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Analysis of proxy response and sensitivities in a coupled general circulation model

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In the analysis and interpretation of climate data, both from model simulations and observations, it is often of interest to establish relations between the responses of different observables to a global forcing. This problem in its generality is relevant in the context of the identification of emergent constraints for the climate system, detection and attribution studies, and the analysis of proxy data. Recently it has been discussed how in linear response theory it is possible to build proxy response operators, that allow to use the response of one observable to a forcing to predict the response of another observable. The spectral properties of the proxy response functions determine then the properties of statistical predictability at different time scales for the pair of observables. The skill and feasibility of this approach for complex climate data has however not been fully tested yet. In this work we analyse the properties of proxy response in experiments with the coupled general circulation model MPI-ESM v.1.2. We consider ensemble simulations of abrupt CO_2 doubling and 1% per year CO_2 increase scenarios. We study the response of different atmospheric and oceanic variables, and we compute proxy response functions for different pairs of observables. We analyse the predictive power for the different cases, and interpret differences in skills in terms of causal relations among observables. We also study the relation between statistical variability and long term sensitivity, and we discuss differences between ensemble and internal variability in unforced and forced states. We then link our results to the discussion on the interpretation of emergent constraints in climate change simulations.