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

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Motivation

- Liquid water droplets in natural clouds can exist down to -38°C.
- This so called super-cooled liquid water (SLW) plays an essential role in cold cloud microphysics.
- Even small amounts of SLW (<30 g/m²) in clouds dramatically change their radiative effect (radiative forcing).
- Passive microwave (MW) retrievals of SLW depend on accurate models of the SLW absorption coefficient.
- Current models are mainly extrapolations of different liquid water absorption models (color).

Validation approach using RT simulations and observations

Long-term observations of passive and active MW observations and additional instruments like a ceilometer (Löhntel et al., 2011) from the environmental research station Schneefennerhaus (UFS) at 2650m have been used to select ideal cases (thin single layer clouds) for model - observation comparison of the different SLW absorption models.

How large are the model discrepancies?

In this study we compared different SLW absorption models: Ellison (2006), Liebe et al. (1991/93), Ray (1972) and Stogryn et al. (1995):

- While the sensitivity of the MW channel to SLW increases with frequency \(^4\), also the uncertainty in the absorption models increases with frequency.
- Including high frequency channels (e.g. 90/150 GHz) in SLW retrievals for high sensitivity/accuracy means that also current absorption models must be improved.

Differences between the absorption models increase with frequency, LWP and lower temperatures.

References:


Ellison, 2006: Dielectric properties of natural media, in Thermal Microwave Radiation: Application for remote sensing, Editor G. Mätzler, IET Publisher.


Liebe et al., 1993: Propagation modeling of moist air and suspended water-ice particles at frequencies below 1000 GHz, AGARD, Atmospheric propagation effects through natural and man-made obstacles for visible to mm-wave radiation.


DPR

HATPRO

Validation approach using RT simulations and observations

Concept:

Best estimate of the atmospheric state

NWP analysis (COSMO-DE):
Vertical profiles: Temperature, Press., Humidity

Ceilometer: Cloud base height

Radiative Transport (RT) applying different SLW absorption models

Comparison of observed TB with simulated TB range (using the four different SLW absorption models)