VARIATIONAL DATA ASSIMILATION OF DUAL-POLARIMETRIC RADAR OBSERVATIONS AND ITS IMPACT

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ABSTRACT

It is generally known that precise initial condition describing the current state of the weather is not available and difficult to obtain. The error in the initial condition can substantially influence the accuracy of the numerical weather prediction (NWP) forecast. The purpose of data assimilation is to incorporate observational data into the NWP models toward improving the quality of the initial condition. It is an ill-posed inverse problem since the available observations are not sufficient to determine all the degrees of freedom in the numerical models. Variational data assimilation, a common assimilation methodology today, involves finding the analysis of the model initial condition by minimizing a cost function by measuring its distance to the background and to the observations.

Owing to the significant progresses in the high-resolution numerical modeling and data assimilation techniques, the numerical prediction of especially convective storms has been improved substantially. However, it is still a big challenge to predict accurately the evolution of convective events, especially on the per-storm scale (Kain et al. 20113) and related to quantitative precipitation forecasts (QPF). Studies have shown that radar data assimilation can help with short-term prediction of convective weather by providing more accurate initial condition (Sun 2005).

Dual-polarimetric (dual-pol) radar typically transmits both horizontally and vertically polarized radio wave pulses. From the two different reflected power returns, information on the type, shape, size, and orientation of cloud and precipitation microphysical particles are obtained, more accurate measurement of liquid and solid cloud and precipitation particles can be provided (Seliga and Bringi 1976). With the upgrade of the current NWS WSR-88D radar network to include dual-pol capabilities started in 2011, the dual-pol radar network will cover the whole continental U.S. in near future. The assimilation of dual-pol radar data is however challenging work. At present, not many guidelines have been provided on dual-pol radar data assimilation research. It is our goal to examine how to best use dual-pol radar data to improve forecast of severe storm and forecast initialization.

Our presentation will highlight our recent work on assimilating the dual-pol radar data for real case storms. In our study, high-resolution Weather Research and Forecasting (WRF) model and its 3-Dimensional Variational (3DVAR) data assimilation system are used to assimilate the dual-polarimetric radar data collected by the C-band Advanced Radar for Meteorological and Operational Research (ARMOR) radar [located at Huntsville International Airport (34.6804°N, 86.7743ºW)]. Our recent research explores the assimilation of the horizontal reflectivity (Z_H), differential reflectivity (Z_{DR}), specific differential phase (K_{DP}), and radial velocity (VR) for convective storms and snowfall events through the development of new forward operators.

An example of our recent study is shown here in Fig.1. A WRF control run (CTRL) is conducted with no radar data assimilation. Two data assimilation experiments (OPER1 and OPER2) are

conducted using different radar forward operators of dual-pol radar variables with warm-rain microphysical processes. Figure 1 shows reflectivity from the NWS WSR-88D radar image, and 2 hour forecast from the model control run and different data assimilation experiments. As shown in the figure, after the assimilation of ARMOR variables, the main structure of the storm has been captured in the forecast. The intensity and location are very close to the observed one, even though the size of the storm is still smaller than the observed echo.

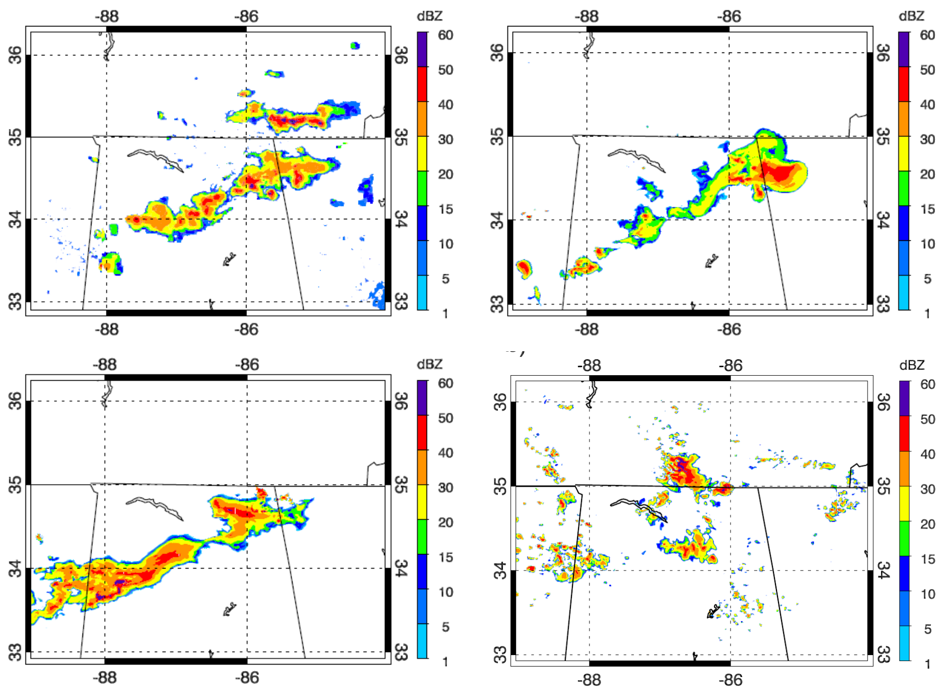

Figure 1 Radar reflectivity at 2 km altitude around 2200 UTC 23 June 2008 from NEXRAD radar image (top left) and forecast from data assimilation experiment OPER1 (top right), OPER2 (bottom left), and the control run (bottom right).

Details of the methodology of data assimilation, the influences of different dual-pol variables on model initial condition and on the short-term prediction of precipitation, and additional results from our ongoing work on the assimilation of dual-pol radar data for snowstorms, will be presented at the symposium.