Review of CP-2024-57

CO2 and summer insolation as drivers for the Mid-Pleistocene transition

by Meike D. W. Scherrenberg et al.

General Evaluation:

The study provides a well-organized review of previous research, systematically summarizing the relationships between insolation, CO_2, regolith deposits, and the periodicity of glacial–interglacial cycles. The motivation behind this study is clearly articulated: to investigate the causes of the Mid-Pleistocene Transition (MPT) by conducting baseline experiments based on reconstructions and examining idealized responses to insolation and CO_2, thereby assessing their respective contributions.

The classification of ice sheets into three distinct stages, considering their size, shape, and susceptibility to melting (i.e., the likelihood of termination), is particularly insightful. The study suggests that a threshold exists whereby large ice sheets are more prone to abrupt changes even under a glacial climate, which is a compelling finding.

By integrating baseline experiments with idealized insolation and CO_2 experiments, the study presents key interpretations: (1) even under low CO_2 conditions, high insolation can still induce ice sheet melting and lead to deglaciation, (2) without sufficiently low CO_2 levels, prolonged glacial periods cannot be sustained, and (3) the variations in glacial–interglacial cycles observed since the MPT can be explained by changes in CO_2 levels.

Furthermore, the study discusses the regolith hypothesis, which posits that variations in bedrock friction influence the ease of ice sheet melting. However, the methodology for idealizing the friction coefficient changes remains somewhat unclear. Specifically, it is not entirely evident what real-world conditions this experimental setup aims to replicate, what assumptions underlie it, and how it contributes to the broader discussion of the regolith hypothesis. Clarifying these aspects would enhance the study's interpretation and its implications for understanding the role of basal friction in glacial–interglacial dynamics.

Regarding the methods section, it would be helpful if the basic settings of the model were explained in more detail rather than simply referencing citations. For example, in the following sentence, it is unclear what is meant by "*do not vary spatially within a model domain.*" Providing a clearer and more detailed explanation of this point would improve the reader's understanding: *"Ocean temperatures are based on de Boer et al. (2013), and while they evolve over time, they do not vary spatially within a model domain."*

Finally, as noted by the other reviewer, the conclusion lacks clarity regarding the precise stance of the study. It remains unclear what the key takeaway is in relation to previous research. Specifically, to what extent does this study introduce novel insights? Is it questioning the conventional view that variations in orbital parameters and the resulting insolation changes are the primary drivers of glacial–interglacial cycles? Is the key finding that CO_2 and insolation become important at different phases of the cycles? Or is the main argument that sufficiently high interglacial CO_2 levels are crucial for the observed lengthening of glacial cycles?

Currently, the significance of the study is not conveyed as a clear and compelling message. Strengthening this aspect would enhance the impact of the paper, ensuring that readers fully grasp its contribution to the broader understanding of glacial–interglacial dynamics.

In any case, the manuscript has been well revised in response to the previous reviewers' comments, and I believe it has reached a level worthy of publication.

Minor Concerns:

L130: "*all data necessary for our simulations*" What kind of data do you use here?

L185: How do the authors explain the fact that the omission of the Antarctic ice sheet in the baseline experiment has led to a 20% overestimation of sea level change?

L213: What is the justification for the experimental setup of "sediment"? A more detailed discussion on the extent to which these results support or challenge the regolith hypothesis would enhance the clarity and impact of the study's conclusions.

Fig2:What is the meaning of forcing index?