



GRUAN fundamentals

(GRUAN basics for new ICM participants)

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Motivation for GRUAN

(GCOS Reference Upper Air Network)

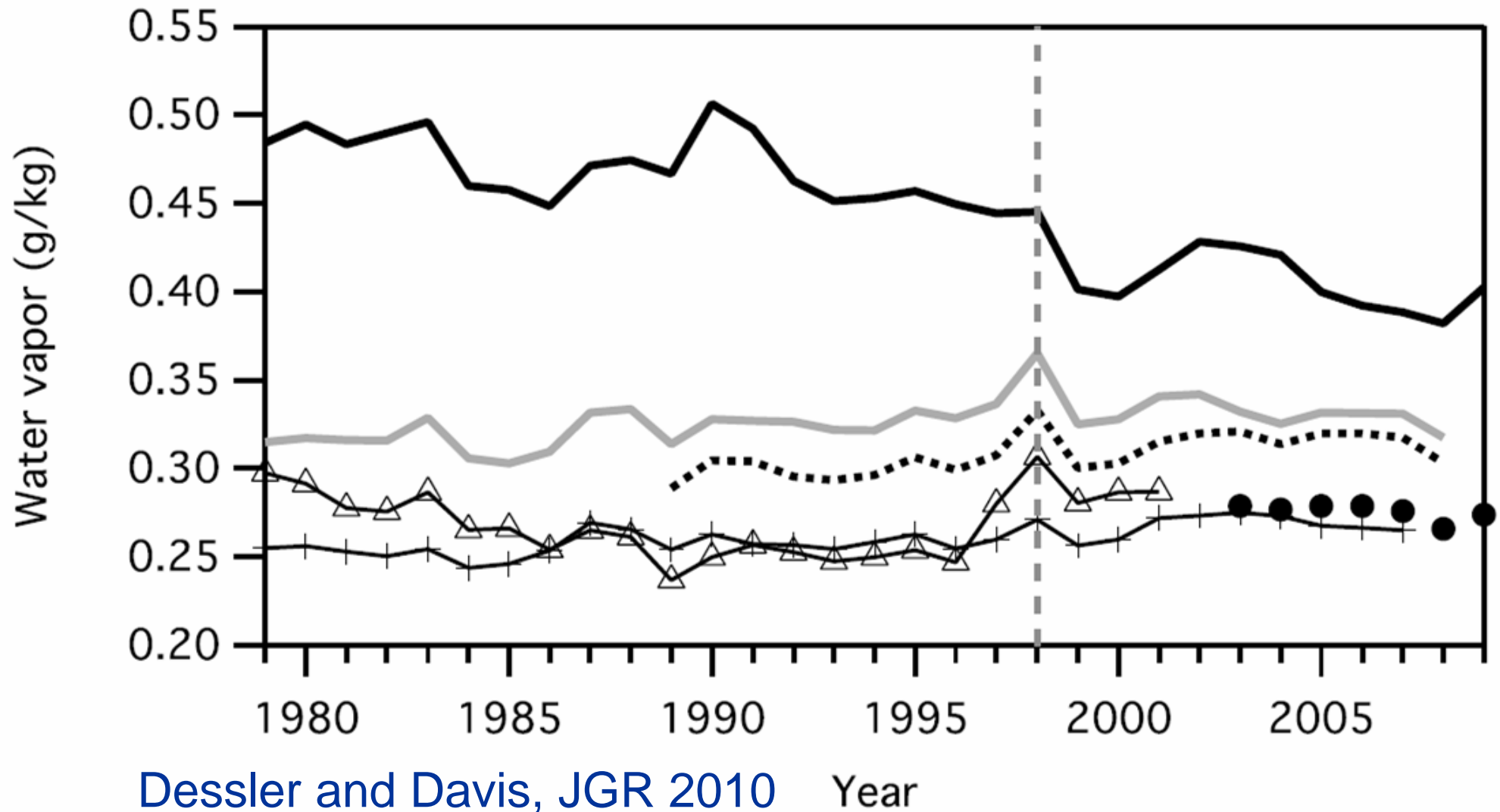
- Lower troposphere (PW):
- “Radiosonde, GPS and satellite observations of tropospheric water vapor indicate very likely increases at near global scales since the 1970s”
- Upper troposphere: **Alain Ratier (Dir. Eumetsat):**
“[the satellite community] needs calibrated reference data.”
GCOS science conference, Amsterdam, 02.03.2016
- “... the satellite platform 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

