

The role of GRUAN in climate research

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IPCC AR5 on long term trends

Lower troposphere (PW):

“Radiosonde, GPS and satellite observations of tropospheric water vapor indicate very likely increases at *near global scales* since the 1970s“

Upper troposphere:

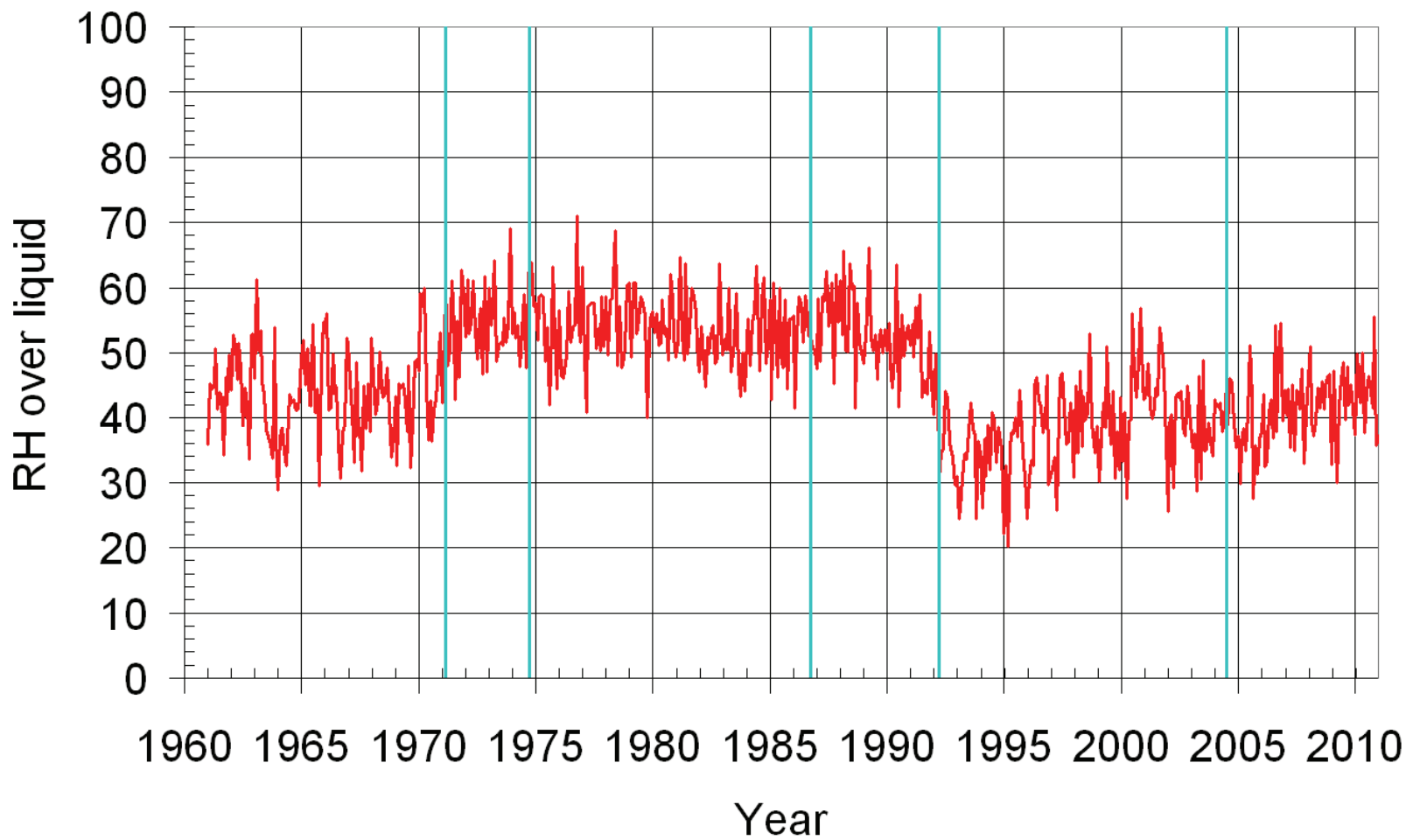
“... the absence of a homogenized data set across multiple satellite platforms presents some difficulty in documenting coherent trends from these records (of upper tropospheric humidity).”

