Distinguishing Between Cloud Liquid Water and Rain Liquid Water Using Passive Microwave Observations

Dave Turner, University of Wisconsin - Madison

with information/data from

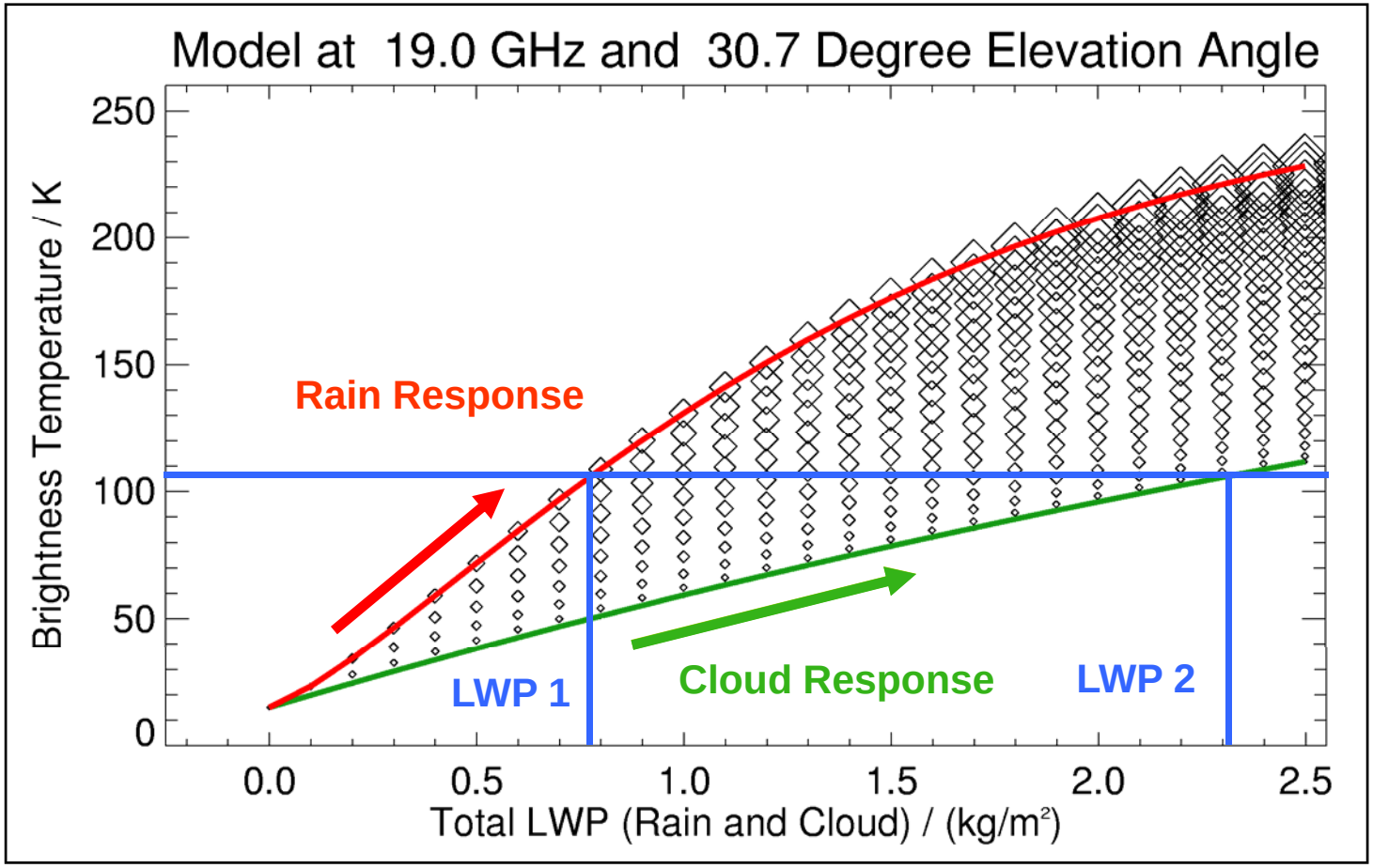
Harald Czekala, Radiometer Physics GmbH

Alessandro Baggaglia, University of Bonn

ARM RPWG Meeting, Madison, Wisconsin, 17-19 September 2007

