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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.

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Short comments (SCs) from the scientific community

Interactive comment on "ESD Ideas: Why are glacial inceptions slower than terminations?" by Ramadhin and Yi. Mikhail Verbitsky verbitskys@gmail.com Received and published: 19 March 2019

Ocean negative feedback may shorten glacial cycles instead of lengthening them The authors suggest that ocean negative feedback may be responsible for a slow ice growth during typical ice-age cycle because "it seems intuitive that negative feedbacks would play critical roles in slowing the pace of a transition between equilibrium states". Unfortunately, this idea is questionable. In fact, an analysis of non-linear dynamical system

model of ice ages can provide a quite nuanced picture, with episodes of stability alternating with episodes of acceleration. Hence, if the mechanism suggested by the authors is real (quantitative arguments have not been provided), one could counterargue that the cause of the asymmetry is to be found in "positive feedbacks" acting during the deglaciation - this might actually be the most frequent explanation. The structure of ice ages cycle emerges from this interplay between negative and positive feedbacks all along the ice age cycle, so it is unclear why the asymmetry (well discussed) would necessarily point to a mechanism that has not been discussed in, to use the authors' words, the "plethora" of other models. Contrary to author's assumption, the ice-age dynamics may be very counterintuitive. For example, it has been shown (Verbitsky et al., 2018), that regardless of the physical interpretation of the positive or negative ocean feedback, the period of glacial rhythmicity is defined by the ratio of intensities of ocean resultant (more positive or less positive) feedback to ice-sheet own negative feedback. When this ratio is high enough, the model exhibits late-Pleistocene type of rhythmicity with a period of about 100 ky. When the ratio is small (this is the case advocated by the authors, i.e., negative ocean feedback is strong enough to compensate for ocean positive feedback) the model exhibits early-Pleistocene type of fluctuations with a period of 40 ky. Thus intensive ocean negative feedback may shorten glacial cycles instead of lengthening them.

References: Verbitsky, M. Y., Crucifix, M., and Volobuev, D. M.: A theory of Pleistocene glacial rhythmicity, Earth Syst. Dynam., 9, 1025-1043, https://doi.org/10.5194/esd-9-1025- 2018, 2018 Interactive comment on Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2019-10, 2019.

Authors Response

Dear Dr. Mikhail Verbitsky,

We are very thankful for the insightful comment.

Verbitsky et al., (2018) presents a model that introduces a dimensionless variability

factor, V. This factor, V is large (0.75) when positive feedbacks dominate, producing 100 kyr cycles while when less positive, V is small (0) and 40 kyr cycles dominate. Since we proposed the dominance of negative feedbacks to explain the slower glacial inception process versus the faster glacial termination, then V should be small in our case and produce 40 kyr cycles instead of 100 kyr observed for the late Pleistocene.

We think in this scenario, yes this seems to be true. However, in this proposal, the conditions facilitating the dominance of the negative sea ice feedbacks are short-lived, and the proposed feedbacks do not dominate for the entirety of the glaciation. If it did then the intermediate stage would be longer and yes the glacial cycle shorter. However, as conditions change to become less favorable, these feedbacks progressively becomes less dominant. For example, ocean circulation changes in the North Atlantic, as the temperature drops, North Atlantic Deep Water formation moves further south as demonstrated by Rahmstorf (2006).

What we are proposing in relation to the V factor in Verbitsky et al., (2018) model means the V may be variable. V is large at the initiation of glacial inception (positive feedbacks are strong) and smaller during the intermediate stage (positive feedbacks are less strong) during the inception process. However, as conditions change the V factor gets larger and the transition to glacial conditions continue leaving the intermediate stage behind.

References

Rahmstorf, S.: Thermohaline Ocean Circulation. In: Encyclopedia of Quaternary Sciences, Edited by S. A. Elias Elsevier Amsterdam, 2006.

Verbitsky, M. Y., Crucifix, M., and Volobuev, D. M.: A theory of Pleistocene glacial rhythmicity, Earth Syst. Dynam., 9, 1025-1043, https://doi.org/10.5194/esd-9-1025-2018, 2018

Please also note the supplement to this comment:

https://www.earth-syst-dynam-discuss.net/esd-2019-10/esd-2019-10-AC4-supplement.pdf

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