

Review for "Brief Communication: Comparing ICESat-2 Altimetry and COSMO-SkyMed Synthetic Aperture Radar Interferometry Grounding Zone Products over Antarctica"

We thank the Reviewer for their careful evaluation of our manuscript and constructive comments, which have helped us improve the manuscript.

This work compares two independent grounding zone products over Antarctica: the ICESat-2 laser-altimetry grounding zone features of Li et al. (2022) and a COSMO-SkyMed DInSAR grounding lines from Ross et al. (2025). It quantifies the distances between the altimetry-derived features (F, Ib, H) and the interferometric grounding line. This work compares recent datasets and the regional breakdown into East Antarctica, West Antarctica and the Antarctic Peninsula is a helpful way to summarise the comparison.

My main concerns are about the methodological framework of the paper and Figure 1C and D. The main takeaway, which is that the break-in-slope (Ib) is closer to the DInSAR grounding line than the landward flexure limit (F), reversing the expected ordering, is very poorly justified and in my view, an incorrect interpretation of the computed metrics. The same inference is not reproduced when the mean absolute separation metric used by Li et al. (2022) is applied. The authors go back on their novel claim in the conclusion, where they admit that the variance of Ib-GL distances is much greater than F-GL distances, "However, we note that the Ib-GL offsets exhibit the largest standard deviations among the three ICESat-2 point classes, indicating that while Ib points appear closer to the DInSAR grounding line on average, this result is not statistically robust and should be interpreted with caution." It makes me wonder why they came upon the order reversal idea in the first place.

We agree with the reviewer that the ordering reported in the original submission is based on signed mean offsets, which are not an appropriate measure of relative proximity because positive and negative distances can cancel. The near-zero signed mean for I_b proxies reflects their distribution, with 43% located upstream and 57% downstream of the DInSAR-derived grounding line. When recomputed as absolute separations, as the reviewer suggested, the ordering is $F < I_b < H$ in every region with the proxy-specific buffers (Antarctic-wide absolute means of 272 m, 507 m and 4730 m, Table 1 in the revised manuscript). This ordering is also maintained when using flow-aligned distances (Table A2 in the revised manuscript), and under all wider buffers we tested (Table A1 in the revised manuscript). Because each buffer limits the range of distances included in its distribution, we now clarify in Section 3.2 that the observed ranking is partly influenced by the buffer widths. We also provide the simulated buffer comparison requested by the Reviewer in specific comment 10. We have revised the Abstract, Sections 3.1-3.3, and the Conclusions to remove the previous claim of a reversed ordering. The revised Abstract states: " I_b proxies are split between upstream (43%) and downstream (57%) positions relative to the DInSAR-derived grounding line, so their signed offsets cancel, whereas 70% of F proxies lie downstream. Both patterns persist for flow-aligned distances and for wider buffers." The distinctive characteristics of the I_b results are therefore their offset distribution and the proportion of proxies located upstream

of the DInSAR-derived grounding line. Section 3.3 lists candidate causes for both, with ice plains as one hypothesis that we do not demonstrate for any of our glaciers.

Furthermore, the temporal offset between the two datasets (ICESat-2 2019-2020 and CSK 2020-2022), is not negligible in the rapidly retreating parts of West Antarctica. This might have further skewed the measured distances. The 1 km, 5 km and 10 km buffers used for filtering F, Ib, H respectively, are not well justified. This filtering scheme also wrongly leads to the conclusion '73% of F points do not correspond to a CSK grounding line' as the filtering removes a majority of points anyway. Figure 1C and D seem to imply that the true grounding line is detected in double difference interferograms. It is widely acknowledged in literature that the hinge line is the feature which is detected by all tidal remote sensing methods. I could not find any justification for the grounding zone representation depicted in Figure 1C, D anywhere in the paper. While I think the theme of this work is suited to Brief Communication, the main method and findings are contentious and poorly supported by the statistics presented in Table 1. I urge the authors to carefully check literature, especially about the grounding zone features which are detectable from tidal remote sensing methods (Friedl et al., 2020). I recommend major revisions before publication. Detailed below are my specific and technical comments.

We address each point here and in the specific comments below.

For temporal offset, 57 of the 73 glaciers (78%) have at least one DInSAR-derived grounding line inside the 30 April to 30 September 2020 overlap with the ICESat-2 product, and the other 16 are compared with the nearest available grounding line. Sections 1 and 2.3 now state this, and Section 2.3 lists temporal and tidal sampling as sources of the measured separations.

Statistics for the 57 glaciers that have temporal overlapping grounding lines with the ICESat-2 grounding zone proxies are given in Table R1.

Table R1. Statistics for the 57 glaciers with temporal overlap between the CSK DInSAR-derived grounding lines and ICESat-2 grounding-zone proxies

Proxy	N	Mean $\pm$ SD (m)	Min (m)	Max (m)	Median (m)	IQR (m)	Upstream (N)	Downstream (N)
East Antarctica: Total 22 glaciers and ice streams								
F	587	182 $\pm$ 330	-926	995	114	388	171 (29 %)	416 (71 %)
I _b	1574	-156 $\pm$ 1005	-4856	3809	-4	558	815 (52 %)	759 (48 %)
H	599	4629 $\pm$ 2539	-4970	9974	4877	3356	24 (4%)	575 (96 %)
West Antarctica: Total 14 glaciers and ice streams								
F	366	224 $\pm$ 333	-800	970	151	472	98 (27 %)	268 (73 %)
I _b	1322	277 $\pm$ 783	-3362	4983	105	518	420 (32 %)	902 (68 %)
H	303	5661 $\pm$ 3107	-5363	9991	6383	5034	11 (4 %)	292 (96 %)
Antarctica Peninsula: Total 21 glaciers and ice streams								
F	235	120 $\pm$ 296	-851	971	60	270	80 (34 %)	155 (66 %)
I _b	670	-21 $\pm$ 757	-4774	4026	14	219	308 (46 %)	362 (54 %)
H	198	3190 $\pm$ 1947	-9495	8233	3110	2226	4 (2 %)	194 (98 %)
Antarctica: Total 57 glaciers and ice streams								
F	1188	183 $\pm$ 327	-926	995	112	405	349 (29 %)	839 (71 %)
I _b	3566	36 $\pm$ 902	-4856	4983	25	401	1543 (43 %)	2023 (57 %)

H	1100	4663 $\pm$ 2744	-9495	9991	4682	3896	39 (4 %)	1061 (96 %)
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Statistics for 16 glaciers that do not have temporal overlap with ICESat-2 proxies are given in Table R2.

