



GRUAN fundamentals

(GRUAN basics for new ICM participants)

Ruud Dirksen
GRUAN Lead Centre, DWD

15th GRUAN Implementation and Coordination Meeting (ICM-15)
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11-15 March 2024

Motivation for GRUAN

(GCOS Reference Upper Air Network)

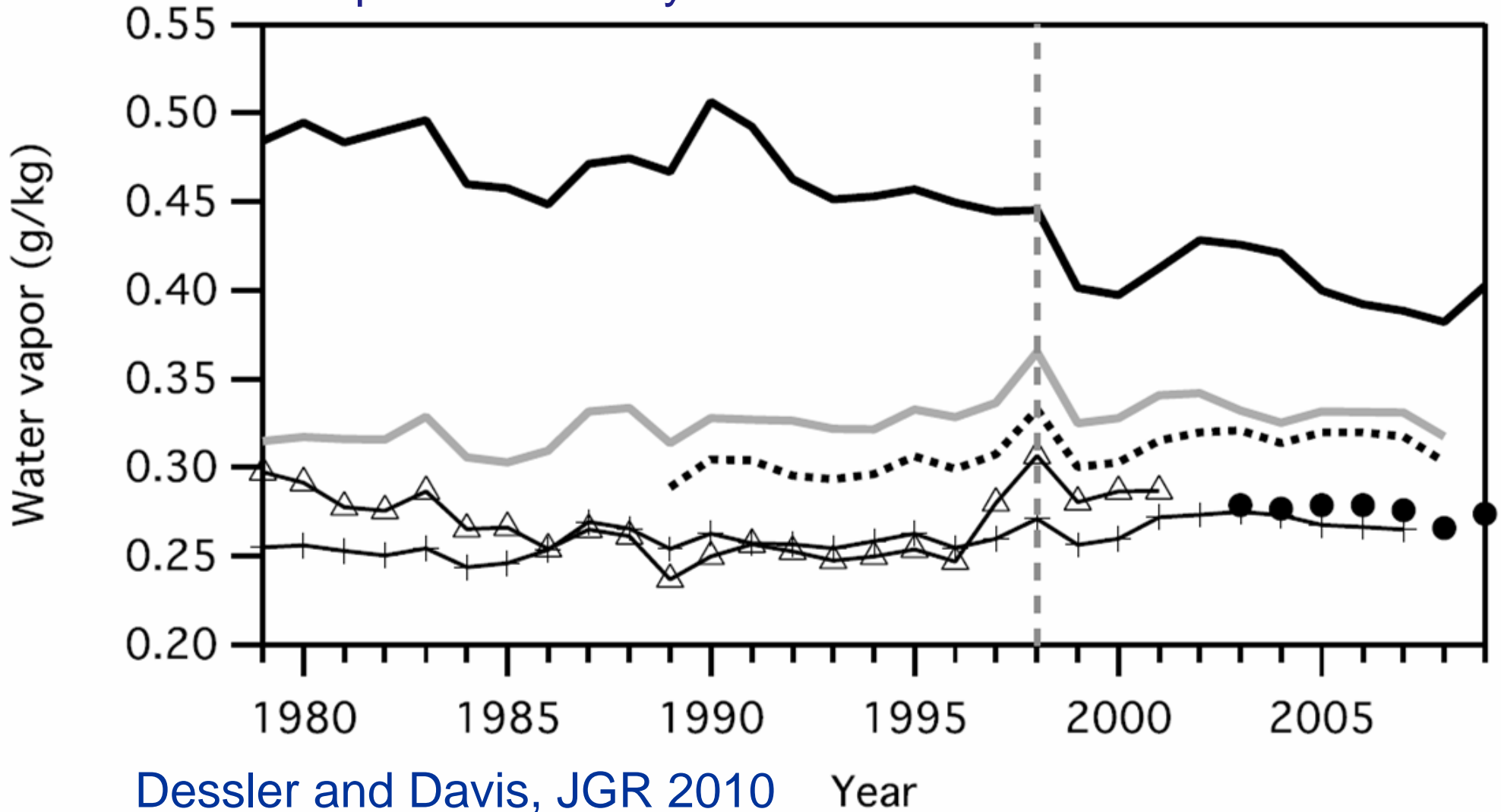
- Lower troposphere (PW):
 - “Radiosonde, GPS and satellite observations of tropospheric water vapor indicate very likely increases at near global scales since the 1970s”
- Upper troposphere:
 - “... the satellite records from these records (of upper tropospheric humidity).”
- Stratosphere:
 - “Because 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

