Discrimination of cloud and rain liquid water path by ground based polarized microwave radiometry: Method, instruments, and results

Radiometer Physics
A Rohde & Schwarz Company

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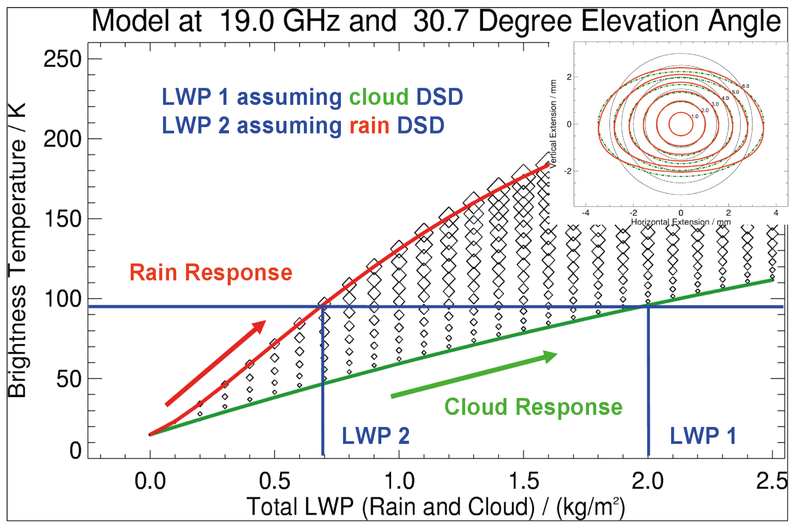
1. The Problem

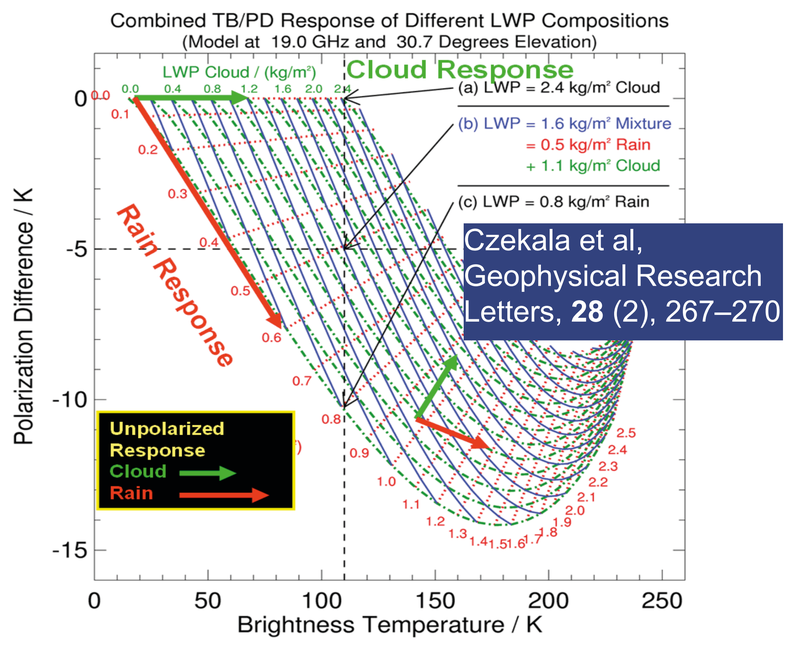
Standard (unpolarized) microwave radiometers are used for liquid water path (LWP) observation. The retrieved LWP is ambiguous in the presence of rain because the emission efficiency no longer depends on water mass alone, but on the drop size distribution (DSD) as well. The DSD is usually unknown, thus the retrieved LWP depends on the a-priori assumed DSD. Clouds with LWP > 300g/m^2 usually contain rain.

Czekala et al, J. Appl. Meteorol., **40**, 1918–1932, 2001(b).



2. Proposed Method

Dual-polarized observations exploit the polarization difference (PD, defined as TB_v – TB_h) that is caused by non-spherical rain drop shape.
When rain drops become larger, they
violate Rayleigh emission efficiencies (→ problem!)
become more flat (non-spherical)
generate negative PD signal (→ solution!)