Stratosphere:

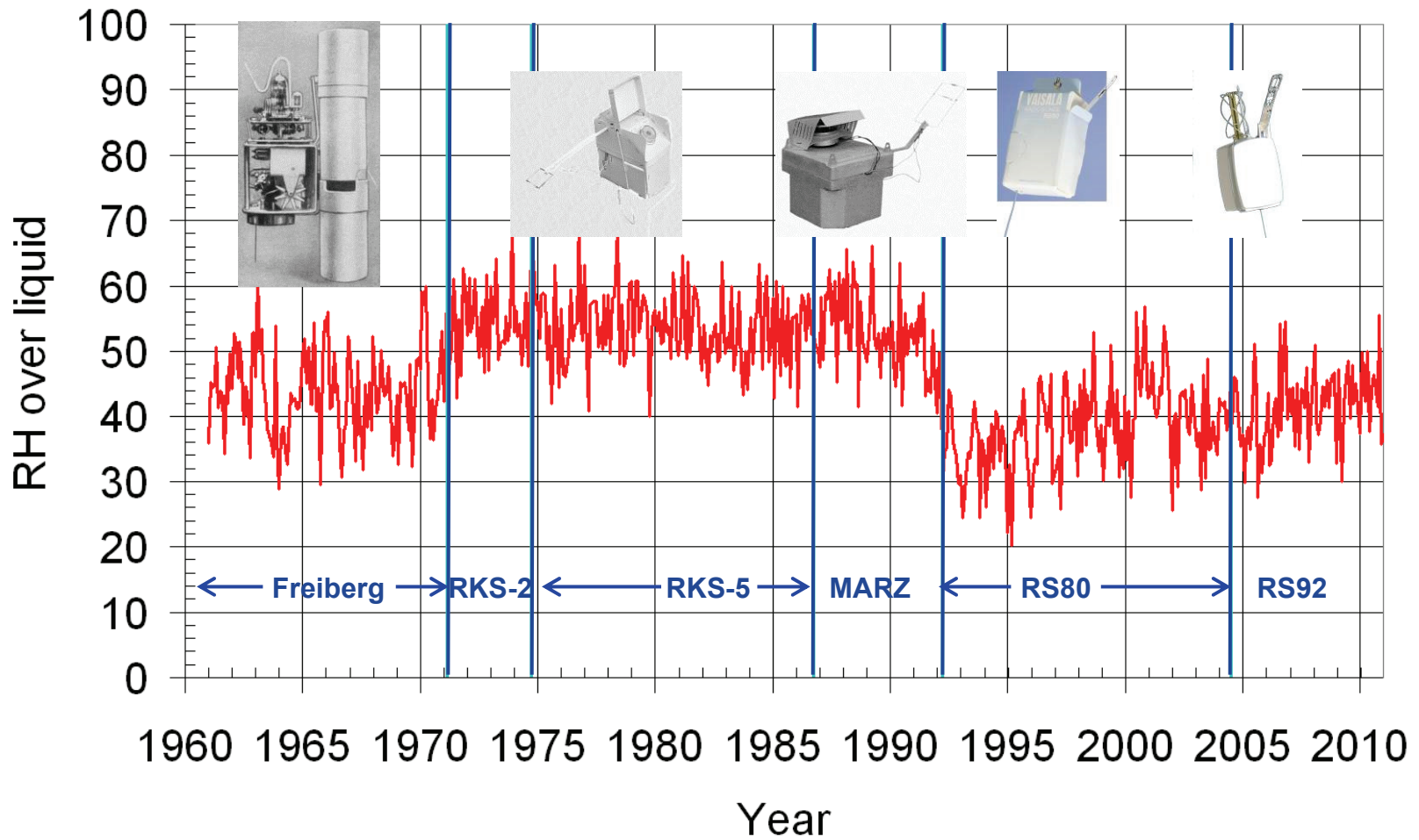
“Because of the large variability and relatively short time series, confidence in long-term stratospheric H₂O trends is low.”

- Lack of good reference measurements for climate observations

e.g.: Lindenberg 8km (0:00 UT)

