Ensembles of 4DVars and Their Use Within a Particle Filter Context

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The standard implementation of particle filters (using sequential importance resampling) is unfeasible in large dimensional geophysical systems. The ensemble of particles is known to collapse (degeneracy phenomenon) when the number of independent observations is large [1,3]. An alternative is to use proposal densities other than the likelihood. In particular, [2] and [3] present an efficient particle filter which combines two elements (a) nudging towards future observations and (b) a step for the stabilization of the particle weights.

In this work we explore another type of proposal density in which the nudging is 'optimal'. In this case, a 4DVar is performed in each one of the particles. Starting with the linear case, we explore the statistical characteristics of these families of 4DVars and their use within the particle filter setting. In the nonlinear case, these characteristic are not straightforward; we try to shed light in these issues.

We start in a perfect model setting using ensembles of strong constraint 4DVars. We then introduce model error and study the characteristics of families of weak constraint 4DVars, but also strong constraint 4DVars where the model error is ignored in the cost function (as is often done in practice). The consequences on the weights of the particles are analyzed, and recommendations on the use of 4DVars as proposal densities will be presented.

References

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