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Using data assimilation for systematic model improvement

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In Numerical Weather Prediction parameterisations are used to simulate missing physics in the model. These can be due to a lack of scientific understanding or a lack of computing power available to address all the known physical processes. Parameterisations are sources of large uncertainty in a model as parameter values used in these parameterisations cannot be measured directly and hence are often not well known, and the parameterisations themselves are approximations of the processes present in the true atmosphere. Whilst there are many efficient and effective methods for combined state/parameter estimation in data assimilation, such as state augmentation, these are not effective at estimating the structure of parameterisations.

A new method of parameterisation estimation is proposed that uses sequential data assimilation methods to estimate errors in the numerical models at each space-time point for each model equation. These errors are then fitted to predetermined functional forms of missing physics or parameterisations, that are based upon prior information. The method picks out the functional form, or that combination of functional forms, that bests fits the error structure. The prior information typically takes the form of expert knowledge.

We applied the method to a one-dimensional advection model with additive model error, and it is shown that the method can accurately estimate parameterisations, with consistent error estimates. It is also demonstrated that state augmentation is not successful. The results indicate that this new method is a powerful tool in systematic model improvement.