Discrimination of cloud and rain liquid water path by ground based polarized microwave radiometry

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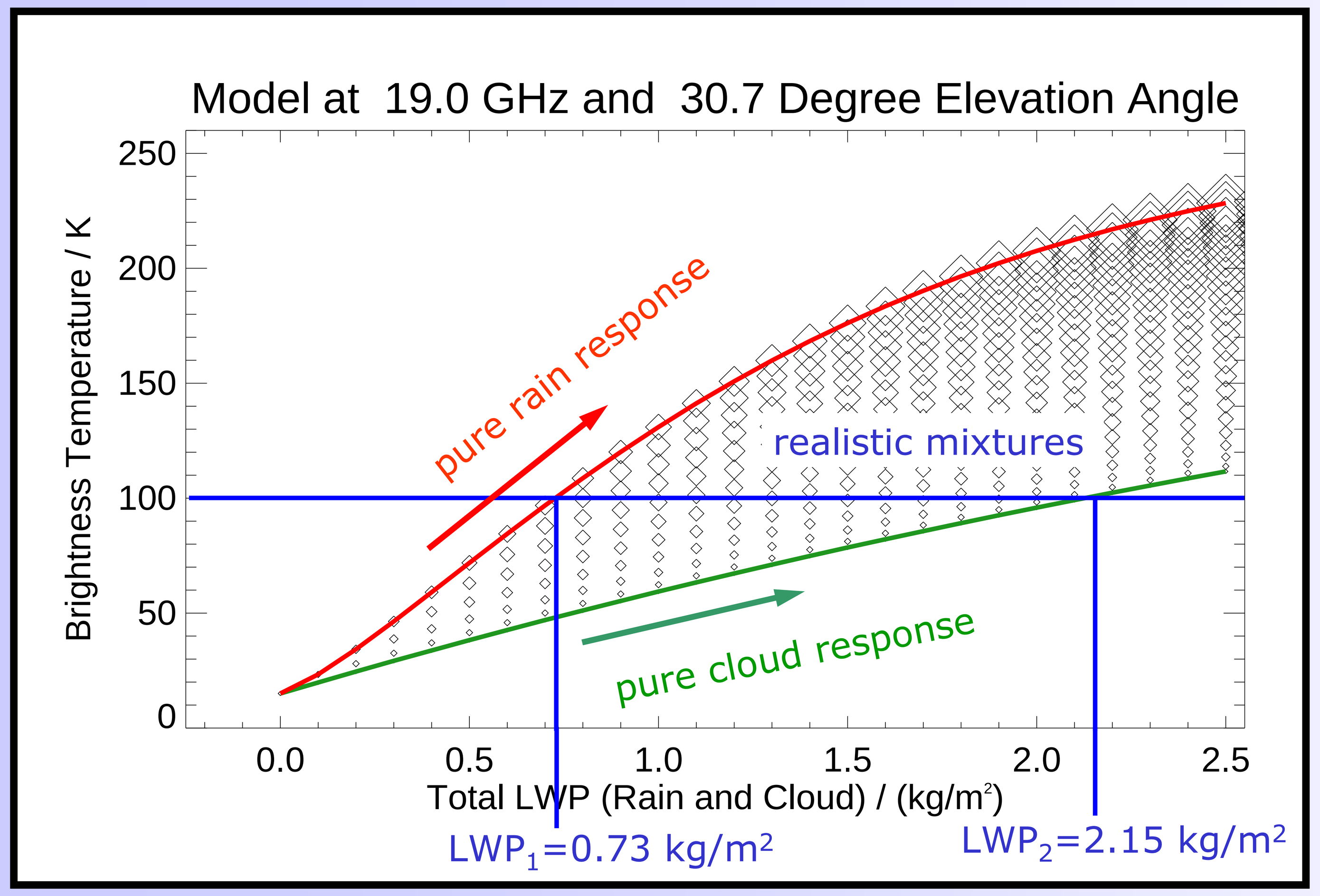
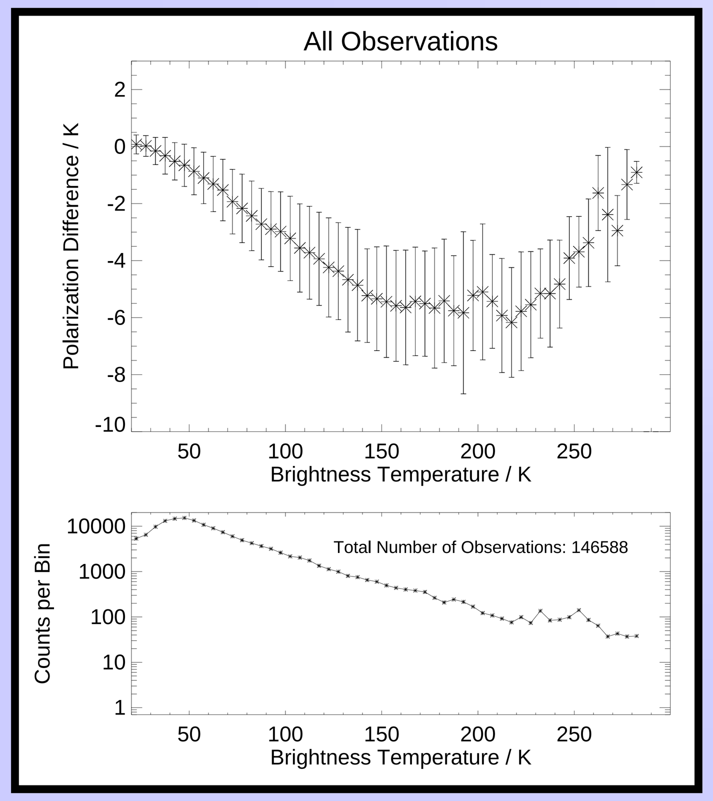
Introduction

