Super-resolution ensemble data assimilation

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Résumé

Increasing the model resolution can drastically improve the performance of a data assimilation system because model fields are in better agreement with high-resolution observations, the corrections are better sustained by the model and the covariances are improved with ensemble data assimilation methods. However, resolution increase yields a cubical increase of the computational cost. Here we propose a new algorithm to leverage high-resolution fields (HR) without the need of running an expensive HR model. Our method, called "Super-resolution data assimilation" (SRDA), combines an ensemble data assimilation system with machine learning. The neural network (NN) emulates an ensemble of HR fields from an ensemble of forecasts produced by a low-resolution (LR) model. This HR forecast is then used to assimilate the HR observations. The HR analysis field is interpolated back to the low resolution and integrated forward to the next assimilation cycle.
We test the approach with a quasi-geostrophic model representing simplified surface ocean dynamics for a model that has a resolution up to four times lower than the high-resolution observations and we use the Ensemble Kalman Filter data assimilation method. We show that SRDA outperforms the low-resolution data assimilation approach and a SRDA version with cubic spline interpolation instead of NN. The NN's ability to anticipate the systematic differences between low and high-resolution model dynamics explains partly the enhanced performance, for example by correcting the propagation speed of eddies. With a marginal increase in the computational cost, SRDA reduces error by 40% compared to the LR version and it approaches that of the HR version (13% larger).

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