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 efficient particle filter (P.v. Leeuwen, 2010) for convective scale data assimilation application. The method is tested in idealized setting, on stochastic models that are designed to reproduce some of the properties of convection, for example rapid development and decay of convective clouds.

The first model is a simplified 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 with respect 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. Furthermore, even a very weak nudging intensity brings notable improvement over SIR. But the results appear to be highly dependent on the observation density used, and on the simplicity of this model.

Another testbed for the particle filter is a modified version of a shallow water model (Würsch and Craig 2013), which contains more realistic dynamical characteristics of convective scale phenomena. Nudging only the velocity among the three field variables (wind, water 'height' and rain) reveals the particle filter to perform comparably well to a regime where only nudging is used. We show that too strong nudging penalizes the results for the unobserved variables. We further show that the efficient particle filter becomes more accurate for spatially scarce observations, and we investigate the effect of nudging different variable fields.

References:

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