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Ensemble Variational Assimilation as an ensemble estimator

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Most of the atmospheric and ocean Data Assimilation (DA) schemes rely on the Best Linear Unbiased Estimation (BLUE). Since BLUE is sub-optimal if the errors of assimilation are non-Gaussian and because of the inherent non-linearity of the models the call for full and optimal Bayesian data assimilation becomes necessary. To improve the ability to handle non-linear and non-Gaussian evolving dynamics, new ways of adapting 3D- and 4D-Variational method into the Particle Filter (PF) or the Ensemble Kalman Filters (EnKF) with non-differentiable observation operators have been proposed.

We seek to objectively evaluate an Ensemble-based Variational Assimilation as an ensemble estimator. First, we test the scheme on the space-periodic Kuramoto-Sivashinsky (K-S) equation,

$$\begin{cases} ut = -\mu^4 ux^4 - \nu^2 ux^2 - uux, \ \ \forall x \in [0, L], \ t > 0, \text{and } \mu, \nu \in^+ \\ \\ \quad {}^i x^i u(x + L, t) = {}^i x^i u(x, t), \ \text{for } i = 0, 1, 2, 3, \ \text{and } \forall t > 0 \\ \\ \quad u(x, 0) = u_0(x), \ \forall x \in [0, L] \end{cases}$$

As a model, the K-S equation plays an important role as a low-dimensional prototype for complicated fluid dynamics systems, due to its chaotic pattern forming behavior. Second, we numerically measure the impact of the non-linearity and non-Gaussianity on the ensemble-based variational data assimilation method solutions. We also examine the impact of the non-linearity and non-Gaussianity on the Bayesian characteristic of the estimation. Results of the numerical tests are discussed and conclusions are drawn .