The Cryosphere Discussions

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Comment on tc-2021-66

Anonymous Referee #2

Referee comment on "Brief communication: Thwaites Glacier cavity evolution" by Suzanne L. Bevan et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-66-RC2, 2021

The presented brief communication article deals with the formation and temporal evolution of a previously identified cavity close to the grounding line at Thwaites glacier. Recent studies identified tipping points for a continued grounding line retreat for Pine Island glacier also located at WAIS [1]. Similarly Thwaites glacier has also been implicated to experience continued retreat of the grounding line [2]. Due to the fast ice flow at the main trunk of Thwaites it is currently challenging to update grounding line positions from InSAR acquisitions. It only remains possible with a small temporal baseline (COSMOS-Skymed, Milillo 2019). Therefore, a detailed time series of grounding line positions is of high interest to the scientific community as it allows to under investigate the melt processes and timescales of grounding line migration directly at the grounding lie, although a derivation of the grounding line from height above floatation is less accurate than InSAR derived grounding lines. It has to be noted that accurate bathymetry and density assumptions are crucial for correct grounding line positions. The used TDM data (if properly calibrated) is an accurate enough reference for the surface elevation.
From the time series of height above floatation measurements the authors concluded that the previously reported cavity remained stable in height and extent and therefore the grounding line position also remained at a position of a slightly upward sloping bed which is predicted by coupled ice–ocean models.

I have some points that need further addressing before publication
- My first comment concerns the vertical calibration of the TDM time series. It is currently only explained in a few sentences. It would be preferable to use more than one IceSAT-2 measurement for calibrating the TDM scene to the IceSAT data. I suggest adding the used IceSAT-2 track in one of the Figures for a better overview. If surface elevations over the crevassed floating parts are used, it is important to calibrate the TDM data also in areas of limited or no signal penetration. A statement about the surface roughness, or distance to the area of investigation should be included. If the surface is rough and crevassed I would see no problem in selecting the area as it was done in the article but the argument is missing. Also a statement about the size of the calibration area is missing. What diameter does the footprint of the IceSat measurement have in the ATL06 data and how what size of TDM area was it compared against? Regarding the calibration of neighboring scenes in the range direction one hast to be careful to also include the TDM baseline uncertainties in the error budget of the adjacent scenes, as the two scenes are not from the same track

and can be characterized by different baseline errors. A baseline uncertainty of 1mm depending on the height of ambiguity adds elevation uncertainties in the order of 1m [3]. Depending on the used method for vertical calibration to IceSAT-2 a tilt in range could be remaining and propagate to the neighboring scene.
- The actual derived grounding line from height above floatation is not displayed in Figure 1. The caption states only MEaSUREs (purple: 1996 and yellow: 2011) and Milillo et al. (white: 2019). A time-series of 2D grounding lines would strengthen the argument of the suitability of height above floatation in this case, especially as it allows for a comparison with InSAR derived grounding lines over the whole area. L. 79 suggests that this was done. If a 2D representation of the grounding line time-series does not reproduce previous InSAR results over the entire area, it has to be stated that the analysis is restricted to the area of the cavity. In this case, results from height above floatation could be calibrated to the InSAR grounding line position.
- The discussion and especially the link to coupled models L 115-120 is difficult to understand. For me the physical process of why a stable grounding and cavity volume is reached after several years (how many?) is not entirely clear. Is this predicted by these models because they take ocean circulation of warm water in the cavities into account? If other models are used, would they predict a growing cavity and subsequent grounding line retreat (L. 120)? How the increasing velocity Fig 3, A1 are used in the arguments from L. 124-134 is not clear. I do not understand the meaning of this sentence "However, bed topography and ice-thickness close to floatation can superimpose rapid local change on the background long-term evolution of Thwaites and other WAIS glaciers in ASE"

Overall the article is of high scientific interest and well presented with clear language. The raised concerns require major revisions.

[1] Rosier, Sebastian H. R., Ronja Reese, Jonathan F. Donges, Jan De Rydt, G. Hilmar Gudmundsson, und Ricarda Winkelmann. 2021. „The Tipping Points and Early Warning Indicators for Pine Island Glacier, West Antarctica“. _The Cryosphere_ 15 (3): 1501–16. https://doi.org/10/gjnwhg.
[2] Joughin, I., Smith, B. E., and Medley, B.: Marine ice sheet collapse potentially under way for the Thwaites Glacier basin, West Antarctica, Science, 344, 735–738, https://doi.org/10.1126/science.1249055, 2014.
[3] Rizzoli, Paola, Michele Martone, Carolina Gonzalez, Christopher Wecklich, Daniela Borla Tridon, Benjamin Bräutigam, Markus Bachmann, u. a. 2017. „Generation and Performance Assessment of the Global TanDEM-X Digital Elevation Model“. _ISPRS Journal of Photogrammetry and Remote Sensing_ 132 (Oktober): 119–39. https://doi.org/10.1016/j.isprsjprs.2017.08.008.

Line comments:
- L. 4 continued
- L. 19 mention the used data ERS, COSMO-Skymed for deriving the grounding lines
- L. 44-46 (See general comments)
  - Choosing only one tie point is not robust
  - Combining adjacent across trade scenes in the overlap region includes baseline errors of in the order of 1m
  - Depending on the surface properties of chosen point there might be an elevation bias due to signal penetration.
  - Is the same point IceSAT-2 measurement used for the entire time series. If so,

thinning rates should be close to 0 and quantified at this location from an independent source.
  - Show IceSat 2 track on Fig 1
- L. 54 What is the result of 0.5m tidal variation in thickness change?
- L. 68. Combining errors: baseline, tidal range, TDM orbit. height above floatation from the two scenes will be characterized by different errors
- L. 78 Could you calibrate f_a on the previous InSAR grounding line positions
- L. 80 loss of 50 to 60m
- L. 88 Quantify value. How many meters above flotation is reported. Could this be explained by erroneous bathymetry?
- L. 97 good agreement to InSAR grounding line locations
- L. 112 thick □ deep - what does imprinted with bed topography mean?
- L. 130 Not justified - Discussion is hard to follow
- Fig. 1
  - Show IceSAT-2 tracks
  - Missing 2D time series of height above floatation derived grounding line positions
  - A legend would be helpful. MEaSUREs (purple, yellow), Milillo et al. (white)
- Fig2:
  - Reword caption: Surface elevation and basal elevation inferred from hydrostatic thickness. The thickness itself is not plotted.
  - Can you also quantify the scaling factor as it was used in the study here.
  - I cannot distinguish the colors of the arrows. The arrows should be labelled.