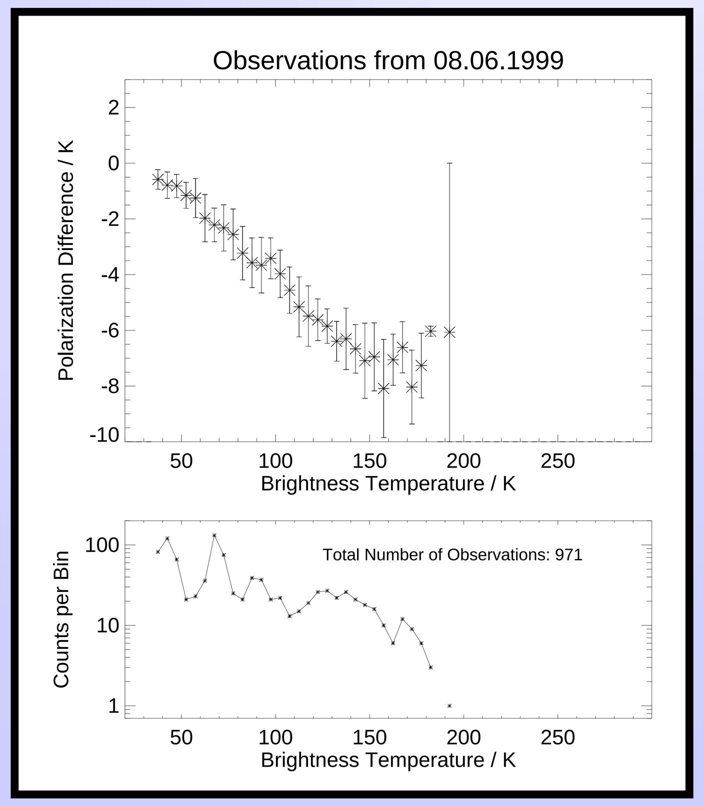
Remote sensing of liquid water path by ground based microwave radiometry is currently limited to unpolarized methods. Rain within the field of view spoils the accuracy of the retrieved LWP due to the ambiguity introduced by the drop size dependent emission efficiency. Mixing of rain and cloud occurs quite often, but cannot be detected and observed properly by standard methods (see figure below for the DSD ambiguity).

