Using Multi-Instrument Retrievals for the Cloudy Atmosphere

- Motivation and Challenges
- A Concept for Integrated Retrievals
- Examples
- Ideas and Questions

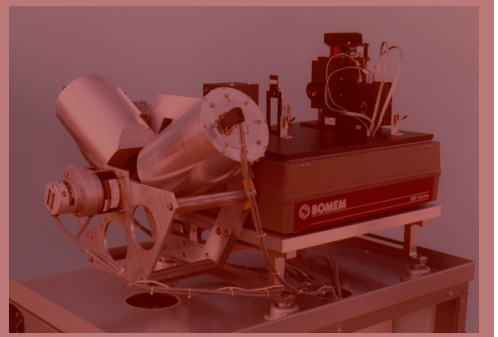
Ulrich Löhnert, University of Cologne

with contributions from: Working group for integrated remote sensing (University of Cologne), H. Russchenberg et al. (TU-Delft), Boers et al. (KNMI), D. Turner (SSEC, University of Wisconsin, Madison)

Ground-Based Remote Sensors are sensitive to ...

wind direction and **speed**
Wind-profilers, Weather-radar
Doppler-Lidar


temperature distribution
MWR, FTIR, RASS, Raman-Lidar

humidty distribution
Lidar, FTIR, MWR, GPS


liquid water
MWR, Cloud radar, (FT)IR
ice water
Lidar, Cloud radar, (FT)IR
precipitation
Weather-radar, MWR

Motivation for Multi-Instrument Retrievals

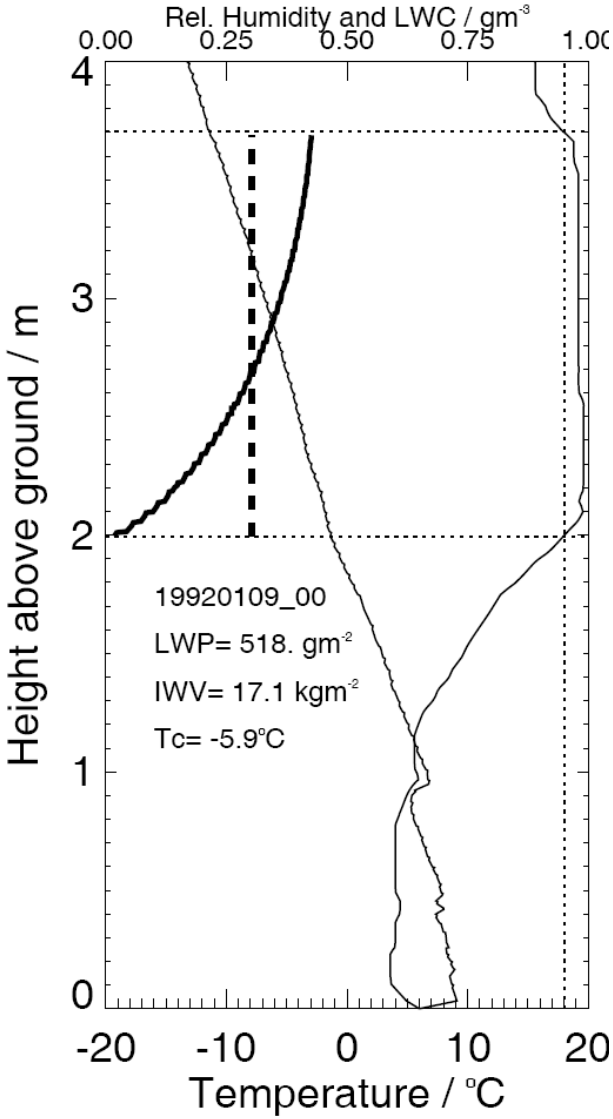
single instrument deficits:
- resolution
- simultaneous sensitivity to other parameters
- ambiguous solution

