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Limitations of time-slice experiments for a dynamical downscaling of climate change scenarios

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Time-slice climate change experiments, in which an atmospheric GCM is forced by SSTs derived from a coupled ocean-atmosphere model, have been widely used over recent decades to explore uncertainties in climate scenarios, and are now considered as an efficient tool for climate change downscaling with high or variable resolution atmospheric GCMs. Nevertheless, there is no real consensus about the design of such experiments and it is not clear that the lack of SST variability and/or feedback does not alter the regional climate response to global warming. In the present study, various pairs of time-slice experiments have been performed with the CNRM atmospheric GCM, in which the SSTs prescribed at the end of the 21st century are calculated as the sum of present-day SSTs and of climatological SST anomalies derived from the CNRM coupled GCM. The pairs only differ by the choice of the present-day SST forcing that is derived from either the coupled model or an observed climatology, and includes or not interannual fluctuations. The results suggest that each experiment design leads to a different climate response at the regional scale, due to the non-linear impact of SST variability, to the relevance of the SST feedback in the tropical oceans, and to potential errors in the prescribed radiative forcing.