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Using machine learning to correct model error in data assimilation and forecast applications

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Recent developments in machine learning (ML) have demonstrated impressive skills in reproducing complex spatiotemporal processes. However, contrary to data assimilation (DA), the underlying assumption behind ML methods is that the system is fully observed and without noise, which is rarely the case in numerical weather prediction. In order to circumvent this issue, it is possible to embed the ML problem into a DA formalism characterised by a cost function similar to that of the weak-constraint 4D-Var (Bocquet et al., 2019; Bocquet et al., 2020). In practice ML and DA are combined to solve the problem: DA is used to estimate the state of the system while ML is used to estimate the full model.

In realistic systems, the model dynamics can be very complex and it may not be possible to reconstruct it from scratch. An alternative could be to learn the model error of an already existent model using the same approach combining DA and ML. In this presentation, we test the feasibility of this method using a quasi geostrophic (QG) model. After a brief description of the QG model model, we introduce a realistic model error to be learnt. We then asses the potential of ML methods to reconstruct this model error, first with perfect (full and noiseless) observation and then with sparse and noisy observations. We show in either case to what extent the trained ML models correct the mid-term forecasts. Finally, we show how the trained ML models can be used in a DA system and to what extent they correct the analysis.

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