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Earth System Dynamics
Discussions

Interactive comment on "ESD Ideas: Why are glacial inceptions slower than terminations?" *by* Christine Ramadhin et al.

Christine Ramadhin et al.

cyi@qc.cuny.edu

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Referee #2 Understanding the mechanisms of Quaternary glacial cycles remains one of the main challenges in the field of theoretical climatology and not surprisingly this problem attracts significant attention. However, although a comprehensive theory of Quaternary climate dynamics is still missing, significant progress has been achieved in recent years in the understanding of glacial cycles and numerous papers on this subject have been published. This is why proposing a new idea in this field requires good knowledge of the previous works. Unfortunately, the manuscript by Ramadhin and Yi shows that this is not the case and already the title of the manuscript and the first paragraph contain a number of factual errors.

Authors Thank you for reading our manuscript and providing constructive comments which have helped to improve the manuscript. We have worked diligently to address each comments and revised the manuscript accordingly.

Referee #2 First, the question posed in the title - "Why are glacial inceptions slower than terminations" - is not correct. Glacial inceptions have the same time scale (order of 10,000 years) as glacial terminations. The asymmetry of late Quaternary glacial cycles is manifested in the fact that typically the time intervals between the end of previous interglacials and the glacial maxima (which is not the same as glacial inception) are an order of magnitude longer than the time between glacial maxima and the onset of the next interglacial state (glacial termination).

Authors Thanks for your insightful comment. We agree and have modified the title to "Why are glaciations slower than deglaciations?". Additionally, we have defined the intervals referred to in the paper; glacial inceptions, glacial terminations and glaciation in terms of number of years from present day.

Authors changes in manuscript From benthic δ18O (‰ records from ODP Site 983 from Raymo et al., (2004) the duration of the last termination is $\sim$ 10ka while the glaciation process including the inception and intermediate stage had a duration of $\sim$ 77ka.

We think this allows sea ice to extend rapidly, increasing albedo, further decreasing temperatures and helps to explain the initial rapid temperature drop observed for this glacial inception period which lasts $\sim$10ka.

Based on temperature reconstruction, the intermediate stage has a duration of $\sim$42ka, where there is increased evaporation due to greater exposed ocean surfaces relative to the initial glacial inception period, and increased precipitation.

Referee #2 Second, 100 kyr cyclicity dominated only over the last million years and not the entire Quaternary as the authors wrote. Prior to 1 million years ago, the dominant cyclicity of glacial cycles was 40,000 years.

Authors This is true, we have revised the manuscript to clarify the period we are referring to which is the latter part of the Pleistocene glaciations, after the MPT.

Authors changes in manuscript Paleoclimate data show that the Earth's climate of the last 2.6Ma is dominated by cold glaciations, recently (after the Mid Pleistocene Transition) the duration of these ice ages is $\sim$100ka with extensive glaciers and warm interglacials with little global ice cover lasting 10-30ka (Imbrie et al., 1992).

Referee #2 Third, glacial terminations do not occur "after a maximum in NH summer insolation is crossed". Glacial terminations typically begin well before the maximum of insolation is reached and, for example, in the case of the penultimate termination, the termination has been completed several thousand years before the maximum of NH summer insolation has been crossed.

Authors We have modified the manuscript to reflect this point, thank you.

Authors changes in manuscript The termination of a glacial period occurs rapidly while the changeover to a glacial period takes tens of thousands of years to be completed resulting in an interesting asymmetrical shape for which there is yet no consensus on the mechanism(s) (Tziperman and Gildor, 2003).

Referee #2 However, my main problem with the manuscript is related to the fact that the authors discuss only sea ice and not continental ice sheets. The latter is only mentioned once while "sea ice" is mentioned 30 times. This makes an odd impression that under glacial cycles the authors understand growing and retreat of sea ice rather than waning and waxing of NH continental ice sheet, which of course is incorrect. There is no doubt that sea ice in both hemispheres does play an important role in climate system dynamics and there are a number of both positive and negative feedbacks related to sea ice which are important for glacial cycles. However, the asymmetry of glacial cycles is related to continental, primarily NH, ice sheets. Whatever the role of sea ice is, it simply has too short time scale to determine durations of glacial inceptions and terminations.

Authors Thank you for pointing this out, relative to land based ice sheets, sea ice is short lived. However, here we think the role of sea though short lived and relatively minor plays an important role when the system is at a bifurcation point. It may serve as a critical parameter in helping the changeover between stable states. Though these sea ice feedbacks may be active during all stages of glacial-interglacial climate variations, they may be critical after thresholds have been surpassed.

Please also note the supplement to this comment:
https://www.earth-syst-dynam-discuss.net/esd-2019-10/esd-2019-10-AC3-supplement.pdf

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