Tropospheric water vapor trends

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

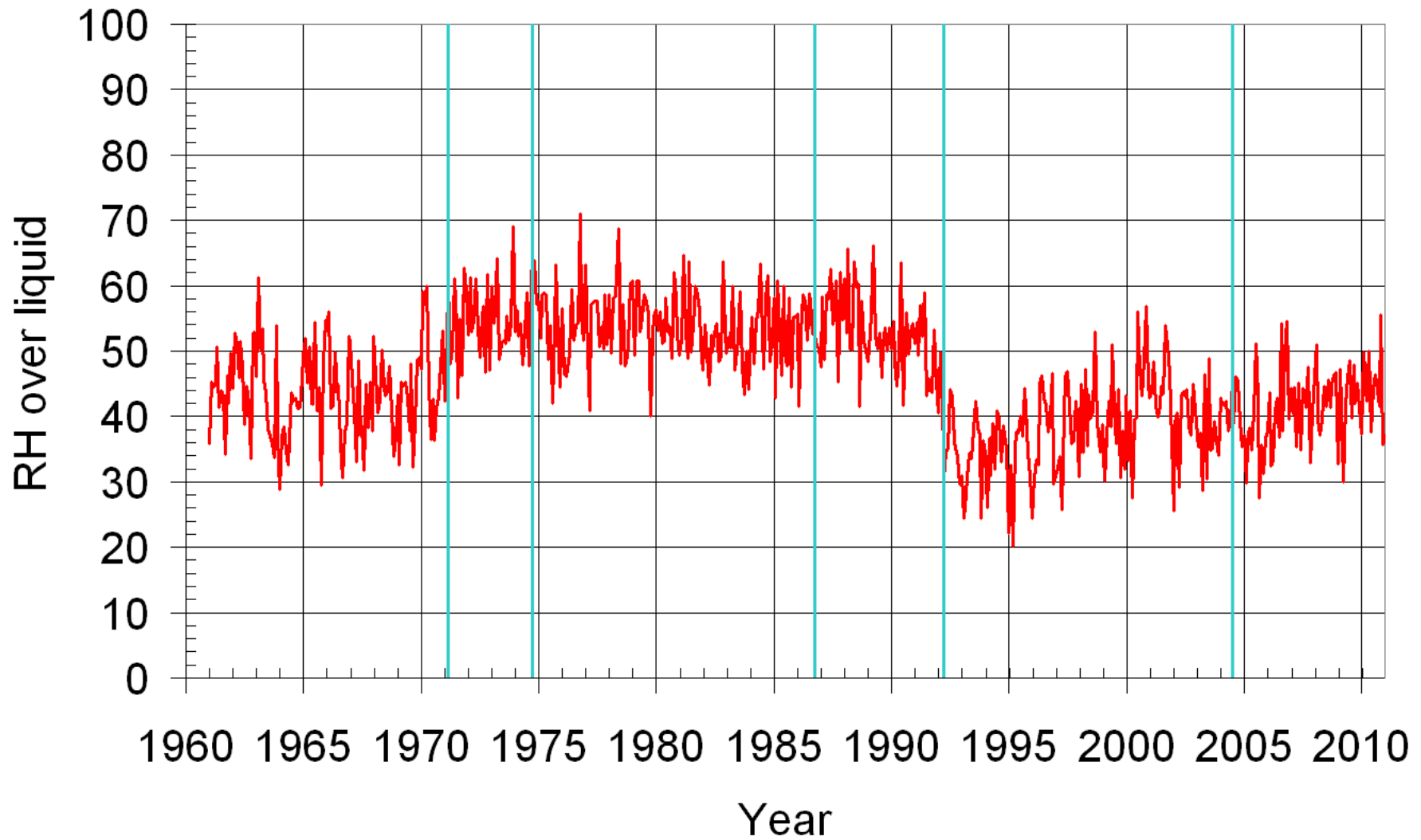


