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Assessment and Selection of GCM Perturbed Physics Ensemble Members Using Observed Top-of-Atmosphere Fluxes

C. J. Rye (1), M. R. Allen (1), R. G. Jones (2), N. Massey (1), F. Otto (1), S. Rosier (1), and The climateprediction.net team (1)

(1) Atmospheric, Oceanic and Planetary Physics, University of Oxford, United Kingdom (rye@atm.ox.ac.uk), (2) The Met Office, Exter, UK

This study presents a new method for constraining general circulation model (GCM) perturbed physics ensembles (PPEs) using observed top-of-atmosphere (TOA) shortwave and longwave radiation fluxes. One problem frequently encountered when using perturbed physics ensembles to produce probabilistic forecasts is efficiency; hundreds or thousands of simulations may be required to identify a sufficient sample (range) of models that agree well with historical observations. In the present study, we address such limitations through the use of multiple linear regression analysis (MLR) to estimate optimal parameter values with respect to the error in TOA fluxes. We choose the TOA radiative fluxes as our performance measure because balancing the globally averaged top-of-atmosphere energy budget is a tuning procedure common to all comprehensive climate models. For our analysis we use HadAM3P, an atmosphere-only GCM. The predictors for the regression model are uncertain parameters that have been identified in previous studies as making an important contribution to simulation uncertainty (e.g., entrainment coefficient, ice fall velocity), while the predictand is the simulated global mean error in TOA fluxes with respect to satellite observations (CERES EBAF). The MLR model is trained on an historical (1990-1999) 300-member HadAM3P perturbed-physics ensemble produced using the climateprediction.net project. The regression model is then used to predict multiple parameter sets that minimise the error in top-of-atmosphere radiative fluxes. After identifying suitable parameter sets, they are used to produce an ensemble forecast of near-future climate (2040-2050). In order to account for uncertainty in the lower boundary conditions, sea surface temperatures and sea ice from the CMIP5 ensemble are used to drive HadAM3P. Our overall aim is to demonstrate an new and efficient technique for assessing and selecting perturbed physics ensemble members for probabilistic forecasting.