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A combined Local Particle and Local Ensemble Kalman Filter for large nonlinear systems

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One of the big problems in particle filtering in large-scale geophysical systems is the relatively small ensemble size. In the Ensemble Kalman Filter this problem is solved by localizing the update, i.e. only observations close to a grid point are used in the analysis of that grid point. In this way small spurious correlations over large distances do not degrade the analysis. Furthermore, the effective ensemble size increases because remote areas have independent updates. The analyzed ensemble members in the Ensemble Kalman Filter are smooth in space because neighboring grid points use overlapping observations, and the error covariances are smooth. In a Local Particle Filter the smoothness of the analyzed particles cannot be guaranteed, because the analysis redistributes the particles over the old particles according to their closeness to the observations, their weights. However, by choosing that particle with high weight that resembles the corresponding one in the Local Ensemble Kalman Filter the most, a smooth-in-space particle can be created. Furthermore, at grid points where all particles are far from the observations and details of the probability density function have little value, the method falls back on the Local Ensemble Kalman Filter directly. In this way we benefit from both methods: a truly nonlinear update when the model is behaving fine, and a first-order guess by the Local Ensemble Kalman Filter when the model is doing worse. The presentation will explain the method and show applications to a multi-layer primitive equation model of the ocean.