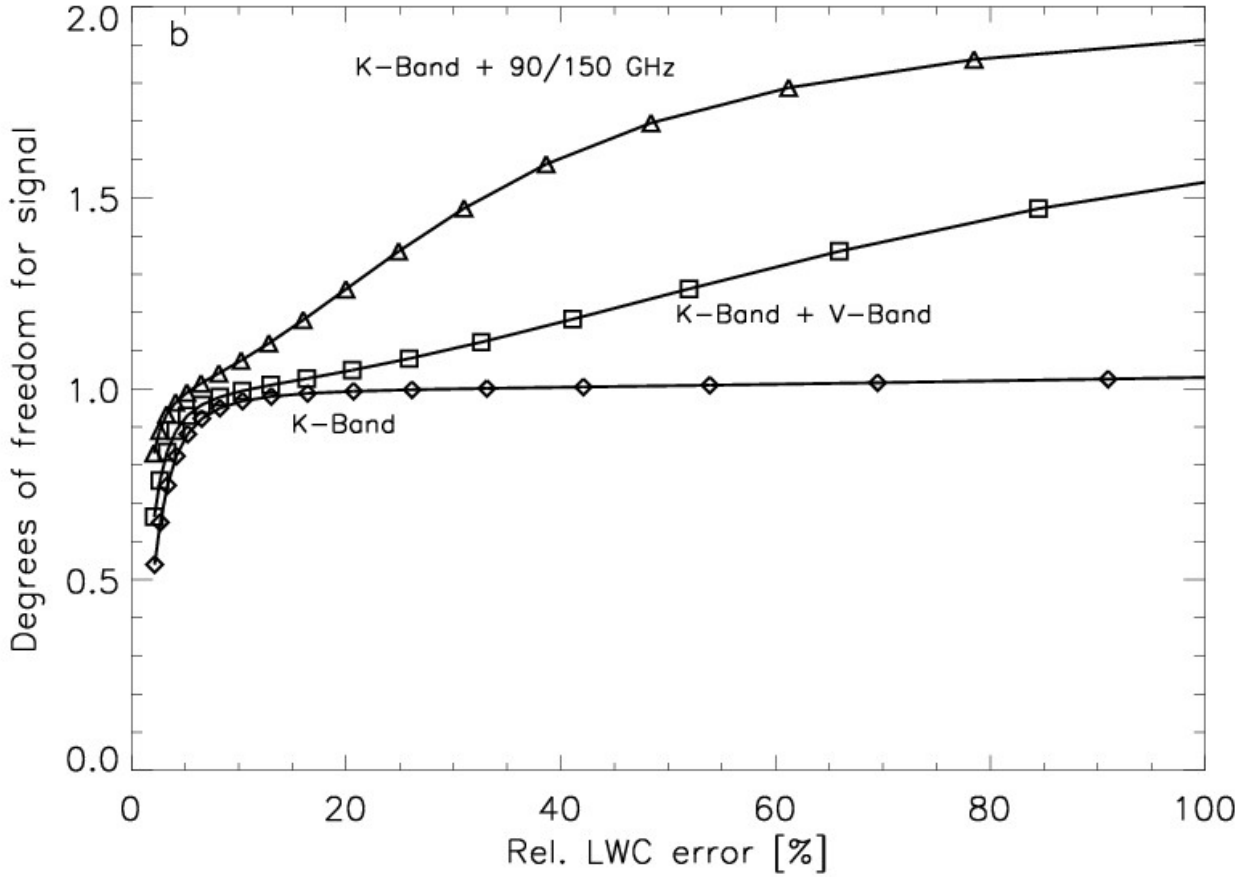
Idea: Find instruments that capture the desired parameter in a complementary way

→ different spectral regions
→ active/passive methods
→ scanning configurations

Challenges for operational applications:
- How to develop physically consistent algorithms??
- Find and develop algorithms that are robust and easy to apply!!
- Are the results significantly better to justify the extra effort / costs??

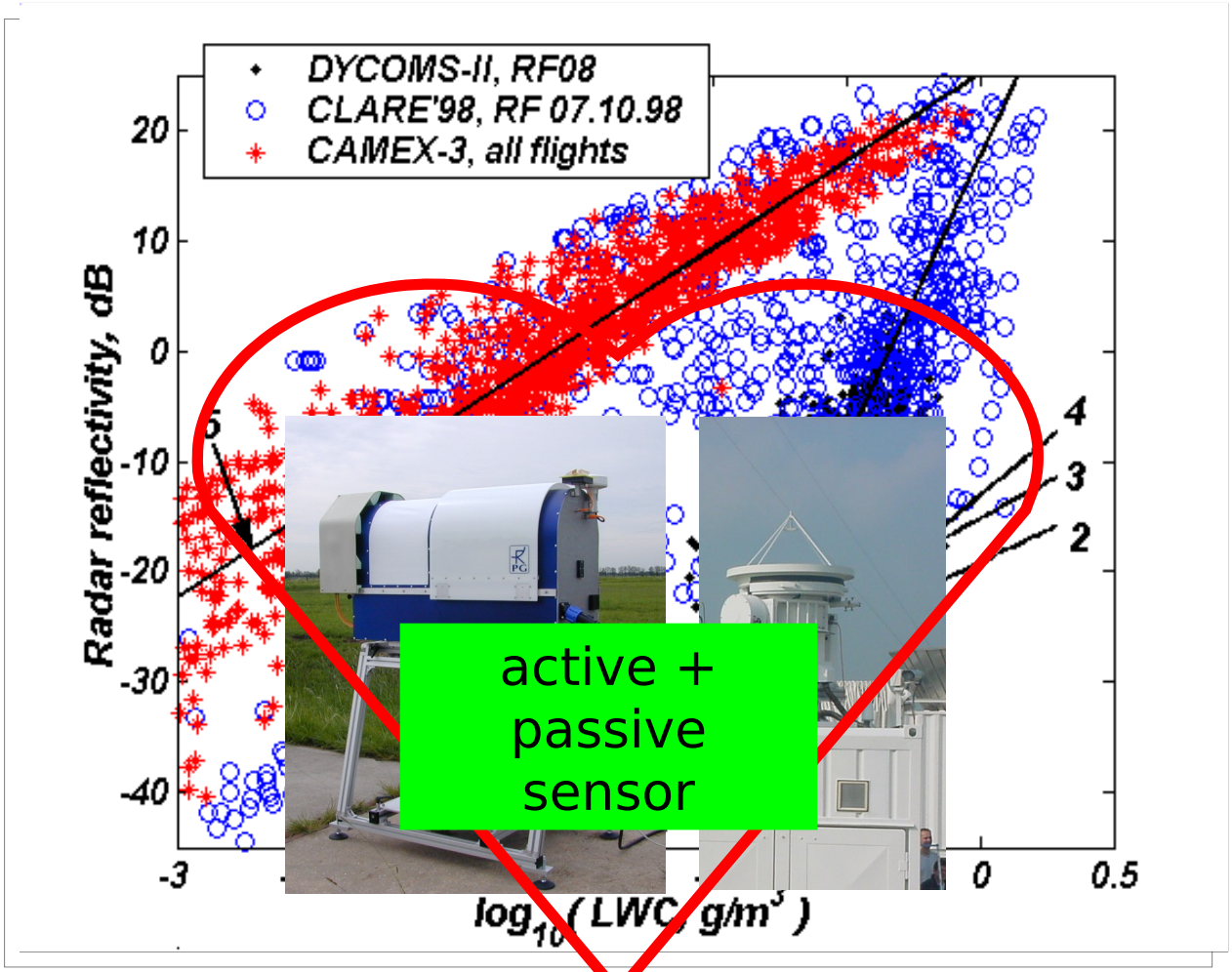
What about profiling of clouds?





