

The Cryosphere Discuss., referee comment RC3 https://doi.org/10.5194/tc-2021-157-RC3, 2021 © Author(s) 2021. This work is distributed under the Creative Commons Attribution 4.0 License.

## **Comment on tc-2021-157**

Anonymous Referee #2

Referee comment on "Antarctic snow-covered sea ice topography derivation from TanDEM-X using polarimetric SAR interferometry" by Lanqing Huang et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-157-RC3, 2021

## **Overview**

The manuscript Antarctic snow-covered sea ice topography derivation from TanDEM-X using polarimetric SAR interferometry by Huang et al. presents the development and validation of a new two-layer plus volume sea ice model with the aim to correct for the height bias associated with InSAR penetration into the snow pack. This model is able to represent the sea ice/snow stratigraphy and associated scattering, and, when simplified and inverted, allows for the estimation of the sea ice plus snow surface topography from TanDEM-X. This retrieval technique shows strong agreement to an Operation IceBridge optical (DMS) DEM that was collected contemporaneously as part of the OIB/TanDEM-X Coordinated Science Campaign.

This manuscript is well-written and thoroughly presents novel methods and results that could be useful to the broader sea ice community. I have a few relatively minor comments and suggestions that should be considered, found in the general and specific comments below.

## **General Comments**

The main comments I have on the manuscript deal with (1) the height threshold used (2) X-band scattering/slush layers and (3) the snow depth parameter.

GC1: To me, it appears there is some mix-up with the height threshold used to keep model-error accuracy to within 25%. In section 4.4, it was stated that the *ice volume*  $(z_1-z_2)$  needs to be thicker than ~1.5m to achieve this accuracy. However, in later sections only ice+snow heights above the local sea surface (effectively the total

freeboard) above 1.5m are used. Doing so filters out ice volumes much thicker than 1.5m, since most of the ice volume is below the waterline.

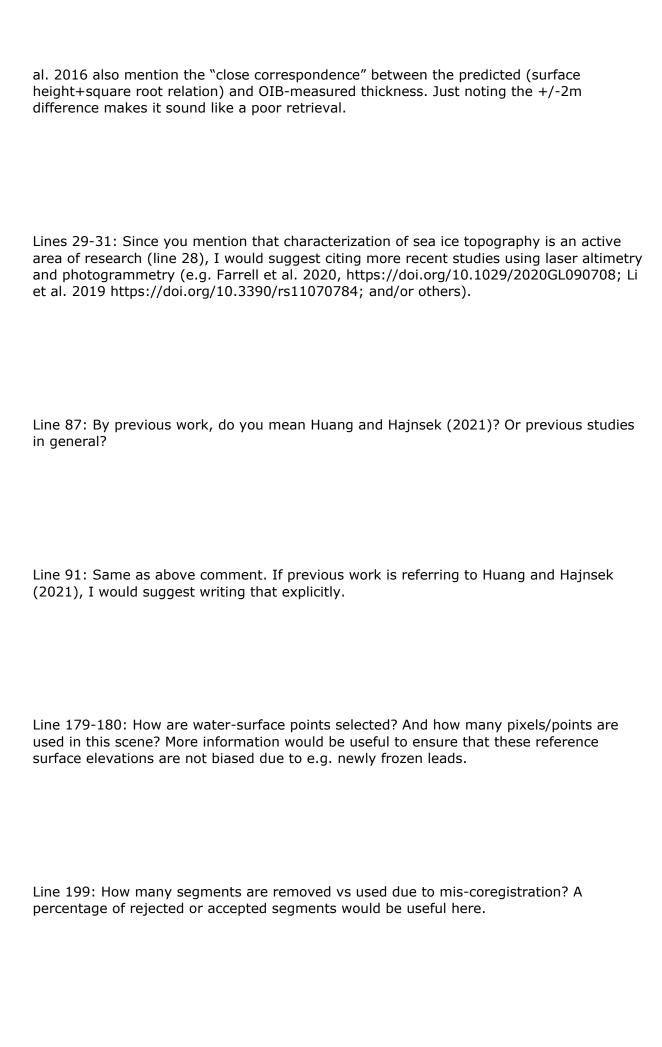
I would suggest the authors confirm that the 1.5m threshold is indeed for the ice volume, and recommend that they filter the InSAR retrieved heights accordingly (which should result in a much lower height-above-sea-surface threshold).

