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The Mid Pleistocene Transition is due to a gradual rather than abrupt change in the climate system

Content

Pleistocene climate is primarily driven by changes of the Earth's orbital parameters. However, the Mid-Pleistocene Transition (MPT) (~0.8-1.2 Ma) which corresponds to a gradual change of interglacial-glacial cyclicity from low amplitude 40 ka cycles to the current high-amplitude 100 ka cycles, remains largely unexplained. So far, models only based on orbital forcing were not capable to reproduce this transition, discarding the hypothesis of an orbitally-driven transition. Internal Earth system climate causes were thus explored as primary drivers of the MPT, as a gradual decrease in atmospheric CO2 concentrations or the removal of the regolith beneath the northern hemisphere ice sheets.

Here, we present a new conceptual model which quantifies the global ice volume over the past 2 Ma. Our model switches between two states, a glaciation state and a deglaciation one, following a threshold mechanism related to the input parameters and the modelled ice volume itself. The modelled ice volume is compared to an ice volume reconstruction inferred from paleodata.

Orbital-only, gradual and abrupt forcing hypotheses are tested using three simulations of our conceptual model in order to compare the relevance of each mechanism. The first one named the "ORB simulation", uses only orbital parameters as forcing inputs. In addition to accounting for the orbital forcing, the second simulation referred to as "ABR simulation" hereafter, includes a time-determined abrupt change that makes it more difficult to trigger a deglaciation. In the third simulation called "GRAD simulation", the initiation of a deglaciation is modulated by a continuous trend throughout the Pleistocene, while the orbital forcing is still considered too.

Our results show that the GRAD simulation best reproduces the change in frequency and amplitude of glacial-interglacial cycles observed during the MPT in the global ice volume reconstruction. Still, the good model-data comparison obtained using the ORB simulation results suggests that the orbital forcing must at least be partly responsible for the MPT. In contrast, the results obtained with the ABR simulation are less relevant. Therefore, we propose that the MPT could be due to the combination of the orbital forcing with an additional forcing characterized by a gradual change across the past 2 Ma. This is compatible with the hypothesis that a progressive drop in atmospheric CO2 concentrations throughout the Pleistocene played an important role in triggering the MPT.

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