Alain Ratier (Dir. Eumetsat):

“[the satellite community] needs calibrated reference data.”

GCOS science conference, Amsterdam, 02.03.2016

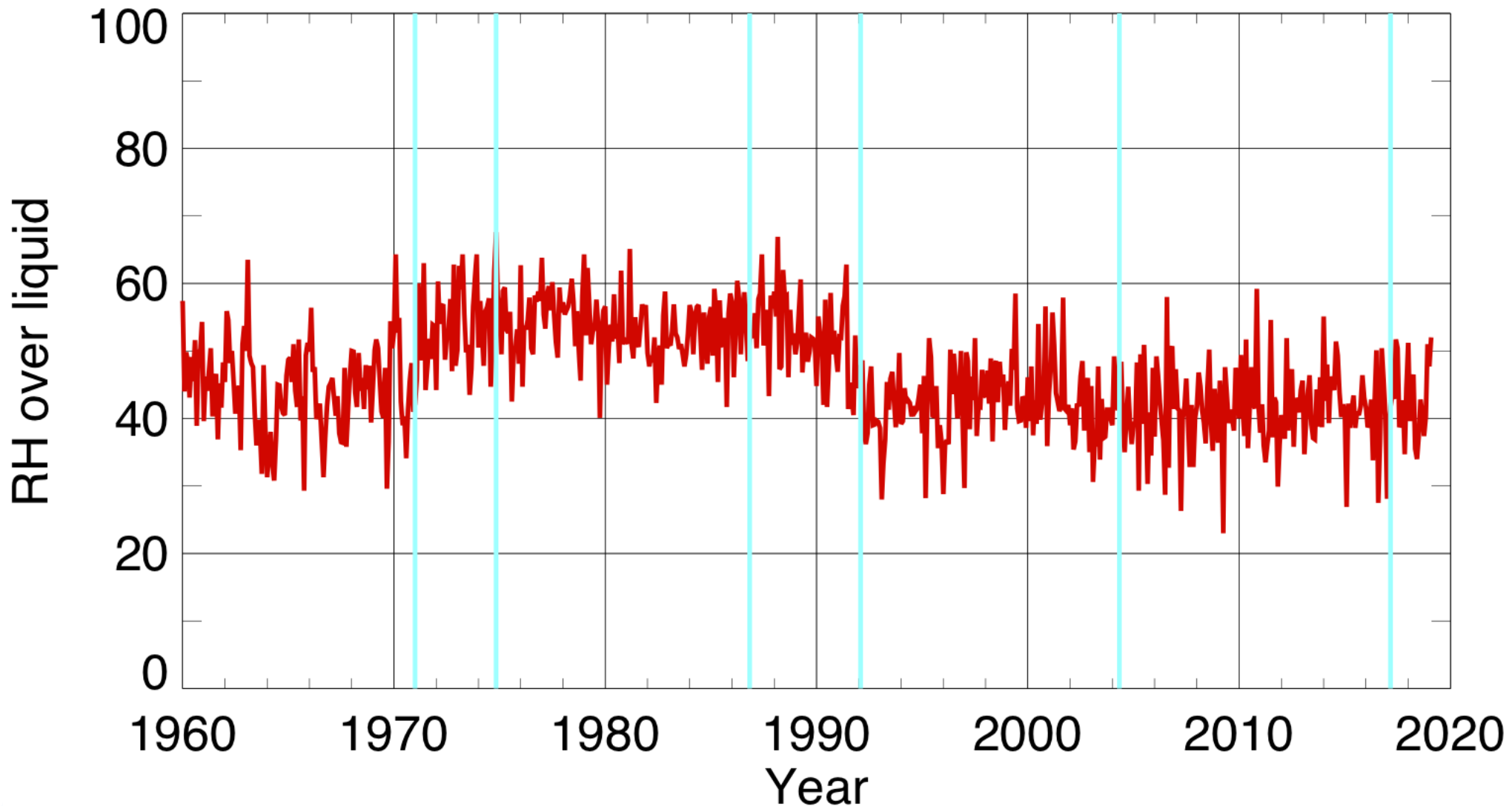
