Reviewer: *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.*

Reply: Thank you for your thorough review.

Reviewer: *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.

Reply: We agree that it would have been ideal to calibrate every DEM with ICESat-2 data. However, ICESat-2 did not acquire data until October 2018 and then only 8 of the TanDEM-X scenes were acquired within 3 days of any ICESat-2 data within their geographic coverage. We therefore used the same point for all DEMs, chosen in a high-elevation, slow-moving location to minimise temporal elevation change at that point. CHANGES PROPOSED: We will expand this section as below and add the ICESat-2 track used to Fig. 1a.

The lack of co-temporal ICESat-2 data also explains why we were unable to calibrate the DEMs in the fast-moving floating areas. The technique for creating interferometric DEMs does not easily lend itself to spatially varying calibration although we accept that varying penetration depths may be an issue. As mentioned in lines 65 to 67 we were able to make an assessment of the vertical accuracy using the post-2018 co-temporal TanDEM-X/ICESat-2 data. The mean and standard deviation of the difference over 24,000 ICESat-2 points being -0.57 m and 2.25 m, respectively. We will produce a map of these point differences for the appendix.

The ICESat-2 footprint is 17 m and we compare the centre of this footprint to an individual 8 m TanDEM-X DEM pixel. We will add this information to the text.

The propagation of baseline errors into the adjacent scene is a good point. We will include a sentence about this although point out that the analysis is mostly confined to the scene that is directly tied to ICESat-2. Thank you also for the Rizzoli et al. (2017) reference, we will amend our estimate of baseline errors to 1 m propagating to 2 m within the neighbouring scene.

Reviewer: *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.*

Reply: CHANGES PROPOSED**:** We have recreated Fig. 1a using height above flotation rather than mapping floating areas, and this makes the DEM-based grounding line much clearer. For Fig. 1a we will now use the most recent DEM (Nov 2020) but also map heights above flotation for 2011, 2014 and 2017 for direct comparison with DInSAR grounding lines as a figure for the appendix, hence addressing the request for 2D representation of the grounding line. It is not simple to match individual 2016/2017 DInSAR grounding lines with DEM ones as the dates do not match exactly and, as reported by Milillo et al. (2019), the DInSAR lines cover a grounding zone that migrates with the tides over 2.5 km.

We would also like to mention here that following communication with Pietro Milillo regarding exact dates for the 2016/2017 grounding lines we obtained new shapefiles which map the GLs differently to those we had earlier. We do not know where the discrepancy originated but are assured that the GLs now mapped are correct.

Reviewer: *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"

Reply: Indeed, the coupled models are able to take into account the response of ocean circulation to changing geometry. Yes, without coupled modelling grounding lines continue to retreat as we do say in Line 20. CHANGES PROPOSED: In terms of time we will be more precise and change 'a couple' to one or two as per Goldberg et al. (2012).

At line 26 we are saying that long-term steady acceleration and thinning are taking place on grounded ice but that locally, where ice is close to flotation, thinning can induce flotation, allow ocean ingress, and rapidly induce a melt/thinning feedback until ocean circulation adjusts.

We will rephrase as 'Bed topography and ice-thickness close to flotation can mean that the observed long-term and steady thinning of Thwaites and other WAIS glaciers in ASE can cause a rapid local thinning induced by a melt/flotation feedback, until ocean circulation adjusts.'

Reviewer: *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.

Reply: Thanks for your help in making these revisions easy to implement.

Reviewer: *- L. 4 continued*

Reply: Corrected.

Reviewer: - L. 19 mention the used data ERS, COSMO-Skymed for deriving the grounding lines

Reply: Will do.

Reviewer: *Choosing only one tie point is not robust*

Reply: We have explained above the necessity for this approach, and we have further also used ICESat-2 data to validate the DEM heights to demonstrate the robustness of this approach.

Reviewer: *Combining adjacent across trade scenes in the overlap region includes baseline errors of in the order of 1m*

Reply: A new presentation of the error budget and its implications will include this point.

Reviewer: *- Depending on the surface properties of chosen point there might be an elevation bias due to signal penetration.*

Reply: This will be covered in the new discussion of errors.

Reviewer: *- 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.*

Reply: This will be covered in the new discussion of errors. We will also refer to this in discussing long-term elevation change shown in Fig. 3.

Reviewer: *- Show IceSat 2 track on Fig 1*

Reply: Will do.

Reviewer: *- L. 54 What is the result of 0.5m tidal variation in thickness change?*

Reply: In response to comments from Reviewer: 1 we will include a tidal correction.

Reviewer: *- L. 68. Combining errors: baseline, tidal range, TDM orbit. height above floatation from the two scenes will be characterized by different errors*

Reply: Agreed and we will add a more thorough discussion as shown above.

Reviewer: *- L. 78 Could you calibrate f_a on the previous InSAR grounding line positions*

Reply: This could be an interesting exercise. A problem would be that DInSAR grounding line locations are very tide dependent and we are unlikely to have a TanDEM-X DEM coinciding exactly in time and tide with the DInSAR mapping.

Reviewer: *- L. 80 loss of 50 to 60m*

Reply: Will change, thank you.

Reviewer: *- L. 88 Quantify value. How many meters above flotation is reported. Could this be explained by erroneous bathymetry?*

Reply: Now that we are using revised grounding line vectors from Milillo, this discrepancy has been removed.

Reviewer: *- L. 97 good agreement to InSAR grounding line locations*

Reply: Will change.

Reviewer: *- L. 112 thick → deep - what does imprinted with bed topography mean?*

Reply: We will change thick to deep. Jordan et al. (2020) were observing that the ice shelf base still contained a signature of the bed implying that melt rates were low. We will change the sentence to:

'and the sub-shelf topography continues to closely follow the contours of the bed topography

Reviewer: *- L. 130 Not justified - Discussion is hard to follow*

Reply: As requested also by Reviewer: 1 we will remove this sentence.

Reviewer: *- Fig. 1 - Show IceSAT-2 tracks*

Reply: Will do.

Reviewer: *- Missing 2D time series of height above floatation derived grounding line positions*

Reply: We will map 2020 in Fig. 1a, and include three (2011, 2014 and 2017) maps in the Appendix.

Reviewer: *- A legend would be helpful. MEaSUREs (purple, yellow), Milillo et al. (white)*

Reply: Yes, will do.

Reviewer: *- Fig2: Reword caption: Surface elevation and basal elevation inferred from hydrostatic thickness. The thickness itself is not plotted.*

Reply: Good point, will do so.

Reviewer: *- Can you also quantify the scaling factor as it was used in the study here.*

Reply: Scaling factor is approximately 8 for these ice thicknesses. We will include this information in the caption.

Reviewer: *- I cannot distinguish the colors of the arrows. The arrows should be labelled.*

Reply: Good point, will do so.