

Interactive comment on “Comparing ice discharge through West Antarctic Gateways: Weddell vs. Amundsen Sea warming” by M. A. Martin et al.

Anonymous Referee #1

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1 General statement

The manuscript “Comparing ice discharge through West Antarctic Gateways: Weddell vs. Amundsen Sea warming” by M. Martin and others studies the impact of ocean warming on future evolution of the Weddell and Amundsen sea sectors for the next five centuries. The authors find that the Weddell Sea sector is much more vulnerable to ocean warming than the Amundsen Sea sector due the topography of these areas, and that even small changes in ocean conditions would rapidly and drastically impact the Weddell Sea sector.

This manuscript presents an important and timely study as ocean has been triggering the changes happening in the Amundsen Sea sector today, however model studies re-

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main inconsistent as pointed out in the introduction. The experiments performed here are appropriate and the paper is generally well written, however some details about the modeling and the experiments performed are missing or unclear. The ocean melting applied, for example, is never shown while this is the main link between the ocean and the ice stream: the discussion focuses on the topographic differences between these two sectors but does not analyze the impact of changes in ocean circulation. Another major point that strikes me is that the authors report that the ocean is warming more rapidly in the Weddell Sea sector, that this area is more susceptible to changes in ocean circulation and that such changes would happen over a shorter time scale; however remote sensing observations show rapid changes in the Amundsen Sea sector and a relative stability of the Weddell Sea sector. I think that this difference of behavior between modeling results and observations should be addressed in the paper. I therefore think that this manuscript would be greatly improved with some clarifications in the experiments performed and some additional discussions.

2 Specific comments

As mentioned above, I think that there is a contradiction between the observations and the modeling results described in this paper. The abstract for example mentions “much stronger warm-water intrusion into ice-shelf cavities in the Weddell Sea compared to the observed Amundsen warming” and “ocean warming in the Weddell Sea leads to more immediate ice discharge [in the Weddell Sea] with a higher sensitivity to small warming levels than the same warming in the Amundsen Sea”. However all observations (gravity, InSAR velocities, altimetry) suggest large changes in the Amundsen Sea sector today, while they show limited changes in the Weddell Sea. How do the authors explain this discrepancy? One possible reason that is not discussed in the paper is the impact of the model initial conditions. All simulations are run starting from a steady-state while the Amundsen Sea sector is far from being in equilibrium. How does this

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impact the simulations? Could it explain this discrepancy of behavior? Does it mean that the ocean is not responsible for the observed changes?

p.1707 l.3: Loss of buttressing is caused by both grounding line retreat and ice shelf thinning (at least for confined ice shelves). This second aspect is not discussed in the manuscript.

p.1708 l.15 and Appendix A3: the initialization procedure and the experiments are clearly detailed in the manuscript, however the number of experiments done, the parameters used and the resolution used for the experiments is not very clear. How many sets of sensitivity experiments are done (by set I mean looking at the impact of ocean for a given initial state)? This is not clearly specified in the manuscript and results from Fig. 7 and 8 are not really discussed. I think this part should be moved from the appendix to the main manuscript, as the uncertainty associated to the results is a critical part. Fig. 8 suggests that the response of the Weddell Sea to a 2K ocean warming is not significantly affected by the initial conditions while the initial state is critical in the case of the Amundsen Sea, with a contribution to sea level rise varying between 0.2 to more than 3.0 m (figure is truncated) after 500 years. To go back to a previous comment, is that linked to the Amundsen Sea being further from a steady-state equilibrium today? And how does this impact the conclusions of the paper?

p.1709 l.12: How does the ocean temperature impact the sub-ice shelf melting rate? Melting rates are never shown in the paper while this is the main link between the ocean and the ice streams. I suggest adding a figure with initial sub-ice shelf melting rates and impact of ocean warming on melting rates for both Amundsen and Weddell Sea sectors. This could also explain the difference of response between these two sectors so it should be added in the discussion.

p.1714 l.2: Why use ALBMAP and not Bedmap2 (Fretwell et al., 2013)? There are some substantial differences in the Amundsen Sea and Weddell Sea sectors, so how do they affect the results presented here?

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3 Technical comments

p.1706 l.9: "Amundsen warming" → "Amundsen Sea warming"

p.1706 l.12: "more immediate ice discharge" → "more immediate increase in ice discharge"

p.1706 l.16-17: Precise what sector you are discussing here.

p.1708 l.1: "deepness" → "elevation"?

p.1708 l.7: "ice needs to get into motion first": I am not sure what the authors mean here as the Amundsen Sea sector ice streams are already the fastest moving glaciers in Antarctica, with a velocity well above 3000 m/yr for Pine Island and Thwaites glaciers.

p.1708 l.15: why do the authors use a 24 km grid while we know that results at this resolution remain inaccurate and grounding is poorly resolved, especially as they also perform simulations at much higher resolution? Fig. 7 is also very noisy at 24 km resolution.

p.1713 l.7: "compare Favier" → "compare to Favier"

p.1713 l.7: for a 50 km wide ice stream, a resolution of 24 km is not going to resolve anything.

p.1714 l.4: "this measure": what measure?

p.1714 l.12: "The melt rates therefore roughly adapt to changing ice-shelf depth": How does it adapt? This part should actually be more detailed and moved to the main body of the text as it is a key part of the model and the sensitivity experiments.

p.1714 l.27, p.1715 l.2, l.4, l.6: Equations should be added to describe these parameters. I appreciate that this paper is concise and does not repeat once again the SIA or SSA equations, however the friction laws or other specific parameters should be clearly stated, the PISM manual being very likely to change in the future.

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p.1715 l.12: There seems to be more than 24 acceptable initial configurations from Fig. 9, so which ones are kept? The range of parameters studies should also be mentioned in the text.

p.1715 l.23: How are the models rescaled from 15 to 12 km? Is it just interpolation?

p.1721: black lines on fig. a and b are difficult to see.

p.1728: Results for the Weddell Sea sector look similar at 5 km and 12 km suggesting that the results are not very dependent on the grid resolution unlike results for the Amundsen Sea sector. For the latter case, results at 2.5, 5 and 12 km are quite different, with a contribution to sea level rise after 500 years varying from 0.5 to 1.2 m in the case of a 2 K increase in the ocean temperature.

p.1730: It is not clear what simulations are kept. The text mentions 22 and 24 simulations kept at 12 km and 5 km but more seem acceptable from this figure. Also the initial condition picked for the Weddell Sea sector ($F_{pw} = 0.91$ and $E_{SSA} = 0.5$) does not seem an acceptable initial guess as described in the figure caption.

p.1731 l.4: The PISM manual is not a proper citation: 1) it has not been peer-reviewed, 2) it is constantly changing and 3) the authors of ice flow models should be credited.

p.1731 l.24: “proper grounding-line positions”: How is that evaluated? Visually or is there a quantitative criterion?

p.1732: These velocities are quite lower than observed today, how does this impact the results?

4 References

Fretwell, P., et al., Bedmap2: Improved ice bed, surface and thickness datasets for Antarctica, *Cryosphere*, 7(1), 375–393, 2013.

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Interactive comment on The Cryosphere Discuss., 9, 1705, 2015.