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Avoiding drift related to linear analysis update with Lagrangian coordinate models

Yiguo Wang, Francois Counillon, and Laurent Bertino
Nansen Environmental and Remote Sensing Center (NERSC), Bergen, Norway

When applying data assimilation to Lagrangian coordinate models, it is profitable to correct its grid (position, volume). In isopycnal ocean coordinate model, such information is provided by the layer thickness that can be massless but must remains positive (truncated Gaussian distribution). A linear gaussian analysis does not ensure positivity for such variable. Existing methods have been proposed to handle this issue – e.g. post processing, anamorphosis or resampling – but none ensures conservation of the mean, which is imperative in climate application. Here, a framework is introduced to test a new method, which proceed as following. First, layers for which analysis yields negative values are iteratively grouped with neighboring layers, resulting in a probability density function with a larger mean and smaller standard deviation that prevent appearance of negative values. Second, analysis increments of the grouped layer are uniformly distributed, which prevent massless layers to become filled and vice-versa. The new method is proved fully conservative with e.g. OI or 3DVAR but a small drift remains with ensemble-based methods (e.g. EnKF, DEnKF, ...) during the update of the ensemble anomaly. However, the resulting drift with the latter is small (an order of magnitude smaller than with post-processing) and the increase of the computational cost moderate. The new method is demonstrated with a realistic application in the Norwegian Climate Prediction Model (NorCPM) that provides climate prediction by assimilating sea surface temperature with the Ensemble Kalman Filter in a fully coupled Earth System model (NorESM) with an isopycnal ocean model (MICOM). Over 25-year analysis period, the new method does not impair the predictive skill of the system but corrects the artificial steric drift introduced by data assimilation, and provide estimate in good agreement with IPCC AR5.