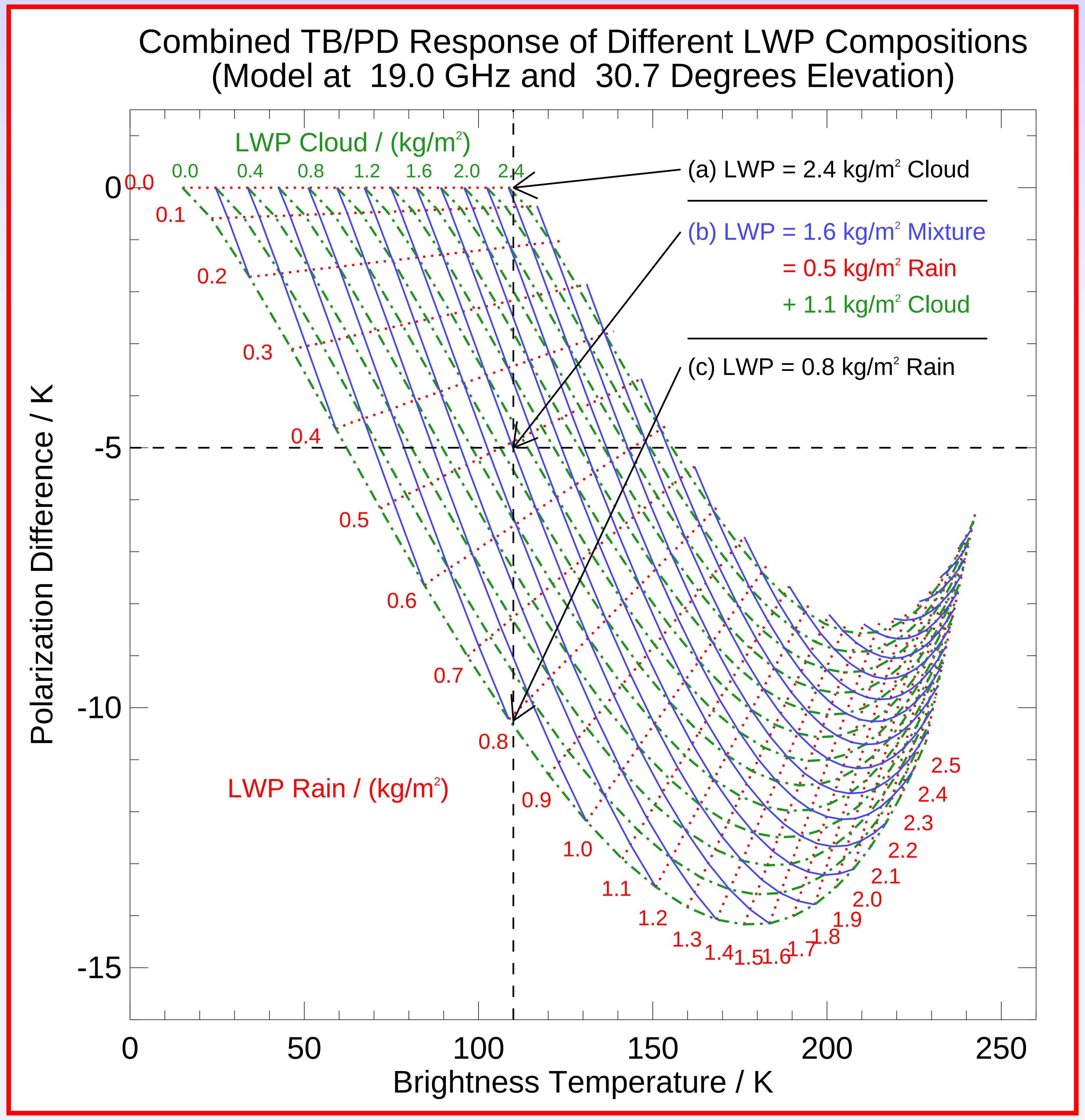


Model calculations

The vector radiative transfer equation (VRTE) was solved with a numerical model. The total LWP was partitioned to the cloud and rain fraction, which were modeled by small cloud droplets (modified gamma distribution with 30 microns modal radius) and Marshall-Palmer rain distributions. The downwelling radiation carries a polarization signature arising from non-spherical rain drops with horizontal alignment. This signature can be used to reduce the impact of the (a-priori unknown) drop size distribution.







