Response to Reviewer Comment #1 (RC1)

We are grateful for the Reviewer's time spent evaluating the manuscript, and for the valuable comments, which we believe have helped improve the manuscript. Please find our response to individual comments below - the Reviewer's original comments appear in black text, while our responses appear in blue.

In this brief communication, Andersen et al. present an updated mapping of glacier grounding lines in the Amundsen Sea Embayment of West Antarctica, using Sentinel-1 Synthetic Aperture Radar (SAR) images acquired with a 1-day repeat-pass during the commissioning phase of Sentinel-1C. These data offer an excellent opportunity to comprehensively update the grounding line record for Pine Island, Thwaites and other glaciers in the Amundsen-sea, which are crucial in the mass balance and stability of West Antarctica.
The authors find grounding line retreat of between 2 and 7 km on Pine Island Glacier since the last available grounding line data from 2011, while Thwaites Glacier grounding lines are within previous mapping efforts of 2023. In the Crosson-Dotson region they find that grounding lines have largely stabilised on their 2020 position.
The manuscript is well written and easy to follow, with excellent quality data. The new up-to-date GL product which the authors make available is valuable to the Antarctic glaciology community. I commend the authors for making this available promptly after the Sentinel-1 acquisitions earlier this year. The authors also do a good job of highlighting the value in short-repeat pass interferometry for ice sheet monitoring, I thank them for this effort.
Overall, the manuscript is timely, significant and will be useful to all glaciologists with an interest in West Antarctica. I have one main general comment which I think it is important to address, plus minor comments on a line-by-line and figure-by-figure basis. I hope that these will be useful in improving and revising the paper.
Thank you for your overall positive evaluation of the manuscript. One goal of the paper was indeed to highlight the value of short repeat-pass interferometry, particularly for monitoring highly dynamic regions such as ASE, so we are happy that this point came across. We address your general, line-by-line, and Figure comments below.

General comment:
My main concern with this manuscript is in how uncertainty in the grounding line position and grounding zone width is reported. I understand that there is a limited amount of data for historic periods and that any grounding line delineation from a single (3 or 4 constituent acquisition) differential InSAR result is only a snapshot of grounding line position in a zone that we know displays substantial tidal migration. However, even with this caveat, I think that the authors could and should provide a more detailed discussion of the impact of this uncertainty on the measured GL retreat. In my opinion, the sentence at line 105: 'Consequently, the reported changes in GL location should be viewed as approximate, as they stem from a comparison of discrete acquisitions' does a disservice to the volume and quality of data available.
The authors quote from Mohajerani et al. 2021 that 'estimates of grounding zone width in the ASE are mostly around 1km but may locally exceed 5km'. This range of 1 to 5 km is comparable to the retreat rates that the authors quote throughout the article and consequently deserves a more thorough quantitative treatment. I do not want to be too prescriptive, given the Brief

Communication format, but suggestions for how to do this could include quoting the grounding zone width from the Mohajerani data where possible, or expanding the supplementary figures to show the estimated grounding zone width where data is available, as it has been done for Cosgrove Ice Shelf and Getz Ice Shelf.

Improving the quantification of these impacts in the manuscript would make the grounding line retreat results substantially more useful to the community by qualifying the results with an uncertainty.

First off, we improved the 2025 ASE GL dataset by utilizing all available double-difference interferograms to generate separate GL retrievals for each double-difference product (and, hence, at different tidal conditions), rather than aiming to generate one contiguous/common grounding line. While this does not allow for an exact estimation of the full grounding zone (as in Mohajerani et al. 2021), this does provide some more context to the 2025 dataset, as most sectors now feature 3-7 retrievals, revealing local effects of short-term, tide-induced GL migration, and hence a "partial sampling" of the grounding zone.