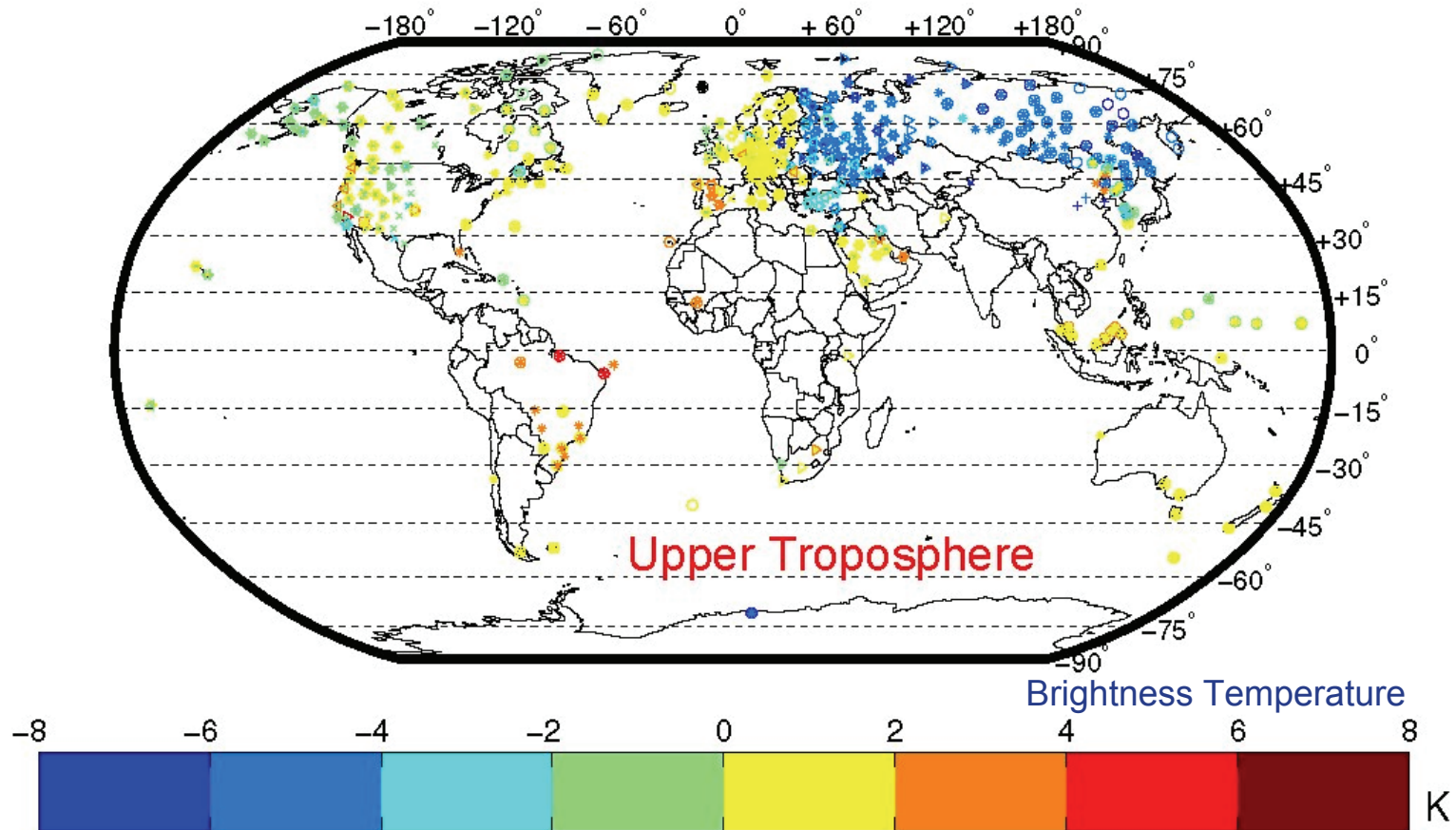


e.g.: Lindenberg 8km (0:00 UT)



Upper Tropospheric Humidity: Difference Radiosonde – Satellite (2013)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Moradi et al. J. Geophys. Res. 2013