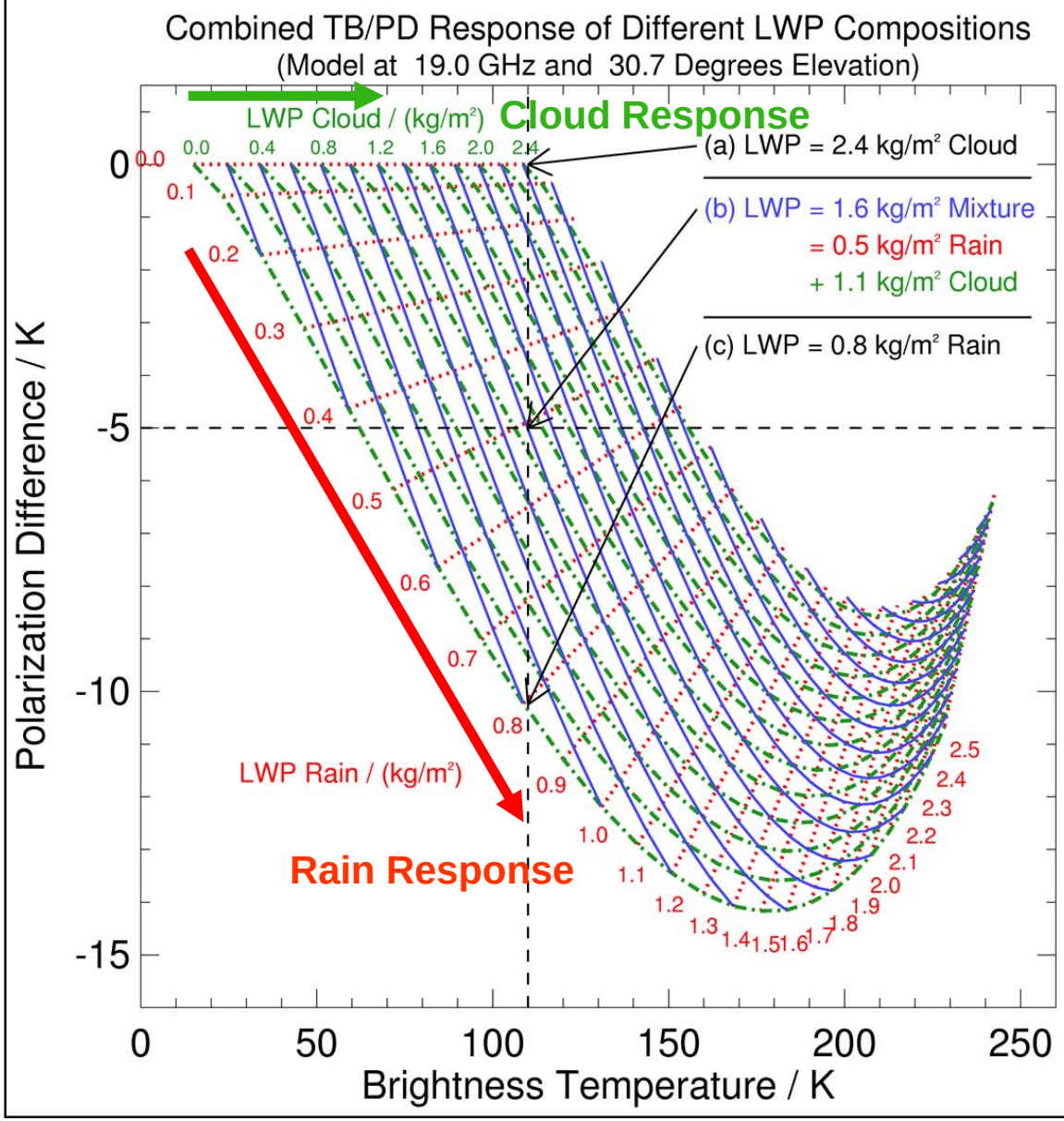
Separating Cloud and Rain Liquid Water

- Sensitivity of TB / LWP dependence different for rain and cloud
- Mixture of rain and cloud unknown
- Ambiguous LWP estimation in the presence of rain



Proposed Retrieval Method

Czekala et al, Geophys. Res. Lett. 28 (2), 267–270, 2001.