Table R2. Statistics for the 16 glaciers without temporal overlap between the CSK DInSAR-derived grounding lines and ICESat-2 grounding-zone proxies

Proxy	N	Mean $\pm$ SD (m)	Min (m)	Max (m)	Median (m)	IQR (m)	Upstream (N)	Downstream (N)
East Antarctica: Total 3 glaciers and ice streams								
F	12	-17 $\pm$ 365	-574	620	-16	284	7 (58 %)	5 (42 %)
I _b	126	107 $\pm$ 935	-2340	2932	86	719	56 (44 %)	70 (56 %)
H	5	1720 $\pm$ 683	606	2576	2030	720	0 (0%)	5 (100 %)
West Antarctica: Total 5 glaciers and ice streams								
F	14	411 $\pm$ 243	11	828	513	399	0 (0 %)	14 (100 %)
I _b	247	68 $\pm$ 697	-2016	4108	64	428	94 (38 %)	153 (62 %)
H	10	2819 $\pm$ 1780	175	5627	2445	2658	0 (0 %)	10 (100 %)
Antarctica Peninsula: Total 8 glaciers and ice streams								
F	39	-11 $\pm$ 287	-706	533	32	459	17 (44 %)	22 (56 %)
I _b	165	80 $\pm$ 1155	-4849	3984	102	491	62 (38 %)	103 (62 %)
H	32	2248 $\pm$ 1457	153	7577	2109	1531	0 (0 %)	32 (100 %)
Antarctica: Total 16 glaciers and ice streams								
F	65	81 $\pm$ 342	-706	828	76	323	24 (37 %)	41 (63 %)
I _b	538	81 $\pm$ 916	-4849	4108	88	491	212 (39 %)	326 (61 %)
H	47	2310 $\pm$ 1503	153	7577	2053	1534	0 (0 %)	47 (100 %)

The spatial distribution of grounding-zone proxies differed between the 57 glaciers and ice streams with overlapping ICESat-2 and DInSAR-derived grounding-line observations and the remaining 16 glaciers without temporal overlap. In the 57 overlapping glaciers (Table R1), F proxies are predominantly located downstream of the grounding line across all regions, accounting for 66-73% of observations, while I_b proxies showed a more balanced distribution, with downstream proportions ranging from 48% in East Antarctica to 68% in West Antarctica. H proxies are overwhelmingly downstream in all three regions (96-98%). Across Antarctica, the mean signed distances are 183 $\pm$ 327 m for F, 36 $\pm$ 902 m for I_b, and 4663 $\pm$ 2744 m for H, indicating that F and I_b observations are, on average, relatively close to the grounding line, whereas H observations are located substantially farther downstream. For the remaining 16 glaciers (Table R2), F and I_b proxies are also predominantly downstream at the continental scale, representing 63% and 61% of observations, respectively. All H proxies in this group are downstream, with a mean distance of 2310 $\pm$ 1503 m. The regional differences are evident, particularly for F proxies in West Antarctica, where all 14 observations are downstream, and all I_b proxies in East Antarctica, where the downstream proportion is 56%. Overall, the two groups exhibit broadly similar downstream-dominated distributions for F and I_b proxies and a consistently downstream distribution for H proxies.

The buffers are proxy-specific because F, I_b, and H lie at different positions across the grounding zone. Widening them (2 km for F, 7 and 10 km for I_b, 15 km for H; Table R3 in this response letter and Table A2 in the revised manuscript) does not change the ranking by absolute distance, but the F-proxy statistics are sensitive to buffer size. Specifically, the mean absolute F offset increases from 272 m with the 1 km buffer to 386 m with the 2 km buffer. We have clarified this buffer dependence in Sections 2.3 and 3.2 of the revised manuscript.

Table R3: Cross-comparison of F, I_b, and H ICESat-2-derived grounding zone proxy data with DInSAR-derived Grounding lines for buffer simulation.

Proxy	Distance Type	Buffer (km)	N	Mean ± SD (m)	Min (m)	Max (m)	CV	Median (m)	IQR (m)	Upstream (N)	Down Stream (N)
East Antarctica: Total 25 glaciers and ice streams											
F	Signed	2	650	241 ± 484	-1940	1989		143	483	185 (28%)	465 (72%)
	Absolute			361 ± 403	1	1989	1.1	208	466		
I _b	Signed	7	1727	-164 ± 1238	-6667	6810		-3	604	889 (51%)	838 (49%)
	Absolute			683 ± 1045	0.1	6810	1.5	296	751		
I _b	Signed	10	1747	-164 ± 1528	-7903	9844		-3	616	901 (52%)	846 (48%)
	Absolute			775 ± 1327	0.1	9844	1.7	306	798		
H	Signed	15	636	4949 ± 2918	-4970	14910		5013	3692	24 (4%)	612 (96%)
	Absolute			5105 ± 2636	8.2	14910	0.5	5013	3641		
West Antarctica: Total 19 glaciers and ice streams											
F	Signed	2	456	362 ± 573	-1896	1981		257	653	106 (23%)	350 (77%)
	Absolute			482 ± 475	0.5	1981	1	337	650		
I _b	Signed	7	1586	272 ± 962	-6678	6682		105	501	518 (33%)	1068 (67%)
	Absolute			523 ± 852	0.1	6682	1.6	235	548		
I _b	Signed	10	1608	337 ± 1573	-9720	9731		107	534	529 (33%)	1079 (67%)
	Absolute			706 ± 1446	0.1	9731	2	243	582		
H	Signed	15	343	6079 ± 3373	-5363	13125		6598	5114	11 (3%)	332 (97%)
	Absolute			6258 ± 3028	59	13125	0.5	6598	5091		
Antarctica Peninsula: Total 29 glaciers and ice streams											
F	Signed	2	286	164 ± 409	-851	1759		66	337	97 (34%)	189 (66%)
	Absolute			282 ± 338	0.3	1759	1.2	167	346		
I _b	Signed	7	849	86 ± 1319	-6969	6855		22	268	374 (44%)	475 (56%)
	Absolute			554 ± 1200	0.1	6969	2.2	141	375		
I _b	Signed	10	870	78 ± 1973	-9921	9924		22	283	386 (44%)	484 (56%)
	Absolute			794 ± 1808	0.1	9924	2.3	148	439		
H	Signed	15	242	3346 ± 3547	-13375	14367		3059	2410	9 (4%)	233 (96%)
	Absolute			3843 ± 2890	153	14367	0.8	3123	2448		
Antarctica: Total 73 glaciers and ice streams											
F	Signed	2	1392	266 ± 508	-1940	1989		150	528	388 (28%)	1004 (72%)
	Absolute			386 ± 424	0.3	1989	1.1	223	497		
I _b	Signed	7	4162	58 ± 1172	-6969	6855		31	435	1781 (43%)	2381 (57%)
	Absolute			594 ± 1013	0.1	6969	1.7	226	583		
I _b	Signed	10	4225	83 ± 1663	-9921	9924		32	460	1816 (43%)	2409 (57%)
	Absolute			752 ± 1485	0.1	9924	2	237	624		
H	Signed	15	1221	4930 ± 3327	-13375	14910		4759	4240	44 (4%)	1177 (96%)
	Absolute			5180 ± 2922	8.2	14910	0.6	4835	4214		

The 73% represents the percentage of DInSAR-derived grounding lines without an F proxy. This metric describes coverage rather than agreement and depends on the buffer distance and the along-track sampling of the ICESat-2 product. Section 2.3 now clarifies this distinction in the revised manuscript, while Section 3.1 attributes at least part of the gap to the buffer distance and temporal

overlap: Pine Island has H proxies but no F proxy within 1 km, and five more glaciers without an F proxy have no DInSAR-derived grounding line during the overlap period.