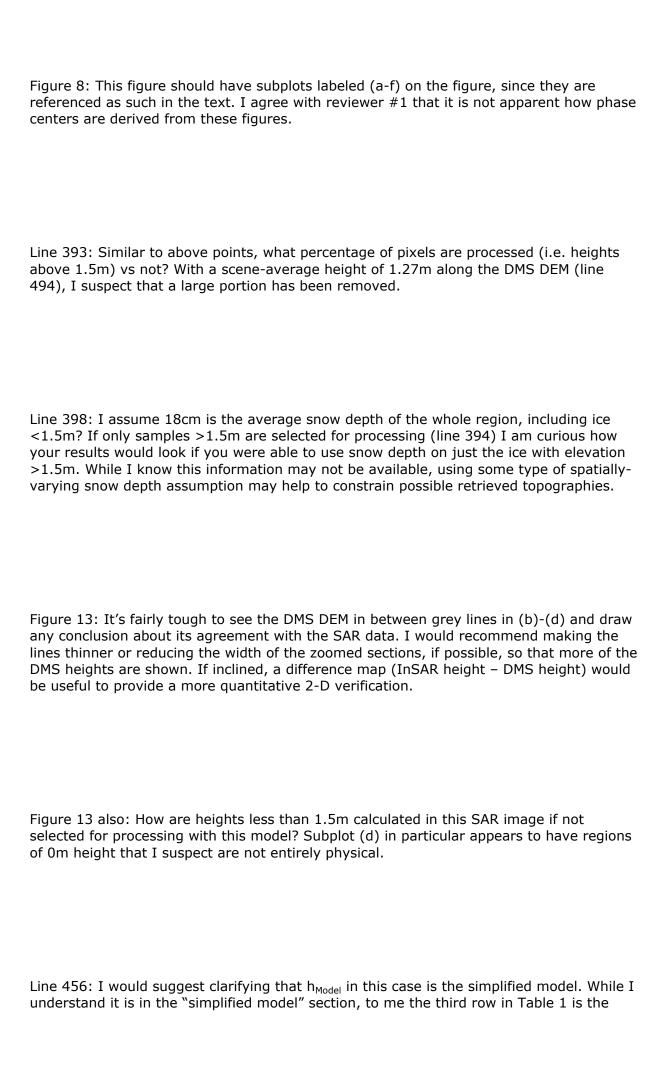
GC2: (This is similar to that from reviewer 1) While the scattering impacts of a slush layer are briefly mentioned, I feel that their impact should either be discussed further or/and incorporated into the model in some way. A slush layer at the snow-ice interface would surely effect the radar return differently than if the snow-ice interface was smooth and dry. Also, some mention of the effects of surface roughness would be beneficial, as snow surface/interface roughness has been found to influence X-band backscatter (Nandan et al. 2016, Remote Sens. Of Envir., https://doi.org/10.1016/j.rse.2016.10.004). Finally, while surface melt may not be present in this particular region or season, a wet snow surface could also influence the X-band backscatter (Dufour-Beauséjour et al. 2020, The Cryosphere, https://doi.org/10.5194/tc-14-1595-2020). This would need to be taken into account if applying this technique to other regions and/or seasons.

GC3: The paper states that the influence of snow depth on  $\gamma_{mod\_T}$  is not negligible, and that a priori data from external sources must be used in the simplified model. If I understand correctly, the passive-microwave-derived snow depth data used as the sole model parameter results in a single snow depth value (18 cm) for each pixel across the scene. While I understand that high-resolution snow depth data is generally not available, this single value is likely not representative of the actual spatial snow depth distribution (and perhaps not realistic for heights >1.5m, as a quick hydrostatic calculation of ice thickness with this snow depth yields abnormally thick ice). Therefore, I'm curious as to the impact of the snow depth parameter on the experimental results (beyond what is shown in the simulated results of figure 8), and if/how the retrieved heights would agree with the DMS DEM under e.g. spatially-varying snow depths.

## **Specific Comments**

-Lines 23-25: I find this sentence slightly confusing as it's written, especially since Petty et





Theoretical model row (as it is the third method). The fact that the RMSE ranges between 0.22 and 0.27 for both models further adds to the confusion.
Line 487: This line (particularly "larger baselines respectively larger $k_z$ values") doesn't quite sound correct as written. Do you perhaps mean the possessive " baselines' "?
Line 499: Should be "25%-error accuracy" to be consistent with previous sections
Technical Corrections
Line 59: Icebridge -> IceBridge
Line 143: iceberg -> icebergs
Figure 1 caption: rectangular -> rectangle
Line 215: `flat-earth removed' should be written as `flat-earth-removed'
Line 254: Provide full names of TDF and TSX at first mention
Line 470: (grammar) well correct -> e.g. adequately/sufficiently/suitably correct

Line 501: comma after "For instance"