Interactive comment on "ESD Ideas: The Peclet number is a centerstone of the orbital and millennial Pleistocene variability" by Mikhail Y. Verbitsky and Michel Crucifix

M. Verbitsky (verbitskys@gmail.com)

Dear Anonymous Referee #1, Thank you for your review. The following is our response to your two questions.

Comment: In your model Eqs. (1) - (5) you represent two ice sheets (Laurentide and Greenland) which are independent from each other. To which extent can the Laurentide and Greenland ice sheets be considered to be independent from each other considering their close proximity? It seems to me that the whole argument rests on this assumption.
Answer: The equations (1) – (5) and corresponding diagram of Fig. 1(a) describe the dynamical system when the Greenland ice sheet is coupled one-way via the climate temperature ω acting as an external forcing for it. We used this configuration for our scaling reasoning. For the numerical experiment, we added a term $-\gamma_2 S_G$ in the equation (3) thus making full coupling of the Laurentide and Greenland ice sheets (lines 122-124). Full coupling is, indeed, important. As we demonstrated earlier (Verbitsky et al, 2019, https://doi.org/10.5194/esd-10-257-2019), millennial forcing may penetrate upscale and under some conditions may significantly change the orbital-timescale dynamics.
Action: To articulate this more clearly, we suggest adding one more panel to Fig. 1 that would show both dynamical configurations:

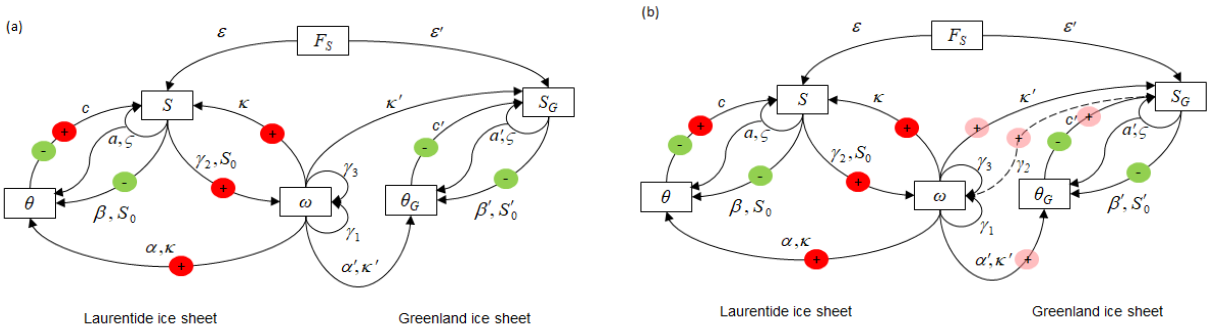

Fig. 1: (a) the dynamical system (1) – (5) as it has been used for scaling reasoning. The Greenland ice sheet is coupled one-way via the climate temperature ω acting as an external forcing for it. Red circles mark positive feedback loops and green circles mark negative feedback loops; (b) the dynamical system (1) – (5) as it has been used in the numerical experiment. The Laurentide and Greenland ice sheets are fully coupled. Pink circles mark weaker positive feedback loops.

Comment: Or could Greenland be substituted with Antarctica (or would the size of Antarctica change the dynamics)?
Answer: Your observation regarding the proximity is correct: We do not consider here a number of mechanisms that might be important in the close proximity of Laurentide ice sheet - our coupling is made through the global albedo and global temperature only. Nevertheless, we cannot simply replace the Greenland ice sheet with the Antarctic ice sheet. Even though the area of the Antarctica is also limited, we may anticipate that the larger area of the Antarctic glaciation implies thicker ice sheet, bigger Peclet number, weaker internal negative feedback, larger amplitude and period of the relaxation oscillations, and, therefore, possibly stronger influence on the global climate including Laurentide ice sheet. Besides,

Antarctic ice sheet volume changes cause stronger sea-level variations, which are immediately distributed worldwide and would immediately affect Laurentide ice sheet, not via the global temperature but via sea-level. For that reason, to answer your question confidently, an additional study may be needed.
Action: We will add this discussion into the text.