Specific humidity at 300 hPa



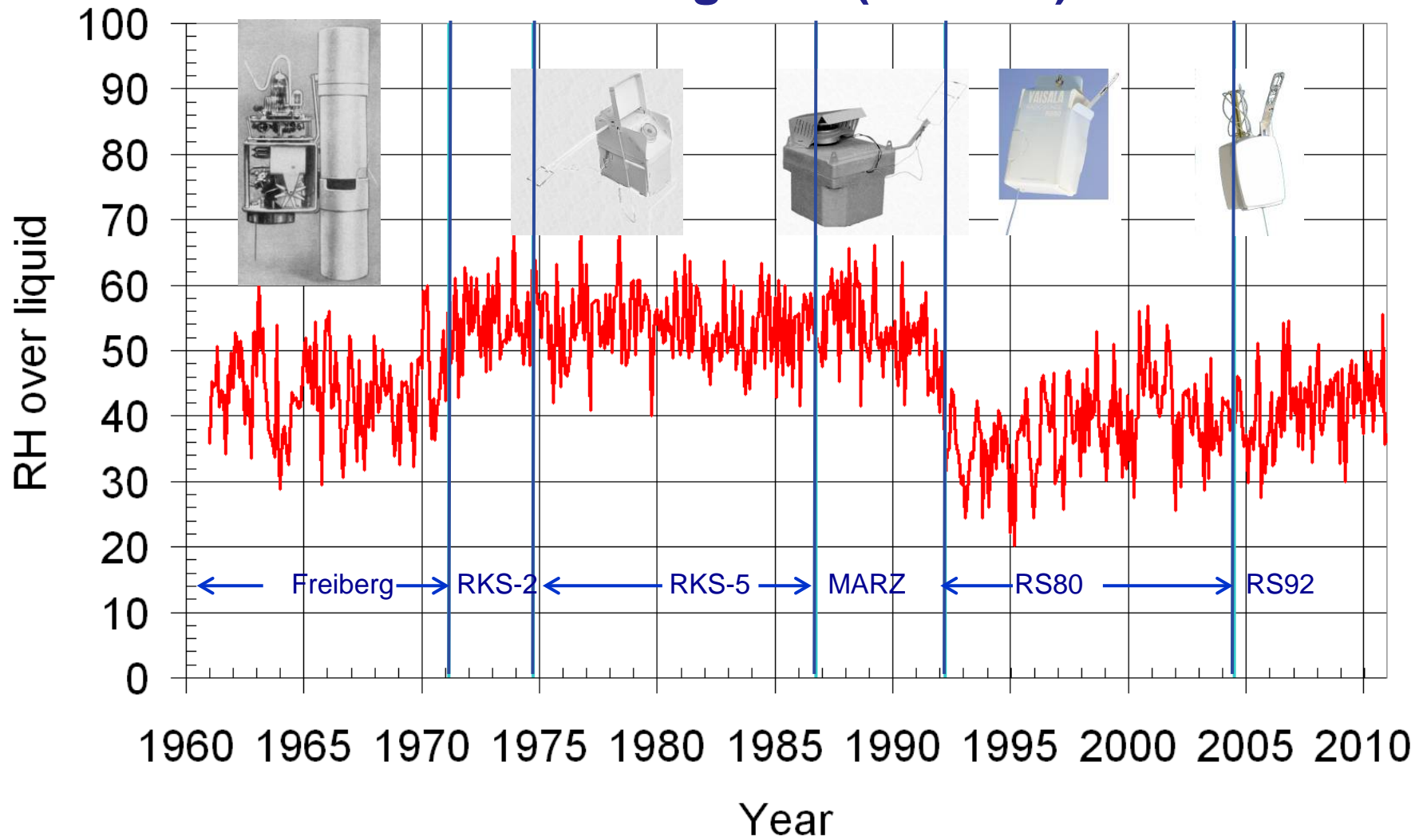
Water vapor trends in the troposphere?

Lindenberg 8km (0:00 UT)



