Microwave transmission: A new tool for remote sensing precipitation and humidity

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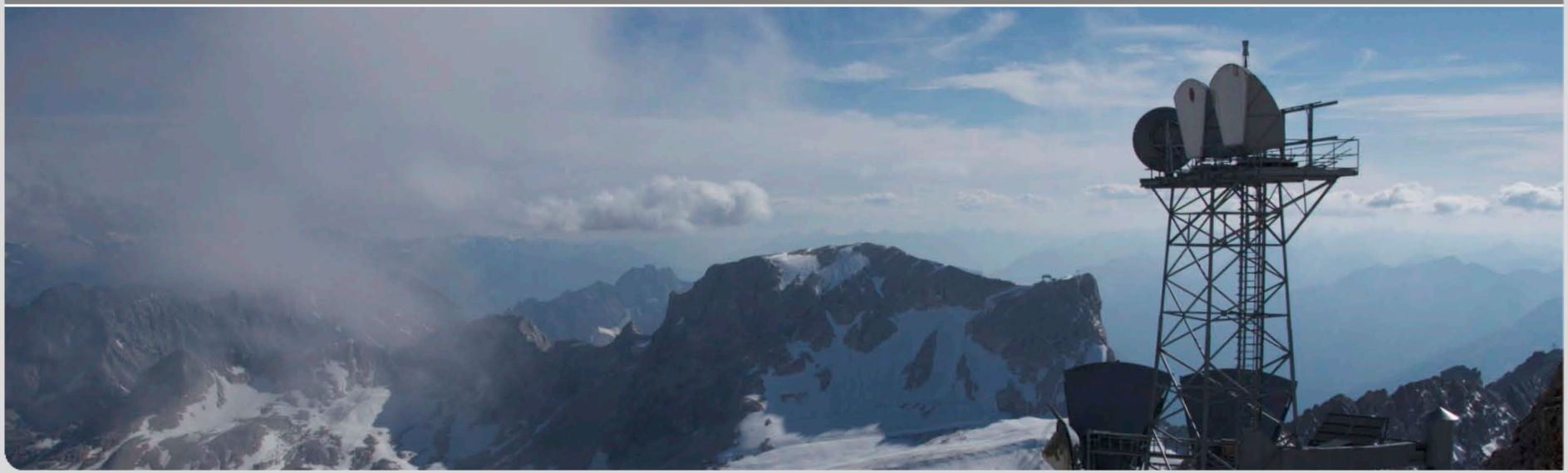
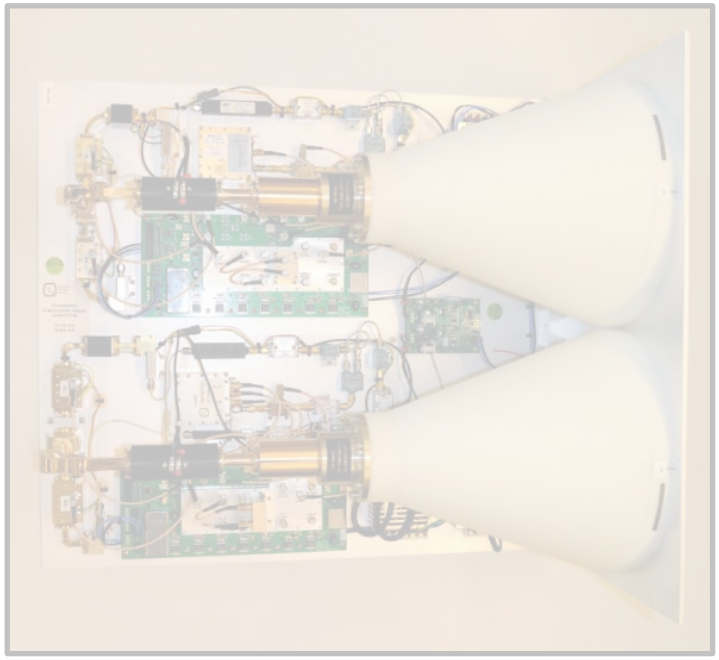


Outline

Commercial microwave links

Precipitation

Microwave transmission experiment



Precipitation & Humidity

Why?

