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Full Field and Anomaly Initialisation using a low order climate model: a comparison, and proposals for advanced formulations

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Full Field (FFI) and Anomaly Initialisation (AI) are two schemes used to initialise seasonal-to-decadal (s2d) prediction. FFI initialises the model on the best estimate of the actual climate state and minimises the initial error. However, due to inevitable model deficiencies, the trajectories drift away from the observations towards the model's own attractor, inducing a bias in the forecast. AI has been devised to tackle the impact of drift through the addition of this bias onto the observations, in the hope of gaining an initial state closer to the model attractor. Its goal is to forecast climate anomalies.

The large variety of experimental setups, global coupled models, and observational networks adopted world-wide have led to varying results with regards to the relative performance of AI and FFI. Our research is firstly motivated in a comparison of these two initialisation approaches under varying circumstances of observational errors, observational distributions, and model errors. We also propose and compare two advanced schemes for s2d prediction. Least Square Initialisation (LSI) intends to propagate observational information of partially initialized systems to the whole model domain, based on standard practices in data assimilation and using the covariance of the model anomalies. Exploring the Parameters Uncertainty (EPU) is an online drift correction technique applied during the forecast run after initialisation. It is designed to estimate, and subtract, the bias in the forecast related to parametric error.

Experiments are carried out using an idealized coupled dynamics in order to facilitate better control and robust statistical inference. Results show that an improvement of FFI will necessitate refinements in the observations, whereas improvements in AI are subject to model advances. A successful approximation of the model attractor using AI is guaranteed only when the differences between model and nature probability distribution functions (PDFs) are limited to the first order. Significant higher order differences can lead to an initial conditions distribution for AI that is less representative of the model PDF and lead to a degradation of the initalisation skill. Finally, both advanced schemes lead to significantly improved skill scores, encouraging their implementation for models of higher complexity.