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

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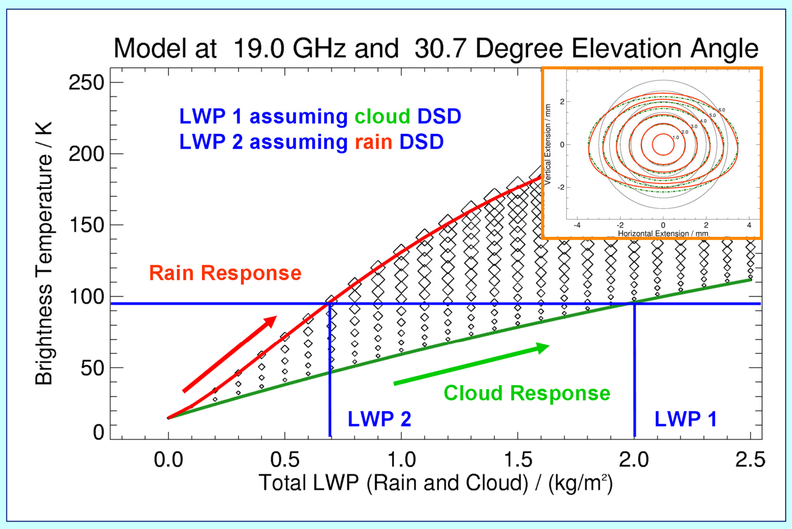
## 1. THE PROBLEM

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.

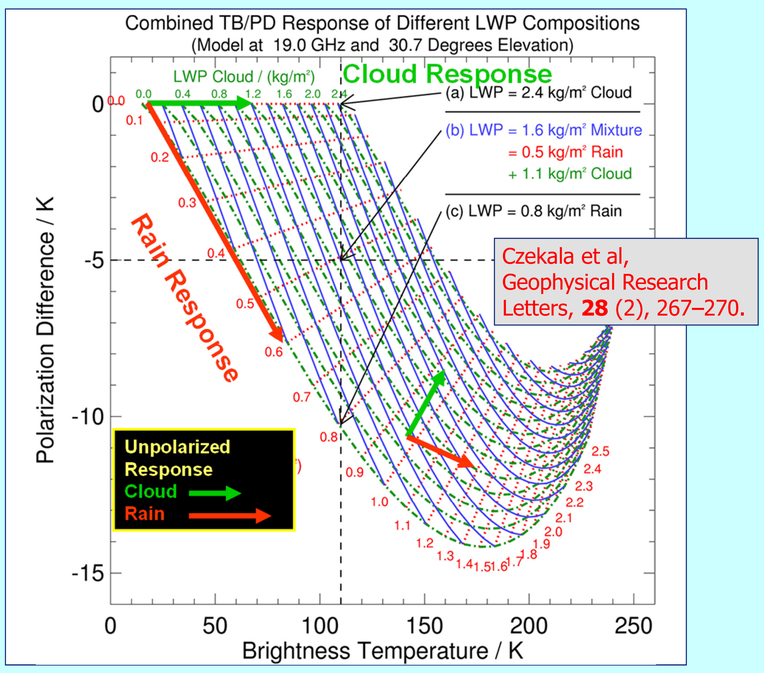
Czekala et al, J. Appl. Meteorol., **40**, 1918–1932, 2001(b).




## 2. PROPOSED METHOD

Dual-polarized observations exploit the polarization difference (PD, defined as TV_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.