Crewell et al., 2009

LWC from Radar



Krasnov & Russchenberg, TUD, NL

Integrated Profiling Technique (IPT)
a 1DVar approach towards multi-instrument retrieval

Measurements = INPUT

passive RS – measurem. + error

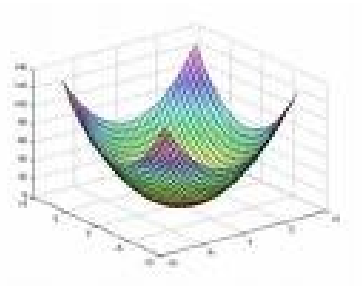
active RS – measurem. + error

in-situ measurem. + error

a priori information + error

Integration

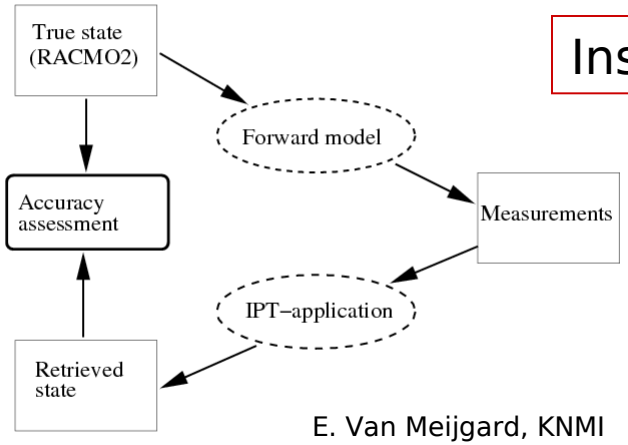
e.g. 1DVAR



OUTPUT

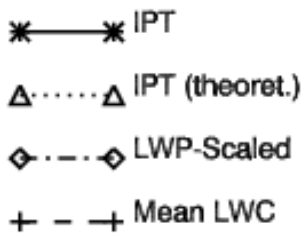
atmospheric composition: temperature, humidity, hydrometeors **+ errors**