- Along red lines: rain LWP constant, increasing cloud LWP (left to right)
- Along green lines: cloud LWP constant, increasing rain LWP (top to bottom)
- Along blue lines: total LWP constant

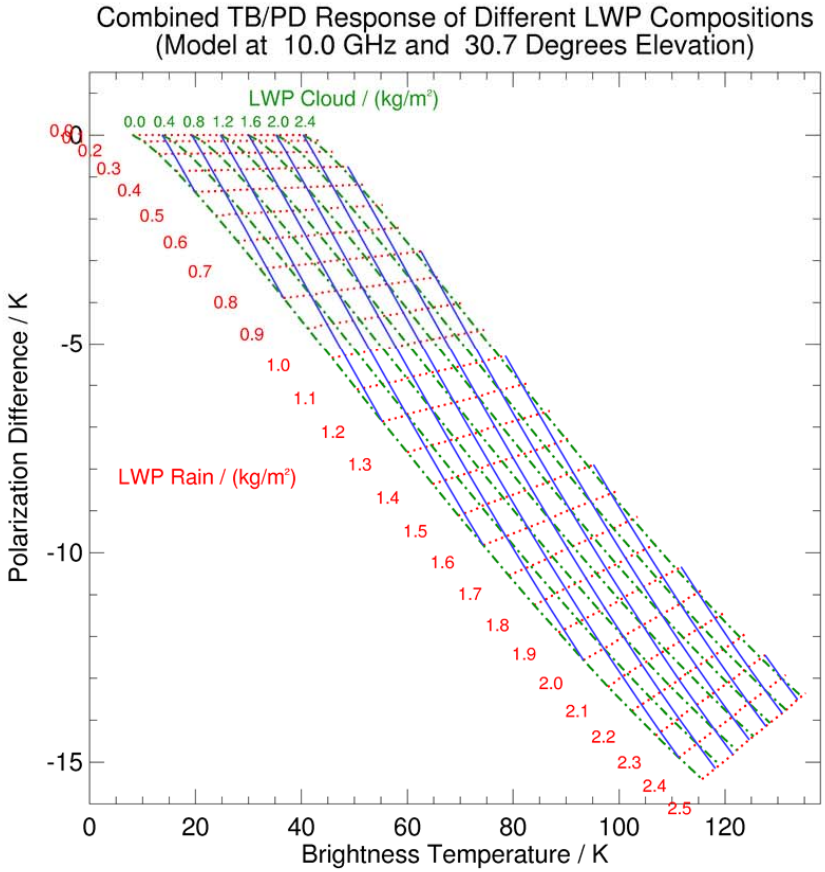
- Simultaneous measurement of brightness temperature and polarization difference
- Independent retrieval of cloud and rain fractions possible
- Accuracy of polarization measurement crucial
- Re-calibration with clear sky conditions

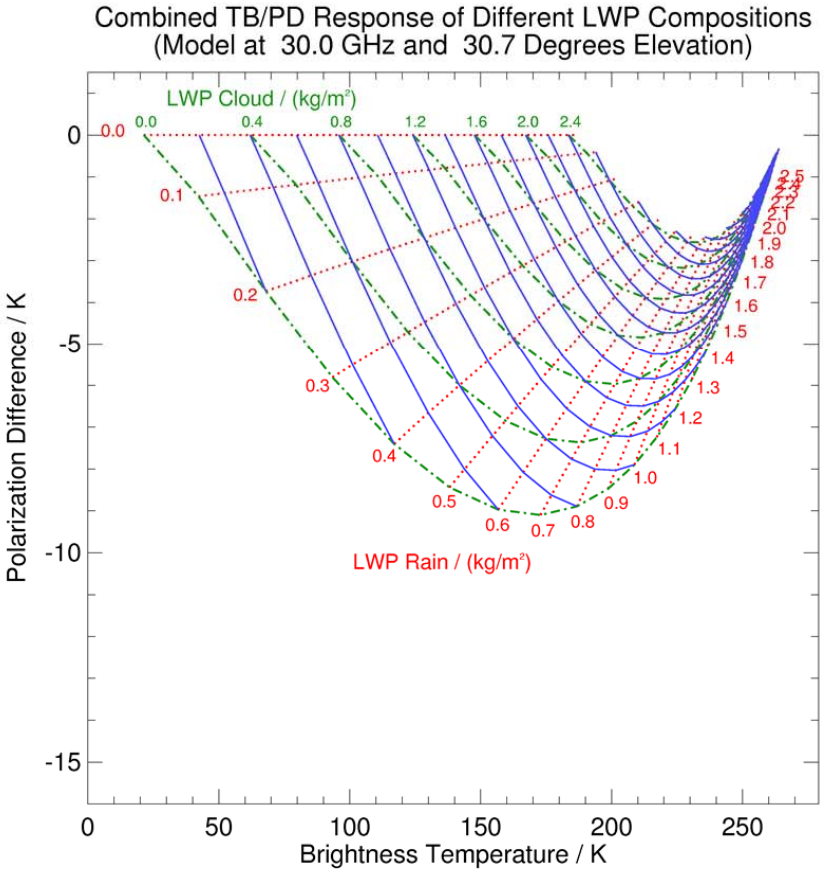
Courtesy of Harald Czekala, RPG

Sensitivity to Frequency

(10 and 30 GHz instead of 19 GHz)

