

## ***Interactive comment on “Variability Scaling and Consistency of Airborne and Satellite Altimetry Measurements of Arctic Sea Ice” by Shiming Xu et al.***

### **Anonymous Referee #1**

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#### General comments

The data used for the study are well presented. But the diagnosis performed are sometimes not enough explained or do not clearly serve the objective. Moreover, it is not fully clear to me which scientific objective is pursued with this analysis. Perhaps too many numbers dilute the aim...

#### Specific comments

[page#3, row#25-27] "On the other hand, by adopting the same the geophysical corrections of CS-2, Yi et al. (2018) effectively aligns the retrieved freeboard across CS-2 products and greatly reduces the systematic differences." Could you clarify ?

C1

[page#4, row#22] "sea-surface height correction" "correction" is not relevant here, I would simply write "sea surface height"

[page#4, row#24] "in the freeboard estimation of the sea floes" I would remove "of the sea floes"

[page#4, row#25] "the freeboard uncertainty that is associated with SSH correction" SSH is not a correction. I would say SSH estimation or SSH retrieval

[page#6, row#33-34] "Since SSH height information are shared among freeboard data, we treat this uncertainty as bias and ignore it in the scaling analysis" I don't fully agree. Sea level anomaly (SLA) interpolation between the leads includes mean sea surface (MSS) error which is not necessarily a bias. At the scale you are focus on, the explanation you give on page#8 row#5-7 seems more appropriate.

[page#7, row#9&18&32] "SSH correction" Not appropriate. Do you mean geophysical corrections (troposphere, ionosphere, tide) ? Or Sea level estimation ?

[page#7, row#15] equation (4) I prefer the (equivalent) formulation by Kurtz 2014  $F_i = F_r + h_s (1 - c_s/c)$

[page#11, row#14] "Since with random samples, the effects of [...] inhomogeneity are very limited" Could you explain ?

[page#12, fig#3] Could you explain how each point of the curve has been computed ? Does the size of the considered area change for each point ? (fig3a) On fig.3b do you change M for each point, leading to a scale = M\*resolution ? I don't understand why STDEV is larger when averaging (3b vs 3a).

[page#12, row#5] "SSH correction" Not appropriate. Do you mean geophysical corrections (troposphere, ionosphere, tide) ? Or Sea level estimation ?

[page#12, row#11-12] It is not so easy to compare fig#3b and #3c as the y-scale are different.

C2

[page#12, row#15-16] "However,  $F_s$  is controlled by both sea ice thickness and snow distribution, and it shows comparable variability as  $F_r$  at larger scales." But  $F_r$ (OIB) is linked to  $h_s$  as it is estimated using  $F_s$  and  $h_s$ .

[page#13, row#6] "Each point represents a local region" Does it mean that 1 point corresponds to the STDEV over  $37.5 \times 37.5 \text{ km}^2$  ?

[page#13, row#10] "As is shown, there exists statistically significant correlation between OIB and CS-2" It seems not so significant to me... and it is even worse at 400m.

[page#13, row#11&15&30]  $p < 0.01$  Could you explain what is  $p$  ? What does it mean ?

[page#13, row#13] "more strict waveform filtering in AWI's protocol as compared with ESA" Could you explain ? Is it linked to waveform classification or editing ?

[page#13, row#29-30] "However, there still exists statistically significant ( $p < 0.01$ ) correlation between VAR of CS-2 and that of OIB/CryoVEx." I am not convinced that the correlation is significant...

[page#13, row#32-34] "For a given location, if the sea ice cover with larger (smaller) variability of  $F_r$  on the small spatial scale, CS-2 also consistently produces  $F_r$  samples that indicate higher (lower) variability." I don't understand this sentence ; could you clarify ?

[page#14, fig#4] What does mean  $p < 0.01$  ? On fig#3b it seems that OIB variance is almost killed when  $F_r$  is averaged over 10 points. It seems not inline with fig#3b.

[page#14, row#1-2] "By using ESA CS-2  $F_r$  product and following Fig. 4.a, we deduce the variability at OIB scale of 40 m (STDEV40m) using CS-2 samples (STDEVcs2)" Could you explain the scientific interest to do so ?

[page#15, row#9-10] "First, after eliminating the effect of random error of ICESat ( $\sigma = 5\text{cm}$ ) from its sample variance" Could you explain how do you proceed ?

C3

[page#15, row#31-32] "Both smaller footprints and wider coverage (through more heterogeneity) could induce larger variability in  $F_s$ " It not so clear to me how you can conclude this...

[page#16, row#1] "covariability" (also on pages#16-18) Do you mean covariance ?

[page#17, row#8] "that the thicker snow cover induce higher total freeboard" But over MYI, there could be ridges impacting  $F_s$ ... I would have expect more correlation between low  $h_s$  and low  $F_s$  over FYI.

[page#17, row#15] "Type-I error" Could you explain what does it mean ?

[page#17, row#21-22] "This result indicates that at small scale, there is complementary relationship between snow depth and ice freeboard." Could you explain what you mean ? I would say they are uncorrelated (opposite variations).

[page#18, row#13] "complementary effect" Could you explain what do you mean ? masking effect ?

[page#18, fig#6] Even if the covariance is positive, it is still around zero ; so I don't see any clear correlation between  $h_s$  and  $F_s$  on this figure.

[page#21, row#7] "This covariability is also reported by other works, including Kwok et al. (2011)" I think that the graphs used in this paper from Kwok are more relevant and easier to understand.

[page#21, row#31] "snow cover tends to complement sea ice topography" Do you mean mask ?

Technical corrections

[page#3, row#25] "On the other hand, by adopting the same the geophysical corrections" There is probably one "the" to be removed.