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Interactive comment on "Comparison of a coupled snow thermodynamic and radiative transfer model with in-situ active microwave signatures of snow-covered smooth first-year sea ice" *by* M. C. Fuller et al.

Anonymous Referee #2

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The manuscript presents the coupling of a multi-layer physical snow model (SNTHERM) driven by NARR observations and an active microwave radiative transfer model (MSIB) to simulate the backscatter signal over first-year sea ice. The study first present a validation of the NARR output relevant to SNTHERM with a comparison with a set of in-situ measurements. The SNTHERM's simulated snow properties pertinent for MSIB are then validated with in-situ snow measurements. Finally, the simulated backscatters from the coupled SNTHERM/MSIB are compared with in-situ scatterometer measurements.

The study is valuable as it explores the development of a processing chain to simulate backscatter from reanalysis over sea ice. However, the introduction and the method sections need some clarification and restructuration. Also, at my sense, because the backscatter simulation is the central topic of the study, the analysis of the backscatter simulations is incomplete.

Hence, I recommend publication in The Cryosphere following some major revisions as outlined in the following report.

1. p.3295-Line.8-9: The term "controlled" is inadequate in the sentence.

2. p.3295-Line.9-15: It is not clear if these 2 sentences make reference to snow on sea ice or snow in general.

3. In the introduction, it is not clear why and how radiative transfer is important. Few sentences introduce assimilation (p.3295-Line.2528; p.3296-Line.12-15) , but it remain vague and dispersed. The introduction would benefit of clearer description of assimilation approaches (see Reichle et al., 2008). Also, in an assimilation scheme, what snow geophysical properties could be potentially inverted from radar?

4. The link to Environment Canada site is not relevant.

5. In the introduction, the litterature cited is mostly based on passive work. What about active radiative transfer modeling? Is there any other active radiative transfer model? Is there any study using active radiative transfer model on land?

6. p.3297-L.9-14: You should keep the sentence more general: Langlois et al., 2009 only use NARR to drive snow models; Langois et al., (2012) use SNOWPACK and MEMLS. Kohn and Royer, 2010 use SNTHERM and HUT.

7. p.3297-L.14: “microwave” downwelling atmospheric emission (not that the method was developped in Roy et al., 2012).

8. Most of the elements in the 2 last paragraphs of the introduction should be put in the

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method section.

9. P.3299.L.16-17: I think the use of the term “operational scenario for simulation of C-band backscatter” is ambigious. Operational use of radiative transfer model sould lead to assimilation approach?

10. Sect. 2.2.1 : This section is confusing. It is not clear which station is where (land or sea ice) and what it measures. A table could also help to better understand. Informations on the 13 January to 23 March 2010 (p.3303-L.24) should be given in this section.

11. Sect. 2.2.2: Even if the dataset is described in Fuller et al. (2014), some more descritpion should be given to help the reader. For example, it is never explained what the 3 samples refer to exactly?

12. Initial conditions : it is not clear how was set all the initial conditions of SNTHERM? Is any spin-up was done?

13. p.3302.L.6-7 : Sentence incomplete?

14. One of the major weakness of the results is the fact that there are stations inland, and stations on sea ice, and the NARR pixel is mixed. Also, NARR information is compared with land station, but for sea ice application? The effect of the mixed NARR pixel on the validation is not well described. These limits should be more clearly answered in the manuscript. Why not choosing a “pure sea-ice” pixel close to the sea ice station and a “pure land pixel” for inland station?

15. p.3303-L.6-9: NARR clearly underestimates the diurnal temperature variation between 22 to 29. What could be the impact of that (lower gradient in the snowpack?)?

16. p.3304.L.17-19: It is not necessarely the case if no meteorological station close to the site is assimilated.

17. All figure : the fontsize must be increased.

18. p.3305-L.26-27: It is not clear in the figure if the snow temperature get above 0°C (add a line at the melting point in the Fig.9 left). Or the model can have snowmelt even if the snow temperature is below 0°C?

19. Fig.10 : how is the dielectric permittivity is calculated (which model?)? Is it part of the MSIB model? This figure could be in the MSIB evaluation section? How is the dielectric permittivity is measured and at which frequency (generally the instruments measure the permittivity at lower frequency than C-band)?

20. P.3306-L.7-9: But in this case, SNTHERM does not take into account the brine wicking anyway. It should be mentionned.

21. Sect. 3.3: It is hard to tell how good the simualtion results are. What other studies obtained for snow on land? But the most imporant point is to evalaute at what point the simulation precision is relevant for assimialtion application.

22. Fig. 6 left: The figure is not very clear.

Minor :

- SNTHERM89.rev4 is not specifically defined in the abstract. - P.3296-L.8 : “to” or “for”? - P.3301.L.11 : “if” or “and”? - Figures : change Rˆ2 for R2

References :

Reichle, R.: Data assimilation methods in the Earth sciences, Adv. Water Resour., 31, 1411–1418, 2008.

Langlois, A., Royer, A., Derksen, C., Montpetit, B., Dupont, F., and Goita, K.: Coupling the snow thermodynamic model SNOWPACK with the microwave emission model of layered snowpacks for subarctic and arctic snow water equivalent retrievals, Water Ressour. Res., 48, W12524, doi:10.1029/2012WR012133, 2012.

A. Roy, A. Royer, J.-P.Wigneron, A. Langlois, J. Bergeron, and P. Cliche, “A simple parameterization for a boreal forest radiative transfer model at microwave frequencies,” Remote Sens. Environ., vol. 124, pp. 371–383, Sep. 2012.

Interactive comment on The Cryosphere Discuss., 9, 3293, 2015.