- Less saturation at smaller frequencies, but smaller sensitivity to rain
- Higher sensitivity to rain with increasing frequency
- Multi frequency measurements allow for complete coverage of LWP range





10 GHz: no saturation, good for heavy precip

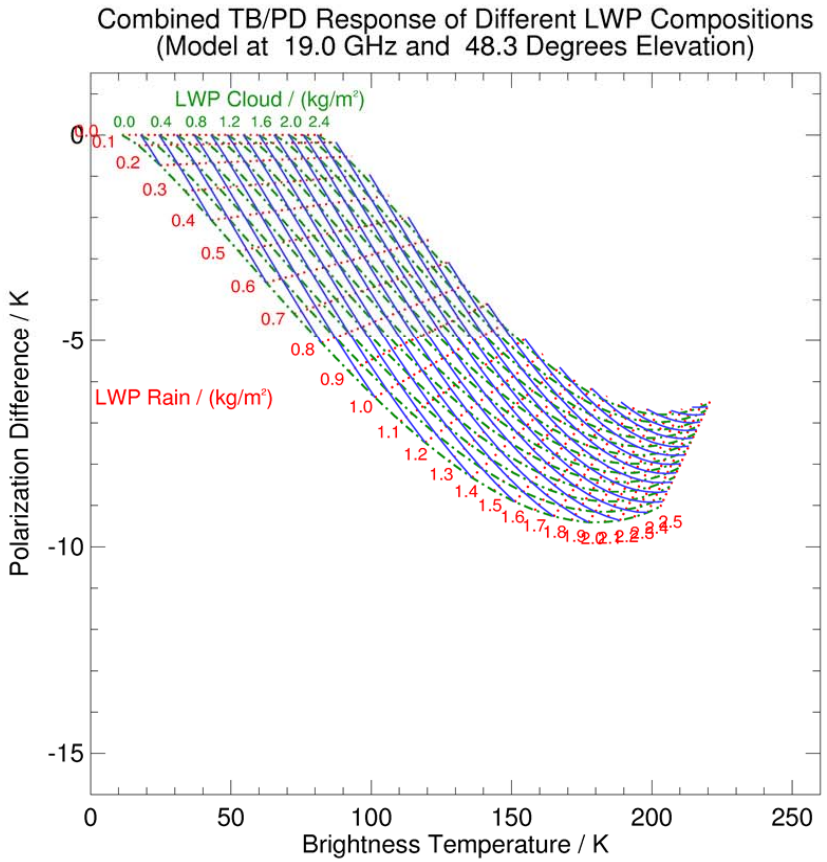
30 GHz, better for light rain

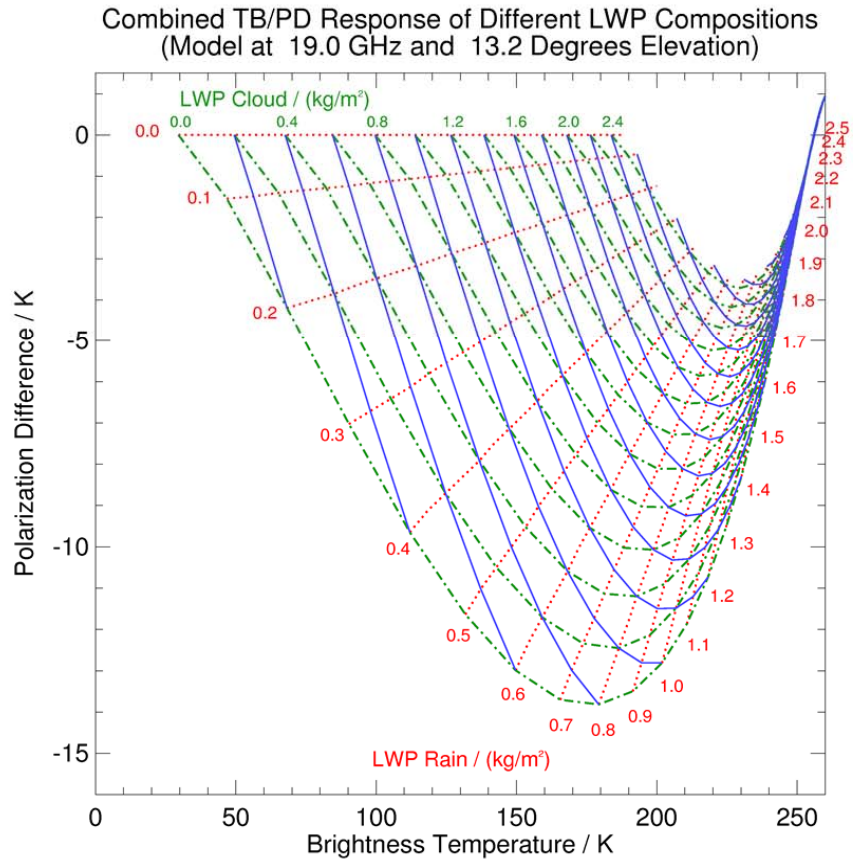
Courtesy of Harald Czekala, RPG

Sensitivity to Elevation Angle

(48 and 13 degrees instead of 30 degrees)