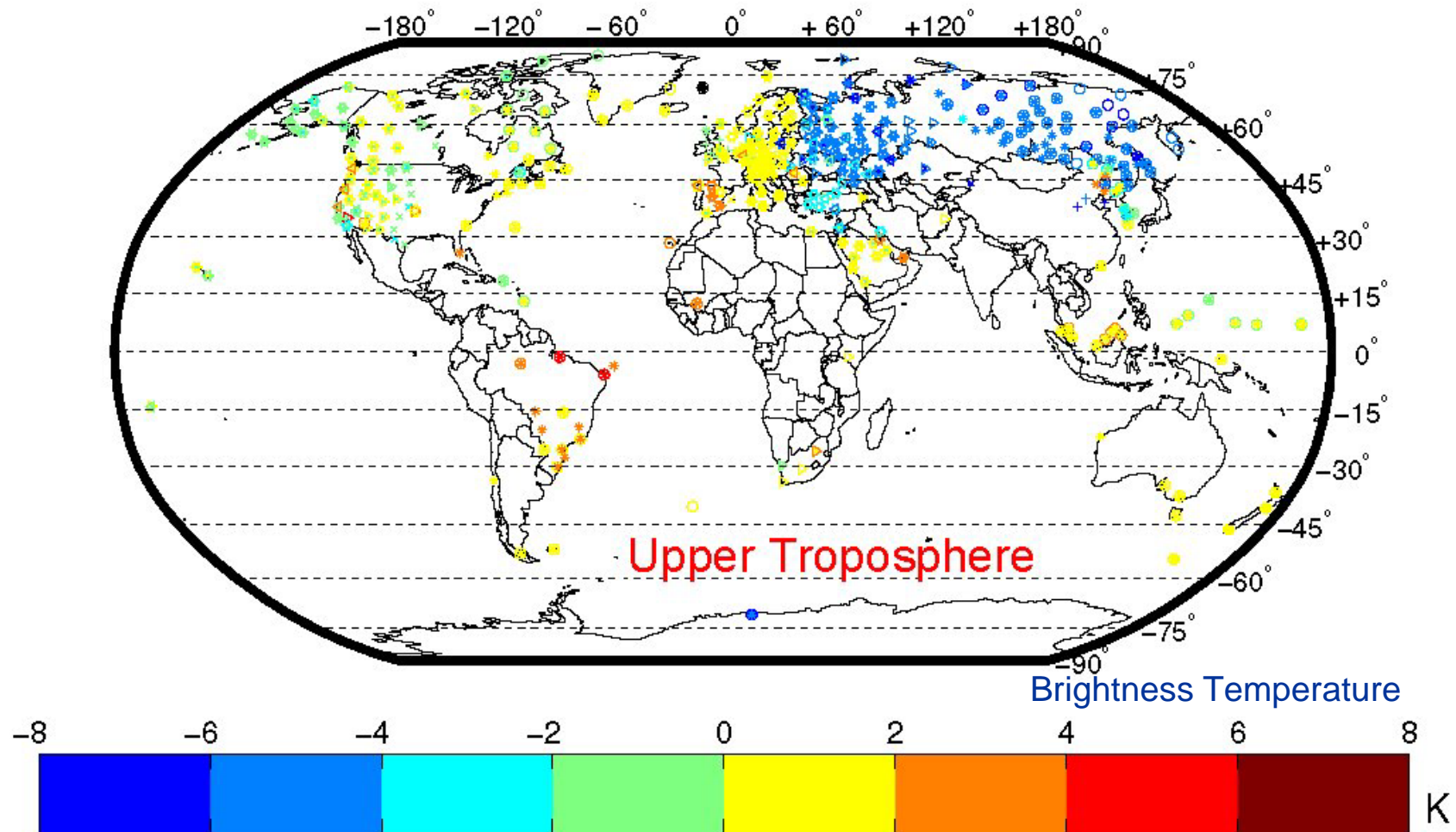
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