Ensemble-variational assimilation with constrained non-stationary spatial convolutions

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Abstract

We propose a new approach to hybrid ensemble-variational assimilation based on direct estimation of a square root, W, of the prior covariance matrix. The W matrix is a spatial convolution filter constrained to model slowly varying in space covariances. It is estimated online by (1) applying a spatial multi-scale bandpass filter to ensemble perturbations, (2) estimating a local spectrum from the ensemble band variances, and (3) converting the local spectra to the rows of W. The estimation of the local spectra is regularized with climatological statistics and can be done in a scale-dependent manner. The estimation scheme can be efficiently parallelized.

The estimated online W matrix is used in a variational analysis scheme. The scheme is fast because a square root of the prior covariance matrix is known to be an efficient preconditioner. The scheme does not require localization.

The technique was tested in static simulation experiments with synthetic data on circular and spherical spatial domains. With a reasonable degree of spatial non-stationarity, the new analysis outperforms the classical covariance-localized analysis for ensemble sizes up to 100. With the ensemble size of 10, the RMSE of the new analysis is 3-4 times closer to the RMSE of the best possible analysis (which has access to the true spatially non-stationary covariance matrix) than the RMSE of the covariance-localized analysis. The performance of the new technique in cycled data assimilation experiments on a 1D domain will be presented at the symposium.

Keywords: ensemble variational filter, EnKF, regularization, spatial convolutions

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