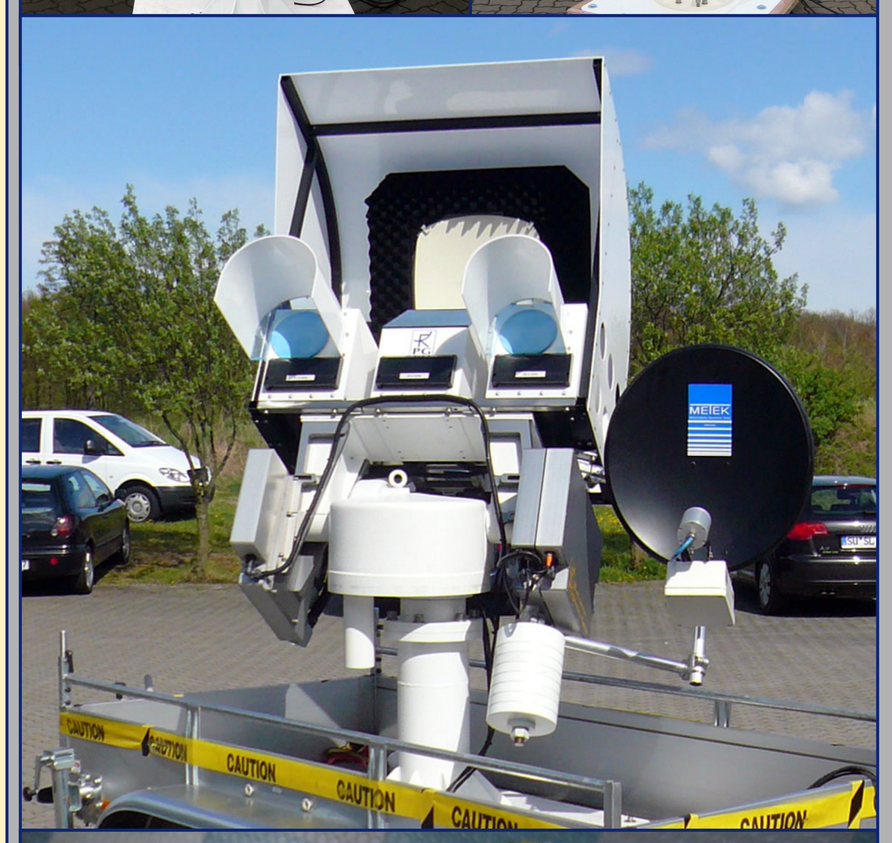
## 3. RPG INSTRUMENT: ADMIRARI

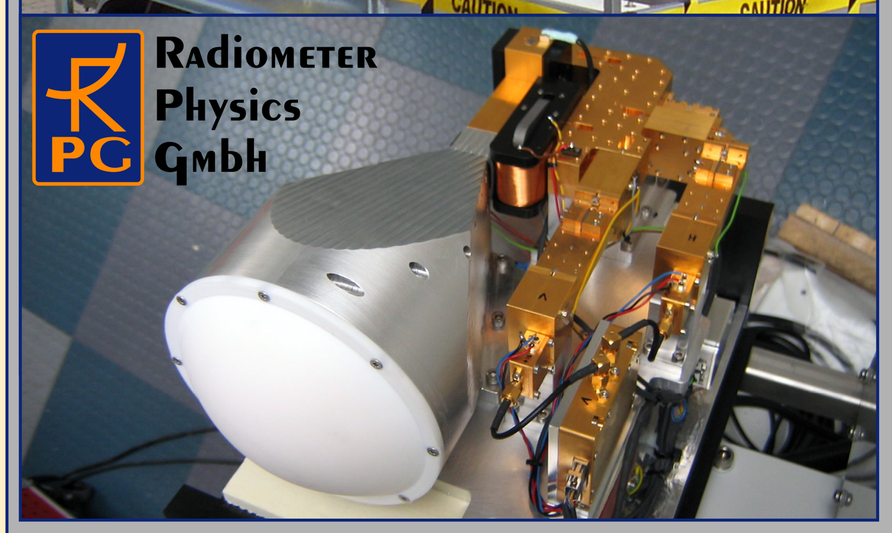
University of Bonn purchased ADMIRARI in 2007 for rain observation, with 3 similar instruments built so far.

- 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 0.05 K
- -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**