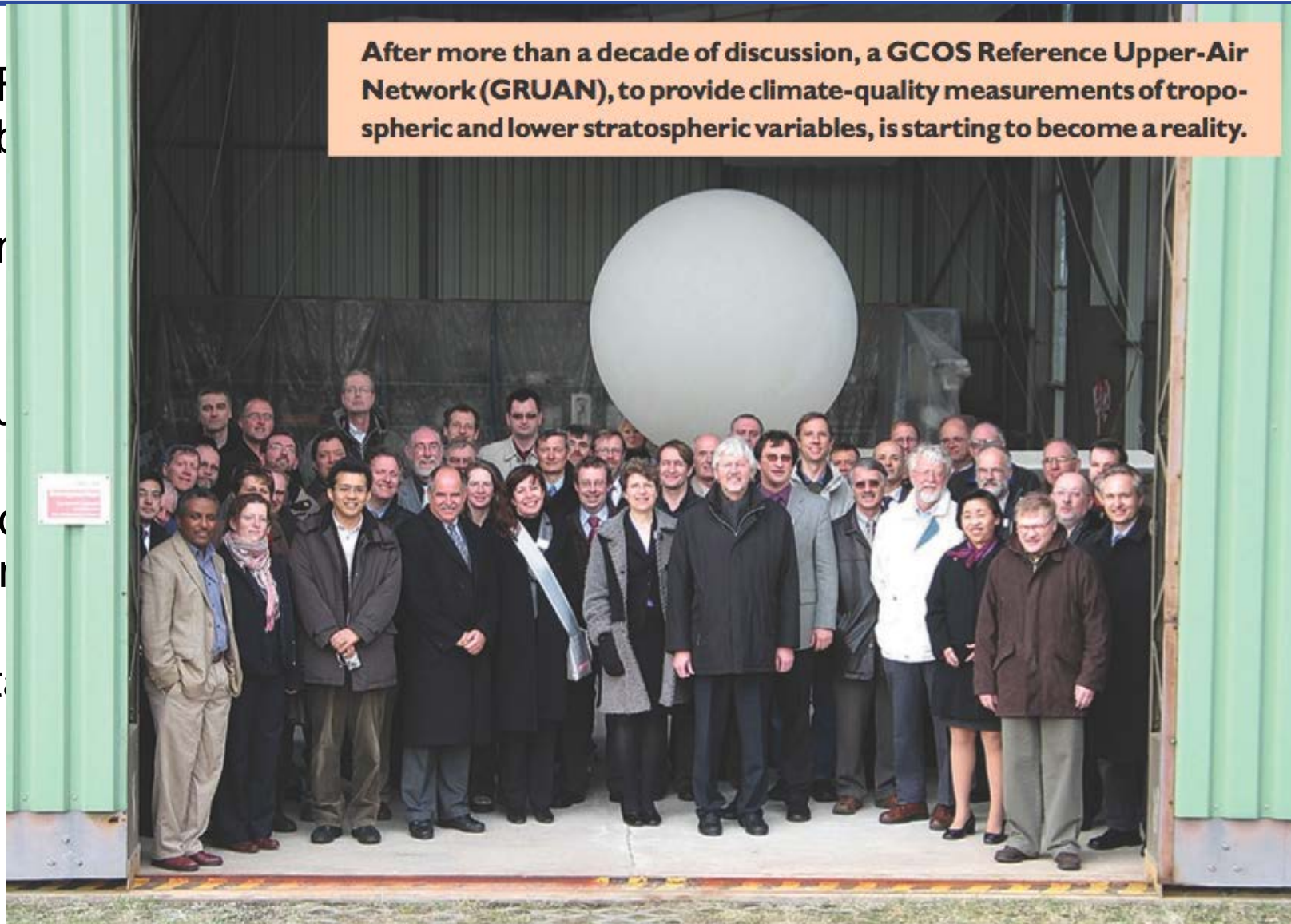
Upper Tropospheric Humidity: Difference Radiosonde – Satellite (2013)