Established methods have disadvantages

- Point measurements
- Distribution
- Wind

- Measures aloft
- Clutter
- Z-R problems

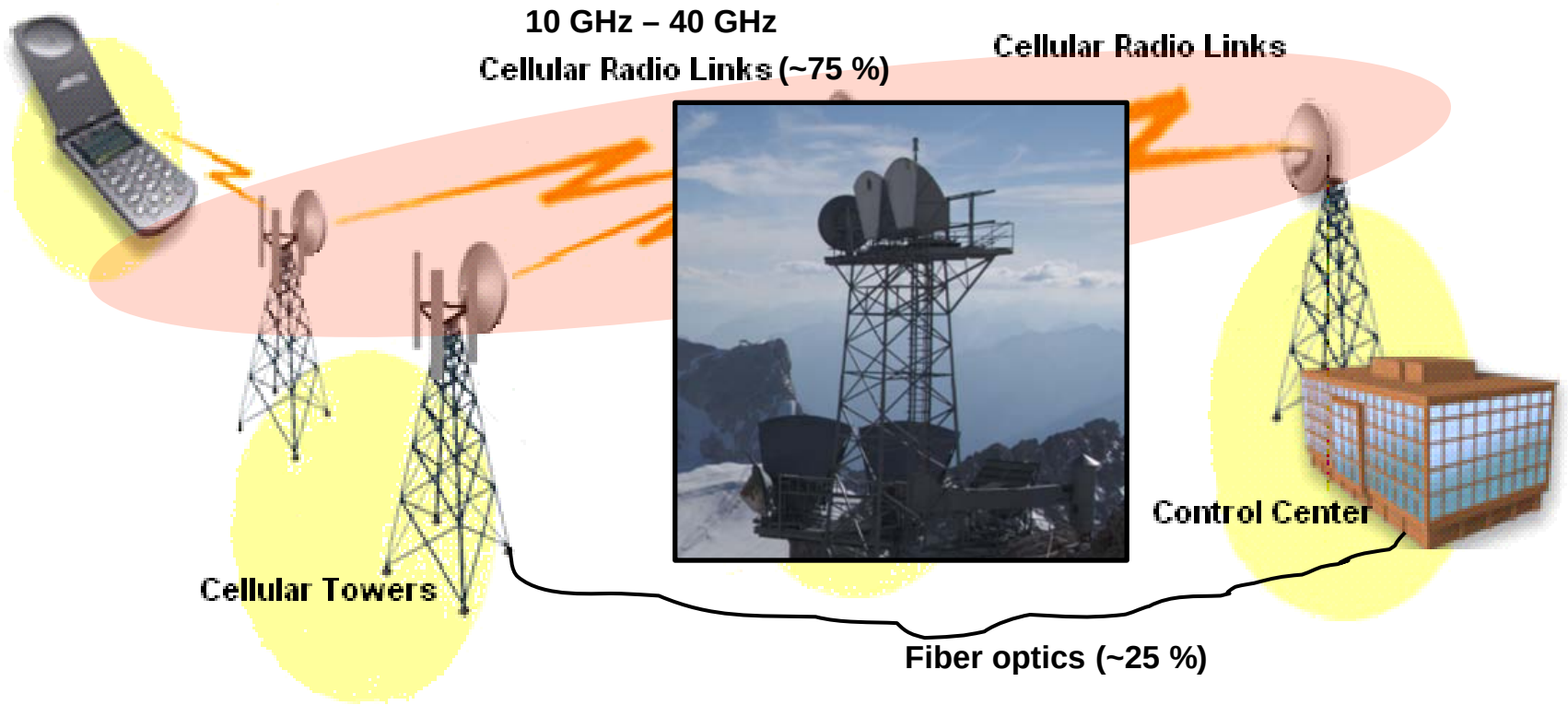
What?

- **Rain gauge**
  - Point measurement
  - At ground
  - Direct measurement
  - Problematic distribution

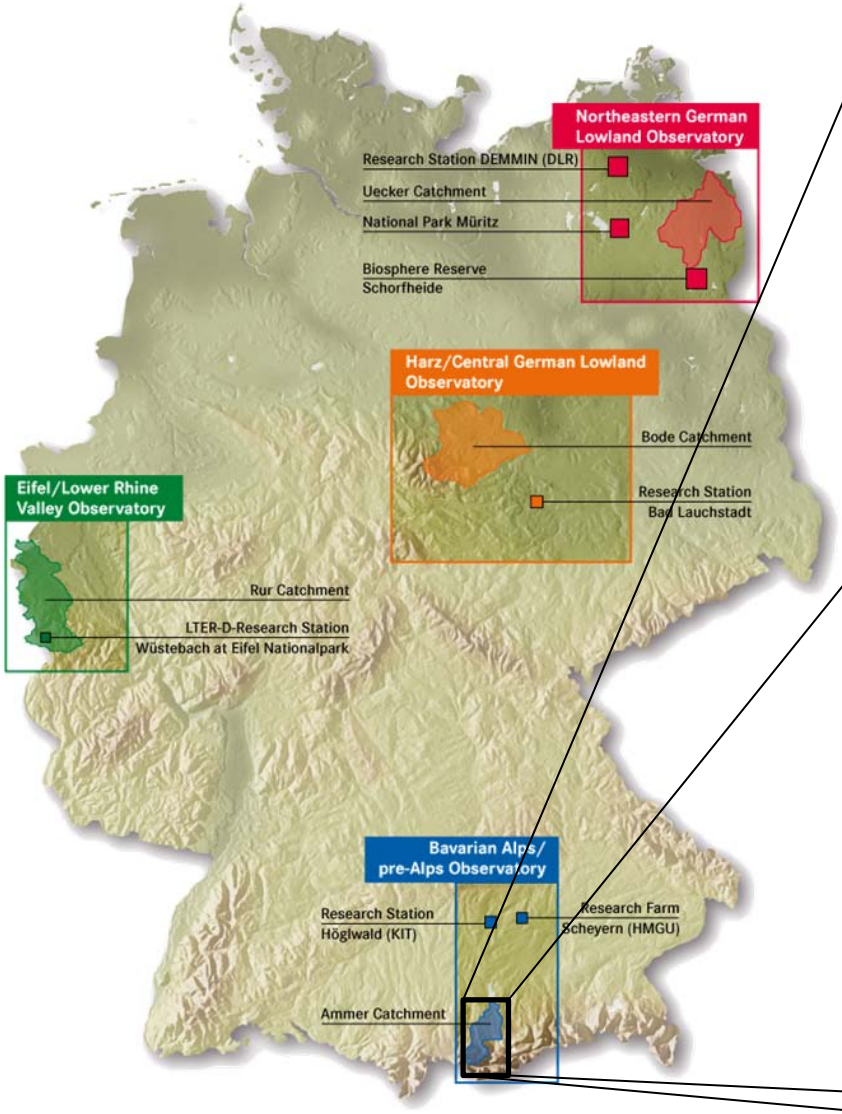
- **Radar**
  - Volume
  - Aloft
  - Indirect (reflectivity)
  - Volume coverage