For Figure 1C, D and the hinge line, we agree that tidal remote sensing methods, DInSAR included, detect the landward limit of tidal flexure, the hinge line, rather than the grounding line itself (Friedl et al., 2020). In the revised manuscript, section 2.1 now states that each DInSAR-derived grounding line "approximates the landward limit of detectable flexure (Point F) integrated over the acquisition interval, not the position of Point G at a single time", and the caption of Figure 2 (previously Figure 1) states that the positions of F, I_b and H in panel C are conceptual. Section 3.1 discusses three possible explanations for the systematic downstream position of the ICESat-2 F proxies, 70% of which lie downstream of the DInSAR-derived grounding line. First, differences in the spatial identification of the grounding-zone boundary by the two methods may contribute to the observed offsets (Friedl et al., 2020). The altimetric F proxy is identified from the second-derivative peak of the elevation anomaly, whereas the DInSAR-derived grounding line is delineated at the most landward fringe, provided that the differential tidal displacement is large enough. Second, grounding-line retreat between the two observation periods could contribute to the downstream offsets if the later DInSAR-derived grounding line is located farther inland. Third, tidal migration of the F proxy may contribute to the variability in offsets in both directions and bias the offset downstream only if the CSK acquisitions sampled larger tidal ranges than the ICESat-2 cycles.

Specific comments

1. Line 35: Please also cite Fricker and Padman (2006).

We have made this correction on page nos.1-2, line no.34-38 in the revised manuscript, as given below:

Accurate mapping of the grounding zone is fundamental for assessing ice mass loss and predicting potential contributions to global sea level rise (Fricker & Padman, 2006; Fricker et al., 2009). The grounding line (GL, Point G) is located within the GZ, which extends from the landward limit of tidal flexure (F) to the inshore limit of hydrostatic equilibrium (H). Within the GZ, a break in slope (I_b) may also occur as shown in Figure 2 (Fricker & Padman, 2006; Brunt et al., 2010; Ross et al., 2024; Li et al., 2022).

2. Lines 39-41: There is virtually no difference in the description of RTLA and PCRA.

We have revised the text to explicitly distinguish the two techniques based on sensor type and what each is primarily used to detect on page no.2, lines 44- 50 in the revised manuscript, as given below:

Grounding zone mapping techniques rely on various remote sensing methods, including differential synthetic aperture radar interferometry (DInSAR), repeat track laser altimetry (RTLA), and pseudo-crossover radar altimetry (PCRA). DInSAR detects vertical ice displacements associated with tidal flexure (Rignot et al., 2011), while RTLA differences laser-altimeter elevation profiles from repeated ground tracks acquired at different tidal states to map

the extent of tidal flexure (F to H), and a single profile also yields the break in slope (I_b) (Fricker & Padman, 2006; Brunt et al., 2010). PCRA compares radar-altimeter elevations at near-intersecting track locations to estimate temporal elevation changes, providing dense temporal coverage from long-running radar-altimetry records but at coarser spatial resolution (Dawson & Bamber, 2017).

3. Line 43: Bindschadler et al. (2011) and Scambos et al. (2007) are the works being mentioned by Li et al. (2022) and should be cited here instead.

We now cite Scambos et al. (2007) and Bindschadler et al. (2011), where the Introduction describes mapping of the break in slope from optical imagery, which is the work of Li et al. (2022) on page no.2, line no.51-52 in the revised manuscript, as given below:

In addition, the break in surface slope (I_b) has been mapped from optical imagery as a proxy for grounding-line position (Scambos et al., 2007; Bindschadler et al., 2011)

4. Lines 48-49: How does specialized preprocessing hinder the comparison of grounding lines?

We have made corrections in the revised manuscript on page no.2, line no.58-62 in the revised manuscript, to make it explicit, as given below:

Additionally, each technique requires specialized preprocessing such as tidal and atmospheric corrections for DInSAR, and tide and inter-mission bias corrections for altimetry-based methods. Because these processing steps (for example, coherence thresholds and flexure detection criteria) are not standardized, they can shift the derived grounding line position independent of genuine physical differences, making it difficult to distinguish true discrepancies between techniques from processing artifacts.

5. Line 51: What do you mean by 'grounding line elevation-based data'?

The phrase was unclear, and the sentence did not add information to the paragraph, which describes the ICESat-2 product of Li et al. (2022). We have deleted it, together with the sentence that followed it.

6. Lines 60-61: The temporal offset of the datasets used here for the comparison is described as acceptable but contradicts the earlier sentences in Lines 45-47.

The explanation in lines 45-47 is intended to describe the broader challenge of comparing grounding-line products when datasets with consistent spatial and temporal coverage are limited. In our specific comparison, the grounding-zone ICESat-2 data product (F, I_b , H proxies) from Li et al. (2022) spans 30/03/2019 to 30/09/2020, whereas our DInSAR-derived grounding lines dataset is acquired in the span of 30/04/2020 to 26/01/2022. Thus, the datasets are not strictly contemporaneous. However, there is substantial temporal correspondence, as 57 of the 73 glaciers (78 %) have DInSAR dates within the overlapping period of the grounding-zone ICESat-2 data product.

For the remaining 16 glaciers (22%), no DInSAR-derived grounding line is available within the overlapping period of the grounding-zone ICESat-2 data product; for some of these glaciers, only 2021 grounding line observations are available. Therefore, the spatially nearest available grounding line is used for comparison. The resulting temporal offset is explicitly acknowledged as

a limitation, rather than assumed to be negligible. We have revised the manuscript to clarify this distinction and to quantify the extent of temporal correspondence between the datasets in the introduction section on page no.2-3, line no.64-75 in the revised manuscript, as given below:

In their study (Li et al., 2022), they have analysed ICESat-2 repeat track data spanning from March 30, 2019, to September 30, 2020, validating it with Sentinel-1 DInSAR observations from 2018. These datasets, however, do not perfectly overlap in time and are restricted to the Filchner–Ronne and Ross ice shelves. Moreover, Sentinel-1 limitations in mapping GZ have been highlighted, particularly for fast glaciers in East and West Antarctica, such as Thwaites and Pine Island (Milillo et al., 2017; Milillo et al., 2019; Brancato et al., 2020; Milillo et al., 2022). In our study, we extend this intercomparison by comparing DInSAR data from the Italian COSMO-SkyMed constellation acquired during 2020-2021 (Table A3) with ICESat-2 observations from Li et al. (2022) across 73 glaciers and ice shelves in the Antarctic (Figures 1 and A2). Although the datasets are not strictly contemporaneous, substantial temporal overlap exists, with 57 of the 73 glaciers (78%) having the first primary and secondary acquisitions of each DInSAR pair (Table A3) are within the overlapping period of the ICESat-2 data product. For the remaining glaciers, the nearest available DInSAR-derived grounding line was used. The resulting temporal offset is considered a limitation of the comparison, particularly given the potential for grounding-line migration between observation dates.

