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Interactive comment on "Empirical sea ice thickness retrieval during the freeze up period from SMOS high incident angle observations" *by* M. Huntemann et al.

Anonymous Referee #1

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General Comments

This manuscript derives and validates an empirical sea ice thickness algorithm over the 0 to 50 cm thickness range for SMOS measurements between 40 and 50 degrees incidence angle. The higher incidence angles allow consideration of both intensity and polarization difference, which complements a previously published algorithm focussed on measurements between 0 and 40 degrees incidence. Validation was performed using MODIS derived ice thickness and airborne EM bird measurements. While algorithm derivation is clearly described and the performance seems reasonable, the validation should be significantly enhanced as it is presently limited to only a single MODIS scene and a single EM flight. I feel the manuscript could be significantly improved if the following issues are addressed:

1. Aside from Figure 4, how were the HIGHTSI and TOPAZ simulations used in the study? As stated on page 4381 line 15, training for the algorithm only used cumulative freezing degree day (CFDD) estimates derived from NCEP reanalysis. Were the NCEP CFDD estimates assessed using the other approaches to determine uncertainty? What is the sensitivity in the algorithm parameters to the use of the CFDD as the training dataset compared to the other options?

2. Page 4385 line 20: "Figure 4 reveals a high correlation of the SMOS brightness temperatures TBh and TBv with the SIT from the models up to about 30 to 40 cm thickness." Calculate this correlation, not just for area 7 shown in Figure 4, but for all the training areas in Figure 3. Is there a reason why this analysis should be limited to the freeze-up season of 2010? Why not also compute the correlations for SMOS versus the models for 2011 and 2012? This would provide more robust statistics on the relationship between simulated ice thickness and SMOS brightness temperature. The correlations could also be binned by simulated ice thickness (i.e. compute the correlations for 0-10 cm, 10-20 cm, etc.

3. Section 4.1: assessment of the empirical SMOS retrievals with the MODIS thermal imagery is limited to a single case from 4 December 2010 in which a large portion of the MODIS scene is cloud covered. In order for this comparison to be meaningful, an increased number of cases must be considered - there must be other MODIS scenes available for other regions with thin ice and low dynamics. It's noted on line 21 that analysis of 2 more scenes is in the SMOS ice thickness ATBD. Why not include these results? Multi-temporal correlation analysis of MODIS ice thickness versus SMOS ice thickness would significantly strengthen this section. It is especially important to look beyond a single day of MODIS imagery since the EM bird analysis in Section 4.2 covers only a single day.

4. Section 4.2: Why were 12.5 km polar stereographic SMOS data from NSIDC used

for the comparison with the EM bird measurements? What are the impacts on the SMOS measurements on the re-gridding process and if it's available why not use the improved spatial resolution data for all the analysis? Page 4389 line 19: "The variability of the EM bird ice thickness dots illustrates the variability of the sea ice thickness within one SMOS grid cell." The map in Figure 7 does not effectively show the agreement between the EM bird and the SMOS estimates. I suggest producing probability distributions of the EM bird measurements within each SMOS grid cell, and determining where in the distribution the SMOS retrieval falls. This would provide a quantitative assessment that is currently missing, and better address the scale difference between the EM bird and SMOS. The comparison with the EM bird also shows a slope near 0 for ice thickness values between 20 and 40 cm, which is problematic, although I suppose the EM bird results would have been stronger had there been more thin ice (thickness <0.2 m).

5. Section 4.3: It looks like at least 10% of the grid cells in Figure 8 show a negative day to day change in ice thickness. I presume this is related to ice dynamics. It would be useful to show a seasonal time series of the day to day changes across the thin ice areas of the Arctic, binned into 3 categories: negative change (= poor consistency check), small positive change (= good consistency check), large positive change (= poor consistency check). This would give an indication of the proportion of thin ice thickness retrievals that pass the consistency check through the early ice growth season.

6. Previously published SMOS ice thickness algorithms used measurements in the 0-40 deg incidence angle range (Kaleschke, L., et al. 2012.. Geophys. Res. Lett. doi:10.1029/2012GL050916). In Section 5 it would be interesting to outline a strategy for how the retrievals from different algorithms could be integrated.

Editorial Comments Page 4380 line 20: I would not state only snow grain size here, but note that the general overlying properties of the snow cover on the sea ice are important, as you discuss in Section 5.

Page 4381 line 24: spell out 'second' instead of 's'

Page 4382 line 12: "…there were man-made emissions during the early phase of the SMOS mission…" As currently written, this implies that RFI was a problem only during the early phase of the mission, which is not the case.

Page 4384: add citations for the NCEP and ERA datasets.

Page 4385 line 12: change 'results' to 'time series'

Page 4385 line 16: change 'stuck' to 'remain at'

Page 4386 line 16: how are the MODIS observations HIRLAM driven? This is not clear…

Page 4387 line 14: typo - 'interaval'

Page 4387 line 22: remove 'used'

Page 4388 line 20: r value of 0.892 is stated here; 0.83 in the caption to Figure 6.

Page 4389 line 4: typo – 'Institut'

Figure 2: add a colour bar

Interactive comment on The Cryosphere Discuss., 7, 4379, 2013.