- Change in total optical thickness with path length
- Sensitivity changes with elevation angle
- Field-of-view problem towards low elevation angles





48 degrees, closer to nadir

13 degrees, closer to horizontal

Courtesy of Harald Czekala, RPG

ADMIRARI

(ADvanced MIcrowave Radiometer for Rain Identification)

3-wavelength polarimetric microwave radiometer with
azimuthal and zenith scanning capabilities

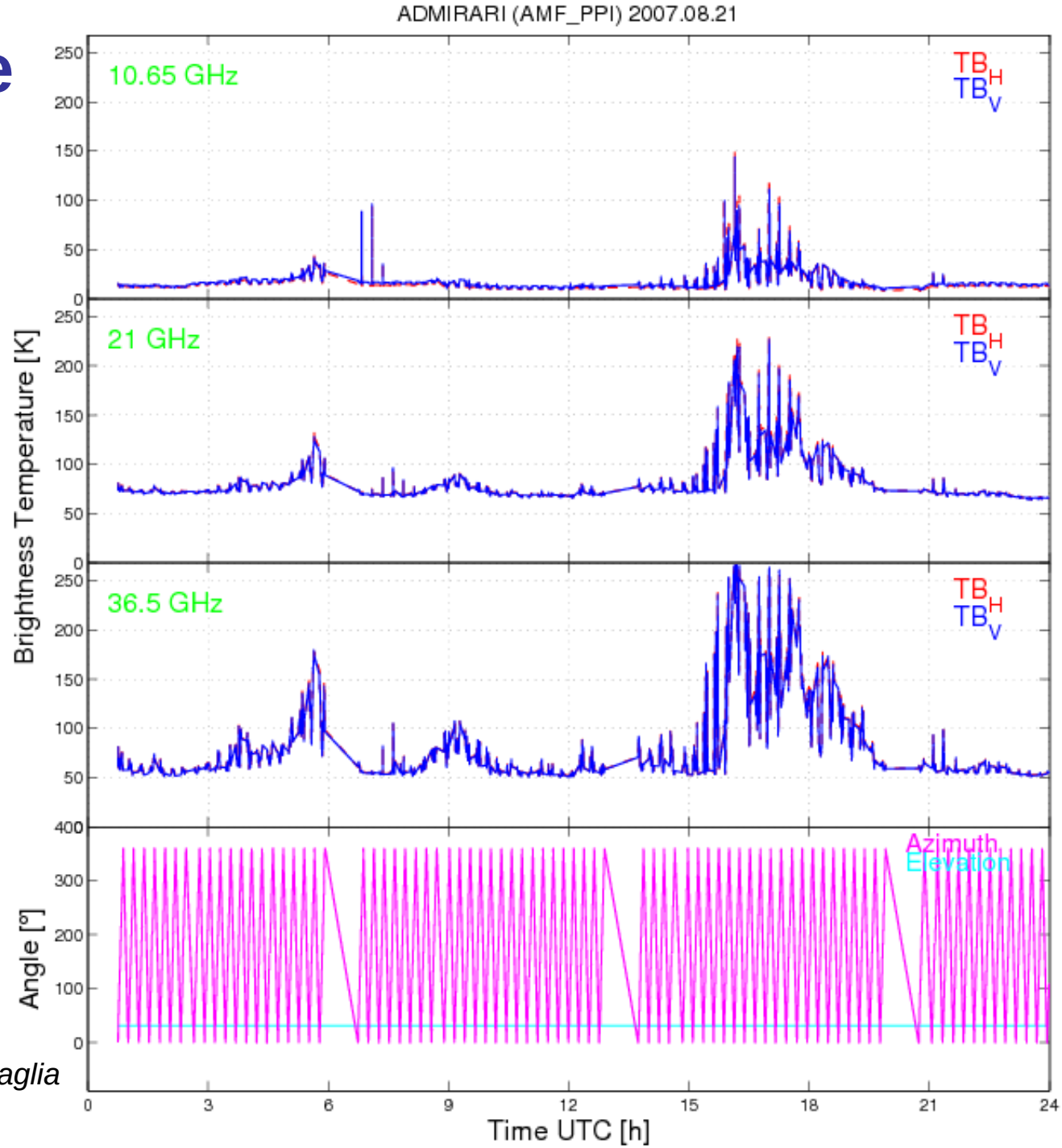
ADMIRARI at AMF and Hornisgrinde Super Sites during COPS 2007