7. Figure 1

(a) A, B: It is hard for me to map the bins to grid and the labels on the x axis. It seems like the bin edges do not correspond to the displayed numbers. I would suggest plotting both the histograms on the same figure, in different colors. This would make them easier to compare and would also immediately convey the message that Ib-GL distances have a near 0 mean Gaussian distribution while F-GL is slightly skewed and has a smaller standard deviation.

We have revised Figure 1 (page no.4) of the revised manuscript by plotting the F-GL and I_b -GL distance histograms together in the same panel using different colors. This makes the distributions easier to compare and clarifies that the I_b -GL distances are approximately Gaussian and centered near zero, whereas the F-GL distances are slightly skewed and have a smaller standard deviation.

1(b) C, D: I did not find sufficient evidence up to this point or later in sections about the ordering of the grounding zone features as shown here. All existing literature concerning remotely sensed grounding lines state that the grounding zone feature detected in DInSAR phase is closer to the hinge line, i.e., the landward limit of ice tidal flexure. Even though Friedl et al. (2020) states "... F derived by remote sensing is usually located somewhat seaward of the true limit of tidal flexure (≈ 100 m – a few km), depending on the method's sensitivity to vertical deformation (< 1 cm – tens of cm) (Rignot et al., 2011a; Rosier et al., 2017; Vaughan, 1994).", they clearly state, "Tidal remote sensing methods aim at measuring a landward limit of ice flexure associated with F." The only documented case where the first break in slope is landwards of the landward limit of flexure is for ice plains (Brunt et al., 2011). The BedMachine surface elevation profile does not seem to indicate the presence of an ice plain for Bailey. Please check with other ice elevation datasets.

In our analysis, we do not prescribe the relative positions of the F, I_b, and H proxies with respect to the DInSAR-derived grounding lines based on an assumed physical ordering. We have also not interpreted the presence of an ice plain as the cause of the observed spatial relationships for glaciers where the I_b proxies show unexpected positions relative to the DInSAR-derived grounding lines. Rather, the objective of this work is to provide a spatial comparison between two independently derived grounding-zone datasets. Individual acquisition times are not available for the ICESat-2 grounding zone proxies, which prevents us from making a direct temporal correspondence between individual ICESat-2 proxies and the DInSAR-derived grounding lines.

For Bailey Ice Stream, the available DInSAR-derived grounding-line dataset begins with the date 02/06/2020 and includes additional grounding lines derived from subsequent interferometric observations. Based on the proxy-to-grounding-line comparison, 182 grounding-zone I_b proxies are located upstream (landward) and 169 proxies downstream (seaward) of their nearest DInSAR-derived grounding line. Thus, the proxies are distributed approximately equally on both sides of the grounding lines, rather than exhibiting a systematic displacement in a single direction.

Using the signed distance convention adopted in the manuscript, with positive values indicating downstream (seaward) locations and negative values indicating upstream (landward) locations, the mean value of distance for the I_b proxies is -57 ± 1175 m, compared with 181 ± 363 m for F proxies. This indicates a substantially larger variability in the spatial position of the I_b proxies relative to the DInSAR-derived grounding lines. When absolute distances are considered, the mean separation is 750 ± 905 m for I_b proxies and 294 ± 279 m for F proxies, indicating that the F proxies are, on average, spatially closer to the DInSAR-derived grounding lines. These results are presented as a statistical outcome of the spatial comparison rather than as evidence for a reversal of the physically expected ordering of the grounding-zone features. This interpretation is also explained in the Results and Discussion section of the revised manuscript.

In response to the reviewer's comment, we examined surface elevation profiles along the glacier-flow direction from grounded toward floating ice, using the profile shown in Figure R1. We extracted Bed Machine ice-surface elevations and REMA DEM elevations (spatial resolution of REMA DEM is 32 m, which is downloaded from OpenTopography) at 60 points spaced 500 m apart. Both datasets show generally low surface gradients along the analyzed profile, with slopes ranging from 0.01° to 0.44° for bed-machine ice surface elevation and 0.01° to 0.67° for REMA (Figures R2A-B and R3A-B, respectively).

However, a low surface slope is one of the characteristics of an ice plain, and the DEM-derived elevation and slope profiles alone cannot establish or exclude the presence of an ice plain at Bailey Glacier. We therefore cannot use these profiles to resolve whether the observed spatial relationships reflect ice-plain morphology. Instead, we interpret the upstream/downstream distribution as an empirical result of the spatial comparison between the independently derived ICESat-2 grounding-zone proxies and DInSAR-derived grounding lines, while acknowledging that temporal differences between the datasets and differences in their physical sensitivities and retrieval characteristics may also contribute to the observed offsets.

We have revised the manuscript accordingly to clarify that the upstream/downstream distribution is an observed result of our spatial comparison and is not based on an imposed ordering of the F, I_b, and H grounding zone features in the Results and Discussion sections in the revised manuscript.

We also agree with the reviewer's main point on the grounding-zone representation. DInSAR detects the landward limit of tidal flexure (the hinge line), not the grounding line itself (Friedl et al., 2020). Section 2.1 in the revised manuscript now states that the DInSAR-derived grounding lines of Ross et al. (2025a) approximate Point F; the caption of Figure 2 (previously Figure 1) states that the F, I_b, and H positions in panel C are conceptual, and the manuscript no longer describes the DInSAR-derived grounding line as Point G.

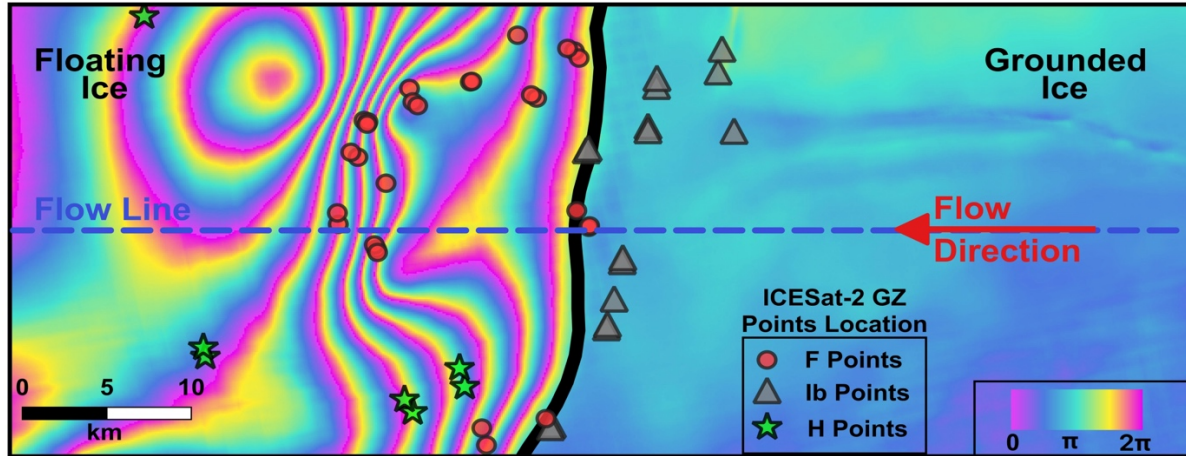


Figure R1. Profile line indicated by the blue dashed line along which the bed elevation is calculated in the plot given in Figure 2(D) of the revised manuscript.

