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The impact of the temperature-CO_2 decoupling on the state-dependency of paleo climate sensitivity during the late Pleistocene

Peter Köhler (1), Andrey Ganopolski (2), Gregor Knorr (1), and Lennert Stap (1)

(1) Alfred-Wegener-Institut Helmholtz Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany (peter.koehler@awi.de), (2) Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany

Climate change projections for the future are uncertain, also due to inter-model differences. The application of these models to paleo times, which can be constrained by reconstructions, is therefore essential, not only to gain a better understanding of past climate changes, but also for model validation purposes. In this respect both data- and model-based approaches have been used to generate time series of global temperature changes, ΔT_g. The ratio of ΔT_g over radiative forcing, ΔR, defines the specific equilibrium climate sensitivity S, and has been suggested to be state-dependent, potentially increasing towards warming climates, and therefore suggesting climate sensitivity for the future to be at the upper end of the range of published results (Köhler et al., 2015, 2017). Here we reanalyse existing time series of ΔT_g and ΔR for the last 800,000 years and show that this proposed state-dependency of S is only found if ΔT_g is based on data (reconstructions), and not if ΔT_g is based on models (simulations). We furthermore identify that in data-based reconstructions ΔT_g is decoupled from atmospheric CO_2 predominantely during times of decreasing obliquity (identical to periods of land-ice sheet growth and sea level fall), while in model simulations ΔT_g and CO_2 vary in phase throughout. This multi-millennial decoupling of CO_2 and temperature has been suggested to be partially caused by a sea level-induced surge in magma and CO_2 fluxes from oceanic hotspot volcanoes and mid ocean ridges (Hasenclever et al., 2017). The neglection of these feedbacks between the solid Earth and the climate system in recent Earth system models is partly responsible for the data/model misfit, and illustrates our current limitation in the model-based interpretation of the paleo records. Paleo-based estimates of S might be restricted to data without this ΔT_g-CO_2-decoupling leading to a 20% smaller quantification of S for interglacial conditions of the late Pleistocene.

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