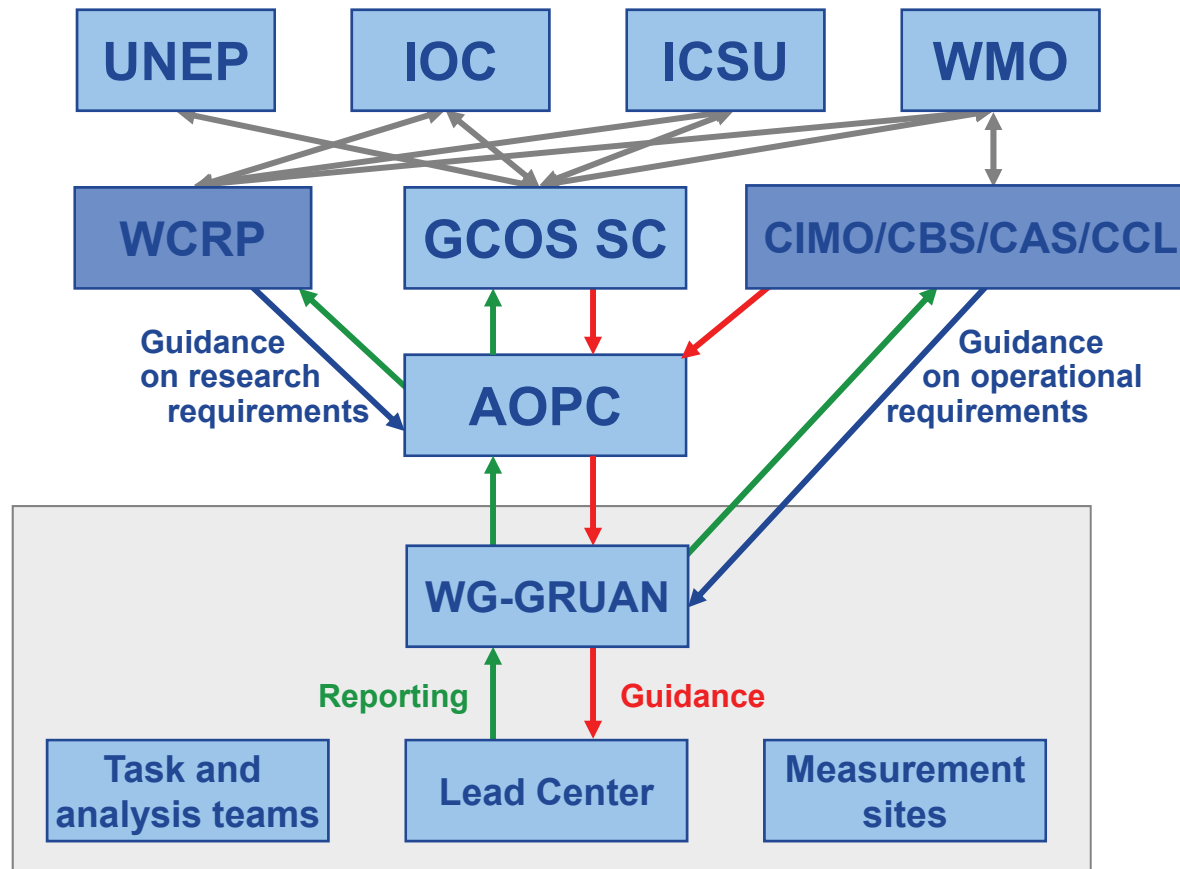
The GCOS Reference Upper Air Network (GRUAN):

- Started in 2008
- GRUAN is response to the need of WMO and the Global Climate Observing System (GCOS) for the highest accuracy data possible
- Ground based network for reference upper air observations for climate under GCOS and integrated into WIGOS
- Currently 22 sites, with the aim to expand to 30 to 40 sites worldwide
- Cooperations: GAW, GUAN, NDACC

GRUAN sites

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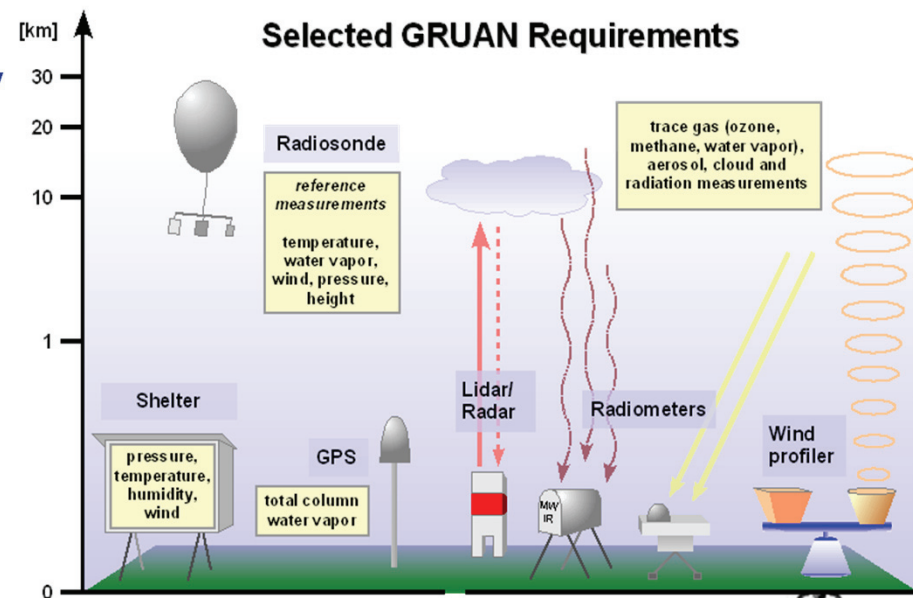
- Lead Centre: day-to-day management of the network (Lindenberg)
 - Coordination among stations
 - Archival and dissemination of GRUAN data