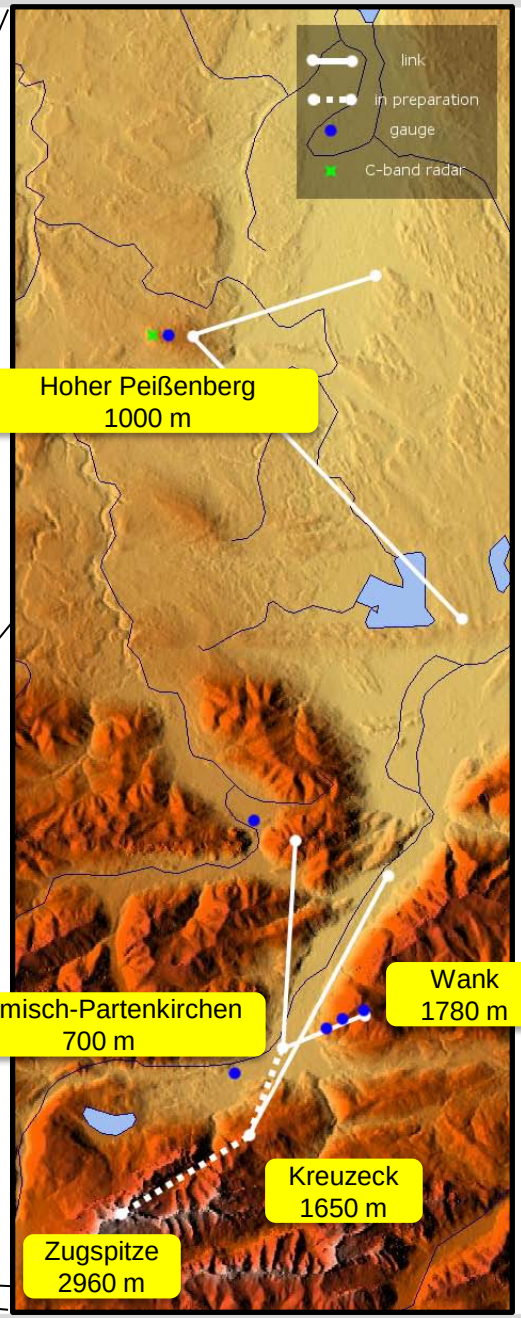
How?

Precipitation **O**bservation by **Ce**llular Network **M**icrowave **A**ttenuation