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Moradi et al. JGR 2013

- GRUAN
- Observations
- Ground-based
- Climate
- Currencies
- Infrastructure
- Standards

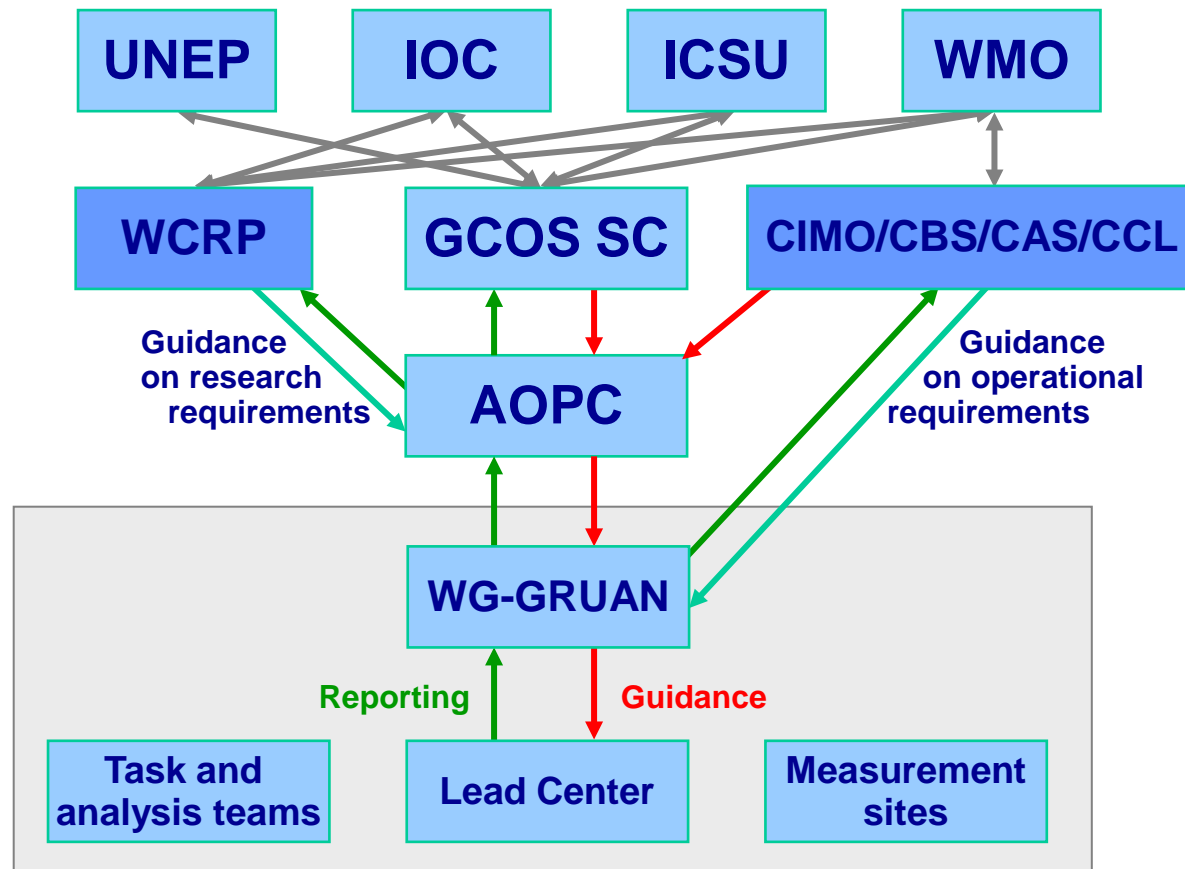


After more than a decade of discussion, a GCOS Reference Upper-Air Network (GRUAN), to provide climate-quality measurements of tropospheric and lower stratospheric variables, is starting to become a reality.