Proposed method

The figure above shows the response of brightness temperature (TB) and polarization difference (PD=TB_v–TB_h) to varying amounts of LWP (along blue lines the LWP is constant). The LWP is the sum of rain LWP (constant along red lines) and cloud LWP (constant along green lines). The response to different rain and cloud mixtures is a two dimensional plot because of the negative PD asociated with rain. If only TB is used for retrieval, the above diagram is condensed to a one-dimensional line. The retrieved LWP for a measurement of 110 K can be 2.4 to 0.8 kg/m², depending on the assumed drop spectrum. With the PD information of -5 K the LWP retrieval can be pinned down to a more precise value corresponding to the respectice cloud and rain fractions.

Validation

Measurements with a 19 GHz dual polarized microwave radiometer over a period of two years strongly support the model calculations when averaging all data of different seasons. Single events show a more precise match of model and measurement.

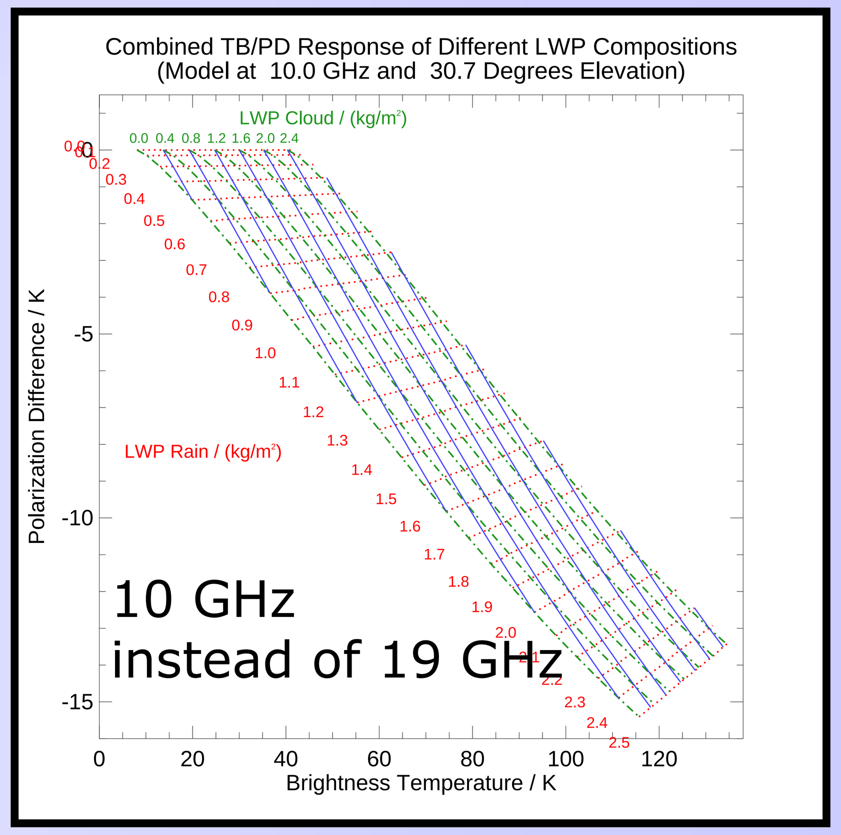
Multi channel and multi frequency observations

