

Second round of reviews

We thank the reviewer for his thorough comments which again improved the paper.

The manuscript has undergone substantial revision and now aligns much more closely with the standards required for the publication of scientific findings than the initial version. The overall structure has been significantly improved, resulting in enhanced logical coherence and readability. It is also noteworthy that a distinct and consistent name for the dataset has been established. This is very helpful in distinguishing between the different datasets.

Furthermore, all issues raised during the initial review have been adequately addressed.

Nevertheless, it is recommended that the manuscript be subjected to a final, thorough revision by the authors, particularly considering its length. Special attention should be given to the use of precise scientific language, the correction of typographical errors, and the consistency and clarity of figure and table captions.

A substantial revision has been made, improving the readability of the paper. A particular has been made on improving the conciseness of the paper, which led to a reduction of ~1000 words compared to the previous iteration. Typographical errors have been corrected and the captions have been re-read and clarified.

Nevertheless, I have some minor comments. Please check line numbers in manuscript file: `essd-2025-653-manuscript-version3.pdf`

Line 20: under sea ice cover → during sea ice coverage

This has been corrected in line 20. under sea ice cover → during sea ice coverage

Line 72: Typo. Armitage

This has been corrected in line 64.

Line 97: I think the pulse-limited footprint is enough, since RA-2 belongs to the pulse-limited footprint altimeters. I don't think the size of beam-limited footprint makes sense. I'm also not sure how to precisely calculate a beam limited footprint from a pulse-limited nadir-looking radar altimeter. For SARAL the same.

This has been corrected in line 89 and line 94 with the removal of beam-limited footprints references.

Line 106: The biggest difference of CryoSat-2 compared to Envisat and SARAL is that CryoSat-2 carries a SAR (Delay-Doppler) altimeter. This should be mentioned.

The associated paragraph has been rewritten, and the sentence : "In contrast to Envisat and SARAL, it carries a SAR (Synthetic Aperture Radar) altimeter, SIRAL (Wingham et al., 2006). In SAR mode (SARM), along-track Doppler processing narrows the effective

along-track footprint to approximately 300m, reducing the measurement noise compared to conventional pulse-limited altimeters “ has been added line 98.

Line 120: I think the LAN_SI product needs an url or reference or at least information from where it is coming from.

We've added : Land Sea Ice thematic product (LAN_SI; Aublanc et al., 2025) line 114

Figure 2: Caption: I think “surface echo characteristic” must be rephrased. The altimeter observes a surface reflection or radar echo. No characteristics. Maybe it would also help to separate the upper plot to left and right better fitting to the waveforms below. I would delete the part starting with “The retracking... “ until the end. This is not necessary to explain the figure.

Replace the caption by Figure 2: (a, top) Schematic of a satellite altimeter operating over the open ocean; (a, bottom) the corresponding radar echo (i.e. waveform) reflected by the open-ocean surface. (b, top) The same altimeter over sea ice, passing above a lead; (b, bottom) typical quasi-specular waveform reflected by a lead, with the epoch estimated by the retracking algorithm indicated by the red point.

Line 192: “It is combined with a multiple criteria classification” Who is combined? What does this mean?

Replaced by This neural-network classification is complemented by a multiple-criteria classification based on thresholds applied to waveform parameters, following Poisson et al. (2018). line 181

Figure 3: I'm not sure if every altimeter dataset you use is labeled as L1b data. I think in case of Envisat and SARAL it's SGDR, but I'm not sure. I just would delete “L1b” and leave waveforms.

Switch to only waveforms (Figure 3 and its caption)

Line 211: “Squire, 2020” I can't find this reference.

We've added the reference to the bibliography (Squire, 2020)

Line 236: Why 5 Hz? When and how is this done?

Open ocean observations are downsampled to a shorter frequency to reduce computational cost. This is standard practice in altimetry. Added the sentence : This is because the open-ocean along-track data are down-sampled from their native high-rate posting to 5 Hz (~1.3 km along-track spacing) prior to interpolation. This down-sampling, applied after the editing described above, reduces the computational cost of the optimal interpolation while retaining scales well below the correlation length scales used in the mapping (Sect. 3.4).