Seidel et al. 2009

GCOS Reference Upper-Air Network



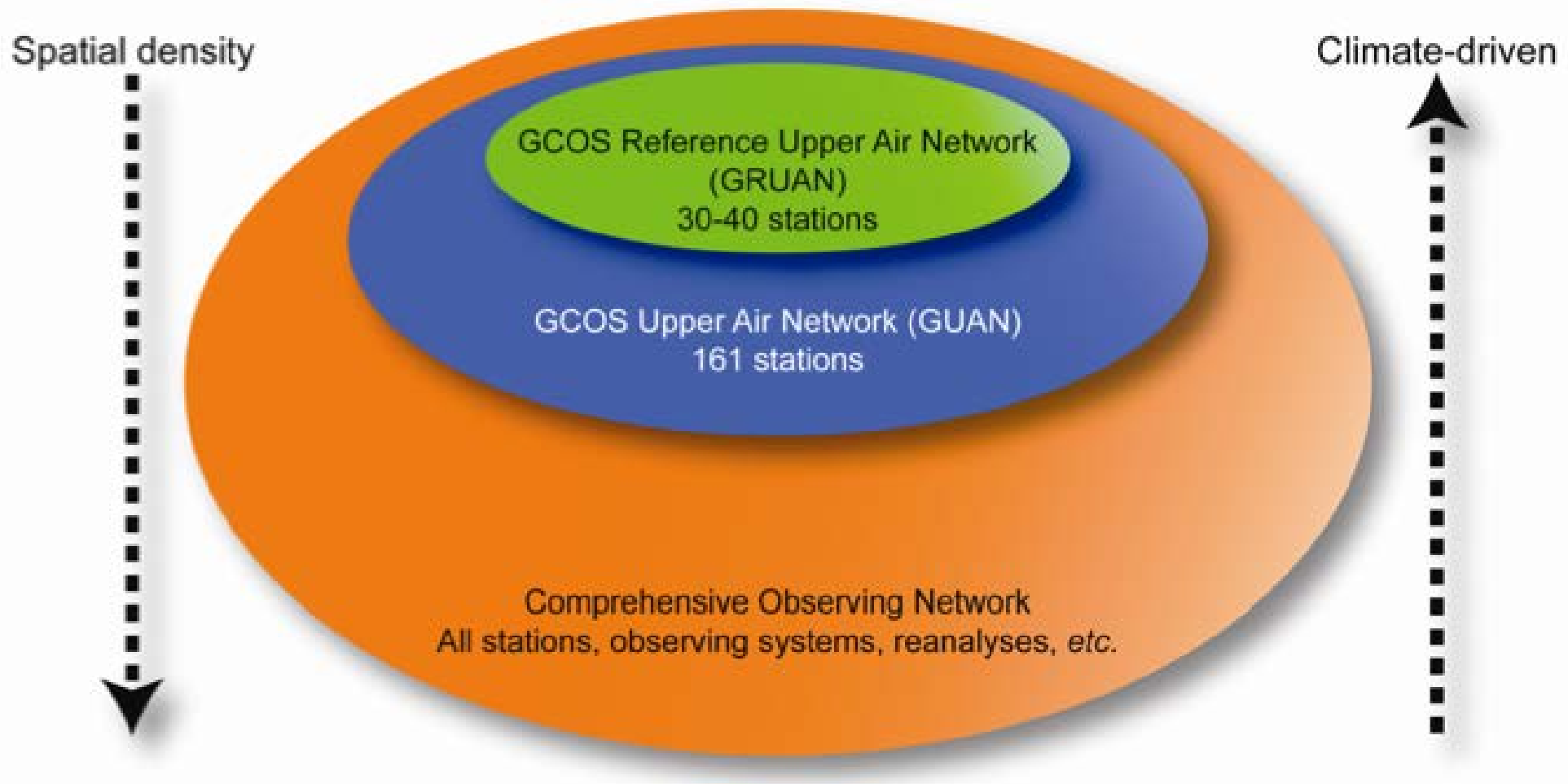


AOPC:
Atmospheric
Observation
panel for climate

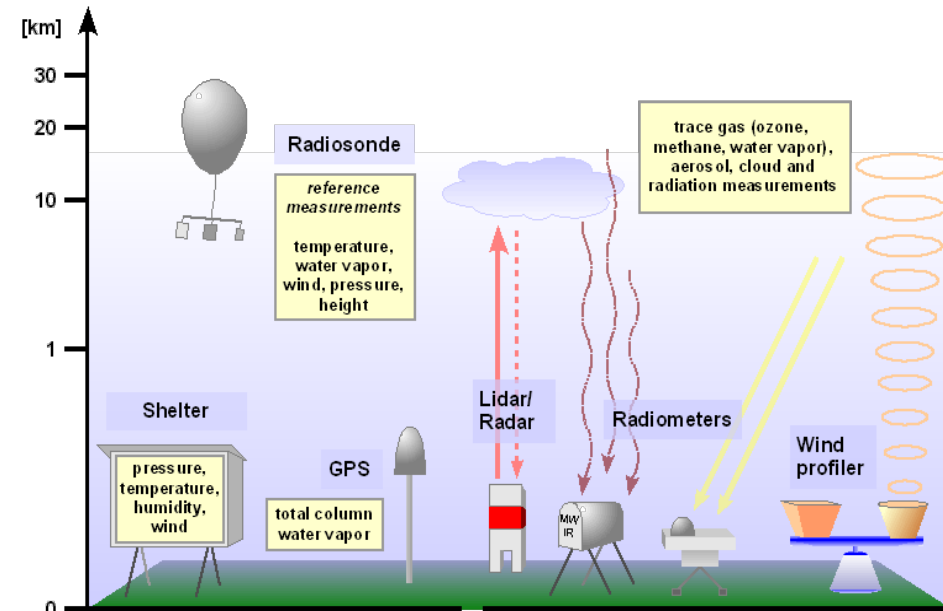
- Lead Centre: day-to-day management of the network
 - Coordination among stations
 - Archival and dissemination of GRUAN data

