On the Statistical Relationship between Sea Ice Freeboard and C-Band Microwave Backscatter – A Study with Sentinel-1 and Operation IceBridge

The authors present a study on the local extrapolation of freeboard statistics using Sentinel-1 backscatter. I found the paper to be well written and researched. The results add value and new insight into a recently emerging topic in the scientific discourse concerning the combination of altimetry and SAR instruments. The methodologies used are well suited to the investigation.

Overall, I think the paper certainly merits publication and should be ready for it after a few additions/clarifications.

Major:

1. **Concerning smaller scales:**
   I think it would be beneficial for the evaluation of the extrapolation scheme to also assess the accuracy of the predicted freeboard distribution on a smaller scale or per-pixel basis. Especially concerning the ICESat-2 results, the 27km segment length is quite large and it would be very interesting to know how well the relationships from HH brightness to freeboard distribution hold on a smaller scale. It would also make it easier to compare the accuracy of this extrapolation to existing methods (Macdonald 2024, Kortum 2024).

Minor:

2. **Concerning the matching of OIB/ICESat-2 and Sentinel-1:**

   a. I think the time differences between the different acquisitions should be mentioned, especially when discussing the coregistration/collocation. Furthermore, I think it would be beneficial to plot the corrections (meters offset) along the ICESat-2 track. Also, the size of segments used for the matching adjustment should be mentioned (is it the same 3 km as used for the inter OIB matching found in the Appendix?).

   b. I am quite surprised how good the linear correlations are (after correction) between OIB freeboard and sigma_0(HH). These are in large part significantly higher than reported in previous studies (Cafarella 2019, Segal 2020, Macdonald 2024, Kortum 2024). Maybe you could also give the regression without binning for easier comparison with these existing studies.

3. **HV vs HH:**
   In the supplement I see that the observed HV correlations seem similar/stronger than HH, yet in the manuscript you focus entirely on the HH band. I suppose you deem the HH band to be more robust, due to the better signal to noise ratios – but this in my opinion should be reasoned before continuing only with the HH band.

4. **Paper summary:**
   In the Kortum et al 2024 paper, extrapolation is done not for temporally coincident scenes,

but with an allowance of up to 24 hours in time difference between Sentinel-1 and ICESat-2 measurements.

5. **Segment sizes:**
   As scale is quite important with these observations, I think the dimensions of segments (and size of bins) should be mentioned in every figure where they appear, as it is sometimes not obvious at the moment.

6. **Linear regression:**
   A large part of the paper deals with linear relationships between backscatter and freeboard. It should be briefly reasoned somewhere when or why this is a reasonable assumption: It seems the relationship becomes more linear at larger scales for example, but at smaller scales linearity might be stronger simplification.

Spelling etc.:

There should be a small non-breaking space between units and numbers (10 m not 10m).

L.62 'organised into racetracks' – I am not familiar with this expression. Maybe 'organised in a racetrack pattern' is easier to understand.

L.183 The segment size (I believe 9 km) should be mentioned here.

Fig. 4: I believe it should be 'Binning' not 'Bining'

L.331: 'sea **ice** drift'