

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-227

Anonymous Referee #2

Referee comment on "A comparison between Envisat and ICESat sea ice thickness in the Southern Ocean" by Jinfei Wang et al., The Cryosphere Discuss.,
<https://doi.org/10.5194/tc-2021-227-RC2>, 2021

General comments:

This work compares the Antarctic sea ice thickness products by radar and laser altimetry with upward looking sonar and the meteorological indicator FDD as reference datasets, which has its specific value in estimating and understanding the two satellite altimetry products to some degree. However, since the two SIT products used in this study seems not consistent (with low correlation coefficients and high RMSDs) and even have opposite results, and the causes leading to the differences have not been analyzed thoroughly, more work is needed to be done before published in . The authors are encouraged to quantify and compare the various uncertainties of SIT by the two sensors, exhibiting the principle factors that cause the differences between the products, and even proposing a strategy or a method to assimilate the two kinds of altimetry to a decent degree (as stated by the authors in L411), which would be more worthwhile for the authors to dig into. Based on these considerations, I suggest to decline the paper at its current status. My comments are as follows:

Major concerns:

L90-92. I think the comparison of the two SIT products with ULS is not appropriate since the single measurement point (6-8 m) cannot represent a grid with 50 km or even 100 km. Moreover, only the uncertainty of sea ice draft derived with ULS 5-12 cm is presented (L152-153), the uncertainty of SIT derived with Eq. 4 is missing and Fig.3 also lacks error bars for ULS, thus making the comparison unreliable. "Both Envisat and ICESat SIT have been interpolated onto each ULS location in the nearest neighbour way" (L183-184) further introduces huge uncertainties. Based on these considerations, it is not recommended to use ULS as a comparison data source. ULS can be used if the Envisat or

ICESat footprints spatio-temporally coincide with it, and the uncertainty of SIT derived with ULS is clear.

The difference between the Envisat-based actual SIT, i.e., the mean thickness of the ice-covered fraction of the grid cell area (without open water areas) (L122-123), and the ICESat effective sea ice thickness, i.e., mean thickness per grid cell including open water areas (L141-142), is not tackled nor discussed for the two datasets.

Considering the huge differences between Envisat and ICESat SIT products (as can be seen in Fig. 9 and Table 7), the main object of this work should not stay at just comparing those products, but concentrating on the qualitative and quantitative analysis of the causes leading to the differences. Currently, these issues are only simply discussed in Section 4. Following works may be considered by the authors:

- L253-254 About the sentence "Probably inferring that ..." Is it really the key reason for SIT overestimation of Envisat than ICESat in autumn? The similar doubt also appears in summer (L262-263).
- L21 and L256-257. Why on earth the mean Envisat SIT decreases while the mean ICESat SIT increases from autumn to spring? This should be supported with supplement experiments.
- L360-361. "The largest effect might not come from the impact of ice deformation on the snow-depth retrieval but might be due to the difference between actual snow depth from that represented by the climatology." Can the influence of climatology quantified?
- I didn't see solid evidences supporting the statement "The potential overestimation of sea ice freeboard caused by range biases accounts for much of the differences between Envisat and ICESat SIT in summer and autumn, while the biases of snow depth are not the dominant cause of the differences."

L124 The sea ice thickness derived with the modified ice density approach, i.e., Eq.3 can be considered to be updated to the new OLMi method (Xu, et al. (2021). "Deriving Antarctic Sea-Ice Thickness from Satellite Altimetry and Estimating Consistency for NASA's ICESat/ICESat-2 Missions." Geophysical Research Letters. <http://dx.doi.org/10.1029/2021GL093425>), which showed the modified ice density approach in Kern et al. (2016) would overestimate SIT.

Minor concerns:

L22-24 Please quantify the percentage of the uncertainties caused by the radar backscatter and snow depth products respectively.

L64 "the radar altimetry SIT retrievals" to "SIT retrieval by the radar altimetry"

Are the densities used in Eq. 1 and Eq.2/3 the same? If not, how does it influence the SIT retrieved by the two sensors?

L166 and L271 MF-MJ or MJ-MF? MJ-ON or ON-MJ? Please unify them throughout the paper, such as those 'MJ-ON' (in the text) or 'ON-MJ' (Fig. 8).

Why is it called snow depth climatology (L66, L118), snow-depth climatology (L119), or snow climatology (L363), and what is the real difference between them and the actual snow depth? Besides, what is the meaning of "have the character of a climatology" (L386)?

L270 "from the model" is unclear.

L274-276 I don't think it is an adverse pattern comparing MJ-ON with FM-MJ. Please also make "different abilities" clear.

L284-285 the weighted average is in the first row instead of in the last column?

L379-381. The sentence "Therefore, ...the ice-snow column" is hard to understand. For example, "underestimations of sea ice and snow observations" is not clear, is it sea ice thickness and snow depth underestimation? What is the "apparent ice density"?

Fig.8 Suggest to use the same Antarctica background (in grey) as that in the other figures such as Fig. 4/5/6 since we can notice the big blank area along the Ross Sea coast in this figure.

Table 4 what's N? It should be introduced in the title. Same happens in Table 5/6/7.

Table 5. I suggest to also compute the difference between ENV and ICE at grid scale instead of just subtract with the computed statistical values (the "Difference" column). I mean, the mean of the third column of Figure 4/5/6 should be computed. Based on the figures, I think the two values would be different.

Table 6. "sea ice thickness differences" should be followed by "with standard deviation in brackets"