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Interactive comment on “Improved scattering radiative transfer for frozen hydrometeors at microwave frequencies” by A. J. Geer and F. Baordo

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Particle orientation is not yet generally considered in satellite-based passive microwave remote sensing at frequencies of 183 GHz and below. This can be explained from both a scientific and a practical point of view. Scientifically, many modelling studies have indicated that particle orientation could affect the v-h polarisation difference at 37 GHz and 85 GHz, with the effects coming from preferentially-aligned raindrops or small cloud ice particles. However, observational studies suggest the effects on brightness temperatures are limited in magnitude and not particularly widespread. Prigent et al. (2001) saw polarisation differences in SSM/I radiances of order 6K at 85 GHz that

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they attributed to the effects of ice cloud. Polarisation signals are much clearer to see at higher frequencies with limb-sounding instruments because there is no possibility of confusion with polarised emission from the surface and because the cirrus optical depth can be quite high in this geometry. However, the effects are still relatively limited. At 122 GHz, Davis et al. (2005) saw polarisation differences of order 3K in a channel where the presence of cloud could cause brightness temperature depressions of up to 50K. This might be explained because the radiative effects of small ice particles, the ones most likely to be preferentially oriented, are limited at lower microwave frequencies. For the larger more radiatively important frozen particles, shapes would tend towards aggregates or graupel, and it is likely that random particle orientation would be a reasonable model.

Practically speaking, currently available scattering databases are based on random orientations, so without doing new DDA calculations, there would be no way of addressing the issue. Further, it is another complication in an already complicated area, and we have had to be careful to focus the study rather than get lost in all possible microphysical complexity.

In summary, treating particle orientation would be difficult practically and with brightness temperature effects that may be in the order of no more than 10K in the up-to-183 GHz range, treating these effects more carefully is unlikely to radically improve results in the context of NWP models. The really interesting place to start considering particle orientation is with future sub-millimetre instruments like the Ice Cloud Imager on a future EUMETSAT mission. The results from these missions might well percolate back down into improved modelling in the up-to-183 GHz range. However, I would hope that the issue of oriented particles could be left for the future rather than treated in the current work.

The Liu database is an average over random orientations is mentioned once in the manuscript, in section 3.1. However, the fact that oriented particles are not considered could certainly be made more prominently, with a brief reference to the observational

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and modelling work in this area.

Davis, C. P., Wu, D. L., Emde, C., Jiang, J. H., Cofield, R. E., & Harwood, R. S. (2005). Cirrus induced polarization in 122 GHz aura Microwave Limb Sounder radiances. *Geophysical research letters*, 32(14).

Prigent, C., Mishchenko, M. I., Rossow, W. B., & Pardo, J. R. (2001). Microwave polarized signatures generated within cloud systems- Special Sensor Microwave Imager(SSM/I) observations interpreted with radiative transfer simulations. *Journal of Geophysical Research. D. Atmospheres*, 106, 28.

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