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Testing particle filters on convective scale dynamics

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Particle filters have been developed in recent years to deal with highly nonlinear dynamics and non Gaussian error statistics that also characterize data assimilation on convective scales. In this work we explore the use of the efficient particle filter (P.v. Leeuwen, 2011) for convective scale data assimilation application. The method is tested in idealized setting, on two stochastic models. The models were designed to reproduce some of the properties of convection, for example the rapid development and decay of convective clouds.

The first model is a simple one-dimensional, discrete state birth-death model of clouds (Craig and Würsch, 2012). For this model, the efficient particle filter that includes nudging the variables shows significant improvement compared to Ensemble Kalman Filter and Sequential Importance Resampling (SIR) particle filter. The success of the combination of nudging and resampling, measured as RMS error with respect to the 'true state', is proportional to the nudging intensity. Significantly, even a very weak nudging intensity brings notable improvement over SIR.

The second model is a modified version of a stochastic shallow water model (Würsch and Craig 2013), which contains more realistic dynamical characteristics of convective scale phenomena. Using the efficient particle filter and different combination of observations of the three field variables (wind, water 'height' and rain) allows the particle filter to be evaluated in comparison to a regime where only nudging is used. Sensitivity to the properties of the model error covariance is also considered. Finally, criteria are identified under which the efficient particle filter outperforms nudging alone.

References:

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