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www.the-cryosphere-discuss.net/7/C3352/2014/

Interactive comment on “The microwave emissivity variability of snow covered first-year sea ice from late winter to early summer: a model study” *by* S. Willmes et al.

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Thank you very much, we are very grateful to referee #3 for your questions and comments to our manuscript.

P5711, l. 13-14:

We agree that this could have been misunderstood since these values were not shown in the original manuscript. We now scaled these values to the range [0..1] and provide an additional supplementary table (see pdf) that includes monthly emissivity std. dev. per region and frequency (in % to reduce space for digits). This table is also referred to in the text now and contains the values mentioned in the abstract. We

suggest to include a discussion on these values in relation to sea ice and open water emissivities in the conclusion section: Given an emissivity contrast of sea ice and calm open water which amounts to approximately 0.4, 0.3 and 0.1 for 19V, 37V, and 85V, respectively (Eppler et al., 1992) these computed emissivity variabilities would imply significant complications for the discrimination between sea ice and open water in the late spring / early summer season especially at 85 GHz and similar frequencies. The values in the discussion were wrong because they are not the maximum values of all regions from the pre-melt period (they were from Apr/Oct instead May/Nov). This is now adjusted such that abstract and conclusion refer to the same values.

P5713, l.17:

Thank you very much for this comment. We re-phrase this according to the findings of Andersen et al. (2007).

P5713, l. 18: Thank you, this is changed.

P5716, ls.-10-14: Yes, you are right, SNTHERM is allowed to freely simulate vertical temperature profiles in ice and snow with the only constraint that the sea-ice bottom temperature is at the freezing point of -1.8°C. We suggest an additional figure (Fig. 3, see supplement) to show the evolution of snow profiles and associated brightness temperature changes.

As far as spin-up is concerned, we skipped the first 5-days of simulations to adjust a scaling coefficient for the calculation of correlation lengths (P5716, l.28).

P5717, l. 4: This is corrected, thank you.

P5718, ls. 3-5: This is a very good remark. You are right, that these values are not directly caused by melt effects. It is the indirect effect of freeze-thaw cycles and the associated formation of superimposed ice without snow on top. In the observed data it might in fact be associated with open water within the observed footprint. The newly added PDFs in Figure 2 indicate however, that the frequency of these values is of minor importance. The TB37V values <200 K are resulting from cases when nearly all the snow has disappeared and almost only bare ice is left.

Table 1:

In fact, there was a mistake in the computing of these numbers. All the different inits were started with 15 mm grain size instead of 1 mm as in the ref run. This is why they were biased by a too high grainsize! The corrected table is now in the revised version (see supplement).

The table is now described as follows:

“3.3 Initialization effects

Results of our simulations strongly depend on the assumed initial snow properties. As explained above, we have assumed an identical initial snow cover for all regions to be able to consider regional differences of temporally changing emissivities due to seasonally changing atmospheric conditions only. In this section we show how variations of initial snow properties affect the mean emissivity computed by SNTHERM and MEMLS, which are then subsequently modified by seasonal atmospheric changes. In order to do so, we performed test runs with both models by varying the assumed sea ice salinity of 7 ppt (in MEMLS) by ±5 ppt (S02, S12) as well as the initial snow profile (for SNTHERM) in grain size (+0.5 mm, dg15), thickness (15 cm and 50 cm, zs15, zs50) and density (± 50 kg/m^3, D270, D370); wetness is always set to zero at the start of simulations. Additionally, one test run was performed, where a thin ice layer was included at a snow depth of 10 cm (lay1). This approach revealed that the mean emissivity is biased by initialization, while its diurnal, regional and temporal variability (all three expressed in combination by monthly standard deviations) as well as hemispheric differences change in the same ways regardless of the mean signal. (Table 1). The 37 GHz and 85 GHz frequencies are much more sensitive to initialization during the pre-melt period than 19 GHz which is an effect of their smaller penetration depth in comparison to 19 GHz and the resulting larger impact of changes in the snow cover.

