Accelerating an ensemble of variational data assimilations with randomized preconditioning

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Abstract

Data assimilation aims at estimating the state of a dynamical system by fusing a prior estimate with sparse and noisy observations of the system while accounting for their respective uncertainties. This process is essential for determining model initial conditions in numerical weather prediction. In this talk, we explore an ensemble approach to variational data assimilation for uncertainty estimation, which involves solving multiple perturbed systems of linear equations simultaneously. These systems are large scale, include coefficient matrices that are not available explicitly, and are subject to stringent constraints on when the computations have to be finished. Constructing efficient preconditioners is thus of high importance. We describe randomized algorithms for low-rank matrix approximation that are used to construct the preconditioner, and show that the ensemble structure can be exploited to improve the approximation quality via a specific choice of the sketching matrix. The effectiveness of this preconditioner is evaluated through numerical experiments with a simplified atmospheric model and a data assimilation frameworks based on the Object Oriented Prediction System developed by a network of meteorological institutions.

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