Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 6, 4383-4394, 2006
www.atmos-chem-phys.net/6/4383/2006/

Three-dimensional effects in polarization signatures as observed from precipitating clouds by low frequency ground-based microwave radiometers

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Abstract. Consistent negative polarization differences (i.e. differences between the vertical and the horizontal brightness temperature) are observed when looking at precipitating systems by ground-based radiometers at slant angles. These signatures can be partially explained by one-dimensional radiative transfer computations that include oriented non-spherical raindrops. However some cases are characterized by polarization values that exceed differences expected from one-dimensional radiative transfer.

A three-dimensional fully polarized Monte Carlo model has been used to evaluate the impact of the horizontal finiteness of rain shafts with different rain rates at 10, 19, and 30 GHz. The results show that because of the reduced slant optical thickness in finite clouds, the polarization signal can strongly differ from its one-dimensional counterpart. At the higher frequencies and when the radiometer is positioned underneath the cloud, significantly higher negative values for the polarization are found which are also consistent with some observations. When the observation point is located outside of the precipitating cloud, typical polarization patterns (with troughs and peaks) as a function of the observation angle are predicted. An approximate 1-D slant path radiative transfer model is considered as well and results are compared with the full 3-D simulations to investigate whether or not three-dimensional effects can be explained by geometry effects alone. The study has strong relevance for low-frequency passive microwave polarimetric studies.

Final Revised Paper (PDF, 494 KB) Discussion Paper (ACPD)

Citation: Battaglia, A., Simmer, C., and Czekala, H.: Three-dimensional effects in polarization signatures as observed from precipitating clouds by low frequency ground-based microwave radiometers, Atmos. Chem. Phys., 6, 4383-4394, 2006. Bibtex EndNote Reference Manager