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Transient climate simulation of the past 4.5 million years based on the coupled intermediate complexity model iLOVECLIM

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The Earth experienced dramatic climate changes during the past million years, including a long-term gradual cooling from the Pliocene (5.3-2.6 million years ago; Ma) to the Pleistocene (2.6-0.011 Ma) and an abrupt transition from 41-kyr to 100-kyr glacial-interglacial cycles at ca. 1.2-0.8 Ma (i.e., the Mid-Pleistocene transition). Investigating the mechanisms that triggered these climatic responses requires long-term transient climate simulations which can be used to quantify the sensitivity of the Earth's climate to different external and internal forcings. However, few such simulations exist and therefore, key questions regarding the long-term evolution of the earth system remain unanswered.

Here, we used iLOVECLIM, a coupled Earth system numerical climate model of intermediate complexity, to generate a 4.5 Ma transient climate simulation, the longest to date. iLOVECLIM is ideally suited for this task as it requires substantially less computational resources and time to perform transient climate simulations compared to fully coupled general circulation models. We performed the simulations with interactive atmosphere, ocean and vegetation components and used the methodology of previous long-term transient simulations. Briefly, we applied an acceleration factor of five to the external forcings (orbital parameters, greenhouse gases concentration and ice-sheets) and split the 4.5 Ma simulation into 44 chunks run in parallel to reduce the computing time from several years to a couple of months. Each chunk was initialized from an interglacial period, covers at least one glacial-interglacial cycle and has an overlap period of 20,000 years in order to compensate for issues related to spin-up effects and initial conditions. The complete simulation is a composite of all the individual chunks and time-sliding linear interpolation performed on the overlap intervals.

While the simulations are still ongoing, preliminary results demonstrate that our new model set-up and experimental design are able to produce reasonable outputs. When it is completed, the

final simulation will be evaluated against available paleoclimate data and existing transient climate simulations. Apart from running a simulation with all the external forcings combined, we also plan to run subsequent simulations with each individual forcing alone to evaluate the climate responses associated with each. This unique long transient simulation will provide a better mechanistic understanding of the major climate reorganizations that occurred during the Plio-Pleistocene and will be useful for future data-model comparisons and data assimilation endeavours.