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

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We would like to thank Peter Mills for his comment and his interest in our article. Indeed the Burke model neglects higher order reflection terms, as it is also mentioned in the paper (p. 3640, l. 9-23). However, that the Burke model accounts only for upwelling radiation is only partly true. For example, we here consider the case of a semi-infinite layer of air above a layer of ice above a semi-infinite layer of water. For the brightness temperature above the layer of ice TB, the Burke model accounts for 1) the upwelling radiation originating from the ice, 2) the upwelling radiation originating from the water underneath the ice, and 3) the downwelling radiation originating from the ice that is reflected at the ice-water interface and radiates upwards to the air-ice interface. In contrast to a model that accounts for higher order reflection terms, the Burke

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Interactive Discussion
Discussion Paper

model neglects the contribution to the brightness temperature TB from upwelling radiation originating from the ice that is reflected at the air-ice boundary, then radiated downward in the ice and then reflected at the ice-water boundary and radiated upward. Consequently, of course, a model that neglects the higher order reflection terms is only an approximation of the radiation system and the reflectivities at the considered boundaries and the attenuation of the considered layers determine whether this approximation is applicable.

As written in our paper, in Maaß (2013) I have compared sea ice brightness temperatures as calculated with the Burke model and as calculated with a radiation model that is based on backward propagation matrices. This latter approach accounts for higher order reflection terms, and is described in Ulaby et al. (1981) and follows Kong (1975). The comparison showed that for our model setup with one ice and one snow layer and the considered water, ice and snow permittivities, the brightness temperatures from the Burke model agreed with the brightness temperatures from the coherent Ulaby model (when these were averaged over the coherent oscillations).

Here, we use the model that is described in the final report of the SMOS-Ice project as well as in Mills and Heygster (2011), to re-calculate and to compare the brightness temperatures we show in the theoretical investigations in Sect. 3 of our Discussion paper (Fig. 1 and 2). At horizontal polarisation, the brightness temperatures calculated with the model described in Mills and Heygster (2011) are somewhat higher than the brightness temperatures calculated with the Burke model (Fig. 1). With increasing ice thickness the difference decreases and the brightness temperatures are almost similar for ice thicknesses higher than about 30cm. The difference between the models is also quite small at vertical polarisation. The conclusions we draw in our Discussion paper regarding the impact of a snow layer on the ice brightness temperature and the role of the thermal insulation by snow are identical to the results we would obtain if we used the model suggested by Mills and Heygster (2011). When we consider brightness temperatures over thick ice as a function of snow thickness (Fig. 2), we obtain that the brightness temperatures calculated with the model described in Mills and

Heygster (2011) are about 0.4 K higher than the brightness temperatures calculated with the Burke model. This difference seems to be constant over the range of snow thicknesses considered here. The difference between the models is smaller for lower incidence angles and increases with increasing incidence angle θ (not shown here). The difference of 0.4 K corresponds to the average difference for brightness temperatures between $\theta = 15$ and $\theta = 60\ ^\circ$.

Our Discussion paper aims to show the first comparison between modelled and observed SMOS L-band brightness temperatures over snow-covered ice. Thus, because using one or the other model does not change the overall characteristics of the considered radiation (but only the absolute values in the order of 0.4 K for the applications considered here), we think that the Burke model is sufficient to demonstrate the potential of SMOS measurements in this context. For a future large-scale retrieval of snow thickness from L-band brightness temperatures, a more suitable radiation model would of course be advantegeous.