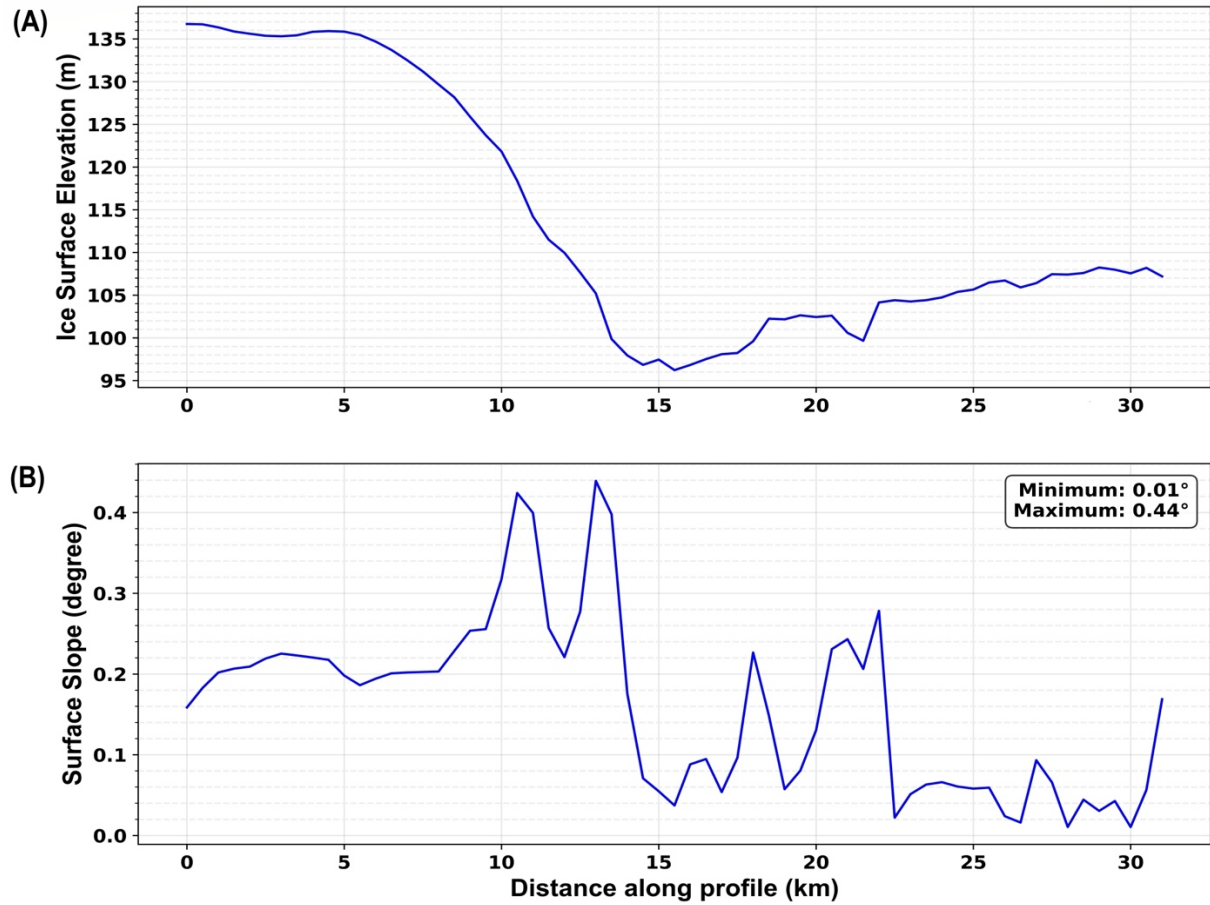


Figure R2. Plot along the profile line (shown as a blue dashed line in Figure R1 and Figure 2 in the revised manuscript) in the flow direction for (A) bed-machine ice surface elevation and (B) surface slope.

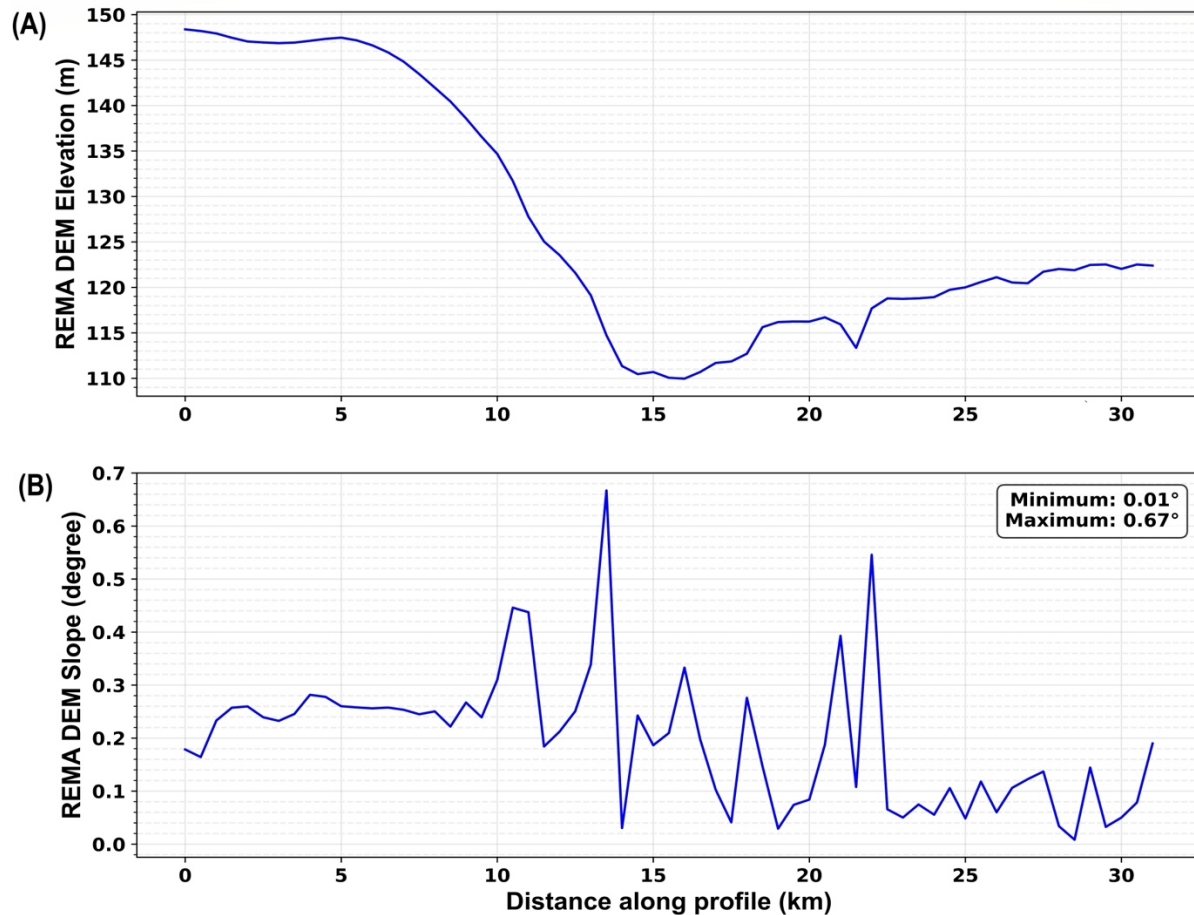


Figure R3. Plot along the profile line (shown as a blue dashed line in Figure R1 and Figure 2 in the revised manuscript) in the flow direction for (A) REMA DEM elevation and (B) REMA DEM slope.

