Effect of Four Dimensional Variational Data Assimilation (4DVAR) Method on Predictability of Heavy Rainfall

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Data assimilation has been used to improve predictability of mesoscale models by reducing uncertainty in initial condition. Three Dimensional Variational (3DVAR) method is usually used for assimilating observational data due to its simplicity. Over the Korean Peninsula, high-resolution asynoptic observational data such as radar data are available. Radar radial velocity and reflectivity data have very high spatial and temporal resolution, and they can provide storm-scale information with mesoscale model. To assimilate high-resolution data efficiently, more sophisticated data assimilation method such as Four Dimensional Variational (4DVAR) method is necessary. Static background error covariance is used and all observational data are assumed to be at analysis time in 3DVAR. However, flow-dependent background error covariance is used implicitly and observational data are assimilated at their observation times in 4DVAR.

To investigate effect of 4DVAR on predictability of heavy rainfall over the Korean Peninsula, ten heavy rainfall cases occurred in recent three years (2006-2008) were selected. Weather Research and Forecasting (WRF) model and its variational data assimilation system, WRFVAR were used in this study, and radar radial velocity data were assimilated. For each case, four data assimilation experiments were conducted: CONTROL (no data assimilation), 3DVAR, FGAT (First Guess at Appropriate Time), and 4DVAR. FGAT outperformed 3DVAR for most cases because asynoptic observational data were compared to background extrapolated to the observation time. For most cases, 4DVAR improved predictability of heavy rainfall compared to FGAT because flow-dependent background error covariance was used in 4DVAR. Additionally, sensitivity to the number of outer loops was investigated by increasing the number of outer loops to 2, 3, and 4. For both 3DVAR and 4DVAR methods, increase in the number of outer loop executed resulted in better quality of background and enhanced predictability of heavy rainfall.

Keywords: WRF, 4DVAR, radar data, heavy rainfall, predictability, outer loop

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