Test region - TERENO pre-alpine



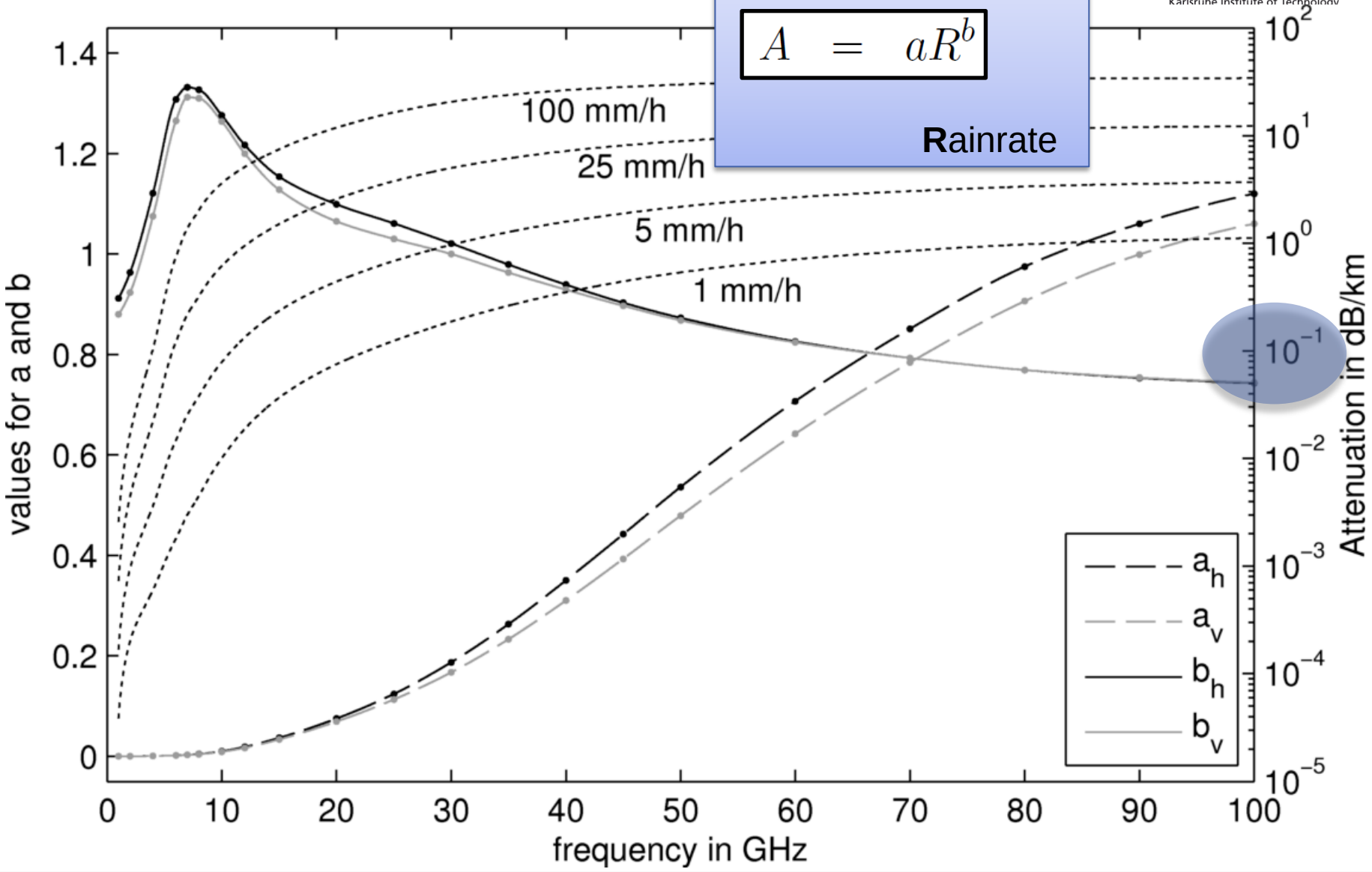


How?

