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A particle filter/smoother with local updating

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The recent application of particle filters in nonlinear geophysical flows is hampered by the relatively low number of particles that represent the model probability density. Several methods have been proposed to circumvent this problem. A popular approach in methods that use inversions, like the Ensemble Kalman filter, is that measurement are allowed to have only influence in a limited area. In this way the updating of the ensemble is done locally, leading to an effective increase of the ensemble size of the order of the number of particles times the ratio of total domain size to influence region of observations. In practical applications ensemble size increases of a factor 100 or more have been achieved. The inverse nature allows the new particles to be spatially smooth mixtures of the old particles because the error covariances are smooth. Another approach that gains interest uses a background probability density from which the ensemble pdf should not deviate too much. This leads again to an inverse problem producing spatially smooth new particles. Disadvantage of the inversions is that the problem has to be linear, or linearized and solved iteratively.

We propose to tackle the nonlinear filter problem using two methods to increase the efficiency of the ensemble without linearizations. We will use guided sequential importance resampling with local updating. The 'guided' means that the observations are brought backward while increasing their error covariance, allowing one to guide the particles towards the true observations already at an earlier time. In importance sampling the relative weights of the particles in the pdf are changed according to the proximity of the particles to the observations. It can be shown that guiding in this way means no approximation to the full problem by simple reweighting procedures. Furthermore, we will apply local weighting. Several resampling methods to obtain spatially smooth new particles are discussed in an application of a highly nonlinear multi-layer primitive equation model of the ocean circulation.