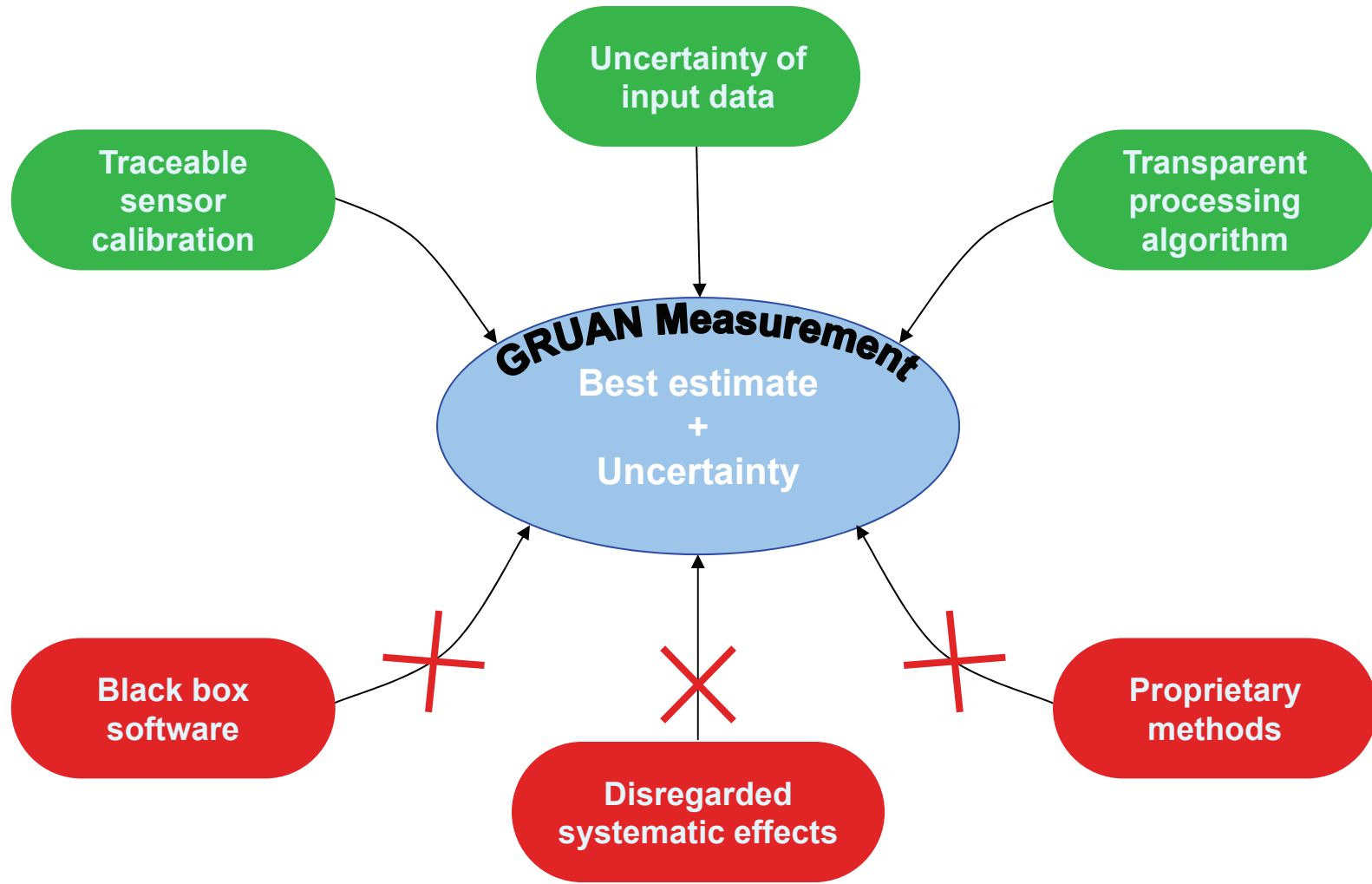
- Maintain consistent observations over decades
- Validation of satellite systems
- Numerical weather prediction
- Deliberate measurement redundancy
- Standardization and traceability
- Quality management and managed change

Priority 1:

- temperature
- water vapor
- pressure and wind

Priority 2: Ozone, ...