Specific humidity at 300 hPa



Dessler and Davis, JGR 2010 Year

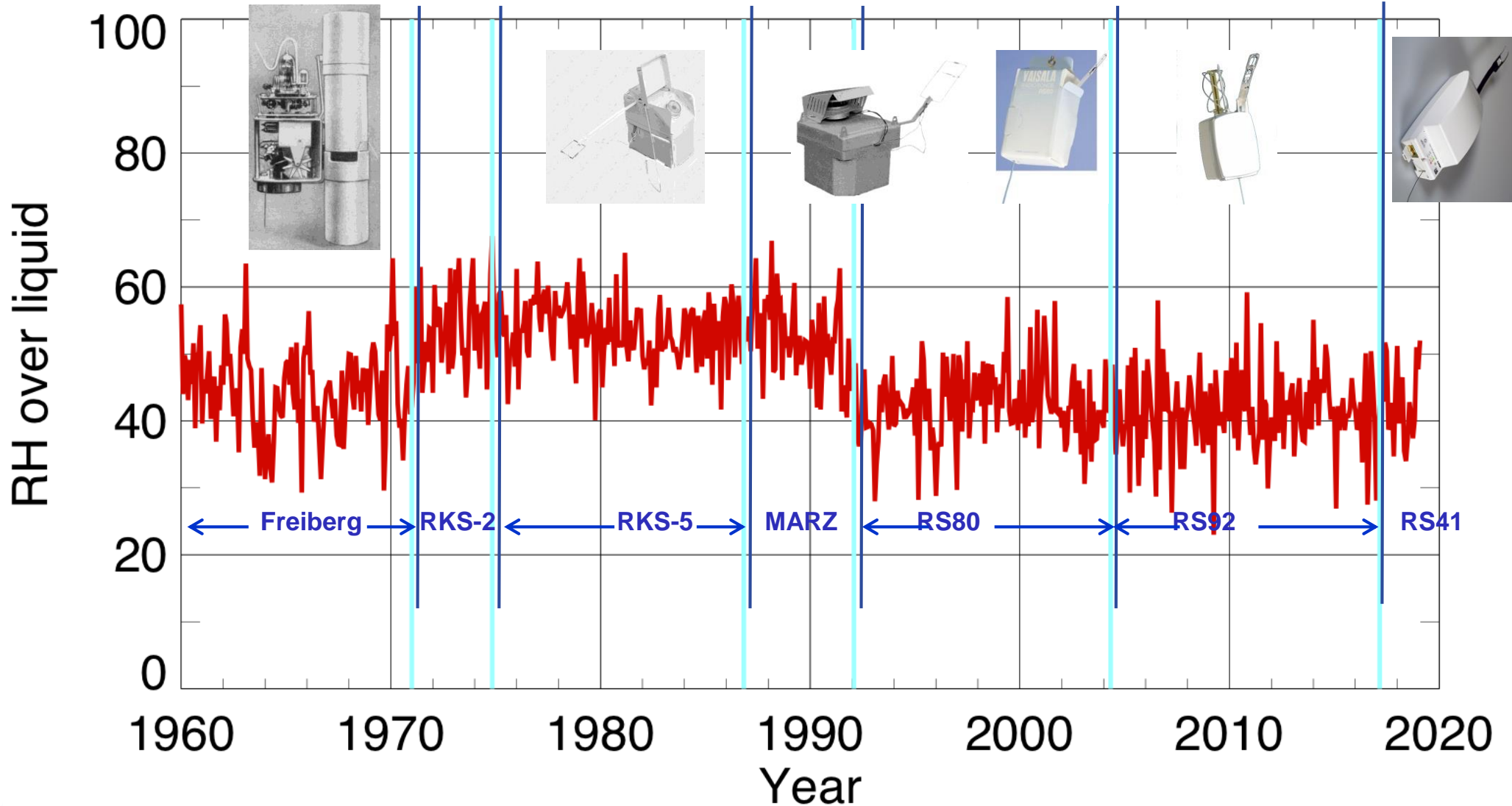
Water vapor trends in the troposphere?