References

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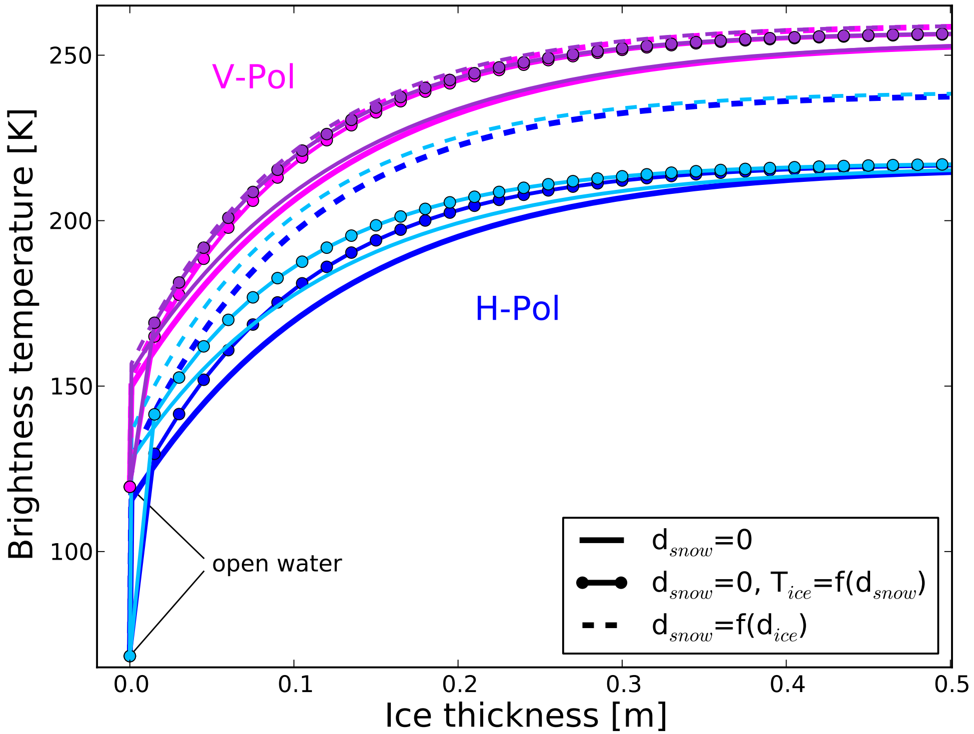

Fig. 1. For figure description see Fig. 1 of the Discussion paper. The purple (V-Pol) and cyan (H-Pol) lines indicate brightness temperatures as calculated from Mills and Heygster (2011).

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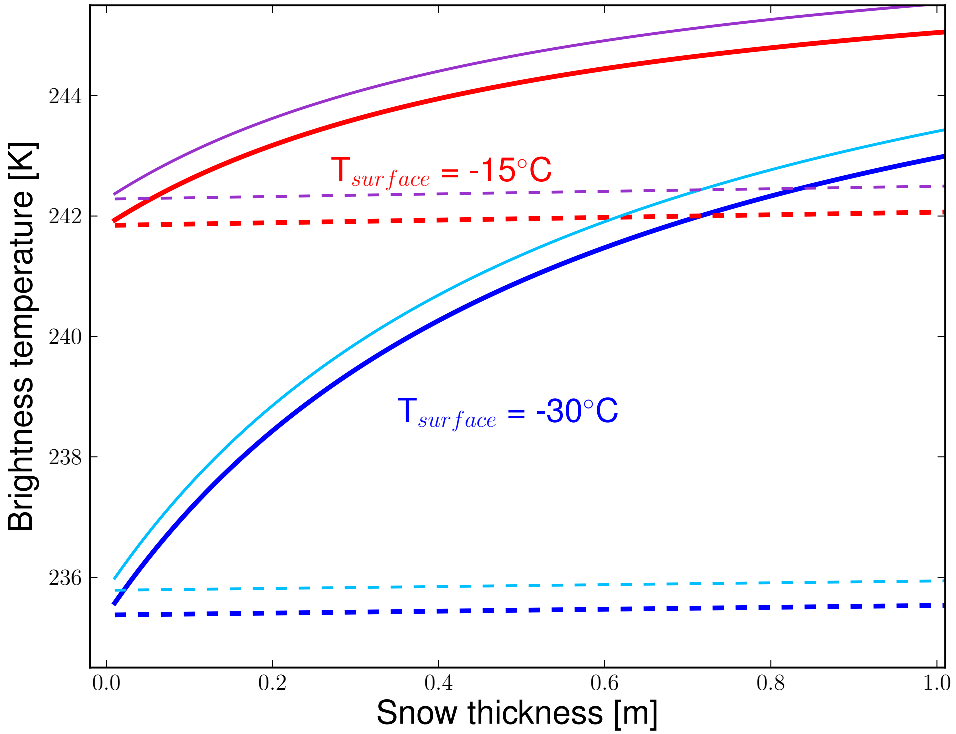

Fig. 2. For figure description see Fig. 2 of the Discussion paper. The purple (-15°C) and cyan (-30°C) lines indicate brightness temperatures as calculated from Mills and Heygster (2011).

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