Radiometer Physics
A Rohde & Schwarz Company

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

Meteorological Institute
University Bonn

Harald Czekala[1], Thomas Rose[1], Pablo Saavedra[2], Alessandro Battaglia[2,3]
1: RPG Radiometer Physics GmbH, Meckenheim, Germany ; 2: Meteorological Institute, Universit of Bonn, Germany; 3: University of Leicester, Leicester, United Kingdom

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.

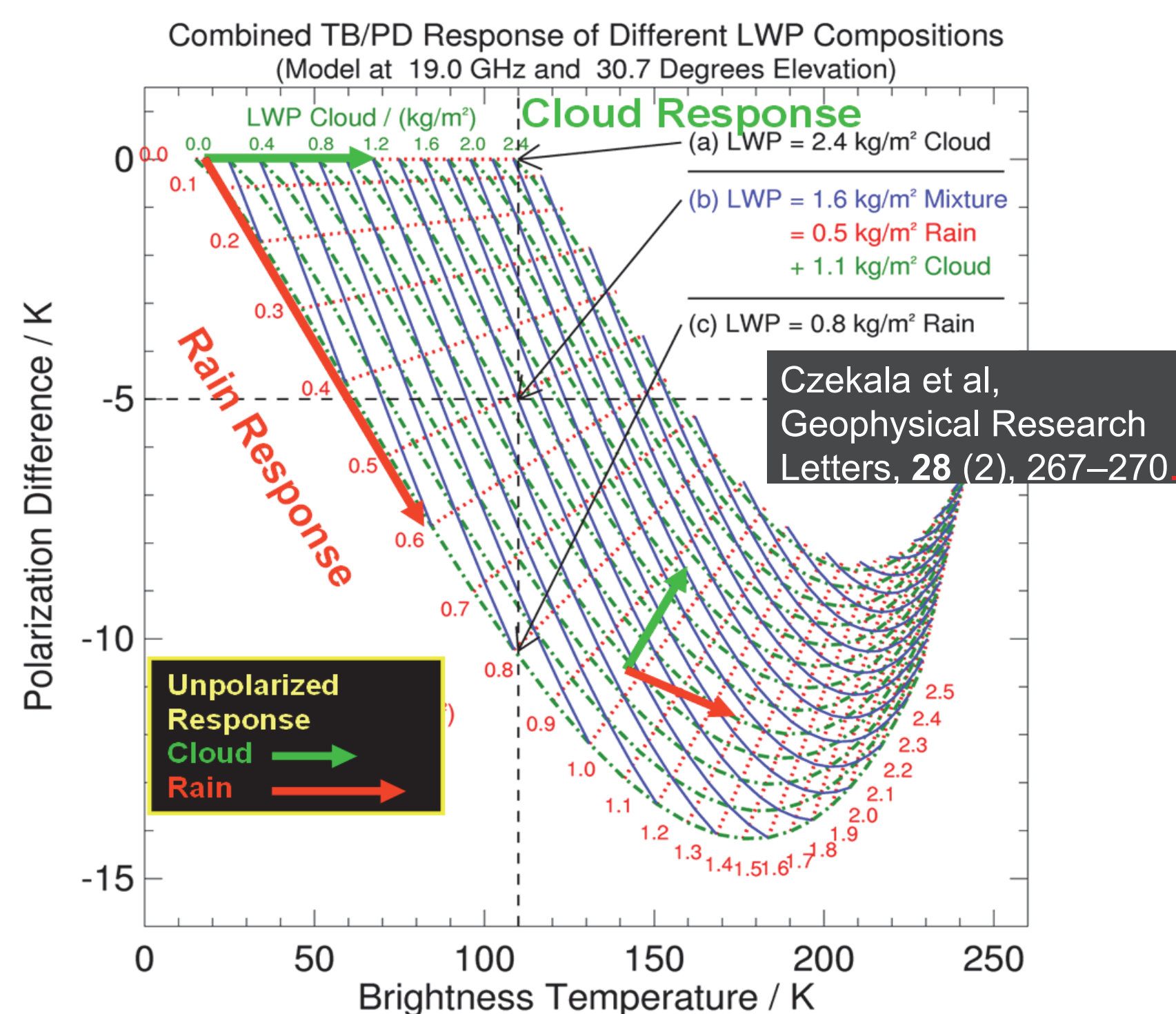Czekala et al, J. Appl. Meteorol., **40**, 1918–1932, 2001(b).
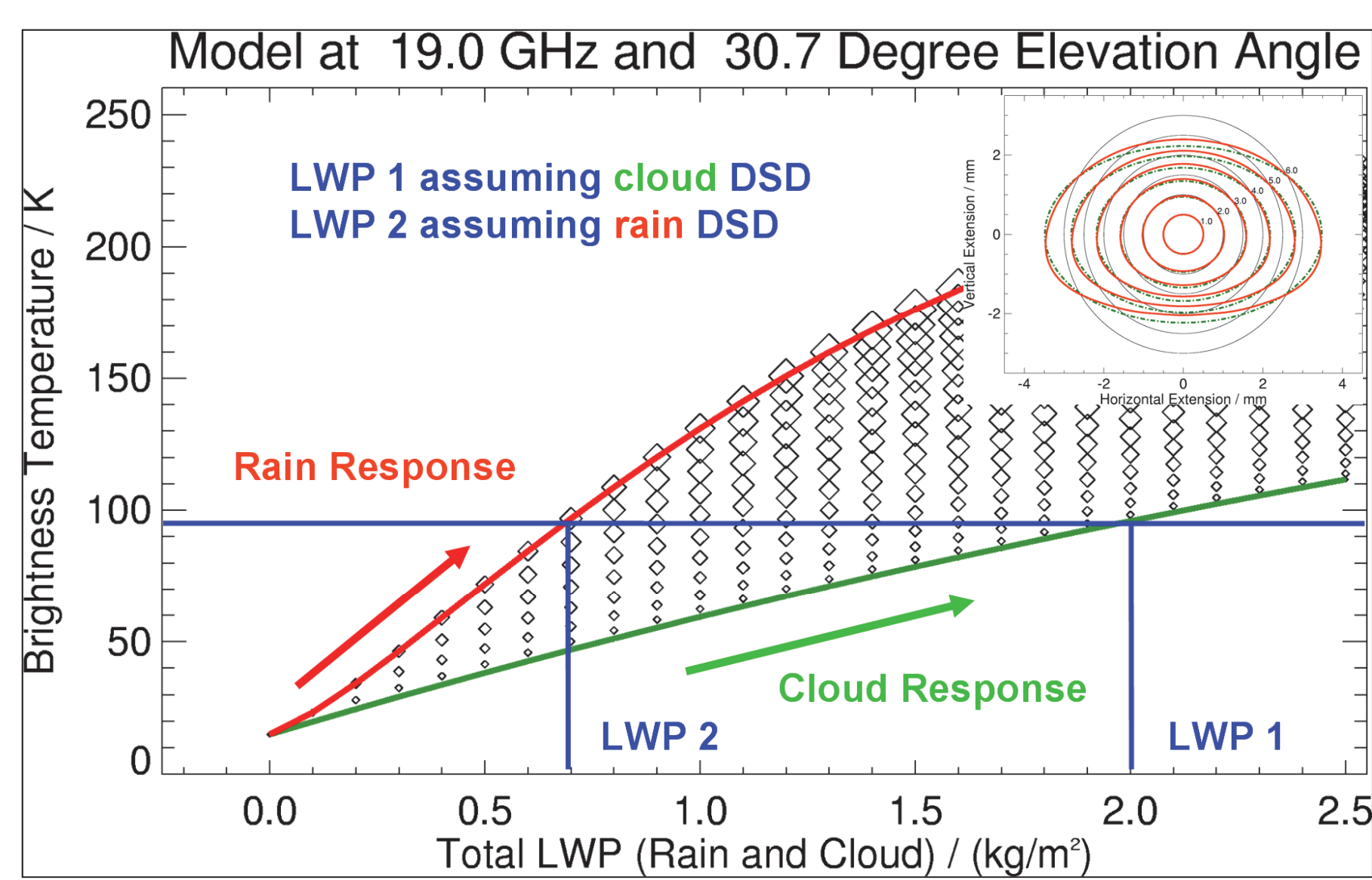
2. Proposed Method