ADMIRARI Details

- Three channels: 10.65, 21.0, and 36.5 GHz
- Each channel is dual-polarized (V and H)
- 400 MHz bandpass
- 1-s temporal resolution (noise level 0.2 K RMS)
- 5º beam width in all channels
- Pointing speed:
  - Elevation: 3º / second
  - Azimuth: 5º / second
- Manufacturer: Radiometer Physics GmbH

Data Example

21 Aug 2007
AMF/Germany

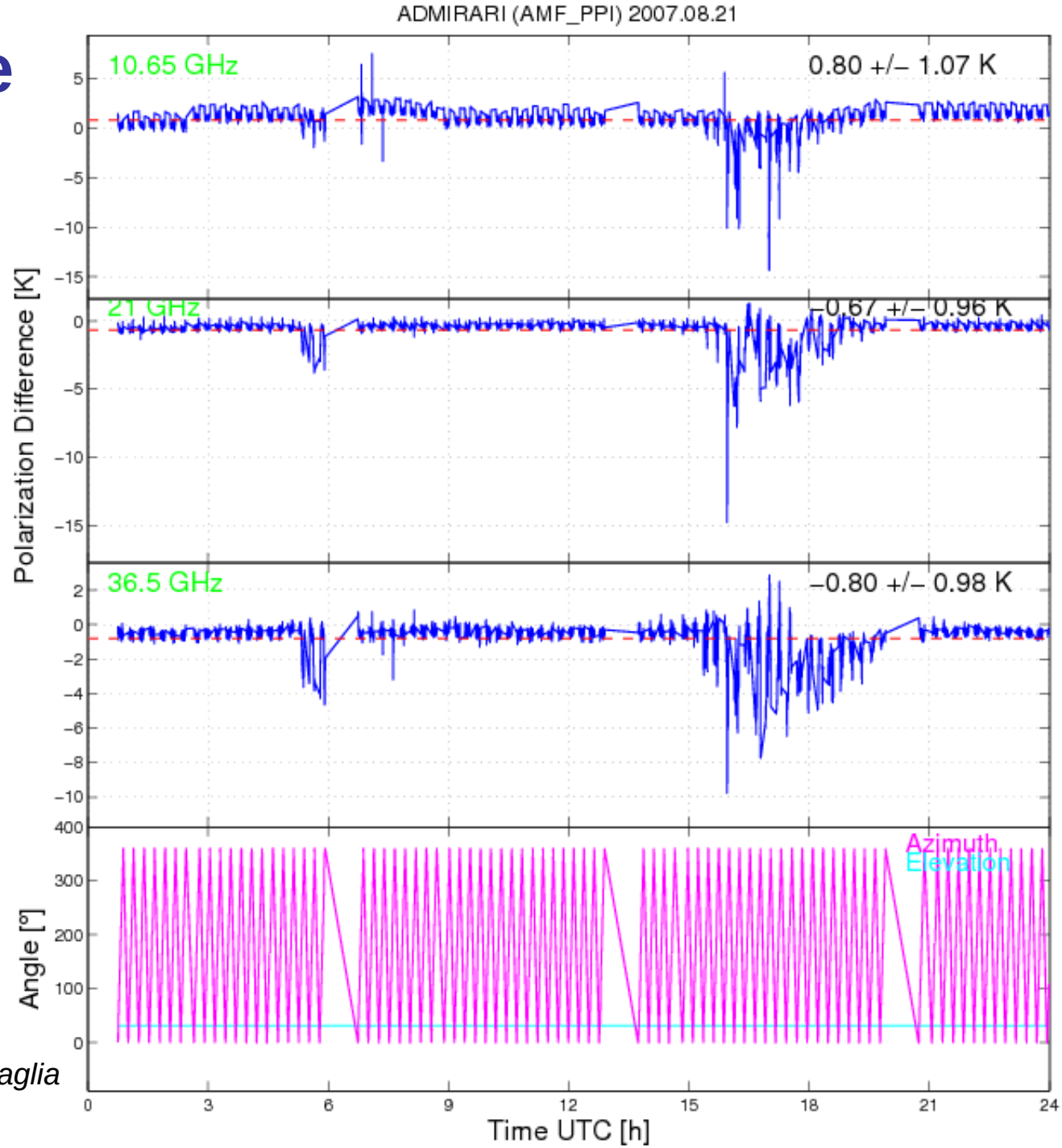


All data at constant elevation angle (30º)

Data courtesy of Alessandro Baggaglia University of Bonn

Data Example

21 Aug 2007
AMF/Germany

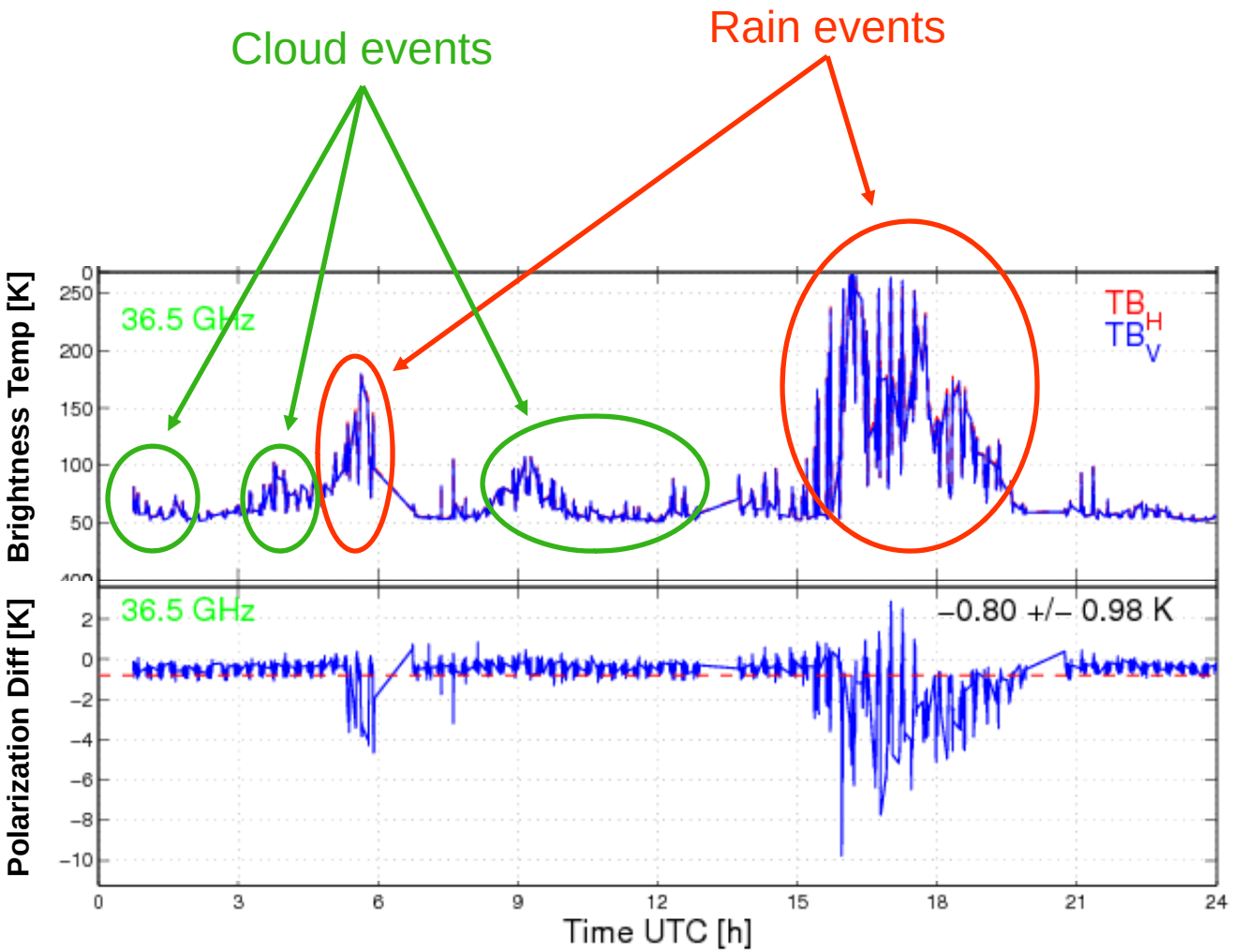


All data at constant elevation angle (30º)