At the same time, we updated Figure 3 (and the associated text in the Results section) to also include a comparison with the 2018 retrievals from Mohajerani et al. (2021) where available, as this is the only dataset that provides a realistic measure of the actual grounding zone (along with the Rignot et al. (2024) Thwaites ICEYE dataset). In some places, e.g. where the Mohajerani et al. dataset is not available, we still make a comparison with the historic single-acquisition GL retrievals, however, we caution that the magnitude of such estimates may, of course, partially be influenced by tide/pressure-induced fluctuations. Here, we argue that the added context of several 2025 retrievals reduces the uncertainty somewhat.

Below we paste the updated paragraphs of the Results section (lines 97-118), which now clearly underlines the difference between datasets providing single-acquisition GLs ("historic" datasets), full grounding zone estimates (Mohajerani et al.), and our "intermediate" product consisting of 1-7 retrievals. It also introduces the updated Text S1/Table S1 (featuring a description of the procedure for estimating tide/pressure-induced Sea Surface Height for all of the double-difference products) and an additional Figure (Figure S2, which documents examples of short-term GL variation). This metadata has also been added to the updated GeoPackage, containing the 2025 ASE GL dataset (contained in the updated Zenodo archive).

"...For the majority of the region, multiple GL delineations were made spanning different tidal and atmospheric conditions (Text S1, Table S1). GLs near the Abbott and Cosgrove ice shelves were captured in 1-2 delineations, while the remaining regions were captured in 3-7 separate retrievals. While this sampling density is insufficient to robustly resolve the full grounding zone, the availability of multiple delineations enables partial observation of short-term, tide- and pressure-induced GL variability. Examples of such short-term GL migration, varying from a few hundred meters to several kilometers, are shown in Figure S2.

Figure 3 shows a comparison between the new 2025 GL delineations and the MEaSUREs Antarctica grounding line product (Rignot et al., 2016), which contains retrievals from the period 1992-2014 for nearly the full region, the ESA CCI grounding line product (ESA AIS CCI, 2021), containing retrievals from the period 1994-2020 for select glaciers, and the COSMO-SkyMed grounding line dataset from Milillo et al. (2022), covering the Pope, Smith, and Kohler glaciers during 2016-2020, overlaid on the BedMachine v3 bed elevation product (Morlighem, 2022). These historic GL products generally rely *on single or sporadic acquisitions per year and therefore represent snapshots of the GL at varying tidal and atmospheric conditions, rather than the full grounding zone. In contrast, the deep learning-based 2018 GL dataset of Mohajerani et al. (2021), although not covering the fastest-flowing glaciers (e.g., Pine Island, Thwaites, Smith), provides an estimate of grounding zone width based on all available 2018 Sentinel-1 data. In the ASE, grounding zone widths inferred from this product vary from less than 1 km to locally more than 5 km.*

Taken together, these differences in temporal sampling imply that apparent GL advances or retreats between products, particularly between single-acquisition historic delineations and the 2025 retrievals, should be interpreted with caution. Where offsets of several kilometers are observed, part of the apparent change may reflect the incomplete capturing of the grounding zone, rather than solely long-term migration. The 2025 dataset occupies an intermediate position between single-acquisition historical products and fully resolved grounding zone estimates, providing improved, although partial, constraints on short-term GL variability."

Line-by-line comments:
8: In my opinion, it would be useful to quantify the increase in mass loss or ice discharge in this opening sentence.
We included the following sentence (line 9), to quantify the mass loss increase: "*Mass loss from West Antarctica increased from 39.5 +/- 19 Gt/y during 1992-2001 to 103.6 +/- 10.8 Gt/y during 2002-2020 (Otosaka et al., 2023).*"

11: perhaps clarify with 'As ocean temperatures rise…'
We expanded the sentence to be more explanatory - the sentence now reads (lines 10-11): "*Melting peaks near the grounding line (GL), the boundary between grounded and floating ice. As warm and saline circumpolar deep water is advected below the ice shelf, GL retreat into deeper basins accelerates ice flow and dynamic thinning, further promoting retreat and decreasing the buttressing potential of ice shelves.*"

14: The source for the quoted 1.2m potential SLR is not clear to me, as the references that follow this are all about GL retreat. This is not trivial, as there are multiple bed products that could support this statement, each with different methodologies and associated errors.
The number stems from Morlighem et al., (2020) (reference pasted below). The 1.2 m figure stems from summing all of the glacier basins in ASE. We now properly reference this (line 16), and provide the number with associated error estimate as obtained from Morlighem et al. (1.26 +/- 0.02 m).

