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Correcting model error with an online Artificial Neural Network

Marcin Chrust, Massimo Bonavita, and Patrick Laloyaux
ECMWF, Earth System Assimilation Section, United Kingdom of Great Britain (marcin.chrust@ecmwf.int)

In both Numerical Weather Prediction and Climate Prediction, achieving improved accuracy and reliability is fundamentally dependent on identifying the sources and reducing the effects of model error. It has been recently demonstrated (Laloyaux et al., 2020) that weak constraint 4D-Var can estimate and correct for a large fraction of model error in the stratosphere, where the current global observing system is sufficiently dense and homogeneous. Accounting for the model error in the entire atmospheric column, specifically in the troposphere, remains challenging due to the difficulty in disentangling different sources of errors with similar spatial scales, and is the focus of current research.

In this work we demonstrate how Deep Learning techniques can be applied to the problem of estimation and online correction of model error. Recent results (Bonavita and Laloyaux, 2020) in the ECMWF Integrated Forecasting System (IFS) have shown that model error can be learned by an Artificial Neural Network (ANN) and applied in a weak constraint 4D-Var data assimilation framework as a model tendency forcing term. Moreover, the error estimation can extend to the whole atmospheric column and result in significantly improved analyses and forecasts. We have recently implemented in the ECMWF IFS the capability of applying online such ANN-based model error. This allows us to extend the application of the ANN-based model error parameterization from the data assimilation cycle to the long forecast step, where a model error tendency correction is continuously estimated and applied as a model forcing. We show preliminary results of the experiments conducted in the IFS framework and discuss our current understanding of the advantages and limitations of these techniques.