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Comment on egusphere-2022-94

Anonymous Referee #2

Referee comment on "Influence of fast ice on future ice shelf melting in the Totten Glacier area, East Antarctica" by Guillian Van Achter et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-94-RC2, 2022

Review of

Influence of fast ice on future ice shelf melting in the Totten Glacier area, East Antarctica

by

G. Van Achter, et al.

Summary:
The Antarctic ice sheet draining into the Southern Ocean via various marine terminating glaciers - aka ice shelves is the major future contributor to global sea level rise. Melting of ice shelves is often highly influenced by the sea-ice conditions at their fronts. This study is investigating the impact of landfast sea ice in front of the Totten and Moscow University ice shelves by using a state-of-the-art coupled numerical ocean-ice model that is regionalized to the wider region of these ice shelves. The investigation focuses on the difference in the ice shelf basal melt rates between recent decades (1995-2014) and the end of the 21st century (2081-2011) - hence investigating the influence of climate warming on the environmental (atmosphere, ocean, sea ice) conditions - with and without a prognostic fast ice coverage. The main outcomes of the study are i) presence of landfast sea ice increases melting rates for both ice shelves under current conditions, ii) climate warming triggers enhanced melting rates at the Totten but not the Moscow University Ice shelves, and iii) without landfast ice the increase in melting rates due to climate warming is larger than with landfast ice.

I rate this as an appropriately well written study of a very interesting aspect. While the presentation of the figures and the material is mostly very clear, I have the impression -

independent of what I wrote in my comments further below - that the manuscript would benefit from a careful reading and perhaps restructuring of the content of one or the other paragraph. One example is the one in lines 195-204. However, overall things seems sufficiently clear to me mostly. I have three general comments and only few specific and editoral comments.

General Comments:
GC1: The paper would benefit from an improved description of the physical processes that the authors expect to resolve with their study. While most of these come at a certain point in the description of the results and/or in the discussion, the readability of the paper as a whole would be greatly enhanced if the authors could come up with research hypotheses ... perhaps along the lines:
Climate warming leads to a reduction of the sea ice cover in the Southern Ocean and hence most likely to a reduction in the stability and duration of the landfast ice cover.
A reduction in landfast sea ice changes the atmosphere-ocean energy fluxes and can impact near-surface ocean currents and the vertical water mass structure.

GC2: There is more in the data than the authors show and discuss. This begins with the differences in the standard deviations shown in Table 2 (why?), continues with little discussion of the temporal variability inherent in the time series of the melt rates (--> What happens in years 6 and 7?), and ends when it comes to incorporating observational datasets to enhance the credibility of some of the statements made - be it with respect to the design of the experiment (keyword ice bergs) or with respect to how realistic is the fast ice cover modeled / where are main ice production sites located.

GC3: Some of the points discussed would benefit from more illustrative figures - such as results obtained with nFST and nFST_WARM in the context of the winter sea ice concentration (and polynya location) or the near-surface ocean currents.

Specific comments:
L25-31: In these lines you refer to the effect of fast ice. While you partly differentiate between multiyear fast ice (L25) and seasonal fast ice (L30) it remains unclear whether there is difference in the impact of these two kinds. Would it make sense to be more clear here?

In addition I am wondering whether it would make sense at this stage, to provide more details about the physical processes by which fast ice protects an ice shelf and/or changes water mass modification such that it has a notable impact on the development of the ice shelf. Describing these processes upfront would also help to understand whether and how the fast ice in the model leads to changes in the ice shelf; are the processes the same? How does a fast ice cover change the water mass properties? How does a fast ice cover protect the ice shelf boundary?

It seems that calving of ice bergs at the ice shelf boundary supported by the action of ocean swell is not among the processes you are taking into account. Is that correct? You could mention this here.

L51: I guess "Those models" refers to the models referred to in L48. Still, in order to estimate the importance (or size of the knowledge gap here) of not including fast ice it might be a good idea to mention about how many models we are talking here.

L102: Remaining questions I have with respect to the model:
- Does the model allow the water to have sub-freezing temperatures (see e.g. Haumann et al. 2020)?
- How does the model "grow" fast ice?
- How does the model treat ice shelf calving and generation of ice bergs?
- How does the model treat marine ice / platelet ice accretion underneath the ice shelf / the fast ice?