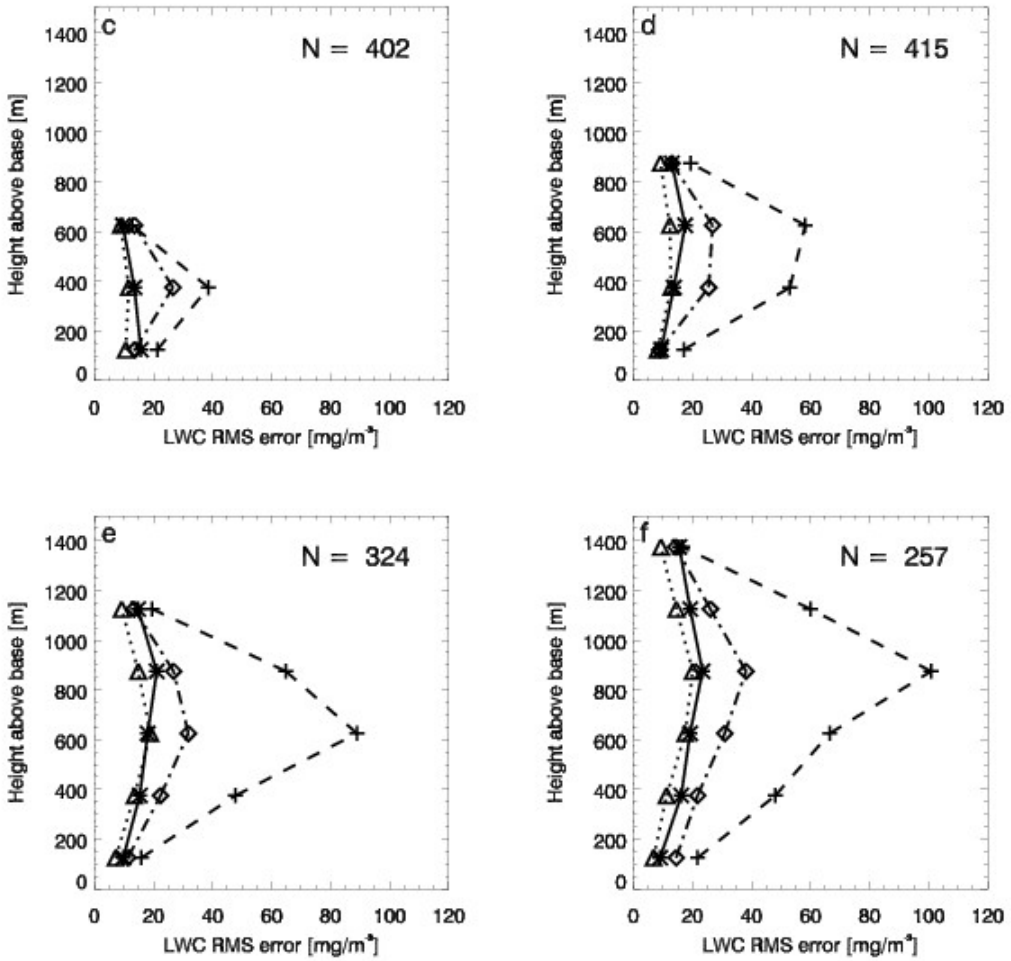
RACMO Simulation: LWC accuracies



E. Van Meijgard, KNMI

Instrument synergy: radar/microwave

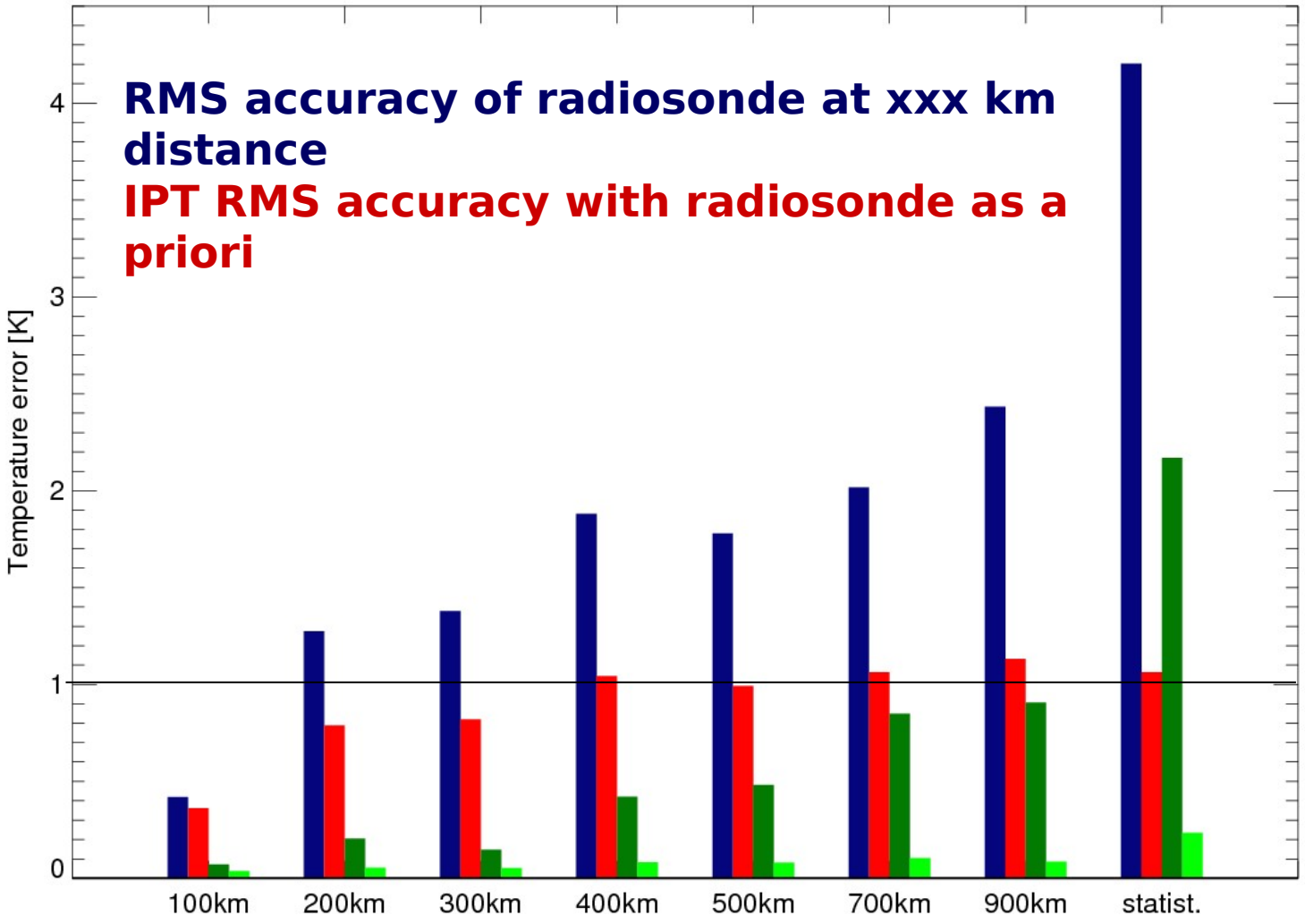




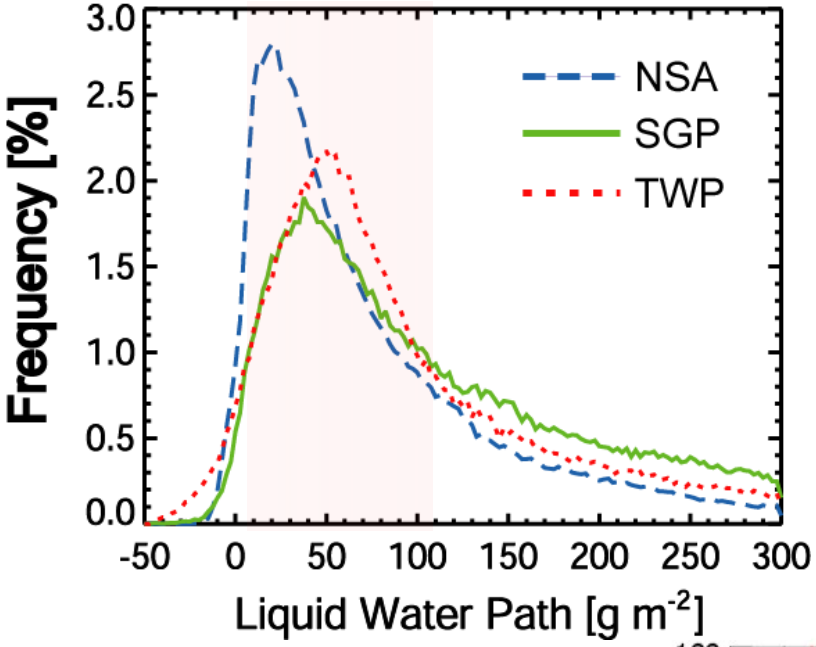
- overall LWC-accuracy: ~30%
- improvement w.r.t. LWP-scaled retrieval: ~17%