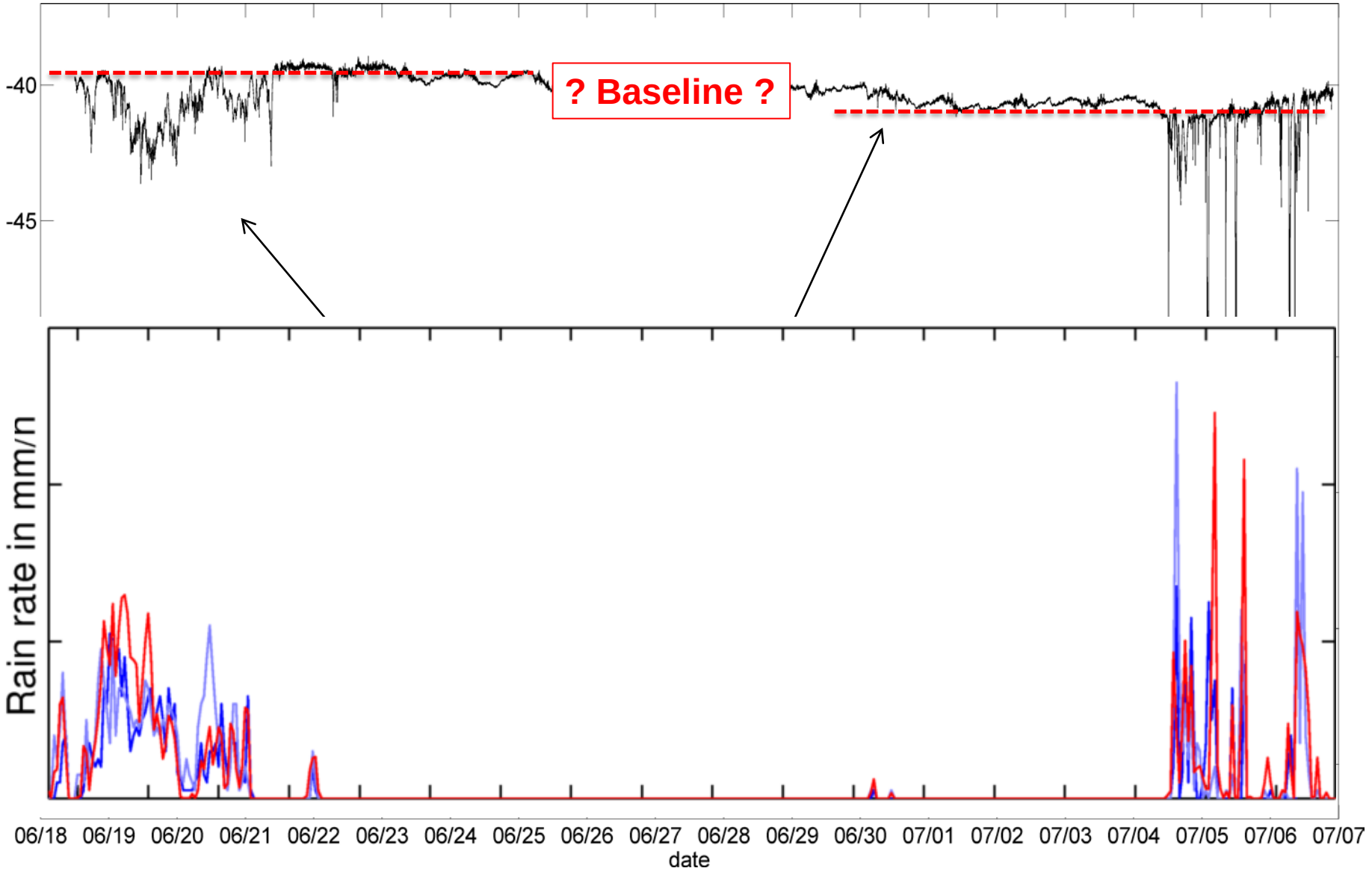
Attenuation

$$A = aR^b$$

Rainrate

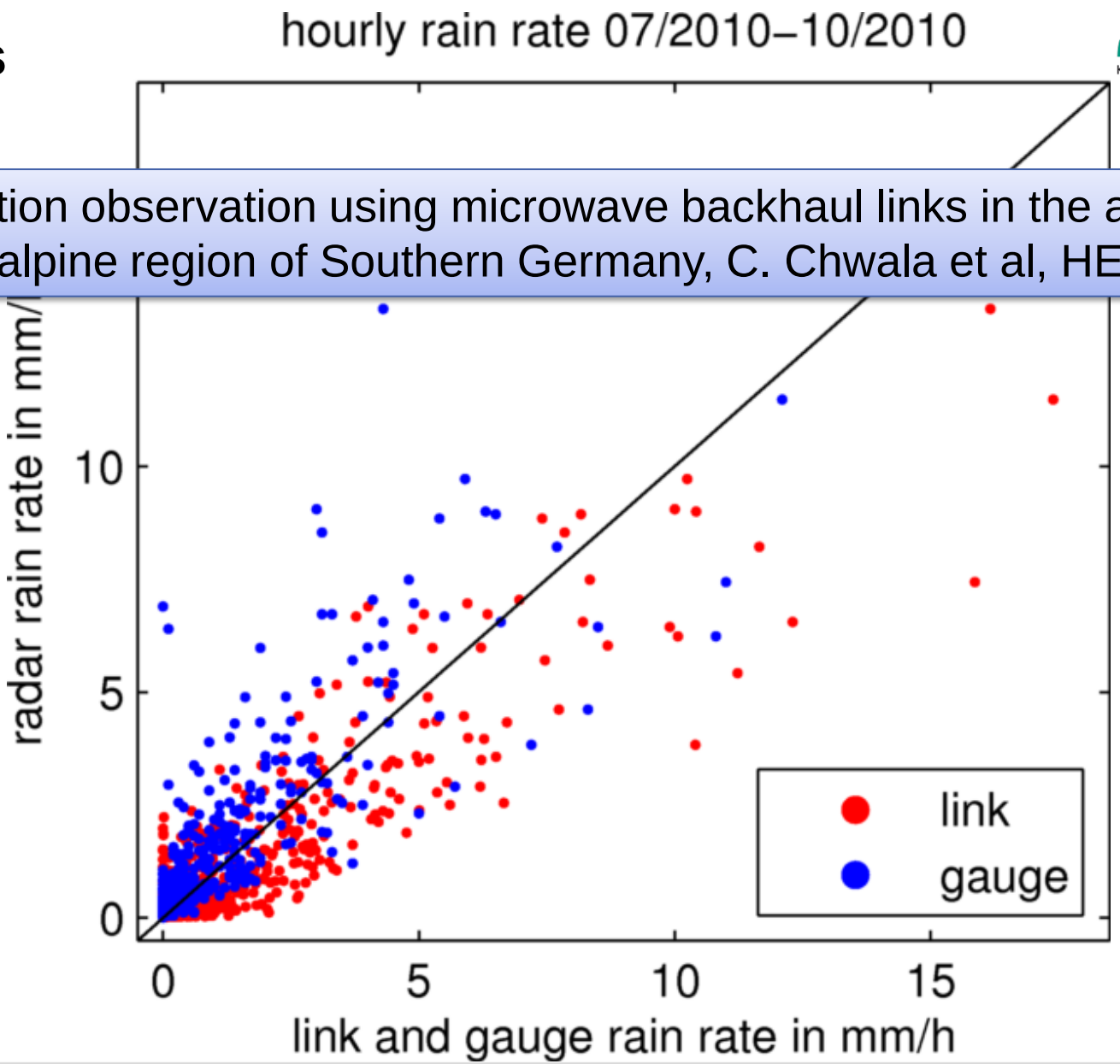


Received power



Results

Precipitation observation using microwave backhaul links in the alpine and pre-alpine region of Southern Germany, C. Chwala et al, HESSD



A good complement

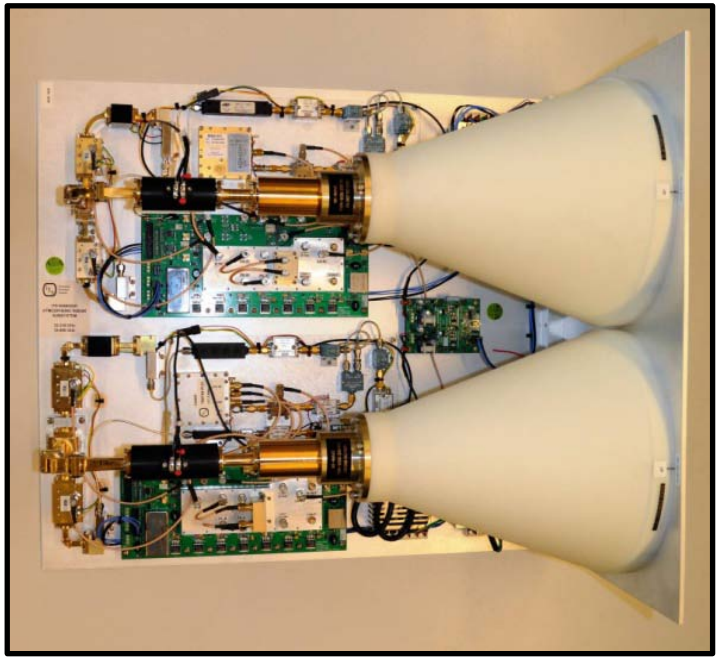
