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Discussions

Interactive comment on "Snow thickness retrieval over thick Arctic sea ice using SMOS satellite data" *by* N. Maaß et al.

Anonymous Referee #1

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This is a nice paper describing a new method for retrieving snow depth on Arctic sea ice. SMOS data is used with a model to simulate brightness temperatures and match with the observations. The data are compared with independent observations from IceBridge to estimate the consistency in the approach. The paper shows well the challenges in using such an approach to retrieve snow depth on sea ice and explains quite thoroughly the limitations of the methods. I believe the information shown here is well worth publishing.

The two key outstanding questions which stand out to me are: 1) Why are the vertical polarization results so much worse? It is mentioned repeatedly in the text, but no physical explanation was put forth. 2) Given currently available data (e.g. ice thickness, temperature data, etc.), how well can the algorithm described in this paper be used to

create an operational snow depth estimate?

Question 2 is the most significant one which I believe should be addressed. Figure 11 hints at such a comparison by showing a map of estimated basin-scale snow depth on sea ice along with the IceBridge measurements, but only using constant surface temperature, salinity, and snow density in the model simulation. In my opinion, it would be best to do a comparison to the IceBridge results using a combination of a best guess or climatology for the thickness/salinity and snow density, and perhaps use reanalysis data (as mentioned in the text) for the surface temperature. Or else mention in the conclusion that this is future work which could be done to validate the method in an operational sense for producing snow depth on sea ice results.

Specific comments

P3634, L16: How sensitive is the model to variations/uncertainties in surface temperature, ice salinity, snow density, and the thickness values? Some plots might be nice to see.

P3635, L10: The accuracy of the SMOS data is ~2 K, how does this propagate into the accuracy of the snow depth retrievals? P3641, L10-16, and Figure 2: The brightness temperature changes by 2-4 K over the expected large-scale range of snow depths (0-0.4 m) and temperature regimes. How does this mesh with the 2 K accuracy of the brightness temperature measurements? For T=-15 C, the range is approximately 2 K, which is at the accuracy level. Does this mean that averaging of the SMOS data is important to reduce noise?

P3637, L12: The IceBridge ATM data footprint size is a circle with approximately 1 m diameter.

P3637, L17-18: The uncertainty in the IceBridge sea ice thickness data set is not set at 40 cm, it can be quite variable as it depends on the number and distance to sea surface reference points (see Kurtz et al., 2013, The Cryosphere).

P3638, L5: Much of the 20-60 cm difference seen by Farrell et al., 2012 was actually due to the spatial offset between the airborne and in-situ measurements.

P3641, L17-24: Given that the method is not able to retrieve snow depth over thin ice, it would be good to quantify this, i.e. what thickness of ice would you put a cut-off for having an error that is too large for reliable snow depth retrieval? This would be useful to determine the applicability of the method over different ice regimes or areas of sea ice (e.g. first year or multi-year ice).

P.3645 L16-17, and throughout the text: The r^2 value is referred to as the correlation coefficient in the text. Typically, r is the correlation coefficient, while what is referred to in the text is the coefficient of determination or r-square value. A slight misnomer.

Section 4.1: Any idea why the horizontal polarization measurements and model data seem to agree consistently better than the vertical polarization results? I am not sure what could cause this, but perhaps the authors could suggest an explanation.

P.3646, L18-21: I wonder how appropriate it is to use average values for the ice thickness and surface temperatures here. I would expect there to be large variability in these quantities, and would expect the associated brightness temperatures to be non-linearly dependent on these quantities. Would it be possible to simulate the brightness temperatures using the mean IceBridge thickness and temperature in each individual pixel? This would seem to be a much better comparison to me.

P.3648, L8: The words 'some K too low' should be replaced. A quantitative number would be best, even if just an approximation.

P3649, L3-4: It would perhaps be best to say that the measured ice concentration, c_ice > 95%, and thus the assumed c_ice = 100%.

P3649, L3-18:Are the pixels with the range of surface temperatures and ice thickness values those measured from IceBridge? It is not clear from the text.

P3649, L23: Should be Table 2, not Table 1.