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Interactive comment on "Simulation of the microwave emission of multi-layered snowpacks using the dense media radiative transfer theory: the DMRT-ML model" *by* G. Picard et al.

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We thank the reviewer for his thorough reading of our manuscript. We also thank her/him for pointing out specific concerns, and we address those in this document. Regarding paper 2, the reference Liang et al. 2006 was erroneously used instead of Liang et al. 2008 (paper 2). The description in section 2.5 of the spline interpolation approach referred to the work presented in paper 2 but the reference was incorrect. We have corrected the reference in this section as well as in the introduction. Furthermore, the section 2.5 presents the approach followed in DMRT-ML and provides a qualitative comparison between both approaches. It is not the purpose of our paper to provide extensive and quantitative comparisons with other DMRT-based models. However, while we accept the reviewer's point, a dedicated community-based inter-comparison would be necessary because the model refereed to by the reviewer is not publicly available. Note that the reference to Liang et al. 2006 in section 3.3. was correct and is unchanged.

Regarding paper 1, our description of the limitation of the QCA-Mie was indeed outdated. We have rewritten the paragraph presenting the different versions of the DMRT theory: "DMRT-ML uses the Quasi Crystalline Approximation with Coherent Potential (QCA – CP) (Tsang et al., 2000b) and is limited to particle size smaller than the wavelength. This may be a limitation at frequencies higher than 37 GHz and with large grains commonly found in aged snow. The calculation for large particles requires a Mie-like development (Tsang et al., 2000a) and is computationally much more intensive than the QCA-CP calculation. In addition, it leads to a form of the phase function that is incompatible with the optimization of the radiative transfer equation resolution used in DMRT-ML (Section2.5). To avoid the strong divergence that characterized QCA-CP with large particles, Grody (2008) proposed an empirical and computationally efficient treatment of this issue. He noticed that snow is composed of particles with a broad range of sizes which results in a smoothing of the undulation characteristic of the Mie – QCA-CP mono-disperse, with optional "short range" stickiness, and optional Grody's based empirical treatment of large particles;

– QCA-CP poly-disperse with a Rayleigh distribution, no stickiness and no large particles. The mono-disperse version is formulated according to Shih et al. (1997). The effective dielectric constant without scattering Eeff0 is obtained by solving the following quadratic equation resonances. Hence, a good approximation of the medium scattering efficiency Qs for large particles is the asymptotic limit, i.e. Qs $\approx$ 2, accounting from the fact that the absorption is weak (e.g., Twomey and Bohren, 1980). If enabled by the user, DMRT-ML applies this idea by limiting the Qs maximum value to 2. Nevertheless, this ad-hoc correction has not the objective to replace the rigorous solution for finegrained studies(Tsang et al., 2000a). Recent versions of DMRT introduce the concept of stickiness. Instead of considering randomly positioned non-penetrable spheres, the sticky spheres are attracted to one another and tend to form clusters with large voids between. This concept is meant to better represent the micro-structure of natural snow using solely spherical grains. In this case, the stickiness is also a means to account for coarse grained snow by considering that such snow is made of small clustered particles. However, DMRT-ML only implements the “short range” version of the sticky formulation which assumes that the clusters are small with respect to the wavelength (Tsang et al., 2000b, pp. 504-505). In this simplified case, the phase function remains identical to that of the nonsticky small particle case for which the optimization of the resolution of the radiative transfer equation works (Sec. 2.5)."

The advantage of our implementation is the reasonable computational cost although the advantage of Tsang et al. 2000 is the rigorous calculation at any frequency/grain size. Our motivation behind the DMRT-ML model was to provide a simple and fast implementation for applications in data assimilation and in parameter retrievals that is comparable with MEMLS and HUT. Our motivation was not to provide the most accurate DMRT-based model as presented in Liang et al. 2008. However, to our experience, the validity range of the small scatterer / low frequency approximation used in our implementation is in most natural snow not constraining. To clearly inform the future users of DMRT-ML, we describe in detail the limitations of this assumption and of the ad hoc correction (based on Grody, 2008) in section 3.2.

Regarding the multi-layer point, we added section 3.6 about the importance of multi-layer for the simulation of natural snowpack. A new figure (now Figure 10) has been inserted to illustrate the influence of the resolution of the profile of snow grain size and density based on data from Dome C in Antarctica. It is difficult to draw general results about layering because it depends on many parameters: the homogeneity of the considered snowpack, the type of snow, and the outputs of interest (e.g. time series, polarisation difference, spectrum).

Several citations have been changed to respond to reviewer’s comment: - for the emissivity-reflectivity relationship: Peake, 1959. - for the limit of independent scattering assumption: Ishimaru and Kuga, 1982. - for the effect of the atmosphere: Rosenkranz, 1998 and Saunders et al. 1999.

We would prefer not to change the order between the validation (Section 4) and the sensitivity analysis (Section 3) because the Section 3 includes several “consistency checks” and addresses the theoretical limitations of the DMRT-ML implementation which precedes the comparison to observations (Section 4).

Interactive comment on Geosci. Model Dev. Discuss., 5, 3647, 2012.