- **Rain gauge**
  - Point measurement
  - At ground
  - Direct measurement
  - Problematic distribution
- **Microwave link**

- **Radar**
  - Volume
  - Aloft
  - Indirect (reflectivity)
  - Volume coverage

Commercial microwave links

Precipitation

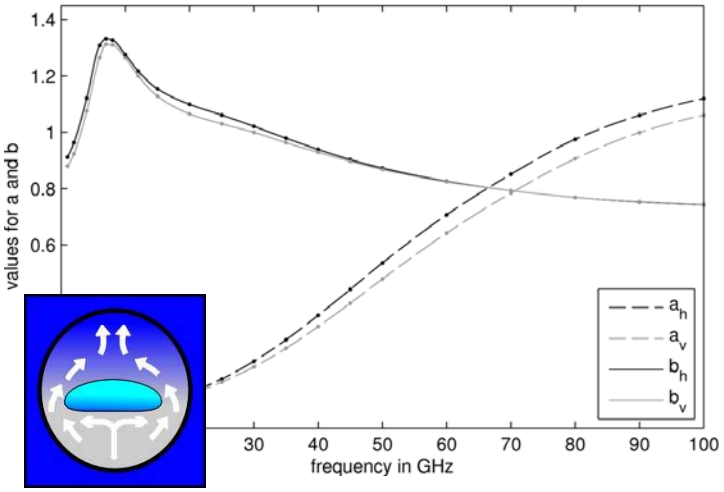
Microwave transmission experiment



Humidity

Why?