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
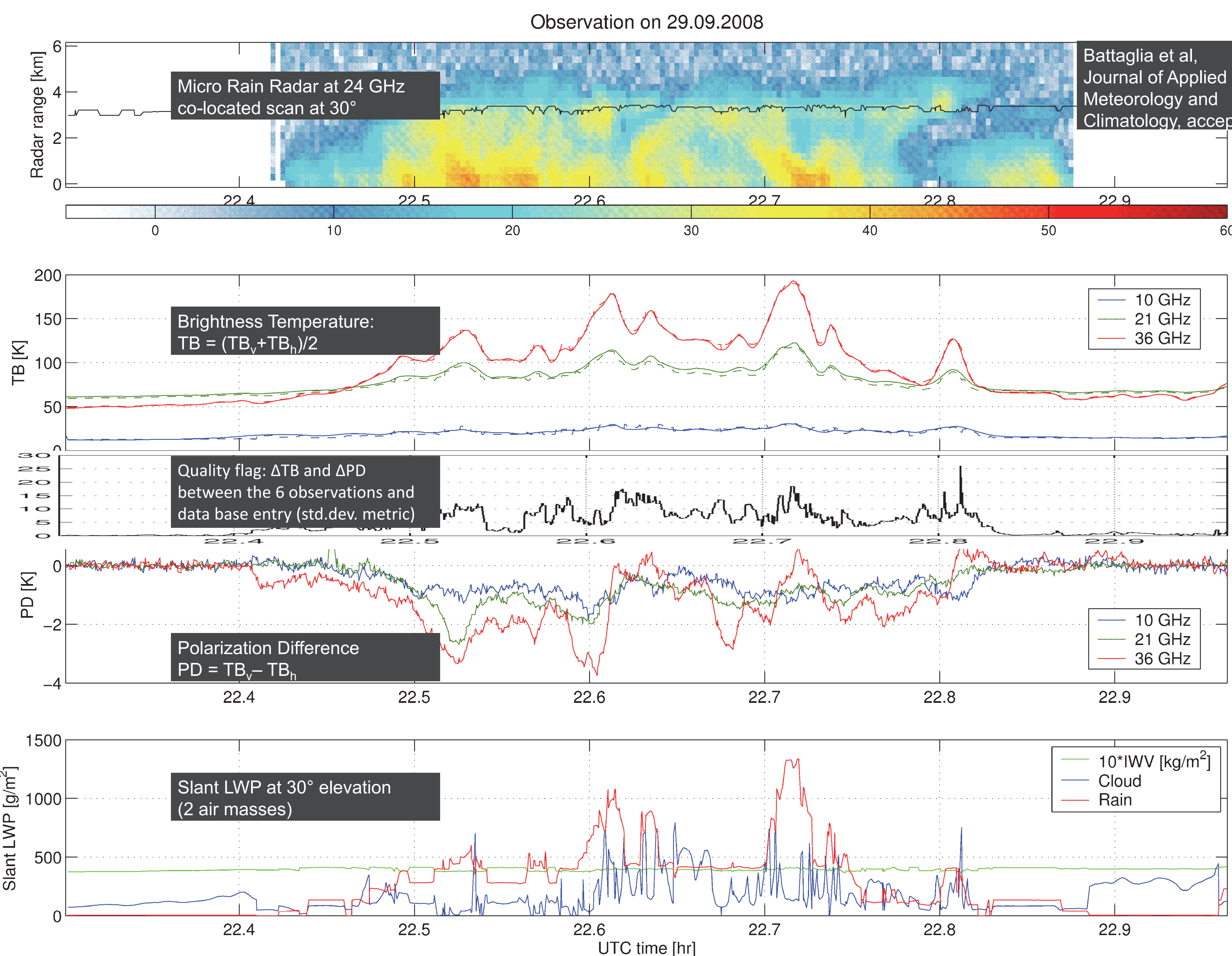- **Standardised radiometer type in RPG program**

