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Highly efficient parallel Kalman smoothing for re-analysis

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Various forms of Kalman filtering, especially different types of Ensemble Kalman filters and hybrid variational/ensemble Kalman filters, have become popular in geophysical data assimilation. Kalman filters work well but they have a characteristic defect in that they leave behind discontinuous model trajectories that do not correspond to physically consistent and continuous model states, and are also less accurate than optimal smooth trajectories. This is a problem in areas such as re-analysis of climate history. For that reason, a smoothing operation that is consistent with the corresponding Kalman filter algorithm is highly desirable.

We have compared the performance on parallel computers and resulting model trajectories and corresponding model errors of two advanced Kalman smoothers, the Fixed Interval Kalman Smoother (FIKS) and the Variational Ensemble Kalman Smoother (VEnKS). The latter is based on the Variational Ensemble Kalman Filter (VEnKF), a hybrid variational-ensemble Kalman filter. The comparison is done using the Lorenz95 model and a random walk based 2D advection model, so that the resulting similarities and differences in performance, forecast skill and the quality of the ensuing model trajectories can be clearly understood and discerned in subsequent analysis.

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