If an initial snow density of 270 kg/m^3 is assumed in the snow pack, the mean 19V emissivity in the WW region in October decreases from 0.946 to 0.934, while a change from 0.873 to 0.832 and from 0.738 to 0.659 is noted for 37V and 85V, respectively. The associated changes in the monthly standard deviation depend on the introduced changes in initialization. For D270 they amount to +0.01 (19V), +0.01 (37V) and +0.02 (85V) and for D370 the standard deviation decreases by -0.02 (37V) and -0.01 (85V), respectively. In general, Table 1 indicates that in thinner snow an increased microwave emissivity variability, i.e. its diurnal, regional and inter-annual standard deviation, can be expected (zs15). The same holds when snow grains are larger at the beginning of initialization (dg15). The impact of the initial sea-ice salinity (S02, S12) and the presence of ice layers (lay1) on the simulated emissivity variability is very small. As such, Table 1 provides insight into the sensitivity of our results to ambiguities in the chosen snowpack initialization.”

Trends

We acknowledge that the observed period is rather short for trend analysis (and state so in a revised version), but nevertheless the given values hold for this period. The figure 1 (below) shows the mentioned e37v data for NOV in the WS region for 10 years (2000-2009). It is obvious that the low average emissivity in first year (2000) probably has a large impact on the derived trend.

As far as the emissivity contrast between sea ice and open water is concerned we want to argue as follows: Although the time series is rather small for a stable trend detection the positive emissivity trends in the WS is mostly induced by an increasing impact of melt events during the months of November and December. This means that an emissivity increase will saturate when melt events become characteristic for the advanced melt stage (Livingstone et al., 1997) and not continue at the same rate.

P5721, l. 17:

We actually re-formulated the conclusion of our analysis to: “The obtained emissivity data characterize the background emissivity variability of snow-covered first-year sea ice due to atmospheric forcing and contribute to a better understanding of sea-ice concentration and snow-depth product accuracies at high sea-ice concentrations. The results need to be interpreted in the context of assumptions and simplifications."

P5722, ls. 9-11:

Good question! Actually a completely new model would be necessary to involve all the mentioned processes. We admit that we cannot come up with a good reply to this remark and that our "suggestion" is in fact somewhat naive. So instead we would like to re-phrase this sentence to: "A completely new thermodynamic snow/ice model would be required to simulate these processes and thereby enable an assessment of combined ambiguities and their regional characteristics.".

P5722, ls. 9-11: Changed, see above.

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/7/C3352/2014/tcd-7-C3352-2014-supplement.pdf

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Interactive comment on The Cryosphere Discuss., 7, 5711, 2013.

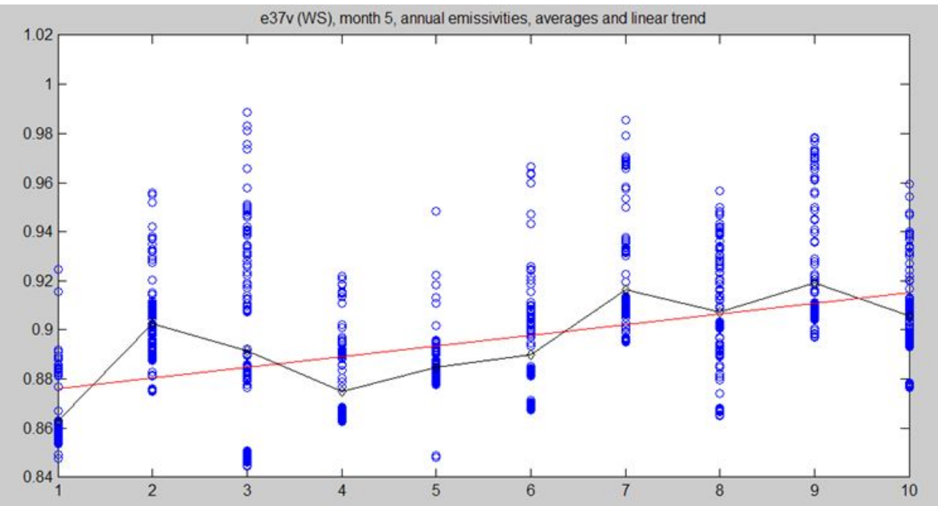

Fig. 1. e37V emissivitiy distribution in WS region vs. year (2000-2009) for NOV, annual averages (black) and linear trend (red)