Hybrid covariance super-resolution data assimilation

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This work extends the concept of "Super-resolution data assimilation" (SRDA, Barthélémy et al. 2022)) to the case of mixed-resolution ensembles pursuing two goals: (1) emulate the Ensemble Kalman Filter while (2) benefit from high-resolution observations. The forecast step is performed by two ensembles at two different resolutions, high and low-resolution. Before the assimilation step the low-resolution ensemble is downscaled to the high-resolution space, then both ensembles are updated with high-resolution observations. After the assimilation step, the low-resolution ensemble is upscaled back to its low-resolution grid for the next forecast. The downscaling step before the data assimilation step is performed either with a neural network, or with a simple cubic spline interpolation operator. The background error covariance matrix used for the update of both ensembles is a hybrid matrix between the high and low resolution background error covariance matrices. This flavor of the SRDA is called "Hybrid covariance super-resolution data assimilation" (Hybrid SRDA). We test the method with a quasi-geostrophic model in the context of twin-experiments with the low-resolution model being twice and four times coarser than the high-resolution one. The Hybrid SRDA with neural network performs equally or better than its counterpart with cubic spline interpolation, and drastically reduces the errors of the low-resolution ensemble. At equivalent computational cost, the Hybrid SRDA outperforms both the SRDA (8.4%) and the standard EnKF (14%). Conversely, for a given value of the error, the Hybrid SRDA requires as little as 50% of the computational resources of the EnKF. Finally, the Hybrid SRDA can be formulated as a low-resolution scheme, in the sense that the assimilation is performed in the low-resolution space, encouraging the application of the scheme with realistic ocean models.