RACMO Simulation: Temperature Accuracies

Synergy: MWR+a priori information

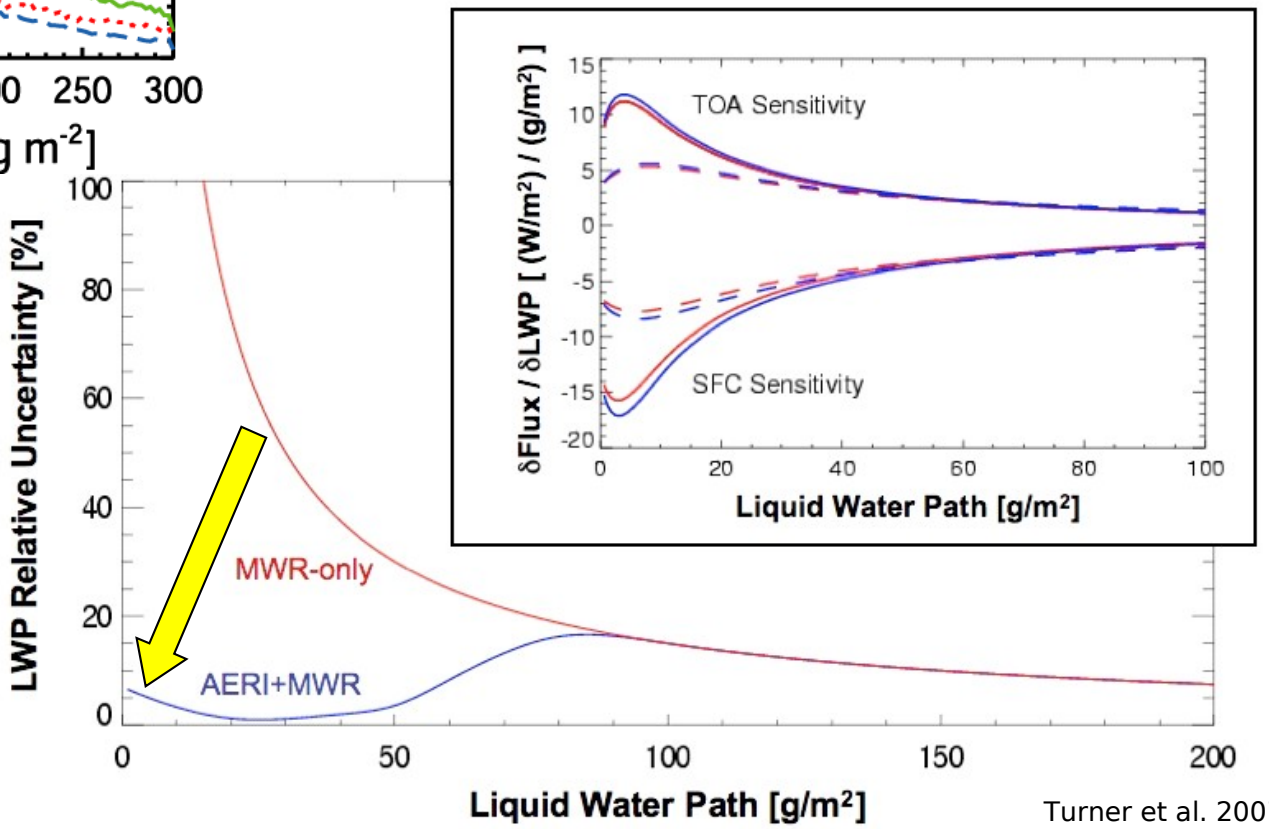


Dealing with low-LWP clouds ...