Characterization & correction of instrument errors/biases

Well-documented

Vertically resolved error estimates

Error sources

- Temperature
 - Radiation
- Humidity:
 - Radiation
 - Sensor time-lag
 - Calibration



Dirksen et al. AMT2014

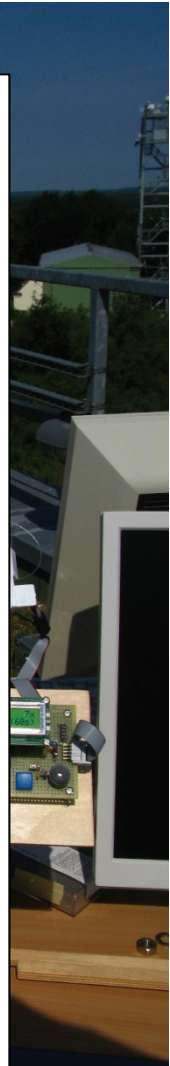
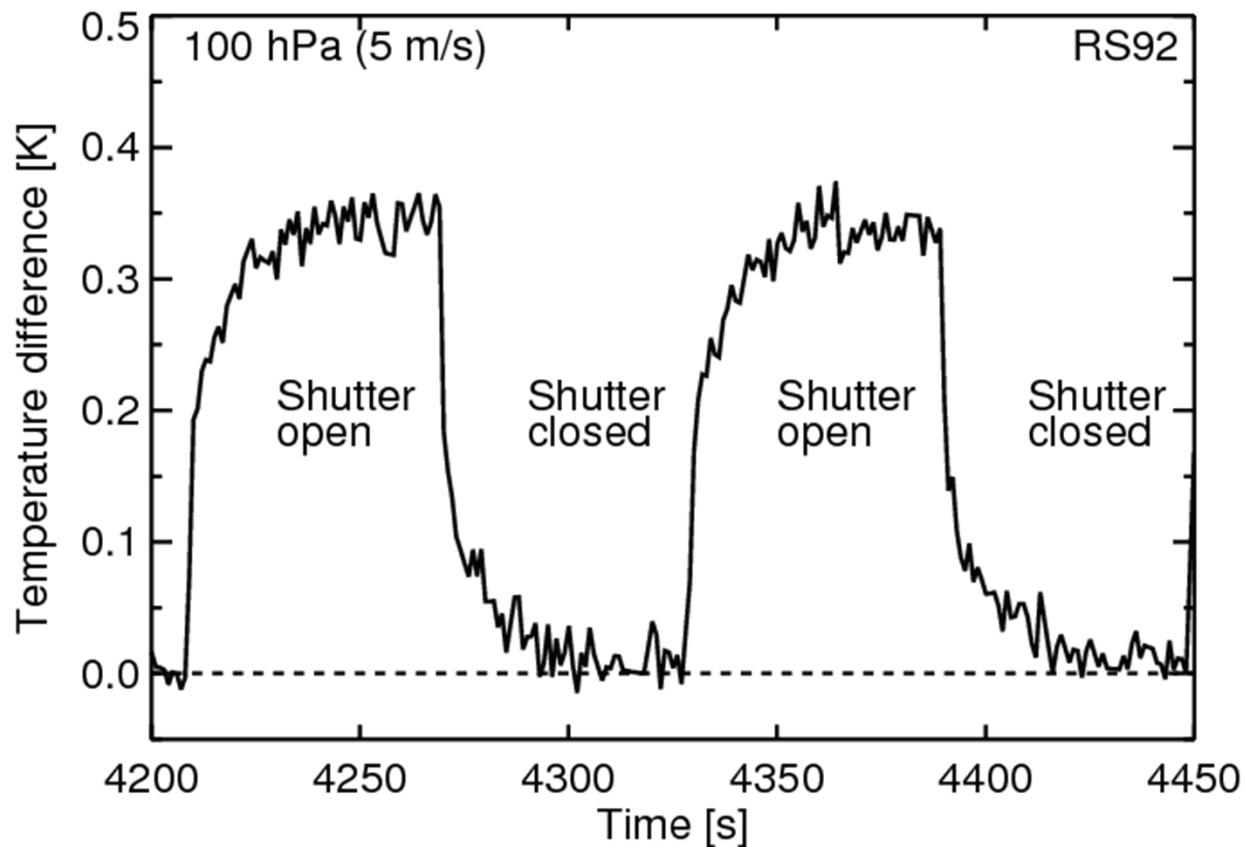
Shadow RS92 records background