Lindenberg 8km (0:00 UT)



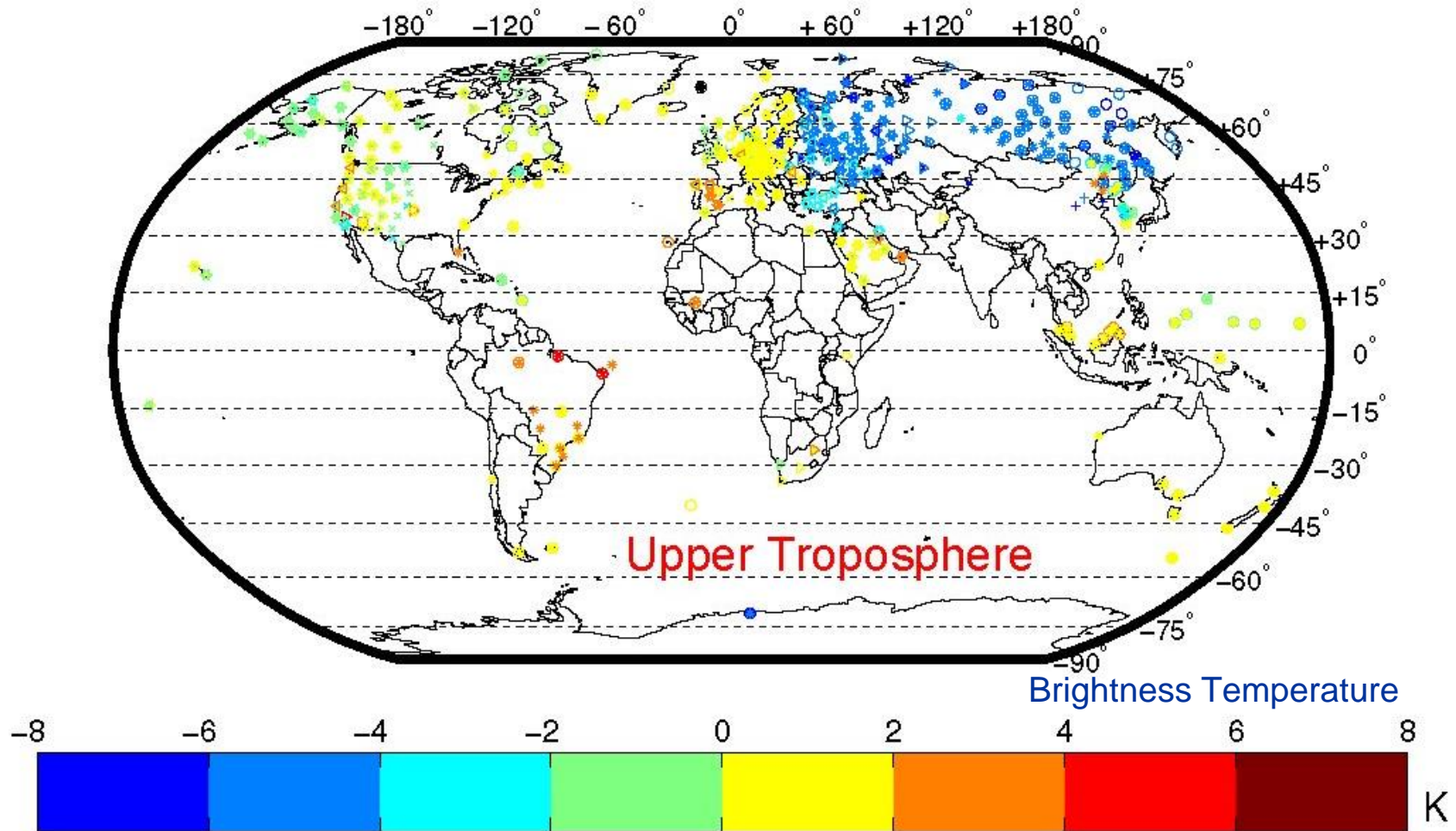
Water vapor trends in the troposphere?