- Support link research
  - More met equipment
  - Shorter path length
  - 2 polarizations
  - 2 frequencies

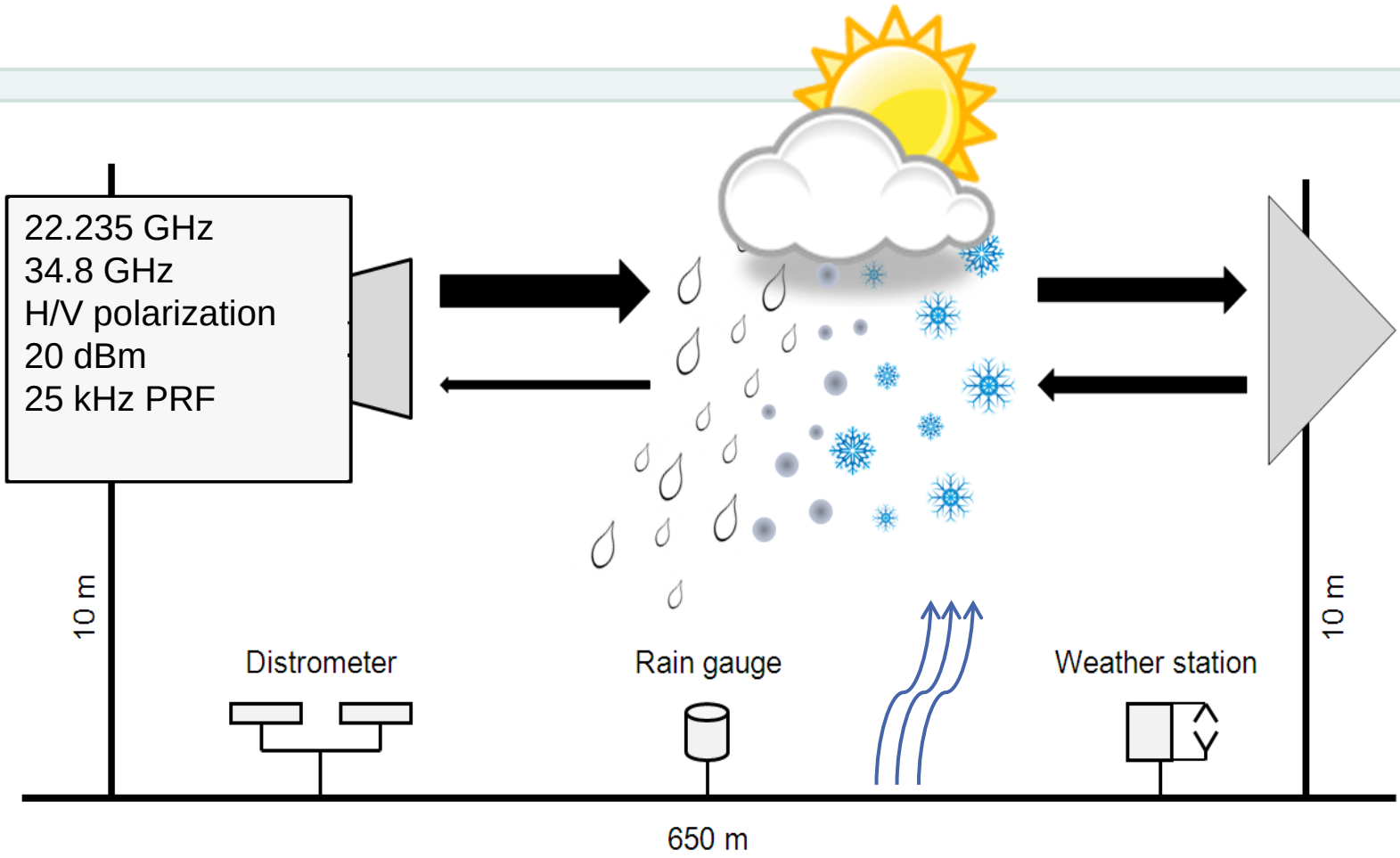


- Additional information
  - Fluctuations
  - Phase

- Distinguish precipitation types
- Measure humidity

Weather model initialization

How?


