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Model climate as a function of forecast lead time in an imperfect model scenario

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Numerical weather and climate models constitute the best available tools to tackle the problems of weather prediction and climate projection. These models have played a key role in the attribution of the observed climate change to anthropogenic causes. However, a better understanding of the current models and the development of improved models are still required to address issues such as the interpretation of climate projections and the large uncertainties still present in regional climate change studies. Two assumptions lie at the heart the climate model suitability: (1) a climate attractor exists, and (2) the model attractor lies on the climate attractor, or at least on the projection of the climate attractor onto model space. In this contribution, two versions of the Lorenz '96 system are used, one as a prototype system and another as an imperfect model, to investigate the implications of assumption (2). In particular, the dependence of model-generated climate on forecast lead time is examined.
It is shown that forecasts produced by the imperfect model rapidly diverge from the system's orbit and that this divergence is mainly due to model error. As a result, climatologies produced from these divergent forecasts show a dependence on forecast lead time. This dependence is characterised by an initial rapid bias growth with respect to the system's climatology. The initial bias growth ends at a saturation level which is reached as the transient period in individual forecasts dies out (spin-up period). Furthermore, it is shown that, once the spin-up period is over, climatologies generated with long-term integrations of both the prototype system and the imperfect model are essentially the same as climatologies generated from short-term forecasts from a perfect and an imperfect model, respectively.
Despite its simplicity with respect to the actual climate system, this study about the Lorenz '96 system shows features that are relevant for climate studies and the understanding of climate models. In order to show this, two examples using real-world data from operational forecasting systems and climate experiments are also discussed.