Figure 4: In the caption you (correctly) write "sea ice concentration" whereas in the title of the panels your write "sea ice extent". This should be harmonized towards "sea ice concentration" or "sea ice area fraction".

Figure 5: In order to avoid readers trying to find the eastward transport associated with the ACC in panels a) and b) it might make sense to annotate more latitudes.
Please remind the reader your motivation to choose a transect (in panel d) that is at the far eastern boundary of your region of interest and therefore quite far away from both the gyre on the shelf and the TIS.

L184: "more variable (+55%)" --> It is not clear to what you are referring to here? To the increase in the standard deviation?

Figure 7, panel a): What happened in years 6 and 7 in TIS? Why are melt rates so similar?

L198: "the presence of fast ice induces less sea ice production and more sea ice melt" --> I am not sure this global statement holds. I would think that it requires to take into account whether you are dealing with seasonal or multiyear fast ice, how far away the ice production sites are from the ice shelf boundaries and how efficient these are in the context of the production of the fast ice itself. It might be very illustrative to show two panels of the kind shown in Figure 4 e) and f) which back up your notion about the change in location of polynyas (and hence areas of high ice production).

L199: The causal link between enhanced upper ocean stratification and enhanced warm water intrusion should be made more clear. It is not immediately understandable. Perhaps it might make sense to show maps of the kind shown in Fig. 5 a), b) that illustrate the ocean currents. One of your earlier arguments was that a loss of fast ice between REF and WARM is responsible for the intensification of the Totten shelf gyre. I am wondering how this gyre looks like in nFST and nFST_WARM. From Figure 5 it is clear that during WARM there is substantially more water transport towards the TIS than during REF.

Table 2: What explains the switch from a lower standard deviation for 1995-2014 for the nFST cases compared to the higher standard deviation for 2081-2100 for the same cases?

L229/230: This might be in part triggered by the intensification of the Totten Shelf gyre, right? It might therefore make sense to come up with a number for the increase in water mass transport (in Sv) near the northeastern edge of the TIS between REF and WARM (see Fig. 5 a, b).

L254-256: "we were forced ... simulations" --> I am not on your page with this statement. There is at least one data set of ice berg distribution around Antarctica that covers more than just two months in a particular year. In addition, I'd say - if you are in doubt whether this limited data set suffices - you could at least compare your modeled fast ice extents in REF with fast ice derived from either MODIS or AMSR-E/2 satellite remote sensing observations. Should - within your period of interest - substantial differences occur in the location and stability of these ice bergs then I would assume that you would discover an increasing discrepancy between your model results and the observations. I would say this is simply about getting the correct data set to look at. Alex Fraser would be one point of contact; Nihashi Oshima another one.

Typos / editoral remarks:
L41: "will" --> Is this a definite change or is this rather something that could happen? Please re-phrease in case.

L113: Please clarify whether Fig. 2b shows salinity profiles before or after bias correction.

L138: "winds anomaly" --> "wind anomalies" to match with "occur".

L146: Would it make sense to note that this first-year fast ice is at a different location?

L154: If we both look at the same gyre (there is only one) then this is the southern limb of the gyre that is amplified - as is even visible in the zonal transport at 66.6 deg S.

L158: "eastern" --> "eastward"

L168: "mostly function" --> "mostly a function"

L169: "This" --> "These"

L185: You could add that the variability even decreases.

L200: "disappears" --> I tend to say it shrinks but it does not disappear - at least not according to Figure 4.

L218: "to broader" --> "to a broader"

L226: "and a fast ice representation" --> I suggest to stress here one more time how accurate the this fast ice representation is compared to observations ... how accurate is it?

L231: And because there is no speed up of any currents nearby?

L241: "are similar by the end of the 21st century" --> This is valid for TIS but not for MUIS which shows a melt rate for nFST_WARM that is about 10% larger than for WARM. Especially if we see this in relation to the melt rates for TIS between REF and nFST which also differ by an order of 10%. I therefore suggest to rephrase this statement.