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Weakly Constrained LETKF for Convective-Scale Data Assimilation

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Often physical properties of a system that we are modeling dictate plausible values of the initial conditions of our numerical models. Unfortunately, by using modern data assimilation techniques as the ensemble Kalman filter algorithm to obtain these initial conditions, physical property of non-negativity is frequently violated. To mitigate this sign problem and to simultaneously maintain the mass conservation, a new concept of combining weak constraints on mass conservation and non-negativity has been introduced in our recent paper (Janjic and Zeng 2021), with a focus on hydrometeor variables in convective-scale data assimilation. The algorithm is fast, easy to implement modification of the local ensemble transform Kalman filter that is able to weakly preserve both properties of mass conservation and non-negativity. In idealized experiments that assimilate radar data in non-hydrostatic, convection-permitting numerical model and update hydrometeor values, we show the benefit of the proposed approach on prediction of atmospheric water variables. Results show that both weak constraints successfully improve the mass conservation property in analyses and both reduce the biased increase in integrated mass-flux divergence and vorticity. Furthermore, the least biased increase is obtained by combining both constraints, and the best forecasts are also achieved by the combination.

Janjić, T., & Zeng, Y. (2021). Weakly constrained LETKF for estimation of hydrometeor variables in convective-scale data assimilation. Geophysical Research Letters, 48, e2021GL094962