GRUAN's relationship to existing observational networks

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

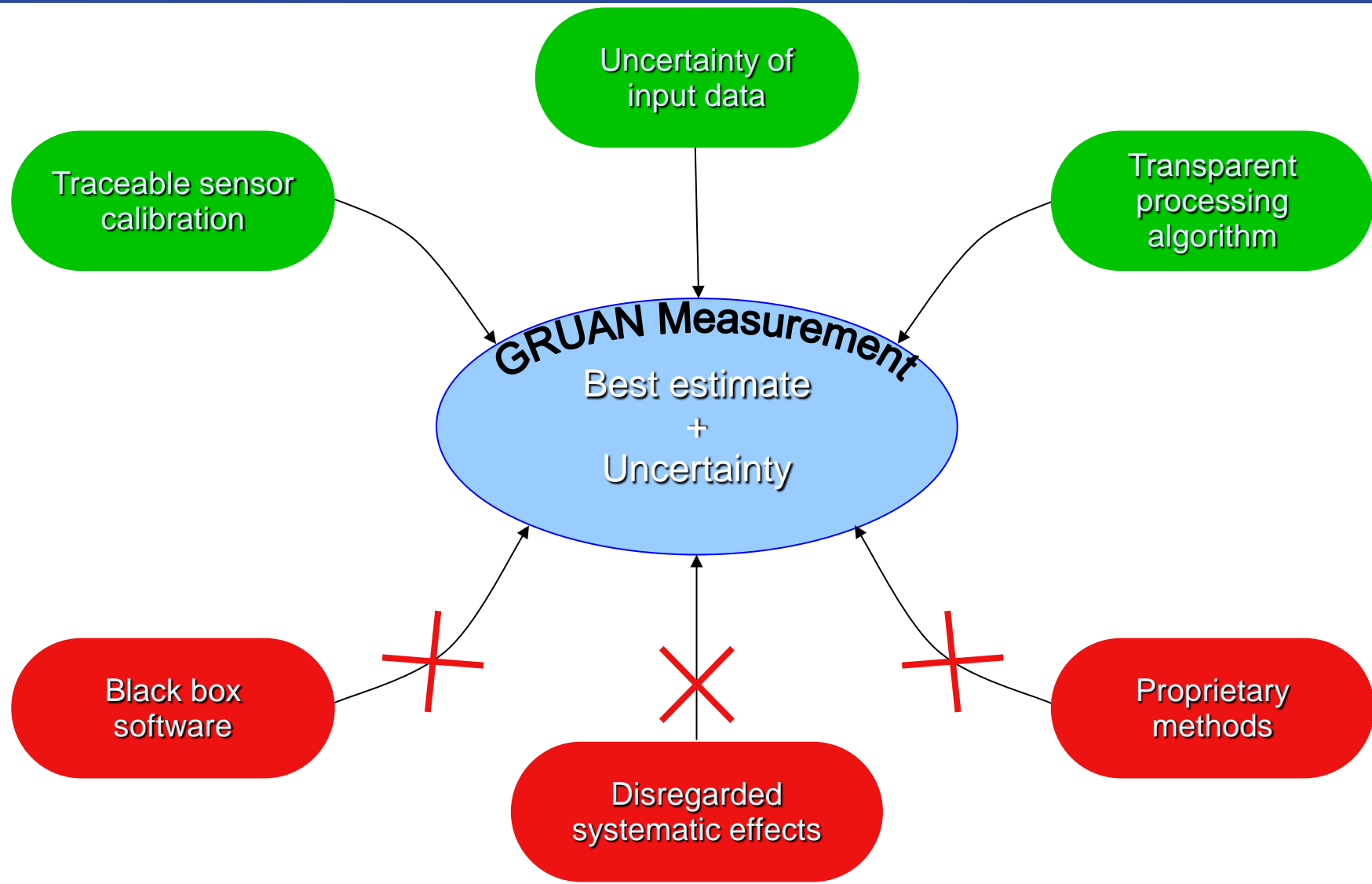


Priority 1: Water vapor, temperature, (pressure and wind)

Priority 2: Ozone, ...

A GRUAN reference observation:

- ✓ Is traceable to an SI unit or an accepted standard
- ✓ Provides a comprehensive uncertainty analysis
- ✓ Maintains all raw data
- ✓ Includes complete meta data description
- ✓ Is documented in accessible literature
- ✓ Is validated (e.g. by intercomparison or redundant observations)

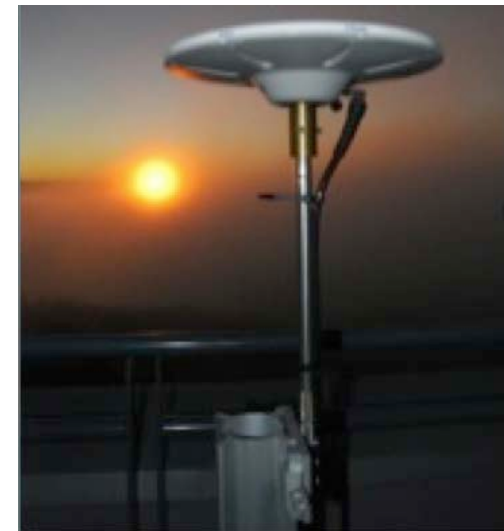
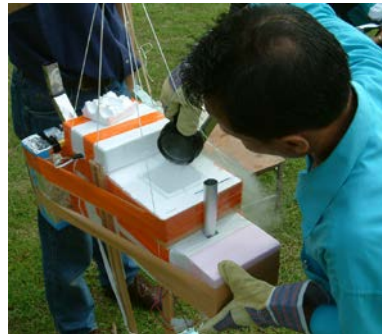


- Change management is mandatory
- A new system, software, or procedure must be evaluated prior to implementation
- Systematic and random errors must be quantified for the new system
- Redundant observations verify the new system (overlap)
- Use transfer functions on old data where required

- GRUAN has a long term view to observations of upper air essential climate variables
- Focus on priority 1 variables to start: Water vapor and temperature (starting to bring in other variables)
- Reference observation means:
 - quantified uncertainties
 - traceable
 - well documented
 - verify in redundant observations
- Management of change utilizes measurement uncertainty

- Assessment of the site's measurement program
 - (e.g. continuity, operational procedures, change management)
- GRUAN-approved measurement quality

- GRUAN Dataproduct for Radiosondes: Vaisala RS92
 - Meteolabor SRS C-34, Meisei RS11-G & IMS-100, RS41, M10
- Other products & data:
 - GNSS total water vapor column
 - Lidar (T, U)
 - Microwave-Radiometer (T, U)
- Archive of ~60.000 Radiosonde-profiles
- > 30 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, lab-facilities)
 - Interaction with user community (annual meeting)