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

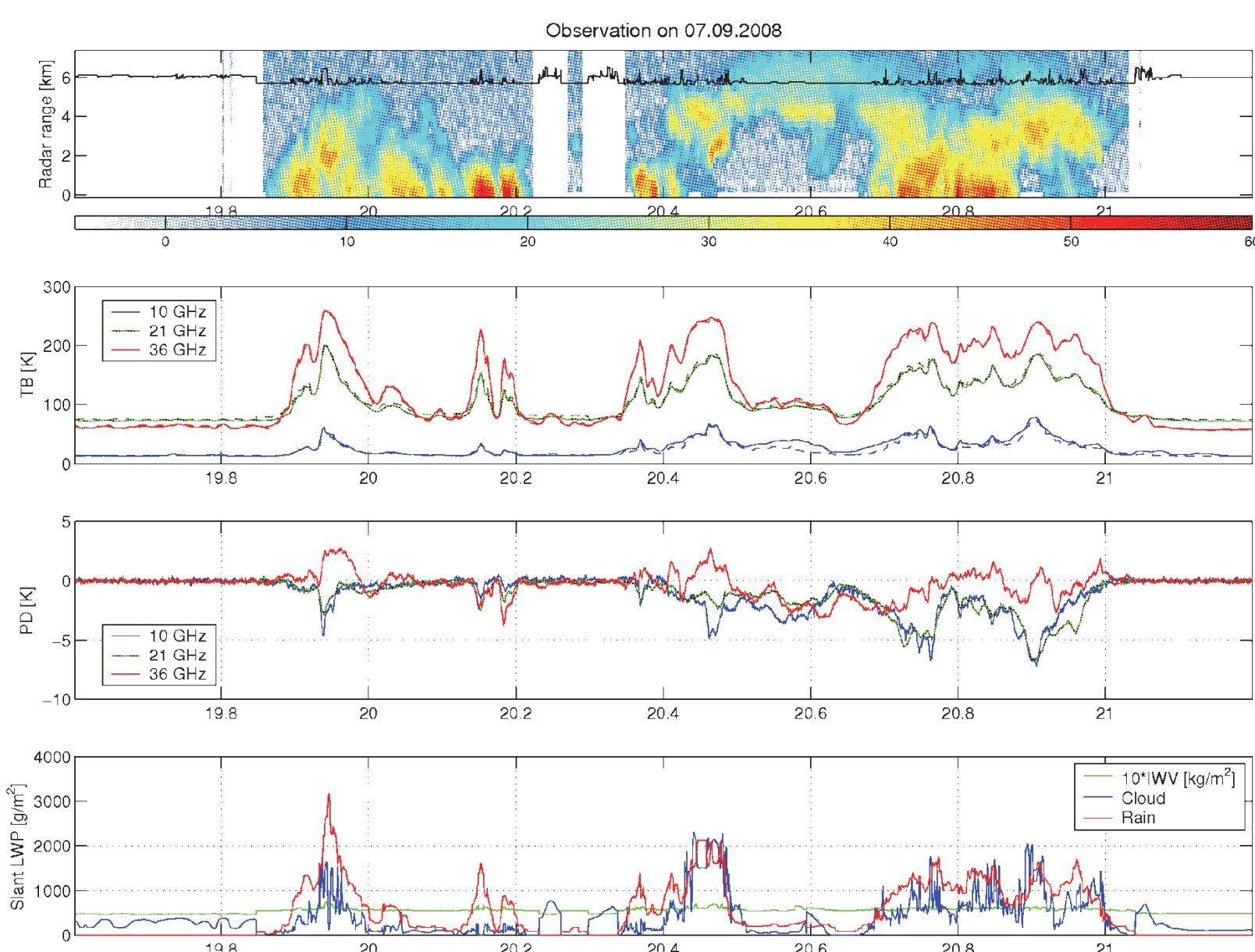Battaglia et al, IEEE Geosci. Remote