Investigation of super-cooled liquid clouds at the Zugspitze mountain using long-term observations of high frequency passive microwave radiometers.

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Super-cooled liquid water (SLW) plays an important role in cold cloud microphysics (precipitation formation) and has a large impact on the radiative forcing of clouds in the solar and infrared spectral regions. Since 2007 SLW-clouds are regularly observed at the research station “Umweltforschungsstation Schneefernerhaus” (UFS, 2650 m ASL) at the Zugspitze mountain in the German Alps with two passive microwave radiometers (MWR) covering the frequency range from 22 to 150 GHz. Thanks to the low water vapor amounts at that altitude the combination of the low and high frequency MWR channels allows a significant improvement of the sensitivity and accuracy of the derived super-cooled liquid water path (SLWP). However, large uncertainties exist in commonly used refractive index models of SLW in the microwave spectral region. These models are fundamental for an accurate derivation of SLW from space-borne or ground-based MWR measurements.
Based on a four-year dataset, we present a statistical analysis of the frequency of occurrence of SLWP at the UFS with focus on meteorological environment parameters and weather regime. The combination of the SLW columnar information from MWR with ceilometer, standard meteorological observations as well as forecast model analyses, allows further characterization of the cloud, i.e. cloud base height and temperature. In addition to the observations we present radiative transfer simulations that highlight the significant impact of the uncertainties in current SLW refractive index models on the derived SLWP. The observations are used to constrain the refractive index model that is most/least accurate in the considered frequency region.