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Application of the iterative ensemble Kalman smoother to a reduced-order air quality model

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The joint estimation of state variables and parameters of geophysical models is a recurring issue for which both ensemble filtering and variational data assimilation methods have proven useful. However, they both have well-known advantages and drawbacks. In this context, an ensemble variational (EnVar) method, namely the iterative ensemble Kalman smoother (IEnKS) has been introduced. It is based on an adjoint model-free variational, but flow-dependent, scheme. Using a low-order chaotic model, it was previously shown to outperform the ensemble Kalman filter and 4D-Var, especially in pronounced nonlinear regimes [1]. Therefore, this EnVar method is well suited to tackle the problem as it benefits from both the ensemble filtering and variational approaches.

In order to assess its performance in the field of atmospheric pollution, a model with 6 chemically reactive species has been coupled to the Lorenz-95 model which represents an advective wind. This model, whatever limited and simplified, simulates ozone chemistry in the lower troposphere with the online simulation of the wind, allowing us to observe feedbacks between these elements. In this potentially strongly nonlinear context, we have performed experiments to estimate the state of the system as well as the forcing parameter of the wind and the emissions of the chemical compounds. We have studied the added value and performance of the IEnKS over the ensemble Kalman filter and 4D-Var with this model.

REFERENCES:

[1] Bocquet, M., Sakov, P., 2013. Joint state and parameter estimation with an iterative ensemble Kalman smoother. Nonlinear Processes in Geophysics 20 (5), 803–818.