Czekala et al, Geophysical Research Letters, **28** (2), 267–270

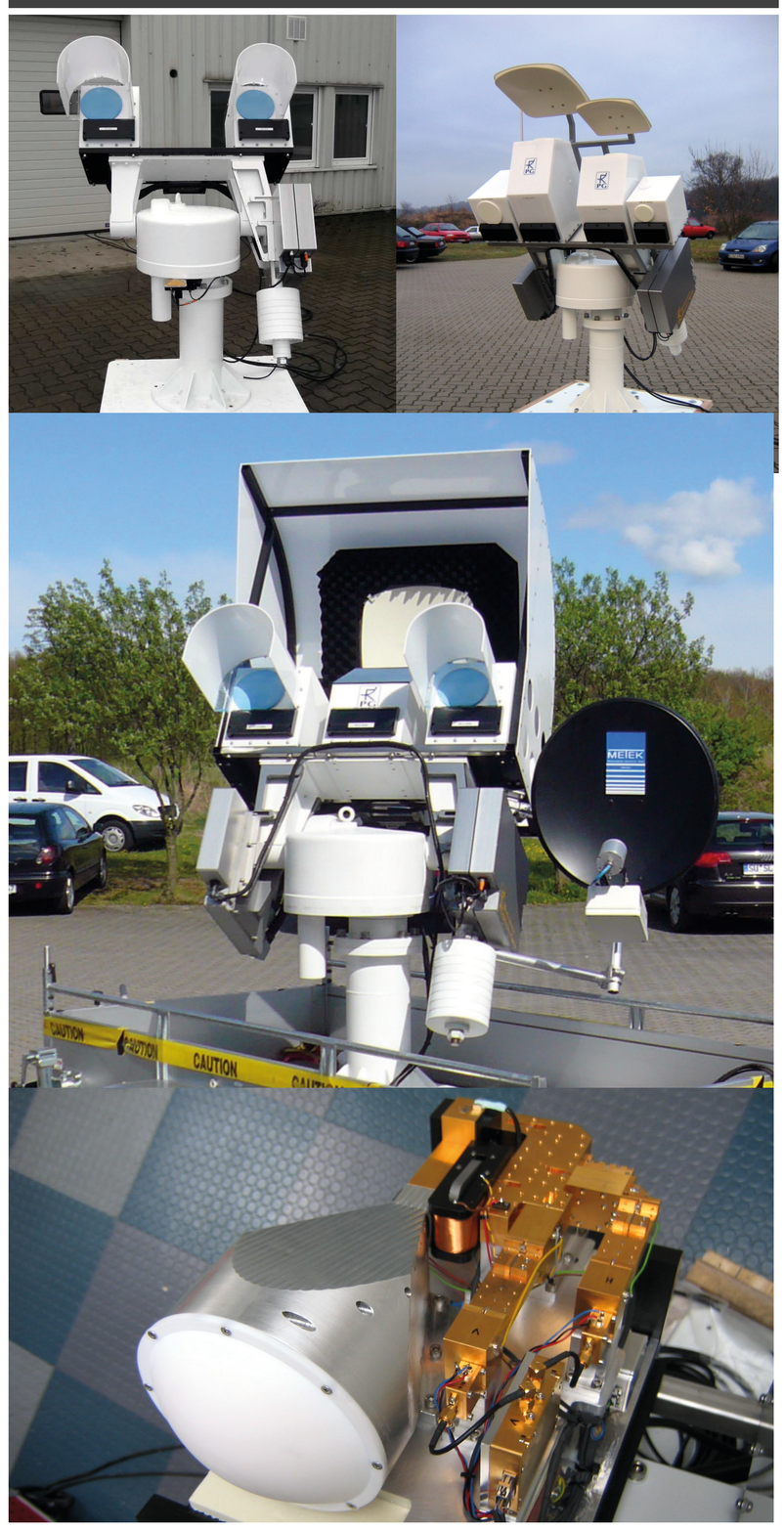
3. RPG Instrument: ADMIRARI

University of Bonn purchased ADMIRARI in 2007 for rain observation, with 3 similar instruments built so far.

