Review of "Building multi-satellite DEM time series for insight into mélange inside large rifts in Antarctica"

Overview:

I appreciate that the authors have done their best to address the comments from both me and the other reviewer. I do, however, still have a few concerns with regards to the novelty and impact of the paper. A DEM-registration method, as MDAM presented here, is in itself not novel, as similar approaches already exist. Therefore, I think that the paper requires a stronger analysis and discussion of the observed melange dynamics to be impactful enough to be published. Please see my comments below for a more elaborate suggestion on how to achieve that. All line numbers refer to the track-changes version of the manuscript.

Minor comments:

MDAM method:

The authors present their DEM-registration method MDAM as being the only existing method which can be used to study 3D melange dynamics, which I would disagree with. While existing methods (e.g., Shean at al. 2019 and Zinck et al., 2023) do not use their DEM-registration methods to study melange dynamics, it does not mean that they cannot be used for that. I do find the MDAM method to be a good addition to the existing methods, but it should be clearly acknowledged that other methods do exist. Furthermore, I miss a discussion of the limitations of the MDAM method. For instance, it seems that both TPs and GCPs are manually chosen, which makes the MDAM method difficult to upscale to larger regions as it would require a significant amount of manual labour. Secondly, the authors mention that the method requires adjustment to be applied to areas such as Pine Island and Thwaites. What adjustments would that be? And why?

Melange dynamics analysis and discussion:

You discuss a few causes behind the observed rift widenings. However, I am still left with an impression that I do not know what caused the widening of the rifts. Why did the melanges not freeze the rifts? How do you expect the rifts to continue their development? Is there anything to learn from the evolution of rift T2, which seems to be two rifts approaching each other and potentially merging? I think that the manuscript could benefit from a more detailed discussion on the impacts of the results. What have we learned from these results which we did not already know? Having a more detailed discussion on that would increase the impact of the paper, its findings, and also on the MDAM method itself.

Results/Methods structure:

The restructuring of the Data and Methods section has improved the readability of the paper greatly. However, there are still Methods elements present in the first section of the Results. In my opinion most of section "3.1 Bias correction and adjusted DEM time series" belongs in the Methods part of the paper and not in the Results, as it describes how you generate the final DEM timeseries. You could keep the figures in the Results, including a description of the improved uncertainty after the bias-correction. However, the sentences describing how you calculate different components (i.e. assigning different weights to TPs in L242-249, the validation method of the bias correction and the data used therefore in L283-291, etc.) should be moved to the Methods section in my opinion. You could also choose to move the entire section to the Methods.

Specific comments:

L40-45: I would suggest rephrasing it to something like this: "Mélanges inside rifts, which consist of shelf ice, snow, sea ice, and water, have been investigated in relation to ice shelf fracturing in Antarctica and glacier calving in Greenland (References). Specifically, reductions in mélange thickness have been observed during rift widening on the Amery, Ronne, and Larsen C ice shelves (References). Furthermore, modelling results indicate that a mélange may... "

L63-64: This is where I suggest you to be careful with how you present the MDAM method as this sentence still reads as if there is a general lack of methods handling heterogenous offsets between individual DEMs. I, therefore, suggest you to acknowledge that other methods already exist, but all with a different goal in mind, than the 3D melange dynamics presented in this paper.

L190-204: Are the GCPs manually chosen? Or are they "computationally" selected based on the mentioned criteria? Please mention what you did in a revised manuscript.

L210-224: Is it correctly understood that the TPs are manually selected? If so, please state that explicitly in the manuscript.

L236-237: The comment about the observed melange thinning seems misplaced here in the Methods section. I would suggest to move it to the Results or Discussion.

L241-292: This is the part which I suggest that you (partly) move to the Methods section of the paper.

Table 1: I do not see the need for this table as the numbers are illustrated much better in Figure 6 and 7.

Figure 10: Please specificy in both figure and caption which is T1 and which is T2.

L321-322: I would suggest to reduce the number of digits: 47.132 km → 47.1 km, 48.324 km → 48.3 km, 1.457 km → 1.5 km, 1.532 km → 1.5 km

Figure 11: Would it maybe make more sense to use two different centerlines for T2 as it seems from Fig. A2 that T2 is maybe two separate rifts approaching eachother rather than one long rift. This would also help to avoid confusion as to why the elevation and volumne is so much higher/bigger in the middle of the central section of T2.

L375-377: I don't fully understand this sentence. What does "this model" refer to? Is that MDAM? And if so, why wouldn't it work for Pine Island and Thwaites? What adjustments would be needed?

L378-386: You mention that a thick melange layer can freeze a rift, but that is clearly not what happens at T1 and T2. Why is that? This entire paragraph in general seems loosely connected. As in, how does the fact that a thick melange layer can freeze rifts relate to the next sentence seracs inside the melange?

L385-386: Calving does not necessarily impact ice shelf stability and as you mention in the following paragraph it seems that these rifts are in areas which do not provide much buttressing. I would, therefore, suggest that you remove the ice shelf stability part of this sentence.

L385: Change Passive Shelf Ice (PSI) to passive shelf ice. There is no need for an acronym which you only use two times.

L404-405: Could you clarify how the MDAM system can bu used to study ice shelf instability and sea level rise contribution?

Typos and grammar:

General grammar comment: The manuscript misses quite a few definitive articles ("the") throughout the text, which makes the text difficult to follow at times. I have only marked a few of them in my review, but I recommend the authors to make use of a grammar tool or similar to locate the remaing missing definitive articles.

L28: Antarctic Ice Sheet (AIS)… → **The** Antarctic Ice Sheet (AIS)…

L49: Be aware of using the definite article "the". Change "earth surface features" to "**the Earth's** surface features"

L52-55: Be aware of using the definite article "the". Change to: "… for example, **the** 500 m ICESat (Dimarzio et al., 2007) and ICESat-2 (Shen et al., 2022) DEMs, and **the** 1000 m CryoSat-2 DEM (Slater et al., 2018). Those from optical and SAR satellite stereo mapping data are of higher resolutions and have the potential for geometric modeling and analysis of rifts and mélange features, including **the** 90 m TanDEM-X DEM (Wessel et al., 2021),

the 30 m ASTER DEM (Tachikawa et al., 2011), and especially, **the** 2 m REMA DEM (Howat et al., 2019)."

L68-69 (Figure 1 caption): Be aware of using the definite article "the". Change to "**The** LIMA mosaic ... **the** RAMP DEM ..."

L81: Change to "The validated MDAM is applied **to** the Filchner..."

L83: Change to "... is the second largest **ice shelf** in Antarctica."

L125: Be aware of using the definite article "the". Change to: "at **the** two shelf margins"

L126: Change "cover the floating ice of the ice shelf." to "cover the floating ice shelf".

L155: Change to "In **a** similar way,"

L246: Change to: "**on** average"

References:

Shean, D. E., Joughin, I. R., Dutrieux, P., Smith, B. E., and Berthier, E.: Ice shelf basal melt rates from a high-resolution digital elevation model (DEM) record for Pine Island Glacier, Antarctica, The Cryosphere, 13, 2633–2656, https://doi.org/10.5194/tc-13-2633-2019, 2019.

Zinck, A.-S. P., Wouters, B., Lambert, E., and Lhermitte, S.: Unveiling spatial variability within the Dotson Melt Channel through high-resolution basal melt rates from the Reference Elevation Model of Antarctica, The Cryosphere, 17, 3785–3801, https://doi.org/10.5194/tc-17-3785-2023, 2023.