Lead observations are kept at their native posting to preserve the sampling density in the ice-covered domain. Line 225

Line 325 – 333: What is the MERIS spatial resolution?

added, with a spatial resolution of ~300m line 304

Line 332: An observation doesn't sit. Please rephrase. Is located?

is located line 309

Figure 10: The caption should be shortened. The individual plots should include the names of the TGs and BPRs. It is quite hard to follow b in e, same as h in k etc... . It would also be helpful if the TGs and BPRs shown were displayed in a different color to make them easier to identify in the map in a.

Replaced the caption to shorten it by (a) Locations of the in-situ instruments (stars: tide gauges; circles: BPRs). (b) 15-day smoothed SLA time series from the Mawson tide gauge (blue) and the co-located SO_SLICE average within 150 km (orange); grey shading indicates sea-ice concentration >10% (EUMETSAT OSI SAF, 2017). (c) 2D histogram of SO_SLICE SLA vs. tide-gauge SLA for all data points with sea-ice concentration >10%, with the regression line (red) and the 1:1 line (dashed black). (d) Same as (b) for the Syowa tide gauge. (e) Same as (c) for the BPRs. (f) Same as (b) for the ANT-17.1 BPR, with an additional 60-day rolling average subtracted to isolate the 15–60 day variability band Switch from a marker difference to a color difference.

Line 619: What are the independent along-track observations?

Modified the sentence line 573 to Independent along-track observations, i.e. measurements withheld from the interpolation (here one year of CryoSat-2 along-track data, see below), serve as ground truth.

Line 622: NSR. The idea of using the noise-to-signal ratio to determine effective resolution is very interesting. However, I think some references are missing in this section. Can the NSR actually be used to determine effective resolution? Are there any references that have done this before? If not, a bit more explanation of the theory is needed here.

This idea is not from us originally, but from Ballarotta et al. we developed a bit what they did in the paragraph (line 712572 adding To estimate it, we follow the procedure from Ballarotta et al. (2019 who used the ratio of mapping-error to signal spectra to characterize operational DUACS products.

Figure 12: I think something is mixed up in the caption? In a black indicates the interpolated along-track sla from the product? I don't understand the numbering, a, b ,c, d? I also would suggest shortening or rephrase the entire caption, it is quite challenging to understand everything correctly.

Fixed the caption and the figure. Replaced the caption by : (a) SLA along one CryoSat-2 pass withheld from the optimal interpolation (black) and the co-located gridded SO_SLICE values (red); the orange and blue shadings indicate two 500 km segments used for the spectral analysis. (b) NSR spectra computed on the orange and blue segments of (a), and the mean NSR spectrum over all segments of this pass (black); the dashed line indicates the $NSR = 0.5$ threshold, and the resulting effective resolutions are given in the legend. (c) NSR spectra averaged over all segments within five latitude bands, and the associated effective resolutions. (d) Map of the effective spatial resolution, estimated from NSR spectra averaged within $10^\circ \times 10^\circ$ boxes.

Line 446: 4.3.2 SLA along track observations vs. SLA maps

Replaced the title by Mapping in the ACC vs the subpolar Southern Ocean as we rewrote the section.

Line 463: ...”the altimeters that are mapped”.... I don’t understand this sentence.

Replaced the sentence by especially if the missions used to construct the maps do not sample the region at the same time as the withheld along-track altimeter.

Line 463: RMSEs :: RMSE values or RMSE

Replaced by RMSE (line 432).

Line 494: Figure 9a a

Corrected

Line 724: The sentence: “By extending the observational...Southern Ocean works....” I think “Southern Ocean works” sounds not scientific. Maybe, to get more comprehensive insights how physical ocean processes in the Southern Ocean take place...

This has been modified with the reviewer suggestion