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Ensemble-Type Kalman Filter Algorithm conserving mass, total energy and enstrophy

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In a recent study (Zeng and Janjic 2016), we explored the effect on conservation properties of data assimilation using perfect model experiments with a 2D shallow water model preserving important properties of the true nonlinear flow. It was found that during the assimilation with the ensemble Kalman filter algorithm, the total energy of the analysis ensemble mean converges towards the nature run value with time. However, the enstrophy, divergence and energy spectra were strongly affected by the data assimilation settings. We tested the effects on the prediction depending on the type of error in the initial condition and showed that the accumulated noise during assimilation and the error of analysis are good indicators of the quality of the prediction.

Having in mind that the conservation of both the kinetic energy and enstrophy by momentum advection schemes in the case of non-divergent flow prevents a systematic and unrealistic energy cascade towards the high wave numbers, we constructed the ensemble data assimilation algorithm that conserves both energy and enstrophy. This is done by extending QPEns (Janjic et al. 2014) to allow for nonlinear constraints using, instead of quadratic programming, the sequential quadratic programming algorithm. Experiments with the 2D shallow water model show similar RMSEs of the algorithm without constraints and the algorithm with only the total energy constrained. The algorithm which constraints enstrophy as well as energy and enstrophy during data assimilation showed smaller RMSE to the one without the constraint on enstrophy. Similar behavior can be seen in the energy spectrum where algorithms which include the constraint on enstrophy are closer to the true spectrum, in particular for wavelengths between 200 km and 1000 km. The enstrophy constraint resulted in a reduction of noise during data assimilation. Finally, the algorithm, with both energy and enstrophy constraint showed the smallest error growth during the two weeks prediction period.

Janjic, T., D. McLaughlin, S. E. Cohn, M. Verlaan, 2014: Conservation of mass and preservation of positivity with ensemble-type Kalman filter algorithms, Mon. Wea. Rev., 142, No. 2, 755-773.
Zeng Y., T. Janjic, 2016: Study of Conservation Laws with the Local Ensemble Transform Kalman Filter, Q. J. R. Meteorol. Soc., 142:699, 2359–2372.