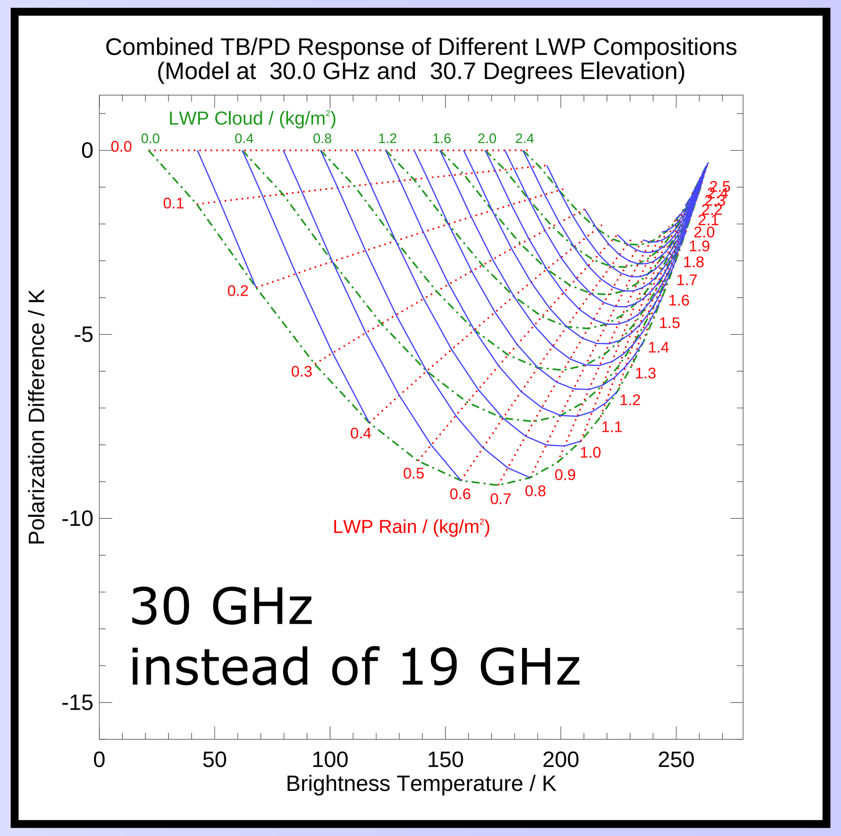
The sensitivity of the PD signal to rain is affected by the optical thickness, which varies with frequency and with elevation angle.

At lower frequencies the sensitivity is reduced, but the signal is better suited for heavy rain observation.

Higher frequencies are better suited for the detection of small rain amounts like in-cloud rain rates and drizzle.

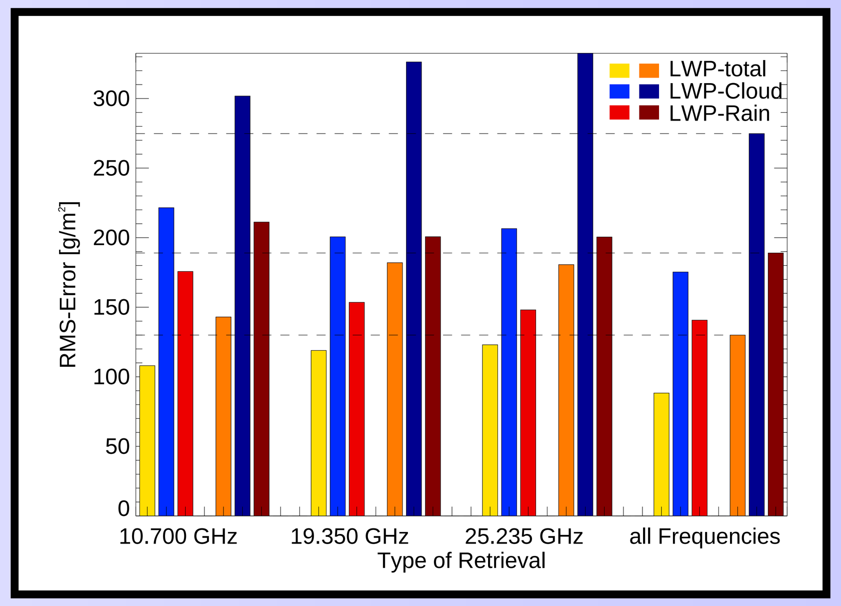
Changing the observation angle has a similar effect as changing the frequency. Both variations offer additional information to overcome the ambiguity arising from DSD variations.





Improved retrieval

The radiative transfer model used DSD data from a cloud model as input. Based upon the TB-PD results a set of retrieval schemes can be set up and compared.



References

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