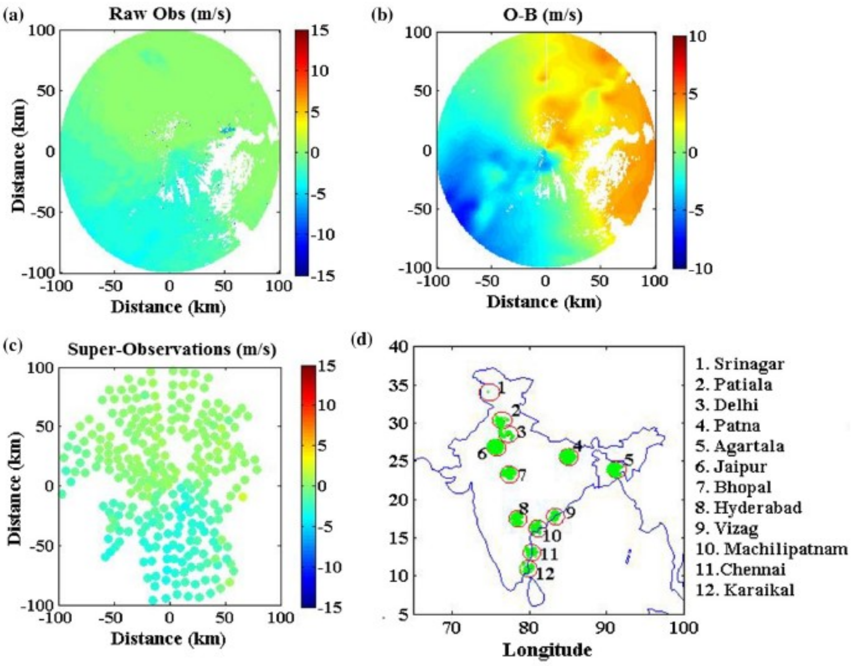

Fig 1: a) Raw DWR observation; b) observed minus background (O – B); c) super-observations from the Chennai DWR station (as an example on 00 UTC 26 July 2016); d) DWR stations (color in the circle represent the amount of observations received).

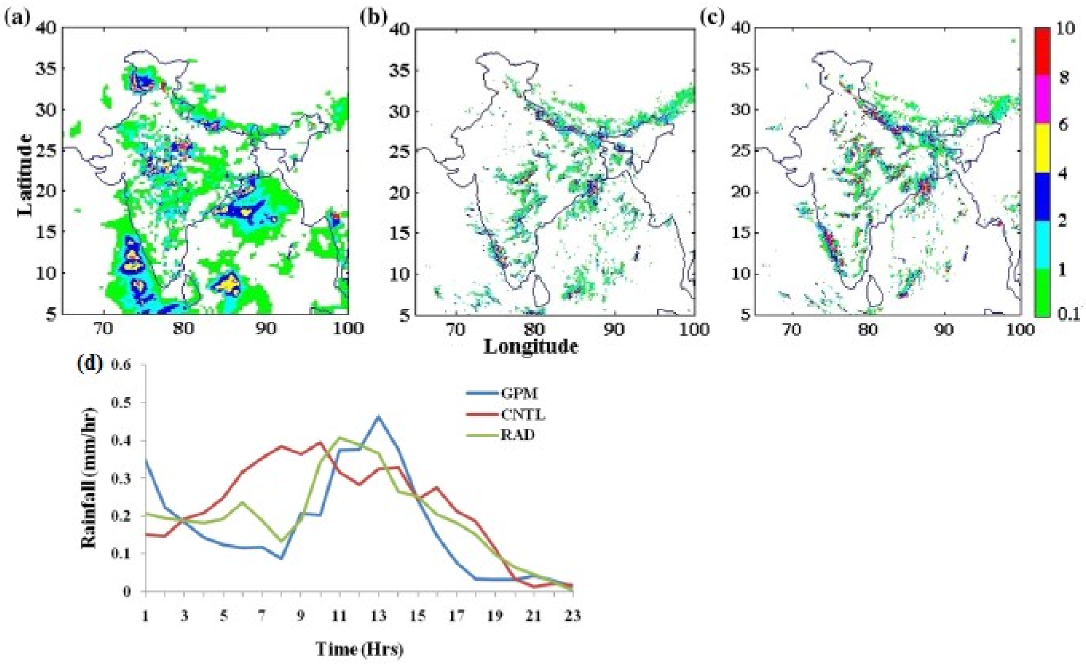

Fig 2: Twenty four hours of accumulated rainfall (cm) of 26th July 2016 from a) merged satellite-rain gauge analysis (NCMRWF-IMD), b) CNTL and c) RAD for day 1 valid at 03 UTC 27 July 2016 d) Hourly variation of area-averaged (20^0–37^0N; 75^0–82^0 E) rainfall of day 1 from GPM, CNTL and RAD simulations of 27 July 2016.