8. Lines 84-85: I suppose the authors are trying to advertise a dataset from their research group but I think saying it is ‘fundamental’ for accurately mapping grounding lines is a bit exaggerated. There are plenty of grounding line datasets which are more spatially and temporally dense than this one such as MEaSUREs (Rignot et al., 2016), CryoSAT grounding lines (Dawson and Bamber, 2017) and AIS_cci (Floricioiu et al., 2021).

The sentence given in Lines 84-85 is intended to refer to the demonstration utility of the DInSAR methodology in general for grounding-line mapping, as supported by the multiple studies cited in the manuscript. However, we have corrected these lines in the revised manuscript for additional clarity on page no.7, line no.97-99 in the revised manuscript, as given below:

DInSAR-based observations have been widely used and demonstrated as an effective approach for mapping grounding lines in Antarctica and Greenland (Milillo et al., 2017; Milillo et al., 2019; Brancato et al., 2020; Milillo et al., 2022; Millan et al., 2022; Ciraci et al., 2023; Ross et al., 2024).

We have also examined the additional grounding-line products suggested by the reviewer, including MEaSUREs (Rignot et al. 2016), CryoSat-2 (Dawson and Bamber, 2017), and AIS_CCI (Floricioiu et al., 2021), in terms of their temporal coverage and suitability for comparison with

the ICESat-2 grounding-zone proxies of Li et al. (2022). The MEaSUREs and CryoSat-2 products provide observations that do not provide suitable temporal overlap with the ICESat-2 dataset for the present comparison. Although the AIS_CCI product covers a broader period (1994-2020), only a limited subset of its grounding-line observations falls within the 2019-2020 period covered by the ICESat-2 dataset. Consequently, these products are not included in the quantitative intercomparison, which uses the CSK DInSAR-derived grounding lines. We have clarified these considerations in the revised manuscript in section 2.1 on page no.7 in the revised manuscript to explain the selection of the CSK product and acknowledge the availability of other grounding-line datasets.

However, the purpose of our study is not to establish that the CSK dataset is more spatially or temporally comprehensive than these existing products. Rather, we have selected the CSK DInSAR-derived grounding lines because they provide substantial spatial coverage over the glaciers investigated in this study and are directly relevant to our DInSAR-based analysis. In particular, 57 of the 73 glaciers (78%) have grounding lines within the overlapping period of 30 April 2020 to 30 September 2020.

9. Section 2.1: Again, I am not against advertising your own group's work, but this section does not add any useful information. The same papers have been cited twice. You could briefly mention examples of the "invaluable insights for monitoring ice sheet stability and advancing climate-related research" provided by this dataset?

We have rewritten Section 2.1 in the revised manuscript. The sentence on "invaluable insights" is removed, and the section now states how each DInSAR-derived grounding line is formed (drawn manually at the most landward fringe of a double-difference interferogram from two 1-day repeat-pass CSK interferograms), what it represents (approximately the landward limit of detectable tidal flexure, Point F), and where the acquisition dates are listed (Table A3 in the revised manuscript).

10. Section 2.3 and Table 1: I think using the 1 km, 5 km and 10 km lines excludes too many ICESat-2 points from your comparison. Reporting all three on a common buffer, with a sensitivity test, would make the comparison more robust.

We agree that the choice of buffer distance can influence the number of ICESat-2 grounding-zone proxies included in the comparison.

First, we revisited the original proxy selection procedure and identified some ICESat-2 grounding-zone (GZ) proxies that had been excluded because they did not satisfy the strict angular constraint applied to the perpendicular projection between an ICESat-2 GZ proxy and the initially selected nearest DInSAR-derived grounding line. In some cases, neighboring grounding-line segments are located in the immediate vicinity, but the proxy did not meet the angular criterion when evaluated against the initially selected segment. We therefore revised the selection procedure to account for such nearby grounding-line segments and included previously excluded ICESat-2 GZ proxies where a clear spatial correspondence with a DInSAR-derived grounding-line segment could be established. This revision provides a more complete representation of the available ICESat-2 grounding zone proxies. The revised procedure is described in Section 2.3 on page no.8 of the revised manuscript.

Second, the original buffer distances of 1 km for F, 5 km for I_b , and 10 km for H are selected based on the spatial characteristics of the respective grounding-zone features and are consistent with the

ranges used in Li et al. (2022) (page nos. 545,548,549). Because F, I_b, and H represent different components of the grounding zone and have different characteristics and spatial extents, we retained these class-specific buffers rather than applying a common buffer to all three proxy types.

We agree that evaluating the sensitivity of the comparison to the selected spatial buffer is important. However, we did not apply a common buffer distance to the F, I_b, and H proxies because these proxies represent different components of the grounding-zone transition and have different spatial relationships to the grounding line.

In particular, the F-proxy lies closest to the grounding line, and therefore we consider a relatively narrow buffer to be more appropriate for this proxy. Applying a substantially larger common buffer to F could incorporate ICESat-2 observations increasingly distant from the F transition and thereby mix observations representing different parts of the grounding zone. For the same reason, broader buffers are more appropriate for the I_b and H proxies, which represent transitions farther from the grounding line.

We have performed sensitivity tests using additional buffers: 2 km for F, 7 and 10 km for I_b, and 15 km for H. The number of included proxies increased from 1253 to 1392 for F (11%), from 4104 to 4162 for I_b (1.4 %) with a 7 km buffer, from 4104 to 4225 for I_b (2.9 %) with a 10 km buffer, and from 1147 to 1221 for H (6.5%). Thus, the original buffers already include the majority of the proxies captured by the wider tested buffers.

The corresponding mean distances also remained overall consistent, with F changing from 178 ± 328 m (1 km) to 266 ± 508 m (2 km), I_b from 42 ± 904 m (5 km) to 83 ± 1663 m (10 km), and H from 4566 ± 2744 m (10 km) to 4930 ± 3327 m (15 km). These results indicate that widening the buffers slightly increases the sample size but does not substantially alter the overall spatial patterns observed in the comparison.