Sens. Lett., **6** (2), 354–358, 2009(a).
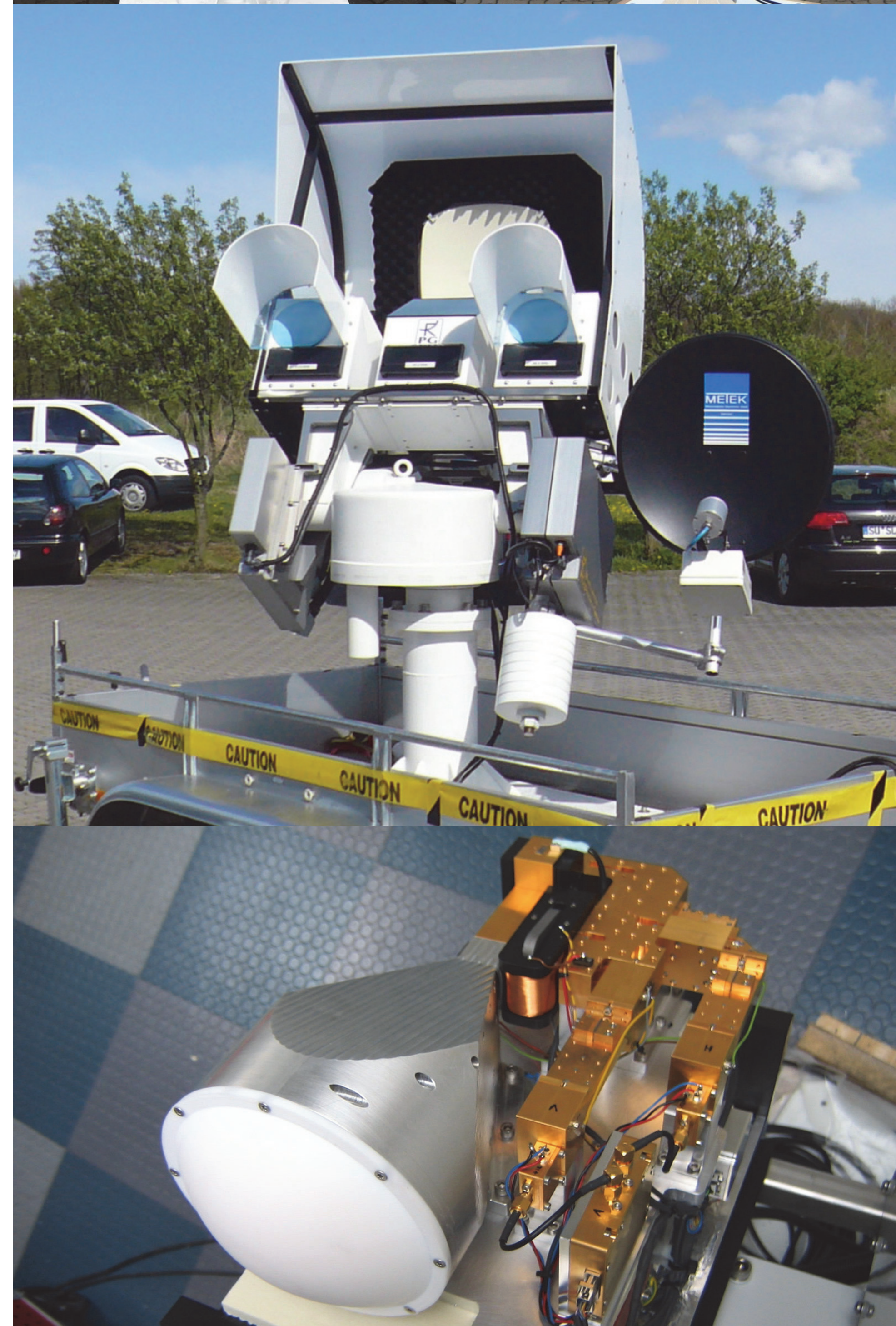
4. Measurement Results / Retrievals

