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Conservation laws and LETKF with 2D Shallow Water Model

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Numerous approaches have been proposed to maintain physical conservation laws in the numerical weather prediction models. However, to achieve a reliable prediction, adequate initial conditions are also necessary, which are produced by a data assimilation algorithm. If an ensemble Kalman filters (EnKF) is used for this purpose, it has been shown that it could yield unphysical analysis ensemble that for example violates principles of mass conservation and positivity preservation (e.g. Janjic et al 2014) .

In this presentation, we discuss the selection of conservation criteria for the analysis step, and start with testing the conservation of mass, energy and enstrophy. The simple experiments deal with nonlinear shallow water equations and simulated observations that are assimilated with LETKF (Localized Ensemble Transform Kalman Filter, Hunt et al. 2007). The model is discretized in a specific way to conserve mass, angular momentum, energy and enstrophy. The effects of the data assimilation on the conserved quantities (of mass, energy and enstrophy) depend on observation covarage, localization radius, observed variable and observation operator. Having in mind that Arakawa (1966) and Arakawa and Lamb (1977) showed that the conservation of both kinetic energy and enstrophy by momentum advection schemes in the case of nondivergent flow prevents systematic and unrealistic energy cascade towards high wave numbers, a cause of excessive numerical noise and possible eventual nonlinear instability, we test the effects on prediction depending on the type of errors in the initial condition. The performance with respect to nonlinear energy cascade is assessed as well.