Data courtesy of Alessandro Baggaglia University of Bonn

Data Example

21 August 2007, AMF/Germany

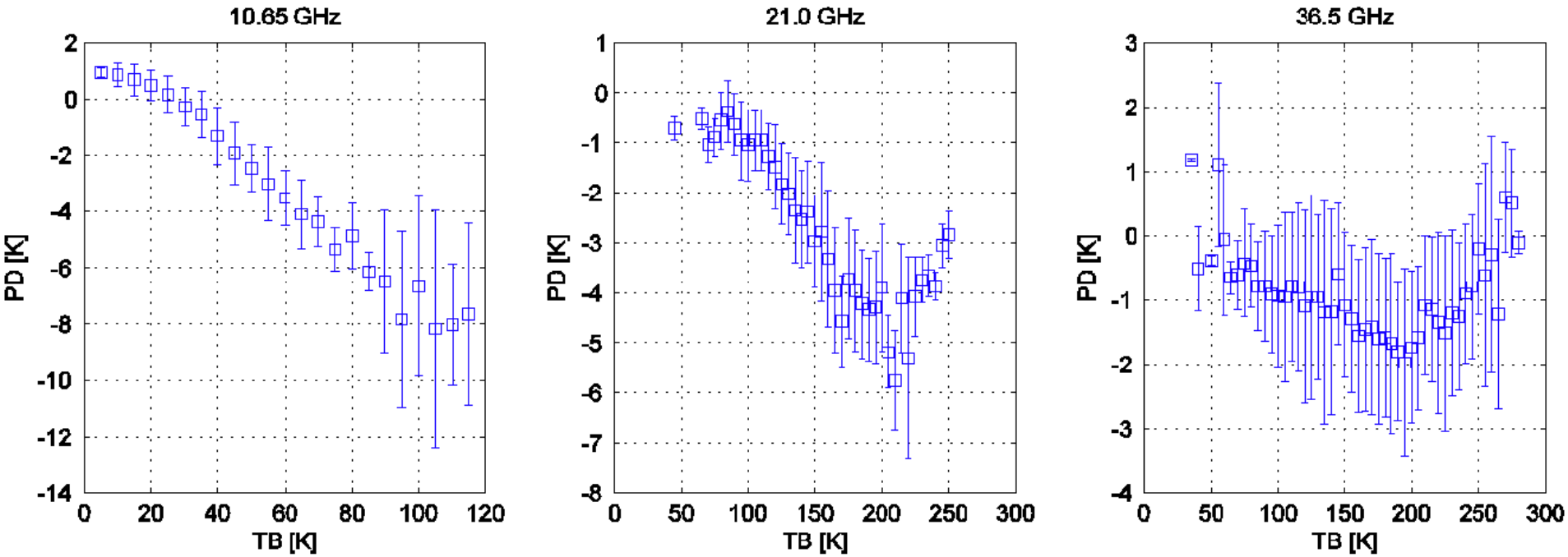


All data at constant elevation angle (30º)

Data courtesy of Alessandro Baggaglia University of Bonn

Brightness Temperature (TB) versus Polarization Differences (PD) for Rainy Pixels

Rainy pixels have been selected according to the gauge located at the ARM facility (RR>1 mm/h)



Data courtesy of Alessandro Baggaglia, University of Bonn

Summary

- We will desire passive radiometers to be co-located with our (future) scanning radar(s)
- Important to partition the liquid water into cloud water and rain water
- Falling rain drops have a non-spherical shape, and imparting a polarization-sensitive signal
- A multi-frequency (to achieve large dynamic range) polarization-sensitive microwave radiometer would be an excellent and complimentary data source with the radar
  - I've highlighted the ADMIRARI since it's commercially available
  - Data are being collected at AMF/Germany site (since 11 Aug 2007) and can be made available to ARM PIs
- Recommend that we consider this radiometer for the deployment with AVA