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)


Micro Rain Radar at 24 GHz co-located scan at 30°

Battaglia et al, Journal of Applied Meteorology and Climatology, accepted

Brightness Temperature: TB = (TB_v+TB_h)/2

Quality flag: ΔTB and ΔPD between the 6 observations and data base entry (std.dev. metric)

Polarization Difference PD = TB_v – TB_h

Slant LWP at 30° elevation (2 air masses)

- 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).

Taiwan, 18.7 and 36.5 GHz
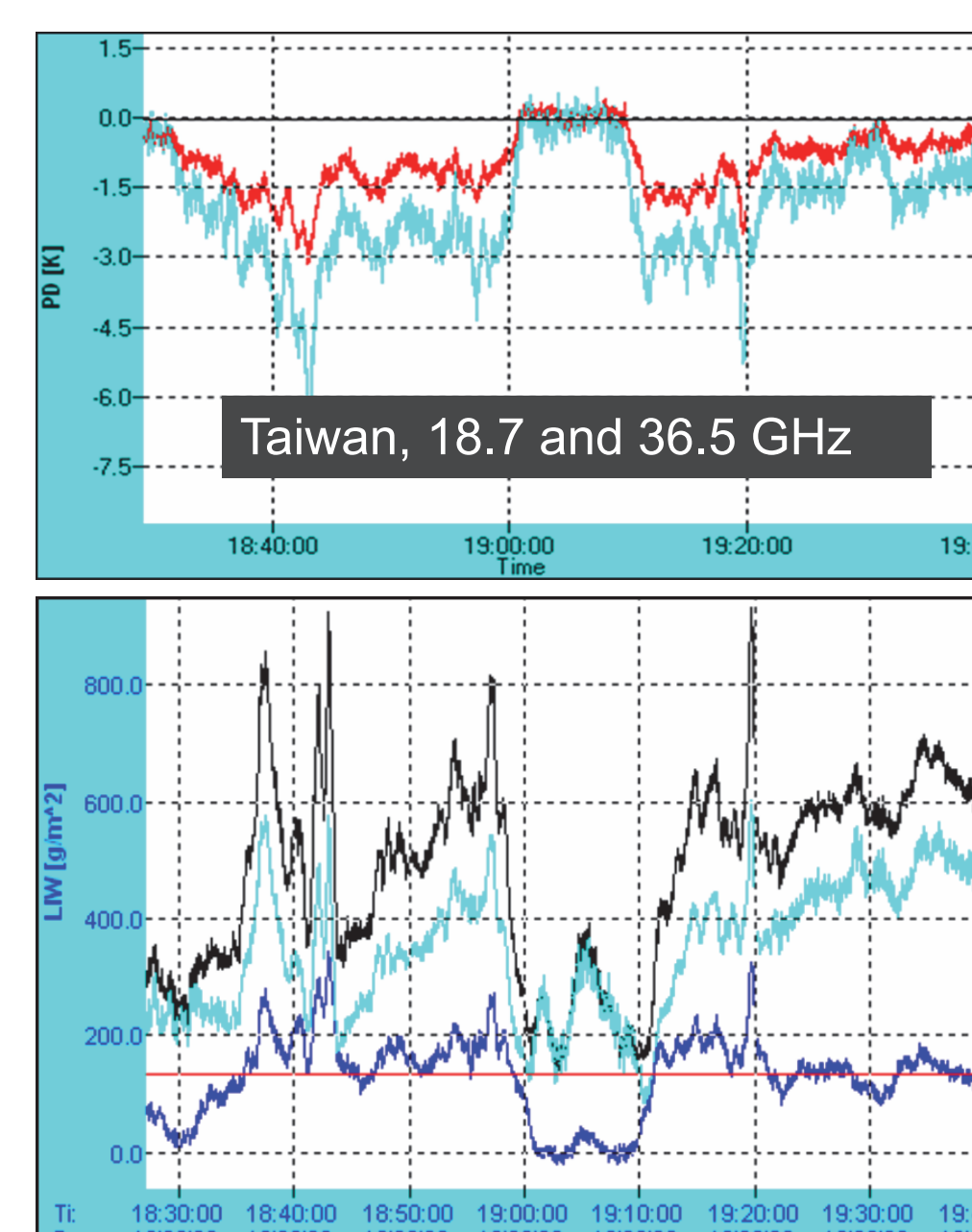
References

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.

Contact:
Harald Czekala, Birkenmaarstrasse 10, 53340 Meckenheim, Germany.
email: <czekala@radiometer-physics.de> or <a.battaglia@leicester.ac.uk>
web: www.radiometer-physics.de

RPG Radiometer Physics GmbH
Birkenmaarstraße 10
53340 Meckenheim, Germany

phone: +49 2225 99981-0
www.radiometer-physics.de
radiometer@radiometer-physics.de