- Frequencies: 10.65, 21.0, 36.5 GHz dual-polarized (10.6: strong rain, 21: water vapour, 36: light rain)
- Trailer-mounted, steerable, deployable
  Rain-protection, Metek 24.0 GHz MRR for validation
- Direct-Detection auto-calibrating receivers:
  Noise-injection and magnetical Dicke-switching
- Thermal stabilization of receivers: better than 0.05K
- -30 °C to +40 °C operating range
- 0.4 K RMS sensitivity @1s integration time
- Absolute system stability: 1.0 K
- **Standardised radiometer type in RPG program**

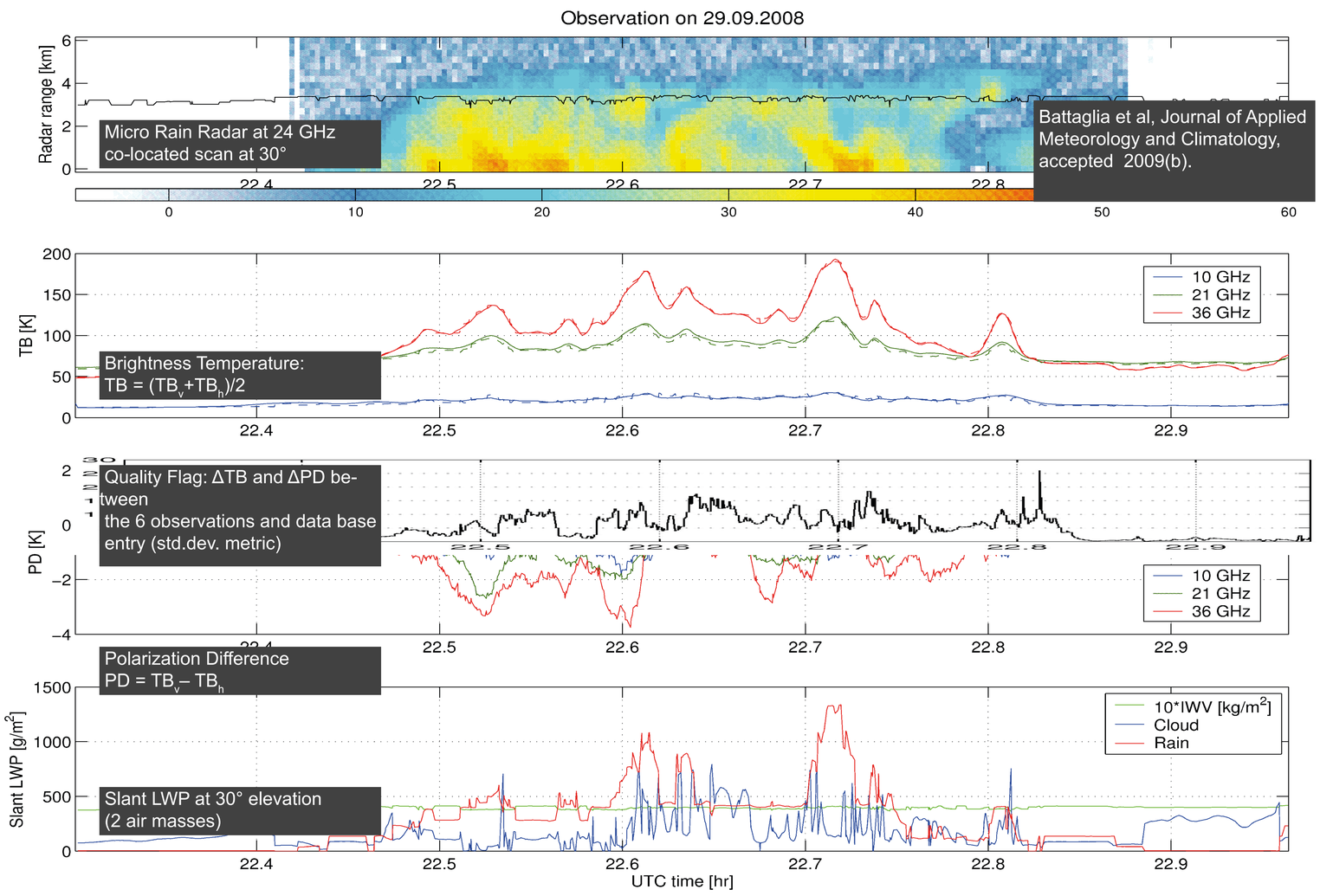
http://www.meteo.uni-bonn.de/forschung/gruppen/admirari/