Lindenberg 8km (0:00 UT)



Upper Tropospheric Humidity: Difference Radiosonde – Satellite (2013)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

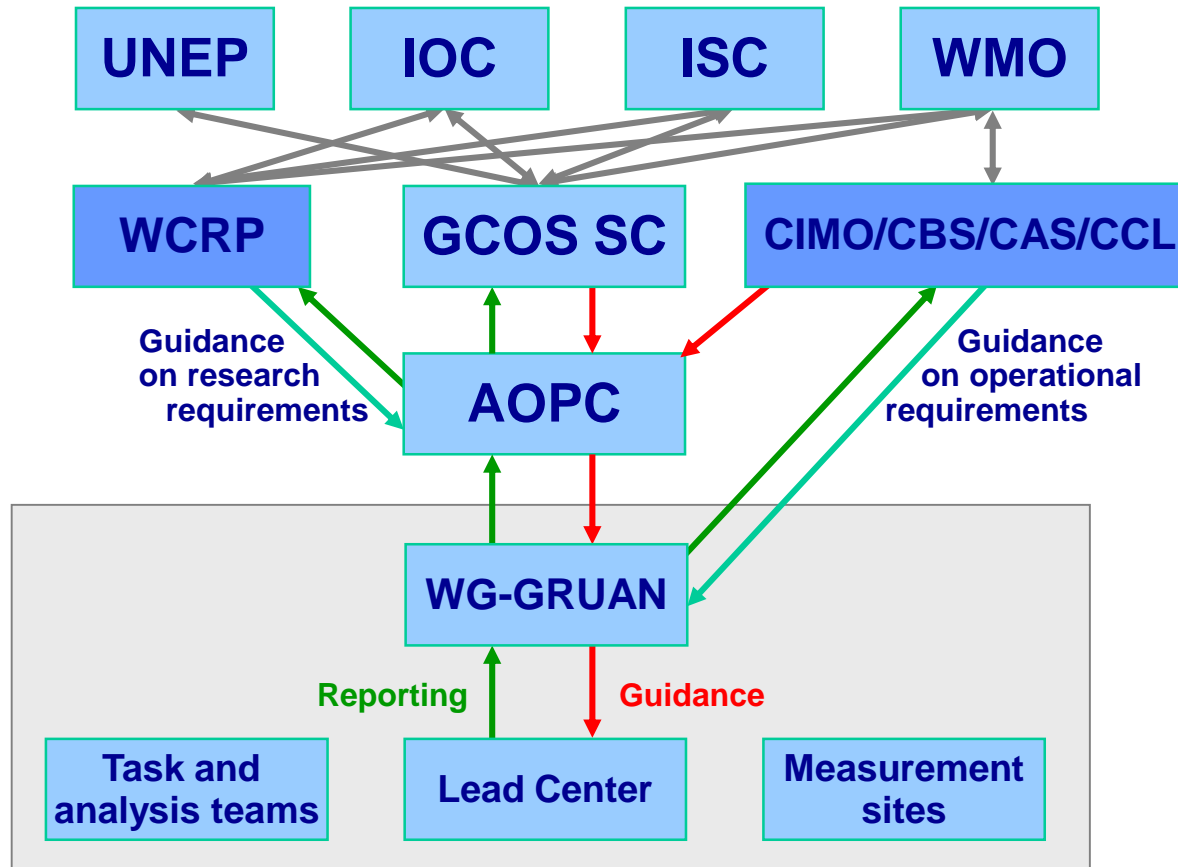


Moradi et al. JGR 2013

- GRUAN is response to the need of WMO and the Global Climate Observing System for highest accuracy data possible
- Ground based network for reference upper air observations for climate under GCOS and integrated into WIGOS
- Currently 33 sites, aim: 30 - 40 sites worldwide