22.235 GHz
34.8 GHz
H/V polarization
20 dBm
25 kHz PRF
10 m
Distrometer
Rain gauge
Weather station
10 m
650 m

Humidity ⇔ Phase

Phase change due to humidity

Governs the speed of propagation

T in Kelvin

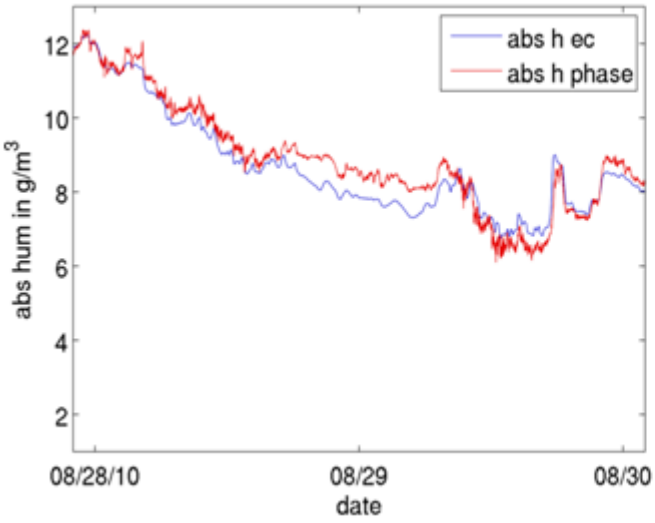
Refractivity $N = 10^6 (n - 1)$

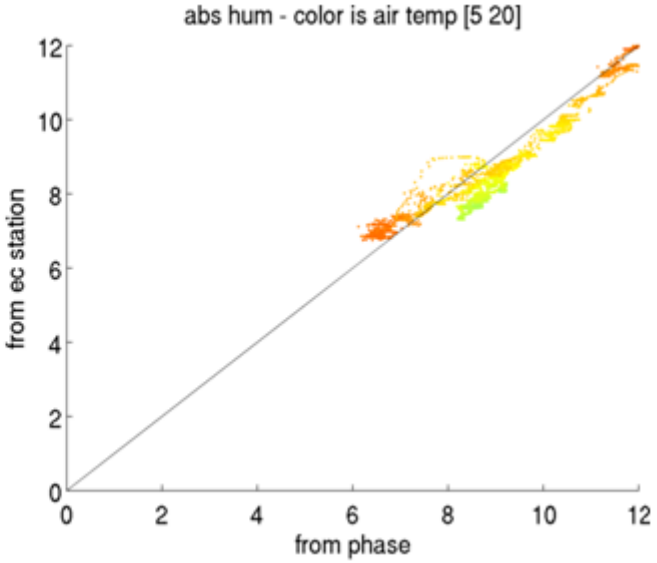
Vapor pressure $P_v \propto hum_{abs} \cdot T$

$$N_{vap} = 64.8 \frac{P_v}{T} + 3.776 \cdot 10^5 \frac{P_v}{T^2}$$

RADIO SCIENCE (1974)
An improved equation for the radio refractive index of air
Gordon D. Thayer

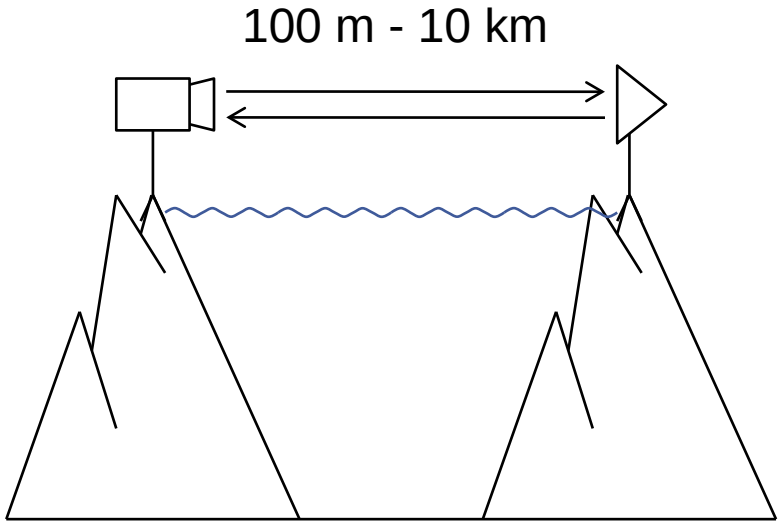
Humidity ⇔ Phase



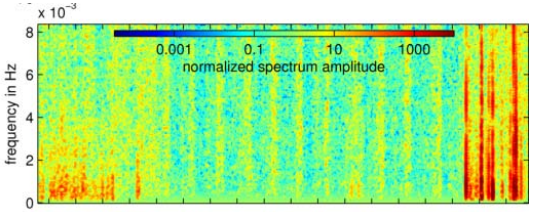


Line integrated absolute humidity:

- at model scale
- over complex terrain
- over water

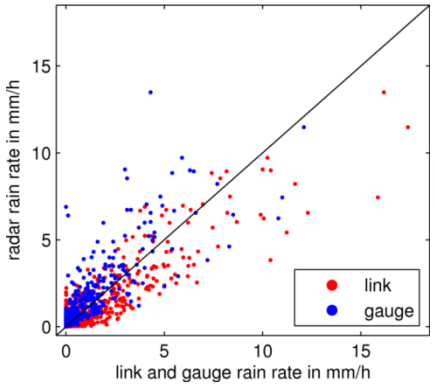


Summary



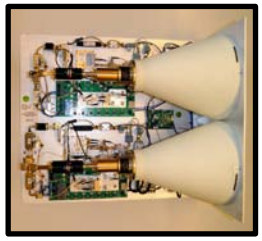
Wet/dry

Rain rate

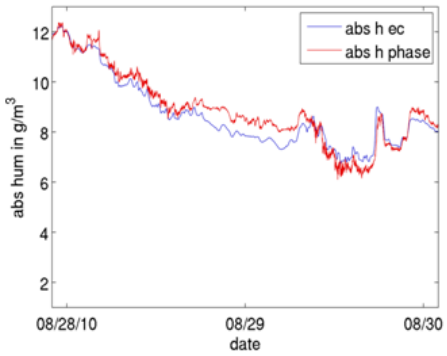


- Robustness
- #links

Outlook



Humidity



- Evaporation
- Sleet/snow

Thank you!