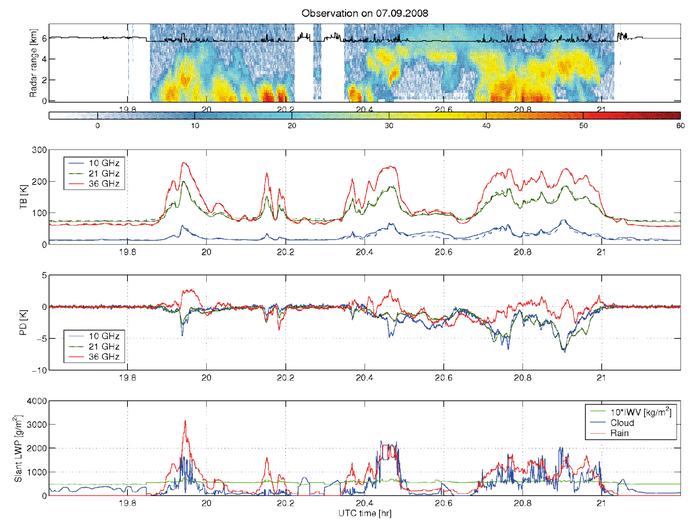
Battaglia et al, IEEE Geosci. Remote Sens. Lett., 6 (2), 354–358, 2009(a)



4. Measurement Results / Retrievals

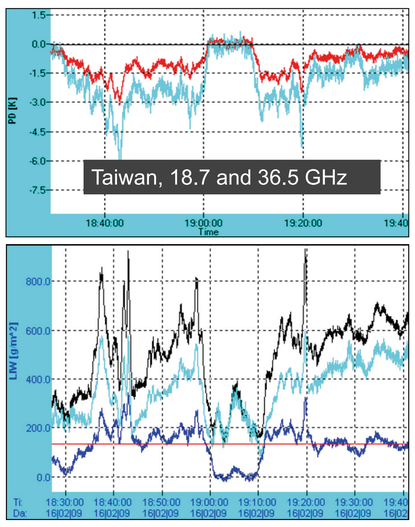
Bayesian retrieval scheme for r-LWP, c-LWP, and IWV based on RT3, RT4, and 3D-MC
3D effects, variation of axis-ratio parameterizations, rain DSD variations
Backward-forward Monte-Carlo scheme (Battaglia), based on importance sampling
Database of (rainy and clear) atmospheres from Goddard Cumulus Ensemble model (> 1e6 samples)





- Radar is not used in retrieval
- good agreement between simulated and measured TB/PD
- Quality flag measures distance of obs. vector to database entry
- Robust r-LWP/c-LWP retrieval possible, *even in strong rain*

Conclusion:
The polarized retrieval technique is well established and offers additional insight into the clouds microphysical properties (DSD).



References

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Battaglia, A., P. Saavedra, T. Rose, and C. Simmer, 2009(b): Characterization of precipitating clouds by ground-based measurements with the triple-frequency polarized microwave radiometer ADMIRARI. accepted for publication by *Journal of Applied Meteorology and Climatology.*

Czekala, H., S. Crewell, C. Simmer, and A. Thiele, 2001(a): Discrimination of cloud and rain liquid water path by groundbased polarized microwave radiometry, *Geophysical Research Letters*, **28**(2), pp. 267–270.

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