The sensitivity test also shows that the F statistics depend on the buffer: no F distance exceeds 995 m with the 1 km buffer, and at 2 km the absolute mean F offset rises from 272 m to 386 m. The ranking by absolute distance ($F < I_b < H$) is unchanged in every region for every buffer tested, but because each buffer caps its own distribution, this ranking is partly set by the buffers, which is explained in section 3.2 in the revised manuscript. The results that persist under every buffer tested are the 43% upstream and 57% downstream split of I_b and the downstream predominance of F.

11. Table 1: The temporal separation of ICESat-2 (Mar 2019-Sep 2020) and CSK (2020-2022) are up to 2 years apart in sectors that are actively retreating. The systematic downstream position of F (74% of points) is consistent with grounding-line retreat between the two epochs. Please justify the offset for West Antarctica specifically, or separate the technique difference from possible retreat, e.g. by restricting to near-contemporaneous acquisitions.

There is a temporal mismatch between the grounding-zone ICESat-2 data product (F, I_b, H proxies) from Li et al.(2022), which spans 30/03/2019 to 30/09/2020, and the DInSAR-derived grounding lines dataset, with data acquisitions spanning 30/04/2020 to 26/01/2022. About 57 of the 73 glaciers (78 %) have DInSAR grounding line acquisition dates within the overlapping period of the grounding-zone ICESat-2 data product. For the remaining 16 glaciers (22%), no DInSAR-derived grounding line is available within the overlapping period of the grounding-zone ICESat-2 data product; for some of these glaciers, only 2021 grounding line observations are available.

Temporal differences between grounding-zone datasets are also present in previous intercomparison studies, including the comparison of the ICESat-2 product with earlier grounding-zone datasets by Li et al. (2022).

We have added the justification for the offset for West Antarctica in the Results and Discussion section on page no. 12 and line no.230-238 in the revised manuscript, as given below:

In West Antarctica, 74% of F proxies and 67% of I_b proxies lie downstream, alongside 96% of H proxies, at increasing signed mean distances of 231 ± 332 m, 246 ± 775 m, and 5573 ± 3113 m (absolute means of 304 ± 267 m, 469 ± 664 m, and 5770 ± 2731 m), respectively. A common downstream predominance across all three proxies is consistent with grounding line retreat between the two observation periods of the two independent data sets. Particularly in this dynamically active sector, the differing magnitudes of the offsets among F, I_b and H and the widening gap between their signed and absolute statistics from F through I_b indicate that the pattern cannot be attributed unambiguously to retreat alone. It more likely also reflects differences in the physical sensitivity and retrieval characteristics of each grounding-zone indicator.

Statistics for 57 glaciers that have temporally overlapping grounding lines with the ICESat-2 grounding zone proxies are given in Table R1, and for the remaining 16 glaciers are given in Table R2.

12. Table 1 and Results: Fig. 8 in Li et al. (2022) shows the maximum distance of F points from Sentinel-1 grounding lines as 2 km. I suppose most of the F points are in the 1-2 km range. The central result that I_b lies closer to the DInSAR grounding line than F is based on a signed mean distance, whereas Li et al. (2022) report the mean absolute separation.

Because the F points are predominantly on one side of the line (~70% downstream) while the I_b points scatter on both sides, the small I_b mean arises mainly through cancellation rather than proximity. Recomputed as a mean absolute separation, the ordering reverts to F closer than I_b . I recommend reporting Table 1 as absolute separations and adjusting the abstract accordingly.

We have calculated the statistics as per mean absolute distance values and added the details in Table 1 on page no. 7-8 in the revised manuscript. We have also included the analyses in the Results and Discussion section on page no.9-12 and corrected the abstract on page no.1. Recomputed as absolute separations with the proxy-specific buffers, F is closer to the DInSAR-derived grounding line than I_b , as the reviewer anticipated (Antarctic-wide absolute means of 272 m and 507 m), and the manuscript no longer claims a reversed ordering (see our response to the general comments).

13. I would recommend plotting region-wide and Antarctic wide histograms of F-GL, I_b -GL and H-GL distances, either in the same plot or in subplots sharing the same distance axis.

We have plotted region-wise and overall histograms for F-GL, I_b -GL, and H-GL distances as Figure A1(Figure R4 in this response letter) on page no.18 in the revised manuscript, as given below:

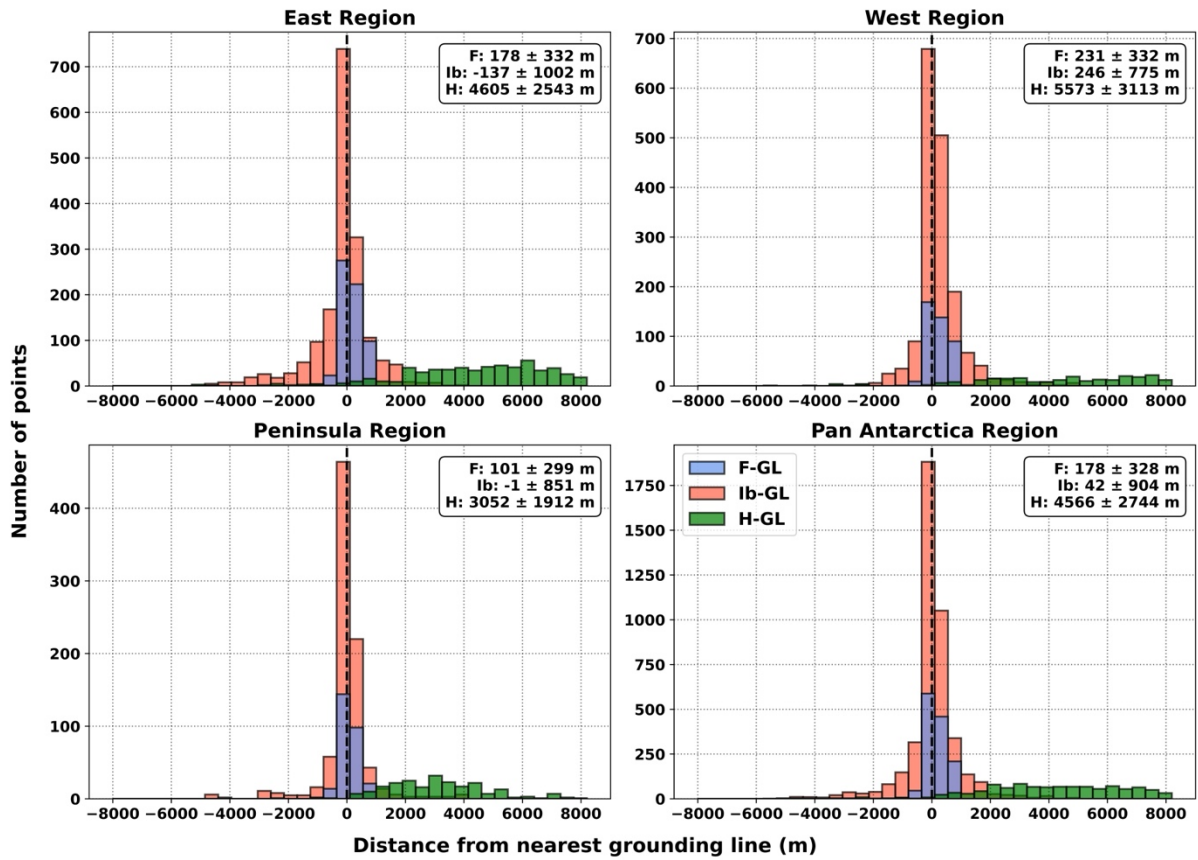


Figure R4. Histograms showing the distribution of ICESat-2-derived grounding zone F, Ib, and H proxies relative to the nearest DInSAR-derived grounding line for East Antarctica, West Antarctica, the Antarctic Peninsula, and pan-Antarctica. The dotted black line indicates the DInSAR-derived nearest grounding line (zero distance). Reference measurements are provided in Table 1 (in the revised manuscript).