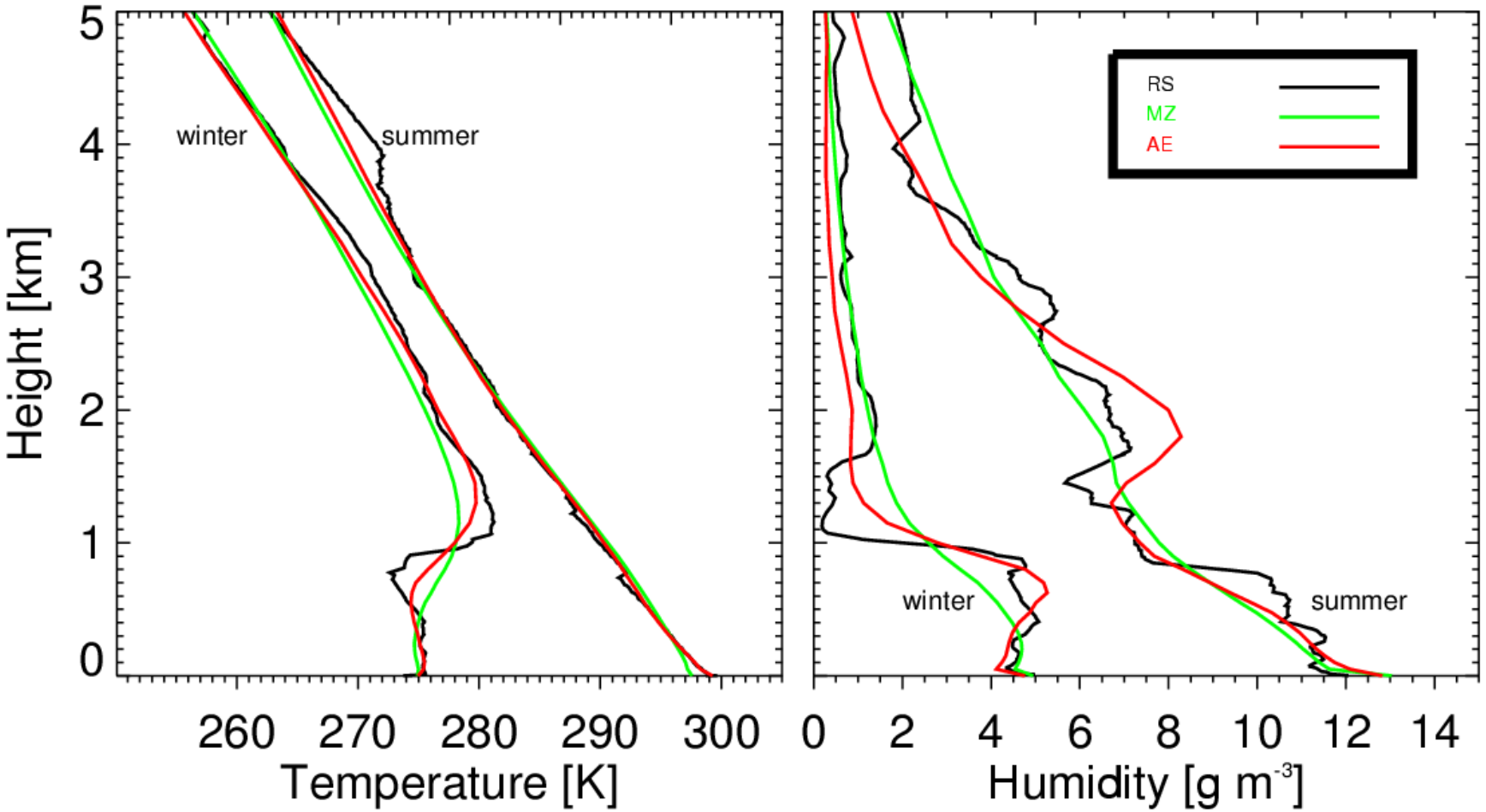
- low LWP-clouds are very frequent and significantly influence solar radiative forcing
- however, these clouds are difficult to measure and model

passive **infrared** and **microwave** measurements reveal high potential for capturing these clouds accurately



