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Transitions between multiple equilibria of paleo climate: a glimpse in to the dynamics of abrupt climate change

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The dynamics regulating large climatic transitions such as glacial-interglacial cycles or DO events remains a puzzle. Forcings behind these transitions are not robustly identified and potential candidates (e.g. Milankovitch cycles, freshwater perturbations) often appear too weak to explain such dramatic transitions. A potential solution to this long-standing puzzle is that Earth's climate is endowed with multiple equilibrium states of global extent. Such states are commonly found in low-order or conceptual climate models, but it is unclear whether a system as complex as Earth's climate can sustain multiple equilibrium states.

Here we report that multiple equilibrium states of the climate system are also possible in a complex, fully dynamical coupled ocean-atmosphere-sea ice GCM with idealized Earth-like geometry, resolved weather systems and a hydrological cycle. In our model, two equilibrium states coexist for the same parameters and external forcings: a Warm climate with a small Northern hemisphere sea ice cap and a large southern one and a Cold climate with large ice caps at both poles. The dynamical states of the Warm and Cold solutions exhibit striking similarities with our present-day climate and the climate of the Last Glacial Maximum, respectively. A carbon cycle model driven by the two dynamical states produces an atmospheric pCO_2 draw-down of about 110 pm between the Warm and Cold states, close to Glacial-Interglacial differences found in ice cores. Mechanism controlling the existence of the multiple states and changes in the atmospheric CO_2 will be briefly presented.

Finally we willdescribe transition experiments from the Cold to the Warm state, focusing on the lead-lags in the system, notably between the Northern and Southern Hemispheres climates.