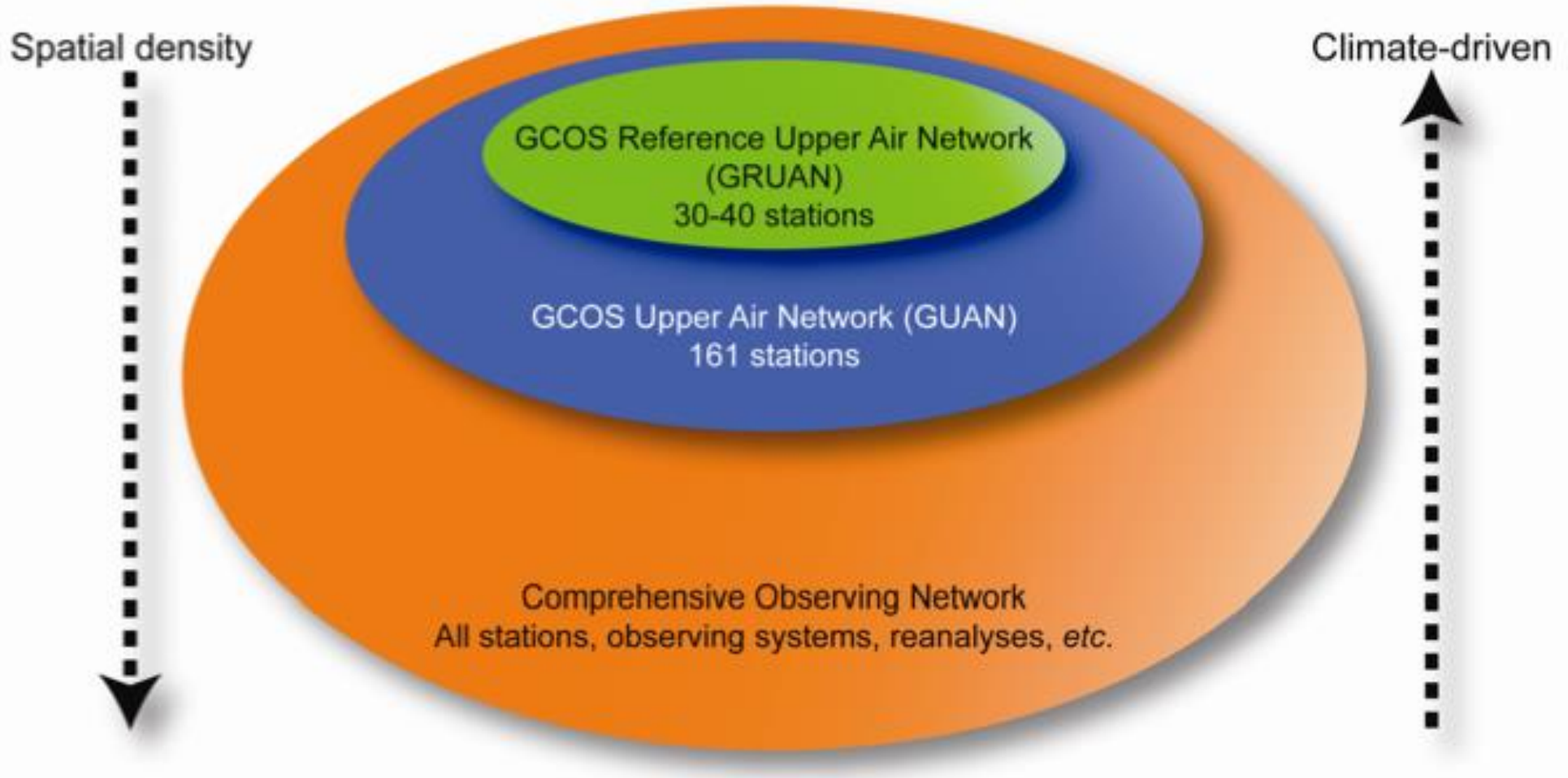




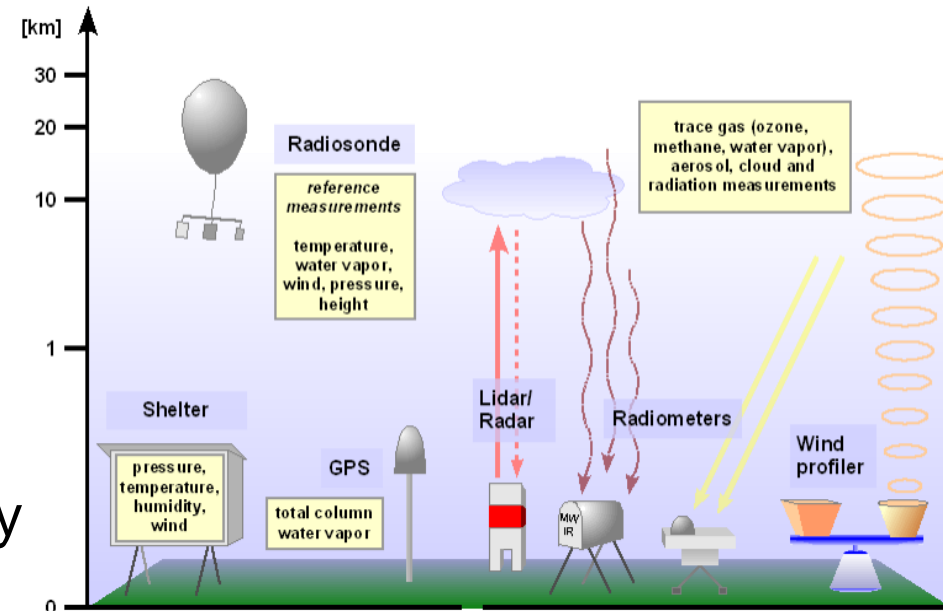
AOPC:
Atmospheric
Observation
panel for
Climate

