Reply to comments

Holly Still and Christina Hulbe

April 18, 2021

Dear Olivier,

Thank you for the additional feedback. The editor's comments are in black and our responses are in blue. Excerpts from the improved manuscript are italicised.

Comments

The caption of Fig. 1 is not precise enough: In (a), you should mention to what refer the white dashed line (limit of the FE model domain?). I would suggest to add a square in (a) showing the limit of (b). Also, "grounding zone" should be "grounding lines". In (b), you should specify what is the white dashed line and yellow lines.

We have added additional detail about the white dashed line in (a) and the cross-section lines in (b). 'Grounding zone' has been replaced with 'grounding lines'. We tried adding an inset square to (a) and we found that it made the map too cluttered. Instead, the SCIR label shows the overlapping spatial extent between (a) and (b).

The improved figure caption:

Pinning points in the RIS. In panel (a), large pinning points are labelled: SCIR = the Shirase Coast Ice Rumples, RI = Roosevelt Island, SIR = Steershead Ice Rise and CIR = Crary Ice Rise. The colour map of surface ice velocity magnitude is from the MEaSURES velocity dataset (Rignot et al., 2011). The black line indicates the grounding lines (Bindschadler et al., 2011) and the white dashed line is the limit of the finite element model domain. Panel (b) shows the along-flow cross-sections intersecting the SCIR in Figs. 3 and 10 (yellow and white dashed lines), and the gates used for mass flux calculations in Table 3. The colour map of ice thickness is from the Bedmap2 compilation (Fretwell et al., 2013). In each figure from hereon, datasets are mapped with a Polar Stereographic Projection with a central meridian of 0° and a standard latitude of 71°S, and in most cases, overlayed onto the MODIS MOA (Haran et al., 2014).

In Fig. 1, on the north part of the shelf, the model domain seems to cut the ice-streams. Why this choice? What type of BC do you apply at the model domain boundary (observed velocity?)?

To the east/north-east of the Ross Ice Shelf, the domain follows the topographic divide delineating the drainage basin of the West Antarctic Ice Sheet ice streams (mapped by Zwally et al. (2012)). To the west of the RIS, the domain is constrained by the Transantarctic Mountains.

We have added a sentence on the boundary conditions to the manuscript (Line 134):

Dirichlet conditions are imposed on the upstream boundaries of the model domain using observed velocity and ice thickness, and zero-slope Neumann conditions are specified on the downstream (ice shelf front) boundary.

line 161: 1000 years is a very long relaxation? Model might reach some steady state already after such a long relaxation period? Usually relaxation periods are of few years to few decades?

Because this is a perturbation experiment, the aim was to achieve as close to zero transients as possible during initialisation. This required centuries rather than decades.

Line 321: Negative response of which variable? (The mean instantaneous velocity change over the whole ice-stream is, however, negative?)

Thanks, we have made the suggested change:

The mean instantaneous velocity change over the lower MacIS and BIS is, however, negative (Fig. 9a).

Caption Fig. 9: Positive values indicate faster flow for the perturbed model without SCIR and ...

Thanks, we have made the suggested change to the figure caption:

The total difference in ice speed between the steady-state, $\bar{B}_{inv}$ reference model (with SCIR) and the perturbed model (without SCIR) at various model timesteps following removal of the SCIR. (a) is the instantaneous response and (b-c) demonstrate the longer timescale adjustment of the ice-shelf and ice-stream system. Positive values indicate faster flow for the perturbed model without the SCIR and negative values indicate slower flow. By a timestep of 150 years, the model has reached a new steady-state. Grounding-line positions are from the perturbed model at timesteps of 1, 5 and 150 years. The velocity contour lines have an interval of 100 ma^{-1}

Line 447: may be also conclude that an inversion alone is not sufficient for transient prognostic simulations and that appropriate evolution equations for the ice rheology and the basal friction would be required to have a correct evolution of these fields induced by evolving flow conditions?

Thanks, we have added two additional sentences to follow Line 447:

The present contribution demonstrates the importance of high fidelity representation of pinning points for simulation of their effects in system models and, by extension, how observed change is interpreted. The use of spatially- and temporally-fixed ice properties and basal friction may also be insufficient to represent a changing pinning point environment. Prognostic simulations of pinning points dynamics will be further improved by the implementation of process-based ice properties and basal friction fields that respond to changing flow conditions.

References

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