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

Anonymous Referee #2

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Knowledge of snow thickness and distribution on sea ice, on a global scale, is critical for estimating sea-ice thickness from spaceborne altimeters. Current approaches for deriving snow thickness on sea ice have their limitations (e.g., AMSR-E) and the authors have done a nice job in presenting a novel method for snow thickness derivation using SMOS data. Through comparisons to snow depth retrievals from the airborne snow radar, the limitations and challenges of the described approach become rather apparent. With a considerable appreciation for the difficulties encountered in comparing the airborne snow depth retrievals to those derived from spaceborne sensors, I recommend the manuscript be published, but would like to see some of the comments and questions below addressed in the manuscript.

Comments and questions

1. Snow density is not constant throughout the snow pack on Arctic sea ice, especially for a thicker snow cover. This should be made clear. What error does this introduce in the simulated brightness temperatures and subsequent snow thickness retrievals? More than likely, it is negligible, but this also needs to be said and shown.

2. Sea ice salinity typically follows and "S" or "C" shaped profile as described by Eicken (1979) for Antarctic sea ice. Assuming a similar profile for the Arctic, what impact, if any, does the assumption of an average sea ice salinity have on the simulated results?

3. Throughout the text, the difference between horizontal and vertical polarization is pointed out, but without any reason as to why the difference is seen. Is there a (geo)physical reason for this occurrence? Could it potentially be the orientation of the brine inclusions (prolate spheroids) within the sea ice, per Vant et al. (1978)?

4. r^2 is the coefficient of determination, r is the correlation coefficient.

5. I would like to see a further work statement in the conclusion.

6. Does surface roughness have any effect on the comparison? Is a sufficiently smooth snow slab, and ice-snow interface, for that matter, assumed for the simulations and derivations?

7. How well would the simulation model work in the Antarctic? With a wet snow cover, the formation of snow-ice, in-flooding, and high salinity sea ice considered.

8. Multiple flights in the Alaskan Arctic, an area known to have first-year sea ice, but, yet, you still consider a 4-m, low salinity, sea ice cover?

P3628, L17: Originates?

P3634: It would be nice to see some concluding remarks regarding typical salinities and thicknesses of first- and multi-year sea ice, and snow density and wetness to provide some justification for future values assumed within the simulation study.

P3637, L12: Reference for the ATM laser altimeter footprint, which is also dependent

upon whether the wide- or narrow-swath data are considered.

P3637, L25: Reference for the IceBridge snow radar footprint

P3638, L5: The spatial offset between the in-situ measurements and the aircraft survey contributes to this, which needs to be stated.

P3638, L23: I was unable to track down the Doronin publication, but per the Warren et al. (1999) climatology, snow density measured in the Arctic winter is closer to 300 kg·m-3. This slightly affects the permittivity of the snow cover and propagates to observed brightness temperatures. However, I would expect similar results and conclusions for the 3 cases considered.

P3639, L24: Rather than "at horizontal and at vertical polarization", maybe "for both horizontal and vertical polarization"?

P3640, L28: 4 m thick is multi-year sea ice. This designation could be made.

P3641, L24: ", in the following section, we simulate. . ."

P3642, L11-13: Is this the average ice salinity?

P3642, L25: Is this snow density the same as the Kurtz et al. snow thickness data set?

P3643, L7: "on the order"

P3646, L18: Why are you using the average ice thickness for the entirety of the IceBridge data set? Why not average over the pixel size of the SMOS data?

P3647, L20: "such that"?

P3648, L9: Reword "some K too low".

P3649, L12: Is this average ice salinity?

P3651, L10: Reference for the minimum detectable snow thickness of the snow radar.

P3655, L12: Neglecting surface roughness should be stated earlier when introducing

the simulation model.

P3655, L20: Perhaps the snow is wet as a result of the increased surface temperature.

References

Eicken, H., "Salinity profiles of Antarctic sea ice: field data and model results," Journal of Geophysical Research, Vol. 97, No. C10, pp. 15545-15557, 1992.

Vant, M.R., R.O. Ramseier, and V. Makios, "The complex dielectric constant of sea ice at frequencies in the range 0.1 – 40 GHz," Journal of Applied Physics, Vol. 49, No. 2, pp. 1264-1280, Mar 1978.

Warren, S., I. Rigor, and N. Untersteiner, "Snow Depth on Arctic Sea Ice," Journal of Climate, Vol. 12, pp. 1814-1829, 1999.

Interactive comment on The Cryosphere Discuss., 7, 3627, 2013.