Turner et al. 2007

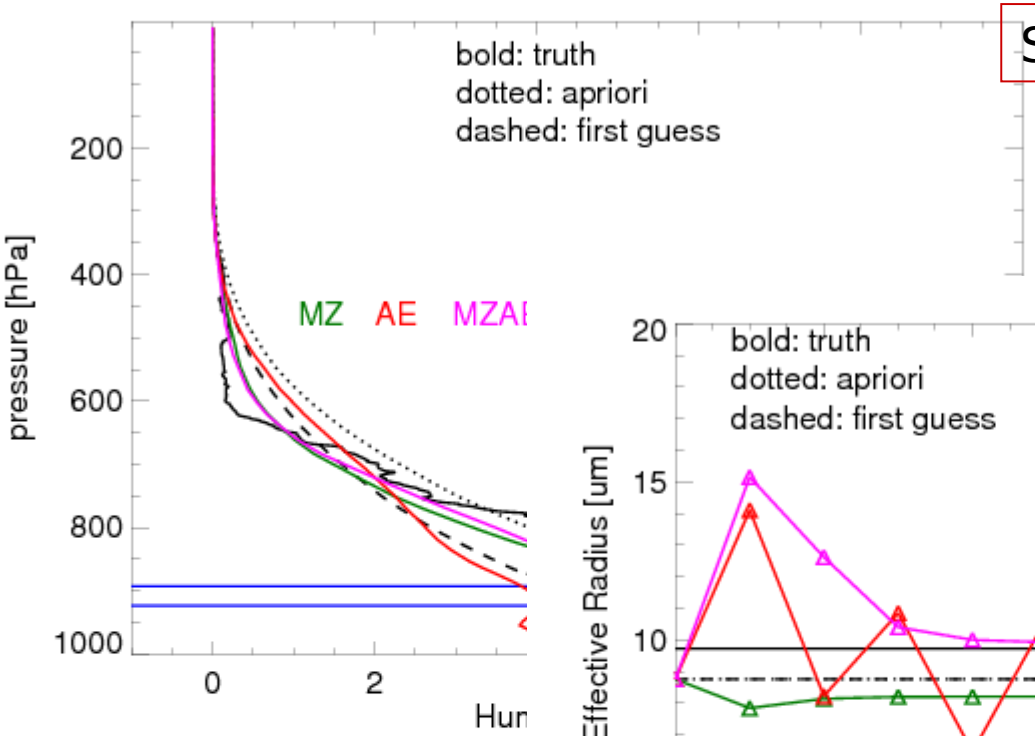
Microwave and Infrared, clear sky

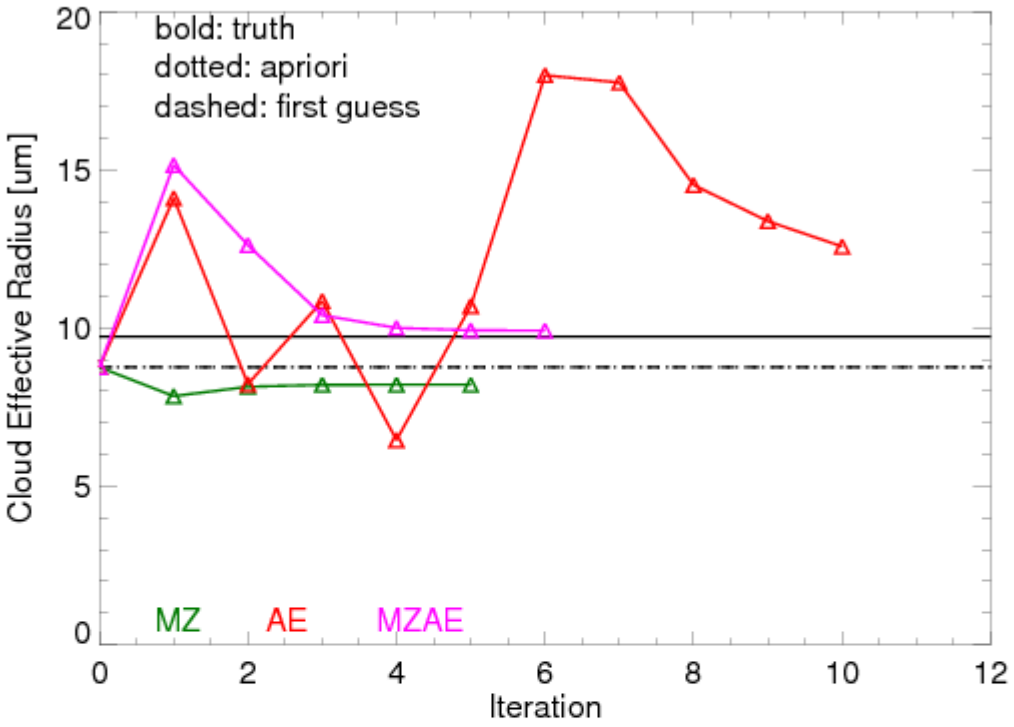


winter: cold and dry
summer: hot and humid

Microwave and Infrared, cloudy sky

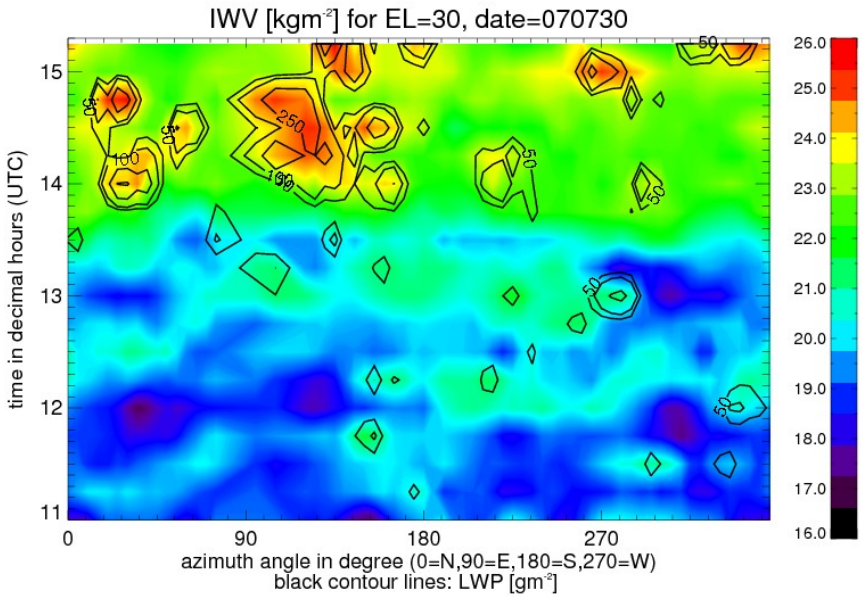
Synergy: MWR+AERI information

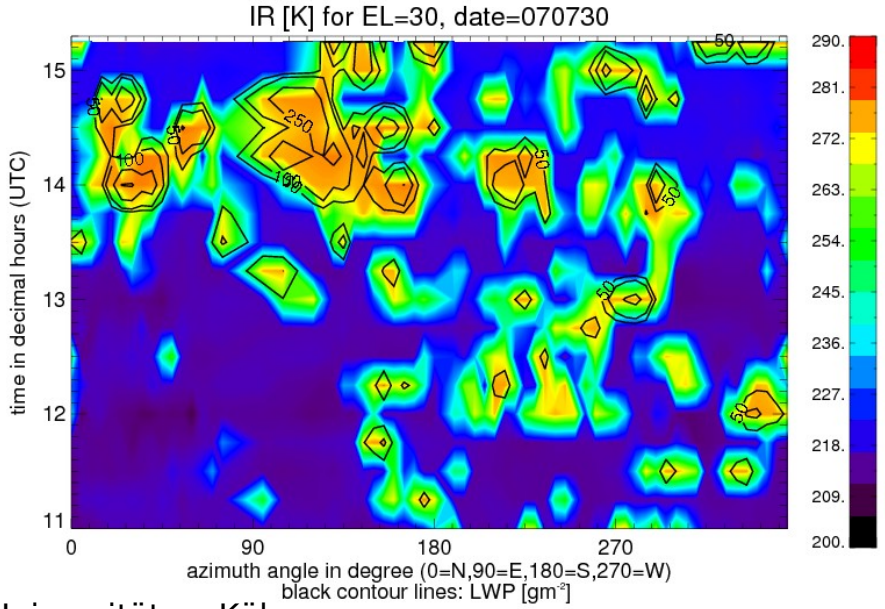




Hemispheric Distribution of WV and Cloud

- Continuous hemispheric scans of microwave profiler, IR-radiometer
- Can provide spatio-temporal BL-evolution
- Are such observations of additional value for meso-scale model evaluation or assimilation?