temperatu

Simultane

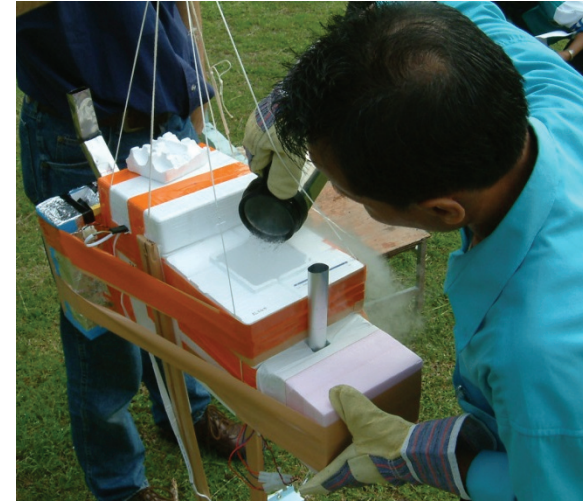
$p=3$ hPa ,

Difference illuminated – background radiosonde

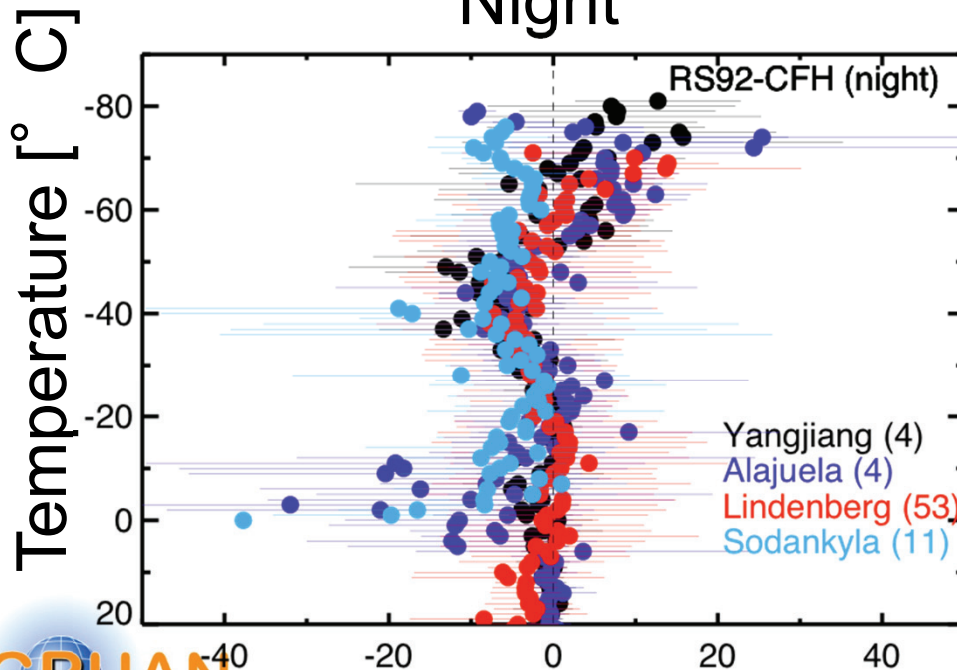


Comparisons of RS92 with frost-point hygrometers

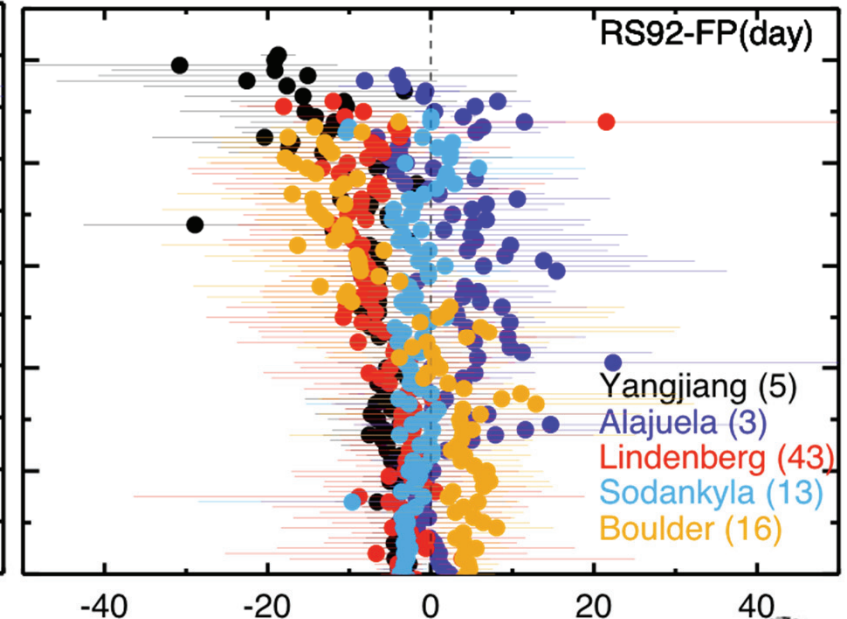
Reference instrument, sensitive to stratospheric water vapor levels



