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# Climate and carbon cycle dynamics in a CESM simulation from 850-2100 CE

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Under the protocols of the Paleoclimate and Coupled Modelling Intercomparison Projects a number of simulations were produced that provide a range of potential climate evolutions from the last millennium to the end of the current century. Here, we present the first simulation with the Community Earth System Model (CESM), which includes an interactive carbon cycle, that continuously covers the last millennium, the historical period, and the twenty-first century. Besides state-of-the-art forcing reconstructions, we apply a modified reconstruction of total solar irradiance to shed light on the issue of forcing uncertainty in the context of the last millennium. Nevertheless, we find that structural uncertainties between different models can still dominate over forcing uncertainty for quantities such as hemispheric temperatures or the land and ocean carbon cycle response. Comparing with other model simulations we find forced decadal-scale variability to occur mainly after volcanic eruptions, while during other periods internal variability masks potentially forced signals and calls for larger ensembles in paleoclimate modeling studies. At the same time, we fail to attribute millennial temperature trends to orbital forcing, as has been suggested recently. The climate-carbon cycle sensitivity in CESM during the last millennium is estimated to be about 1.3 ppm $^{\circ}$C $^{-1}$. However, the dependence of this sensitivity on the exact time period and scale illustrates the prevailing challenge of deriving robust constrains on this quantity from paleoclimate proxies. In particular, the response of the land carbon cycle to volcanic forcing shows fundamental differences between different models. In CESM the tropical land dictates the response to volcanoes with a distinct behavior for large and moderate eruptions. Under anthropogenic emissions, global ocean and land carbon uptake rates emerge from the envelope of interannual natural variability as simulated for the last millennium by about 1950 and 2000, respectively.