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Multiscale ensemble methods for large data assimilation problems

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Ensemble approaches to environmental data assimilation offer convenience and flexibility, as well as the ability to deal with nonlinearities. However, they are computationally demanding and often not practical for large problems. In addition, when ensemble methods rely on small ensemble sizes the effects of sampling error can be significant. Traditional spatial localization methods for dealing with sampling artifacts can have the effect of suppressing valid long-range correlations, leading to unrealistic estimates. This paper describes a new multiscale approach to ensemble estimation that is very efficient and also is able to reduce the detrimental impacts of sampling error. When implemented as a sequential filter the estimation procedure divides into a traditional ensemble forecasting step and a multiscale update. The update compactly represents global statistical properties such as covariances with local relationships between nodes defined on a tree. This greatly reduces the computational effort needed to update large state vectors with large numbers of measurements. The structure of the tree used for the update may be designed to filter noise caused by sampling error while preserving physically valid long-range correlations. The computational and filtering capabilities of the algorithm are illustrated with a large-scale nonlinear computational example.