14. Conclusion: the larger Ib spread is attributed to noisier Ib measurements. Li et al. (2022) actually assign Ib the smallest positional uncertainty of the three features (~ 10 m, versus ~ 80 m for F); the spread therefore reflects the real, variable offset between the break-in-slope and the grounding line, e.g. over ice plains, where Ib can lie several km landward of F (Brunt et al., 2011; Friedl et al., 2020), rather than measurement noise. Please reword.

We have removed the attribution to measurement noise. Because Li et al. (2022) assign I_b a smaller uncertainty (10 m) than F (80 m), retrieval noise alone cannot explain the larger I_b spread. Section 3.3 in the revised manuscript now discusses a variable separation between the break in slope and the grounding line as a possible cause, with ice plains as one documented setting (Corr et al., 2001; Brunt et al., 2011); we have not shown an ice plain at any of our 73 glaciers.

15. Lines 188-189: please clarify that the ~ 0.02 km agreement is the pan-Antarctic mean absolute separation between ICESat-2 Point F and the 2018 DInSAR Point F reported by Li et al. (2022), rather than a Larsen C specific value. Correct the sentence "mean differences were are also".

We have corrected this sentence on page no. 14, line no. 298-302 in the revised manuscript, as given below:

ICESat-2 altimetry, in turn, offers dense, repeated, continent-wide sampling, including at some fast-flowing glaciers that are difficult to survey with DInSAR, and has produced a high-resolution, continent-wide grounding-zone proxy dataset (Li et al., 2022), with a reported pan-Antarctic mean absolute separation of ~ 0.02 km between ICESat-2 F proxies and 2018 DInSAR-derived F proxies, including relatively stable settings such as Larsen C (Li et al., 2020, 2022).

Technical comments

1. Line 43: Remove capitalization for grounding line

This has been corrected in the revised manuscript.

2. Line 49: The pan-Antarctic ICESat-2 grounding zone product is Li et al. (2022); Li et al. (2020) covers only the Larsen C Ice Shelf. Please correct the attribution.

This has been corrected on page no.2, line no.62 in the revised manuscript as given below:

The recent availability of ICESat-2-derived grounding zone proxy data at NSIDC (Li et al. 2022) has provided an extended reference product that can be used for intercomparison.

3. Line 59: You mean to reference Figure 2?

This has been corrected on page no.3, line no.72 in the revised manuscript.

4. Switch the order of Figure 1 and 2 to match the order in which they are referenced.

We have corrected the order of Figures 1 and 2 in the revised manuscript.

5. Figure 1:

(a) Please remake the figure with at least 300 dpi

We have corrected this in Figure 2 (previously Figure 1) on page no.6 in the revised manuscript.

(b) Replot with a fixed aspect ratio so it does not look like the figure is squashed

We have corrected this in Figure 2 (previously Figure 1) on page no.6 in the revised manuscript.

(c) Please correct this sentence in the caption for (C) "green star stands for H point location for ICESat-2 data for grounding zone data"

We have made this correction in the caption of Figure 2 (previously 1) on page no.6 in the revised manuscript.

(d) The bedrock profile is attributed to BedMachine via Morlighem et al., 2017, which is BedMachine Greenland. For Antarctica, cite Morlighem et al., 2020.

We have made this correction in the caption of Figure 2 (previously Figure 1) on page no.6 in the revised manuscript.

6. Figure 2:

(a) Please remake the figure with at least 300 dpi

We have corrected this in Figure 2 (previously Figure 1) on page no.4 in the revised manuscript.

(b) Replot with a fixed aspect ratio.

We have corrected this in Figure 2 (previously Figure 1) on page no.4 in the revised manuscript.

(c) I find glacier/ice stream names to crowd the figure. You could only print those of the examples you show in the subplots and mention the others in a supplementary list/table.

To reduce visual crowding, we have revised the figure by displaying the names only for the glaciers'/ice streams highlighted in the example subplots. The remaining glaciers are identified by numbered markers on the map, with the corresponding glacier names provided in Supplementary Table A3 in the revised manuscript.

(d) There is too much information in the subplots. The colors and contours clash with the grounding lines and points. I recommend making the ice velocity map a little more translucent and changing the color of the I_b points to something that contrasts the velocity colormap.

We have adjusted the opacity level of the ice velocity map and the color of I_b proxies in Figure 2 (previously Figure 1) on page no.4 in the revised manuscript.

7. Lines 95-96: Split into two sentences

We have corrected this sentence on page no.8, line no. 120-121 in the revised manuscript, as given below:

Li et al. (2020,2022) processed repeat ICESat-2 tracks from different cycles using the ATL06 product. They accounted for ocean-loading tidal effects through a “re-tiding” procedure.

8. Table 1:

(a) Correct the title of columns "Points in upstream/downstream" to "Points upstream/downstream"

We have made this correction in Table 1 on page no.7 in the revised manuscript.

(b) Add '%' next to the numbers in last column

We have made this correction in Table 1 on page no.7 in the revised manuscript.

(c) The header "Mean Distance + Standard deviation" should use " $\pm$ ".

We have made this correction in Table 1 on page no.7 in the revised manuscript.

9. Lines 122: if the exact number of ICESat-2 points is known the 'about' should be removed.

We have made this correction on page no.11, line no. 170 in the revised manuscript.

10. Line 122: suggested rewording 'of which 20%, 63% and 17% of the points are F, I_b , H respectively.'

We have made this correction on page no.10, line no.170-171 in the revised manuscript as given below:

Across the 73 glaciers and ice streams analyzed, we cross-compare a total of 6504 ICESat-2-derived grounding zone proxies of Li et al. (2022) (Table 1), of which 19% are F, 63% are I_b, and 18% are H.

11. Line 125: Maximum discrepancy could simply be stated as maximum distance.

We have made this correction on page no.10, line no.176 in the revised manuscript.

12. Line 149: "upstream" is inconsistent with the 96% of H points reported downstream in the same paragraph; this should read "downstream".

We have made this correction on page no.11, line no.216 in the revised manuscript.

13. Line 156: 3973 I_b points here versus 3974 in Table 1. Please reconcile.

We have made this correction on page no.11, line no.200 in the revised manuscript with the updated number of I_b proxies. The I_b count is now 4104 in both the text and Table 1, following the revised proxy selection described in our response to specific comment 10.

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