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High-resolution Ensemble Kalman Fiter with a low-resolution model using a machine learning super-resolution approach.

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Going from low- to high-resolution models is an efficient way to improve the data assimilation process in three ways: it makes better use of high-resolution observations, it represents more accurately the small scale features of the dynamics and it provides a high-resolution field that can further be used as an initial condition of a forecast. Of course, the pitfall of such an approach is the cost of computing a forecast with a high-resolution numerical model. This drawback is even more acute when using an ensemble data assimilation approach, such as the ensemble Kalman filter, for which an ensemble of forecasts is to be issued by the numerical model.

In our approach, we propose to use a cheap low-resolution model to provide the forecast while still performing the assimilation step in a high-resolution space. The principle of the algorithm is based on a machine learning approach: from a low-resolution forecast, a neural network (NN) emulates a high-resolution field that can then be used to assimilate high-resolution observations. This NN super-resolution operator is trained on one high-resolution simulation. This new data assimilation approach denoted "Super-resolution data assimilation" (SRDA), is built on an ensemble Kalman filter (EnKF) algorithm.

We applied SRDA to a quasi-geostrophic model representing simplified ocean dynamics of the surface layer, with a low-resolution up to four times smaller than the reference high-resolution (so the cost of the model is divided by 64). We show that this approach outperforms the standard low-resolution data assimilation approach and the SRDA method using standard interpolation instead of a neural network as a super-resolution operator. For the reduced cost of a low-resolution model, SRDA provides a high-resolution field with an error close to that of the field that would be obtained using a high-resolution model.