A Regional GSI-Based Coupled EnKF-3DEnVAR Hybrid Data Assimilation System for the Operational Rapid Refresh Forecasting System

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A coupled EnKF-3DEnVAR hybrid data assimilation system is developed for the U.S. operational Rapid Refresh (RAP) forecasting system. The three-dimensional ensemble-variational hybrid analysis system (3DEnVar) employs the extended control variable method, and is built on the NCEP operational Grid-point Statistical Interpolation (GSI) 3DVar framework. It is coupled with a recently developed EnKF system for RAP [1] which is used to update and provide to the 3DEnVar the ensemble perturbations. Recursive filters are used to realize covariance localization in both horizontal and vertical directions within the 3DEnVar.

The coupled hybrid system is evaluated with 3-hourly assimilation cycles over a 9-day spring period containing active convection. All conventional observations used by operational RAP GSI are included. To keep computational cost down for potential operational implementation, the hybrid system is run at 1/3 of the operational RAP resolution or about 40-km grid spacing, and its performance is compared to parallel GSI and EnKF runs using the same data sets and resolution. Short-term forecasts initialized from the 3-hourly analyses are verified against sounding and surface observations.

When equal weights are given to the static background error covariance and the flow-dependent covariance derived from 40-member ensemble, the hybrid system outperforms corresponding GSI and EnKF. When the recursive filter coefficients are tuned to achieve a similar height dependency of vertical localization as in the EnKF, the hybrid results are close to those of EnKF. With 20 ensemble members, EnKF, GSI and hybrid with half ensemble covariance perform in ascending order, showing the advantage of the hybrid for small ensembles. Two-way coupling between EnKF and hybrid did not show noticeable improvement over one-way coupling for the testing period. Precipitation forecast skills on the downscaled 13-km RAP grid from the hybrid analyses are better than those from GSI analyses. Dual-resolution results where the hybrid EnVar analyses are performed on the 13-km RAP grid will also be presented at the symposium.

References

[1] K. Zhu, Y. Pan, M. Xue, X. Wang, J. S. Whitaker, S. G. Benjamin, S. S. Weygandt, and M. Hu, "A regional GSI-based ensemble Kalman filter data assimilation system for the Rapid Refresh configuration: Testing at reduced resolution," *Mon. Wea Rev.*, Accepted, 2013.