Night



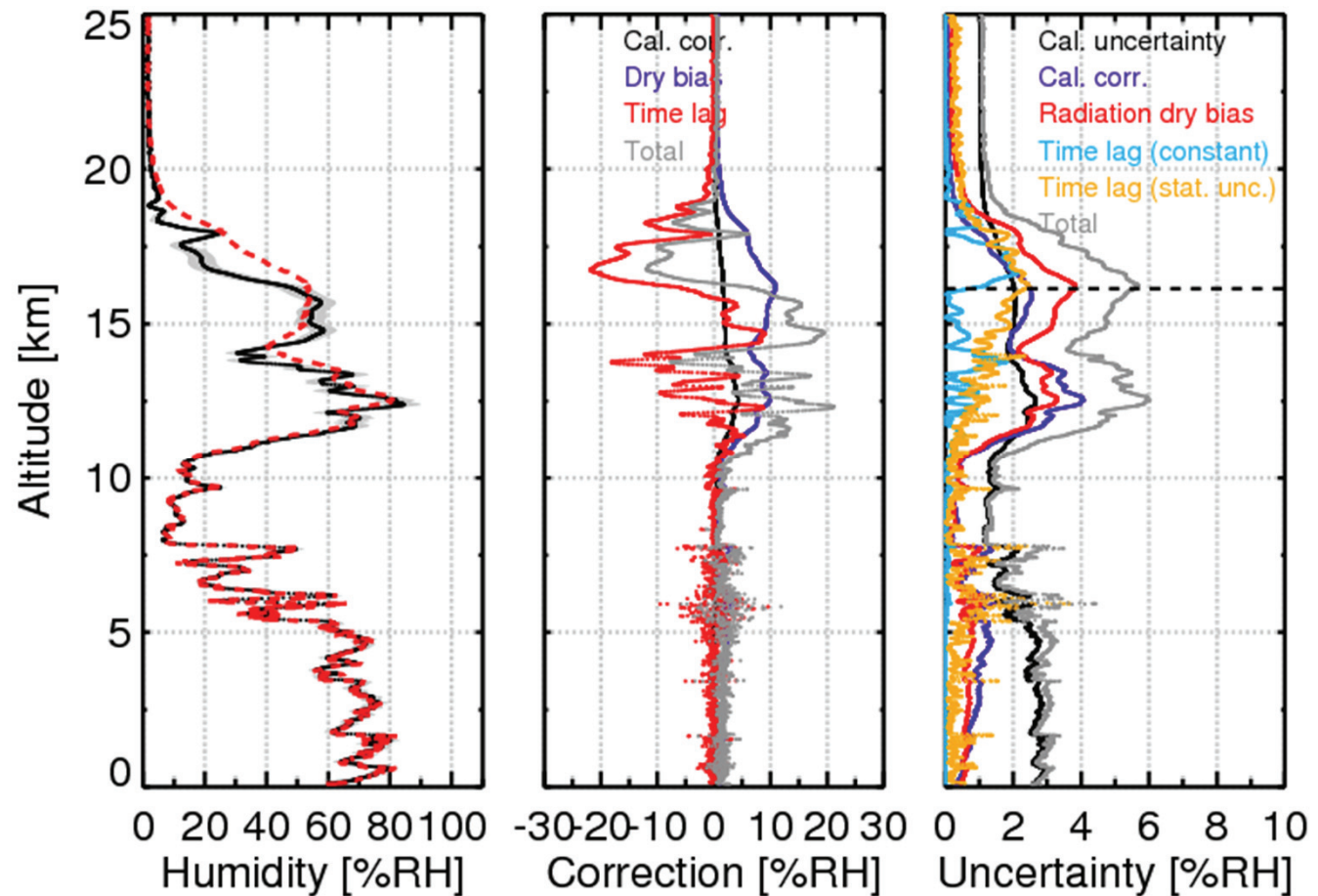
Day



Dominant uncertainties:

- Calibration
- Cal. correction
- Dry bias

Yangjiang 20 July 2010



- GRUAN data product for Vaisala RS92 radiosonde
- Other radiosonde products are developed (Modem M10, Meisei RS11-G, Meteolabor SRS34, Frost point hygrometer)
- Other products & data streams:
 - GNSS total water vapor column
 - Lidar (T, U)
 - μ -wave radiometer (T, U)
- Archive with ~30,000 radiosounding profiles
- > 20 GRUAN-related publications



- Providing long-term reference observations of upper air essential climate variables
 - Quantified uncertainties
 - Well documented
 - Verify in redundant observations
 - Change management
 - Traceable
- Being a network
 - Gaining & sharing knowledge (task teams)
 - Interaction with user community (annual meeting)

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Questions?

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- A long-term continuous upper air measurement program with proper change management
 - New system/software/procedure must be evaluated prior to implementation
 - Quantification of systematic and random errors
 - Verification by redundant observations (overlap)
- Collection of raw and meta data