Morlighem, M., Rignot, E., Binder, T. *et al.* Deep glacial troughs and stabilizing ridges unveiled beneath the margins of the Antarctic ice sheet. *Nat. Geosci.* 13, 132–137 (2020). https://doi.org/10.1038/s41561-019-0510-8

22: Here I would also recommend citing Milillo et al. (2022) and Freer et al. (2023) for remote-sensing observations of the tidal GL migration process.
We added the reference to Milillo et al., (2022) and Freer et al., (2023) at the end of this sentence (line 24).

54: I think the text in brackets is unnecessary here

The sentence describes how Sentinel-1C restored the nominal 6-day repeat coverage, but that only happened after the end of the commissioning phase, so we think it is relevant to include this note.

58: Here the authors might also comment on the impact of deformation and strain on InSAR coherence. Decorrelation is observable in the shear margins of PIG and Smith glacier in Figure 2, so it would be useful to include in this paragraph.

We added “shear deformation” as one of the sources of decorrelation (line 59).

86: Can the authors give an indication of the impact of not having the POE products for S-1C?

This entirely depends on the quality of the individual SAFE product orbit state vectors. Generally, uncertainties in the orbits will cause a degraded coregistration (and hence noisier interferograms - to the point of complete decorrelation in the extreme case). In our experience, using the nominal SAFE orbit files instead of the refined POE (or RES) often leads to no discernable noise increases. For this dataset, we did notice a tendency for residual phase discontinuities at burst boundaries (see Figure S3, previously S2), which could be caused by degraded coregistration. However, while these phase jumps can be problematic if one intends to perform phase unwrapping, they do not really hinder the delineation of grounding lines. So, in conclusion, we do not consider the lack of POE orbits to be a significant source of error for the GL retrieval, yet still find it relevant to mention the fact that precise orbits were not used for S-1C images, to accurately describe the processing.

121: If manuscript length allows it would be good to give an explicit example of one of these local exceptions.

We have added arrows in Figure S2c-d (Figure S3c-d in the updated Supplementary), which indicate the locations where the 2025 GL lies inland of the 2018 GZ estimate. Manuscript length requirements do not allow an extra main text Figure, so we keep this one in the Supplementary Material.

123: I find the references to East/West in this paragraph to describe the geometry of PIG to be quite confusing. I think the authors are referring to East/West in terms of the grid directions of the polar stereographic (EPSG:3031) grid. Typically, many authors talk about the geometry of the shelf with respect to true north, eg the northern and southern shear margins, and to me this is far more intuitive.

We recognize that this description was unclear and ambiguous. We have updated the paragraph accordingly and added labels to Figure 3. We now refer to three separate regions: “Main trunk”, “Piglet Glacier”, and “Lucchitta and Larter glaciers” - all of which are labelled in Figure 3. Additionally, when referring to a direction, we refer to true north/south (adding a true north arrow to Figures 1-3) instead of the “pseudo” east/west directions in the polar-stereographic map projection. The updated paragraph now reads (lines 140-150):

