The ensemble-variational method using observation space localization

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In the ensemble Kalman filter (EnKF), localization can be applied for correlations between model variables, called model space localization, or for correlations between model variables and observations, called observation space localization. Like EnKF, the ensemble variational method (EnVAR) also uses ensemble forecast but in the variational context. Since EnVAR is established with a cost function in the model space, a natural choice for localization in EnVAR is model space localization. By some modifications this study shows that observation space localization can also implemented in EnVAR. Furthermore, when observation space localization is applied, the adjoint of the Jacobian of observation operator is not needed. Although the method still requires the Jacobian of observation operator, this matrix can be replaced by its finite-difference approximations.

EnVAR using observation space localization enables a fair comparison between model space localization and observation space localization in a unified framework. Another fair comparison that can be performed is a comparison between EnVAR and other EnKF methods that employ observation space localization like local ensemble transform Kalman filter (LETKF). Here the same localization length scales can be applied in both methods and the verification scores reveal the difference due to the methods themselves.

A four-dimensional EnVAR system (NHM-4DEnVAR) was developed using the Japan Meteorological Agency limited-area operational model NHM. An LETKF system was run in parallel to provide forecast perturbations for NHM-4DEnVAR. Real observation experiments were carried out for the August in 2014 over a domain covering entire Japan. When compared against LETKF, EnVAR was shown to outperform LETKF. In the EnVAR framework, observation space localization using the horizontal localization length scale of 250 km was slightly better than model space localization below 500 hPa. In contrast, above 500 hPa model space localization was better than observation space localization considerably.

Keywords: EnVAR, model space localization, observation space localization, LETKF, NHM