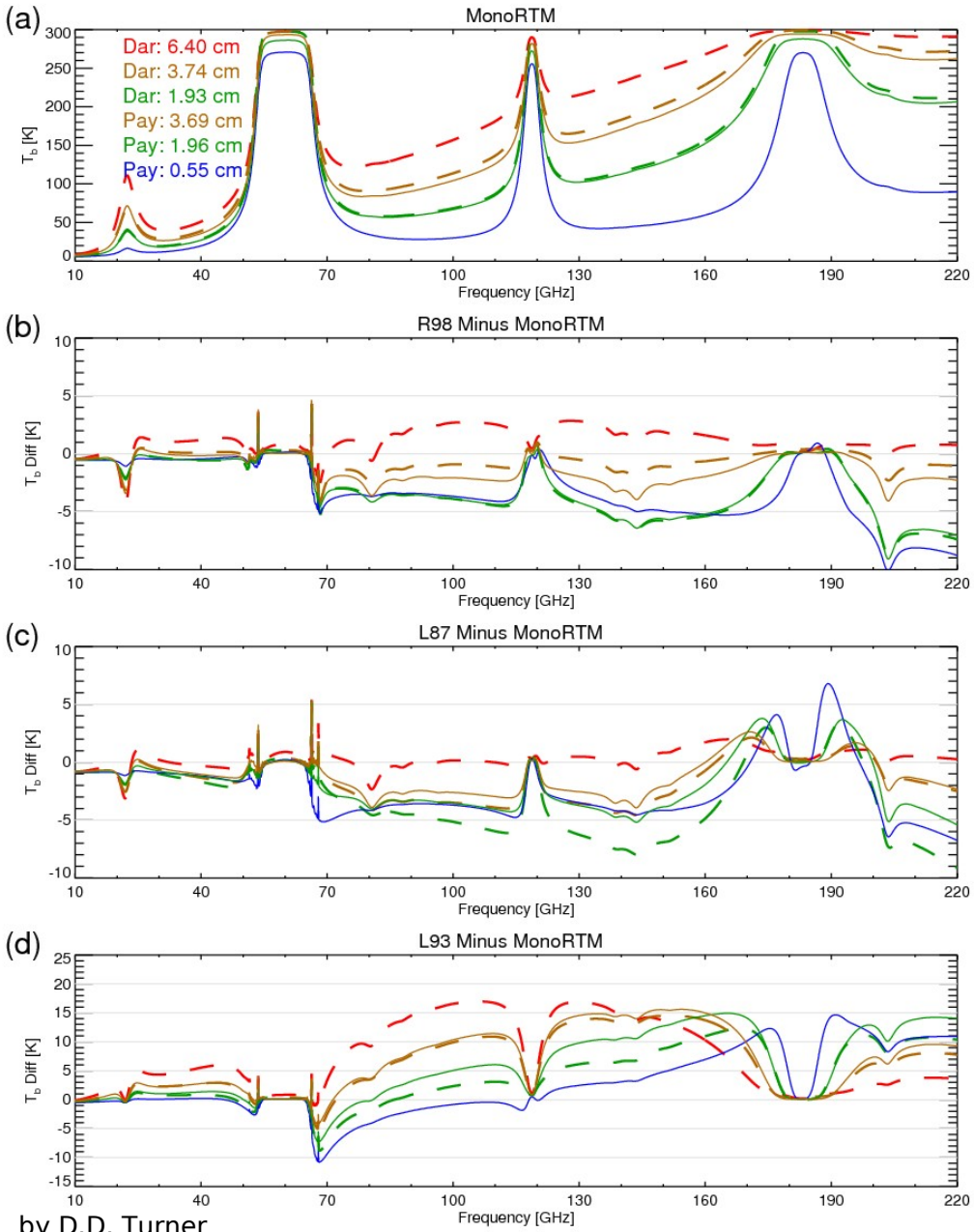




Ideas and Questions for our Action

- **many other promising instrument combinations**
  - → Radar + Lidar (e.g. Univ. of Reading)
  - → MWR + Lidar (e.g. Univ. of Bern, IfT Leipzig)
  - → IR + Lidar (??)
  - ...
- **Where do we need/want to go?**
  - → Identify combinations which are easy to handle & robust, bring forth straight-forward results and are relatievly "cheap" → Network-suitability (WG1 & 4)
    Ceilometer, GPS, IRT, MWR combinations ...
  - → Develop methods for dedicated "anchor stations" for a most complete picture of the atmospheric profile + errors (WG3 & 4)
    Lidar, FTIR, cloud radar, wind profiler combinations ...
- **What are some of the pending problems?**
  - → calibration & instrumental error issues (WG1)
  - → absorption model uncertainties!!! (which WG??)
  - → radar discrepancy (WG4)

Absorption model uncertainties …



6 MONORTM simulations for 2 climatologies, only WV and O_2 considered, 2 overlapping pairs with similar water vapor amount

Rosenkranz '98 - MONORTM

Liebe and Layton '87 - MONORTM

Liebe '93 - MONORTM