“*At Pine Island Ice Shelf, the main trunk GL shows an apparent further retreat of approximately 2-7 km since 2011, following a larger retreat of 15-20 km during 1992-2011. In the main trunk of the glacier - the region with the fastest ice flow - the northern section has retreated by up to 7 km, while the central part has pulled back by approximately 1-3 km. The southern section of the main trunk appears to have been dislodged from a sill in the bedrock topography at a depth of -1000 m and subsequently retreated by around 5 km (Figure 3b). In this critical part of the glacier, where ice* *discharge is at its maximum, the GL has retreated more significantly along the northern and southern flanks than at the center. The southern tributary glacier, sometimes referred to as Piglet Glacier, which flows toward the Pine Island Ice Shelf front, has experienced widespread GL retreat during 2016-2018, averaging around 3 km with localized retreats reaching up to 6 km, particularly in areas where the bedrock slope is slightly retrograde. In 2025, we observe an additional apparent retreat of around 2 km, compared to the 2018 grounding zone (Figure 3b). Conversely, at the northern tributaries (Lucchitta and Larter glaciers), the GL has remained relatively stable, situated on a more pronounced, mountainous, and prograde topography (Figure 3b).*"

132: If article length allows it would be interesting to mention the evolution of the pinning point/ephemeral grounding point in the central PIG shelf which appears in your interferograms.
Good point. We have added the following sentence to comment on this (lines 150-152), as well as a reference to a recent manuscript, which studied this ephemeral grounding feature in detail (Qian et al., 2025): "*Finally, the 2025 interferogram shows the presence of a pinning point in the central part of the ice shelf (Figure 2b), which has previously been identified as an ephemeral feature (Rignot et al., 2014; Qian et al., 2025).*"

Figures:
Figure 1 – I understand that this colourmap has been used in the past to represent MEaSUREs ice speed data, so there are some historical reasons to use it, but in my opinion this is not well-aligned to Copernicus Publications' guidelines for figure composition (https://publications.copernicus.org/for_authors/manuscript_preparation.html#manuscriptcomposition) . I encourage the authors to choose a colourmap that is perceptually uniform.
The underlying optical image mosaic could be clipped to the boundary used for the ice speed data; this would make the figure much neater.
The figure caption should specify which underlying image mosaic is being used.
We changed the colormap for the ice velocity mosaic. Although this version still has some "rainbow" to it, it has far fewer ambiguities than the previous version (we tested it with the Coblis Color Blindness Simulator and did not find it problematic with any types of colorblindness). Also, the main purpose of the ice velocity map here is simply to show where fast-flowing glaciers are located, not to read off exact values from the map.
We generated a true-color mosaic from Sentinel-2 imagery (from January-March 2025) to use as underlay in the updated Figure. This mosaic gives a more representative picture of the ice shelf extent during the period we are investigating. We clipped the ice velocity map to the (approximate) January-March 2025 extent (see comment below). We updated the caption to specify the Sentinel-2 underlay.

Figure 2 – Including a boundary for the current ice shelf calving front, perhaps in white, would be useful for identifying where the InSAR is incoherent due to factors like the shear margin and where it is just ocean.
We added ice shelf calving fronts as white lines in Figures 2 and 3. We manually delineated the front lines based on intensity images from the Sentinel-1 1-day (January-March 2025) dataset.

Figure 3 – the use of green for MEaSUREs, blue for CCI and blue for bathymetry make this figure difficult to interpret. It's quite hard for me to make out the GL in some places, for example on PIG for

the 2014 MEaSUREs GL and on Smith West. For a colour deficient reader I'm concerned that it could be prohibitively difficult. A solution may be to simplify the plot so that MEaSUREs, CCI and Mililllo are on a single colour scheme based on the year.
We recognize that the previous Figure 3 was challenging to analyse, due to the different color palettes. We have updated the Figure by tweaking the colors, so that none of the GL datasets intersect with the underlying bed elevation colormap. The MEaSUREs and CCI datasets now share the same color scheme, as they approximately cover the same period. Note that we have also added the updated 2025 GL to include all individual delineations as well as the Mohajerani et al. (2021) dataset (cf. our response to your General Comment).

Mililllo is spelt wrong in the legend for Figure 3.
Corrected.