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Chaos Theory in Data Assimilation

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Numerical models are far from being perfect. A numerical model is indeed only a model of reality. It employs a number of simplifying assumptions, such as depth averaging of velocities in vertically integrated two-dimensional models, which inevitably produce inaccuracies. In a numerical model, one also discretises the domain and is therefore not able to resolve numerous subgrid-scale phenomena. Errors in the model parameterisation (because most model parameters cannot be directly measured) may contribute significantly to the overall error in a numerical model. It is also impossible to precisely define initial conditions and forcing terms over the entire computational domain. All of these inaccuracies and uncertainties could accumulate to produce poor model results, despite our perfect knowledge of the governing laws.

To combat the inevitable presence of such model errors, a number of approaches for correcting the model results are employed. Data assimilation is a methodology that utilizes information from observations, and combines it with (or assimilate it into) numerical models. A number of different data assimilation procedures can be adopted. These are designed to either improve description of initial conditions at the time of forecast or provide correction of model predictions during a forecast period. The data assimilation procedures may be classified as follows: (i) updating of input parameters:, (ii) updating of state variables, (iii) updating of model parameters and (iv) updating of output variables (error prediction).

In model error prediction techniques such as artificial neural networks, genetic programming or an approach based on chaos theory have demonstrated good forecast skill. By using these techniques, one can combine the forecast of the numerical model (model output) at the point of interest with the latest observed data in order to obtain an improved forecast. Another advantage of such an approach is that it allows the combination of different variables (for example, atmospheric data such as wind speed) to improve the accuracy. This cannot be done in conventional data assimilation methods where the data has to be introduced in the model state in order to be assimilated. This contribution describes an alternative approach of combining observations and numerical model results in order to produce an accurate forecast. The approach is based on application of a method inspired by chaos theory for building non-linear models from data, called Local Models.