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Real-time radar radial velocity assimilation experiments in a pre-operational framework in North China

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A forecast system based on WRF and WRFDA (BJRUCv2.0) is currently developing in Beijing Meteorological Bureau of China with the purpose to improve local and regional short-term meteorological forecasts for potentially dangerous weather events in North China. And assimilation of radial velocities from Doppler radar network is also a significant new feature. In recent years, research efforts have been carried out to develop the radar data pre-processing system and assimilating strategy for the purpose of future operational implementation. And real-time radial velocity assimilation experiments have been performed in the summer of 2011.
There are 4 S-band and 2 C-band Doppler radars, comprising the operation radar network in North China. A radar data preprocessing system was built on the base of the counterpart of VDRAS with the functions to perform quality control, mapping and error statistics.
A two-step scheme is designed to assimilate radial velocity along with other conventional observations, described as follows:
Step i: assimilate conventional observations including sounding, synop, ship, buoy, metar, amdar, etc., utilizing 3 times out-loop of minimization in WRF3DVAR with the regular variance and length scales (=1)of BE.
Step ii: if radial velocity observations can be searched in the assimilation time window (1.5hr), they'll be assimilated against the analysis generated after step 1 as the 1-st guess with the rescaling variance and length scales (= 0.5). In this step, radial velocity is the only type of data to be assimilated.
The pre-operational experiments of BJRUCv2.0 with assimilation of radial velocity are performed during the summer season from 1 June to 31 August, 2011. In order to clearly identify the impact of radial velocity, another Domain2 experiments sharing the identical configurations with BJRUCv2.0 but without assimilation of radial velocity is also setup and runs simultaneously along with BJRUCv2.0 during the period. In this research, we name the two experiments as '3km-radar' and '3km-noradar' respectively. The forecast length of 3km-noradar is only 12hrs.
Monitoring on quality of the data entering the DA system is also an important part for an operational assimilation framework. Statistics are performed with the archived minimization results for each run during the pre-operational experimental period to further check the quality of assimilation for radial velocity, i.e. only the results from STEP ii are considered.
The numbers of valid radial velocity observations available for data assimilation vary greatly from several to more than fifty thousand by run to run. One reason of the variation is due to the data loss caused by instrumental or communicating errors of radar and mostly, is due to the change of weather condition. Obviously, for the runs with much more data available for assimilation, the percentages of the data actually ingested by WRFDA are much lower. For example, there're totally 32,080 radial velocity observations available at 15UTC, Aug 23 and only 59.8% of them are assimilated. But for the run at 03UTC of the same day, 95.97% of the 18669 observations are assimilated. It's easy to understand that much more radial velocity data can be acquired when convections are approaching or occurring than clear skies.
According to the data-screening scheme in WRFDA, the observations with innovation vectors larger than five times of its observation error will be discarded. As the observation error of radial velocity assigned by the radar pre-processing system is mostly around 1ms-1, no innovations more than ±5 ms-1 will be introduced into the model system for each radial velocity observation. Actually, after minimization, most of the RMSEs of final analysis against observation (OMA) are reduced to nearly one-half of OMB, the domain-averaged innovation values mostly between 2-3 ms-1, which is reasonable and means that the assimilation process does work properly.
In this section, the evaluations for cycling forecasts for both experiments are detailed. Excluding the missing forecasts due to hardware failure and script errors on June 10-18, there are totally 636 cycling samples involved in the assessment for each experiment. The evaluations are performed against conventional surface and radiosonde observations. 1-hr precipitation forecasts are verified point-to-point against the 1-hr accumulated rainfall observed

by the AWS network and also against the gridded quantitative precipitation estimations from radar mosaic results.

VERIFICATION AGAINST CONVENTIONAL OBSERVATIONS

The domain-averaged forecast verification scores calculated against surface observations are shown in Fig. 4. Evidently, no significant impact for 2-m temperature is introduced by the assimilation of radial velocity. But the scores for 10-m wind are slightly degraded during the first 0-6hr integration.

PRECIPITATION VERIFICATION

CSI and BIAS scores are calculated against the intensive 1-hr AWS rain-gauge observations with quality control. Fig 6 shows the results of the thresholds of 1.0mm/hr and 10.0mm/hr, respectively.

For smaller thresholds such as 1mm/hr, the improved precipitation forecast skills with larger CSI scores and slightly modifications of under-prediction occur at the beginning stage of forecast. But for larger thresholds (10mm/hr), the precipitation forecast skills are generally improved with larger CSI and less over-prediction. More detailed case studies will be performed in the future.

In this paper, preliminary results of real-time Doppler radar radial velocity assimilation experiments during the summer season of 2011 in a pre-operational framework based on WRF/WRFDA in North China is presented, along with the brief introduction of the radar network, data pre-processing and assimilation strategy. From the 3-month results, no significant improvements can indeed be found against conventional observations because of the localized impact of radial velocities in space and time. But more positive signals are found from precipitation forecast skills, especially for short-term forecasts and larger thresholds.