A Comparison of GSI-based EnKF and 3DVar for Multi-scale Data Assimilation and Prediction of the Genesis of an MCS over the Continental US

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Early studies of storm-scale radar data assimilation (DA) have shown promising results using the Ensemble Kalman Filter (EnKF [1]) [2,3,4]. However, studies using real data cases in complex heterogeneous environments are still very limited. Successful assimilation and prediction of such cases will require the assimilation of observations at multiple scales so that both the storm itself and its associated environment can be analyzed properly. One advantage of the EnKF compared to computational inexpensive 3DVar is its ability to estimate the error covariance at multiple scales flow-dependently through the ensemble covariances. The GSI-based EnKF has contributed to improve the global forecasts by GFS and hurricane forecasts by HWRF through the hybrid data assimilation system. The goal of this study is to extend the GSI-based EnKF for the convective storms over the US and explore its viability for Multi-scale data assimilation and prediction via comparing with the GSI 3DVar.

In this study, a nested data assimilation method is used to assimilate multiscale observations, including both conventional and radar data. For the outer domain, conventional observations are assimilated every 3 hours during a 3-day period with a 12km grid spacing. For the inner domain, radar observations are assimilated every 5 minutes during a 3 hour period. The inner domain was run with a convection permitting resolution (4km), which is nested within the last cycle of the outer domain. The outer domain cycle provides the lateral boundary conditions for the inner domain cycle. Ultimately, it is hoped that such an approach can provide a viable framework for a unified, multi-scale, high resolution data assimilation and ensemble forecast system. Two parallel experiments, using the GSI based EnKF and 3DVar respectively were conducted and their results are compared. Both the EnKF and 3DVar were adjusted accordingly for the inner and outer domains where different scales were resolved.

A case study characterized by initially small storms that grow into a mesoscale convective system during the forecast period was adopted first. During the assimilation period, first guess innovations using GSI-based EnKF consistently outperform those using GSI based 3DVAR for both the outer and inner domain. The improved performance of EnKF is attributed to the more physically realistic flow-dependent and cross-variable error covariance. The advantage of EnKF is also reflected in a more accurate forecast of the evolution of the initial storms that develop into an MCS.

References

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