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

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

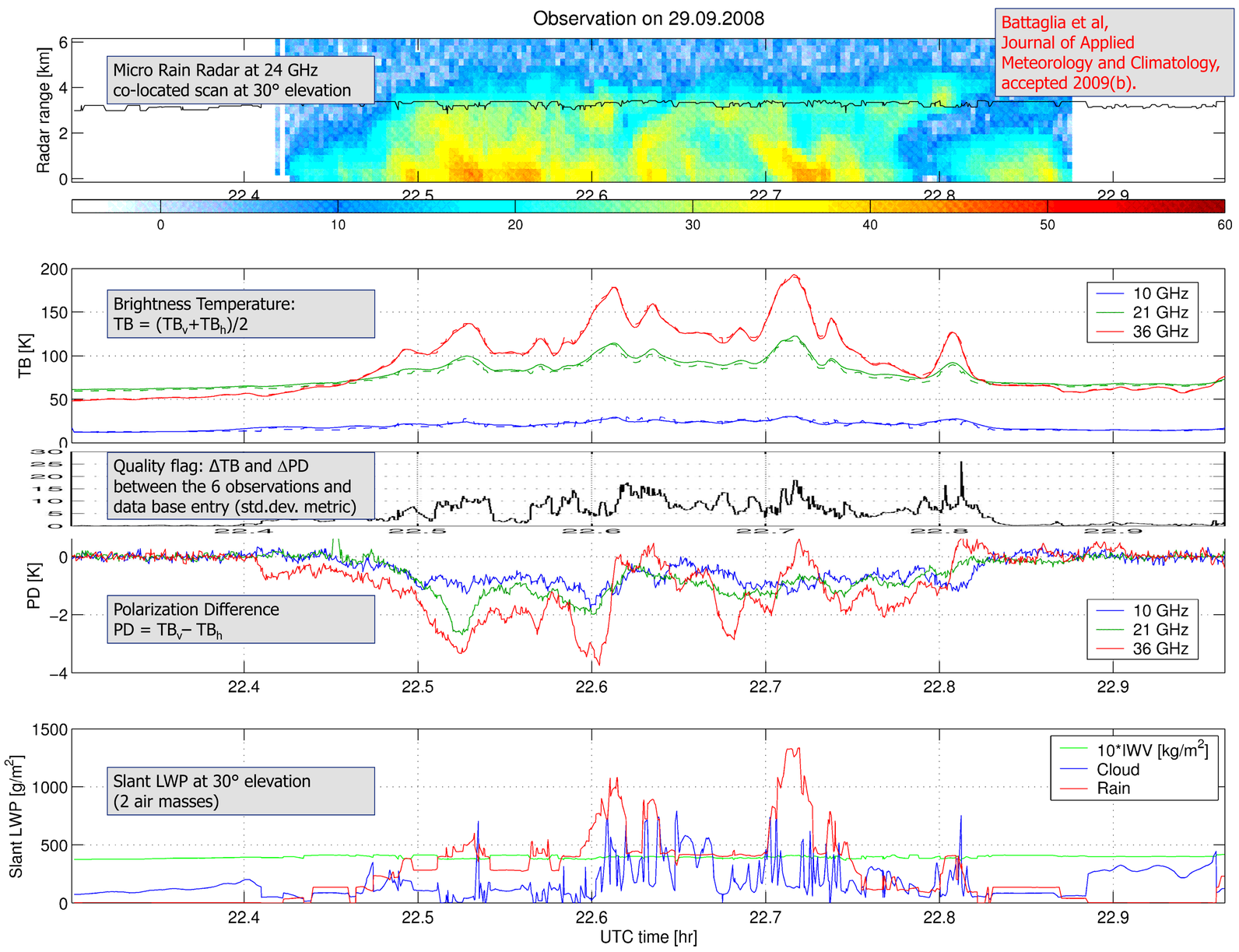


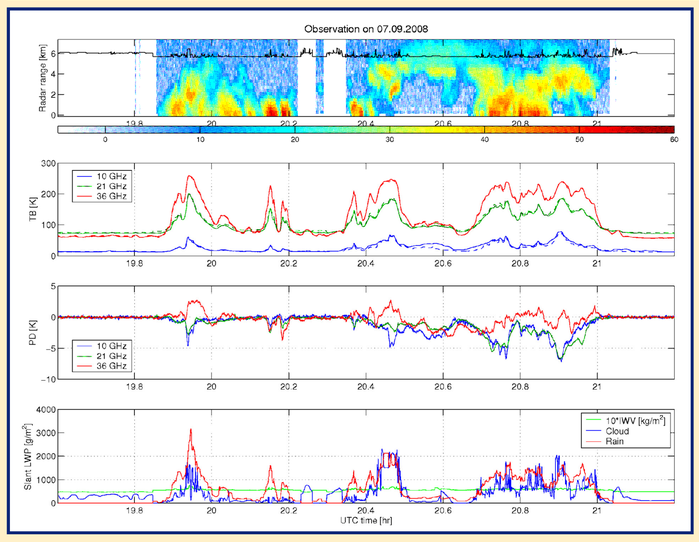

## 4. MEASUREMENT RESULTS / RETRIEVALS

**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)

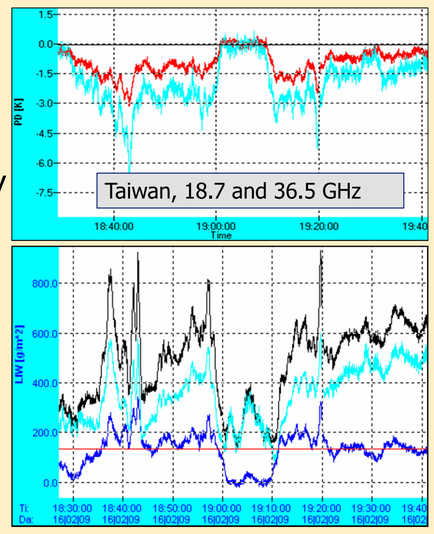



Battaglia et al, Journal of Applied Meteorology and Climatology, accepted 2009(b).




- 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

Battaglia, A., P. Saavedra, T. Rose, and C. Simmer, 2009(a): Rain observations by a multifrequency dual polarized radiometer. *IEEE Geosci. Remote Sens. Lett.*, **6** (2), 354–358.

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.

Czekala, H., S. Crewell, A. Hornbostel, A. Schroth, C. Simmer, and A. Thiele, 2001(b): Interpretation of polarization features in ground based microwave observations as caused by horizontally aligned oblate rain drops. *J. Appl. Meteorol.*, 40, 1918–1932.

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