- 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



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

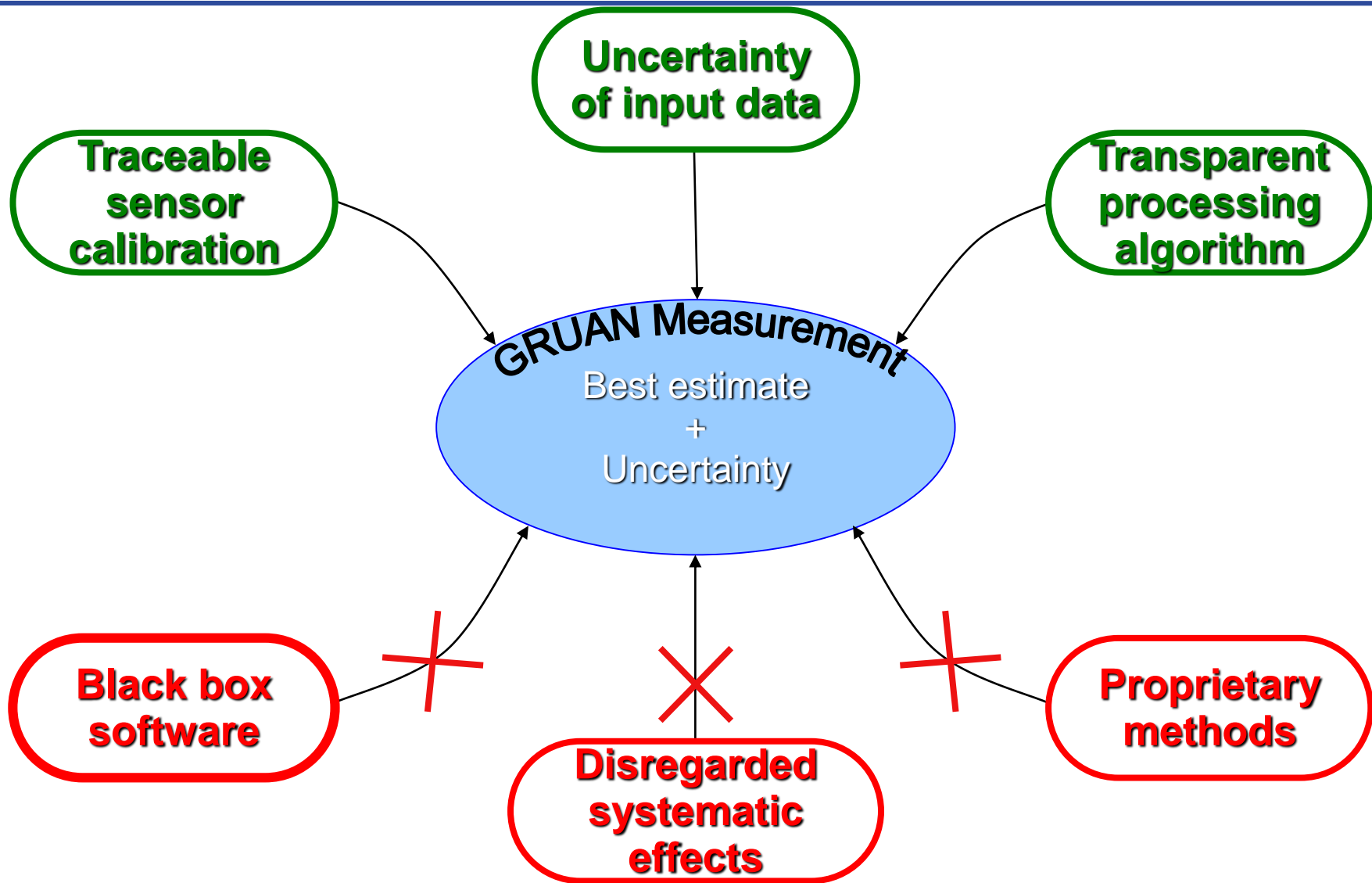


Priority 1: Water vapor, temperature, (pressure and wind)

Priority 2: Ozone, ...

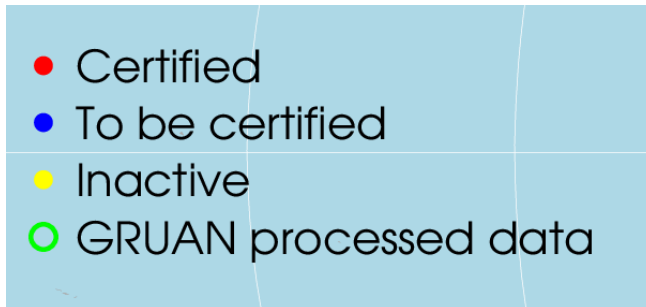
A GRUAN reference observation:

- ✓ 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
- Example: RS92-RS41 transition

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



GCOS Reference Upper-Air Network



GRUAN Sites

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



CAB



LIN



PAY



TAT



NYA



SNG



LAU



BOU



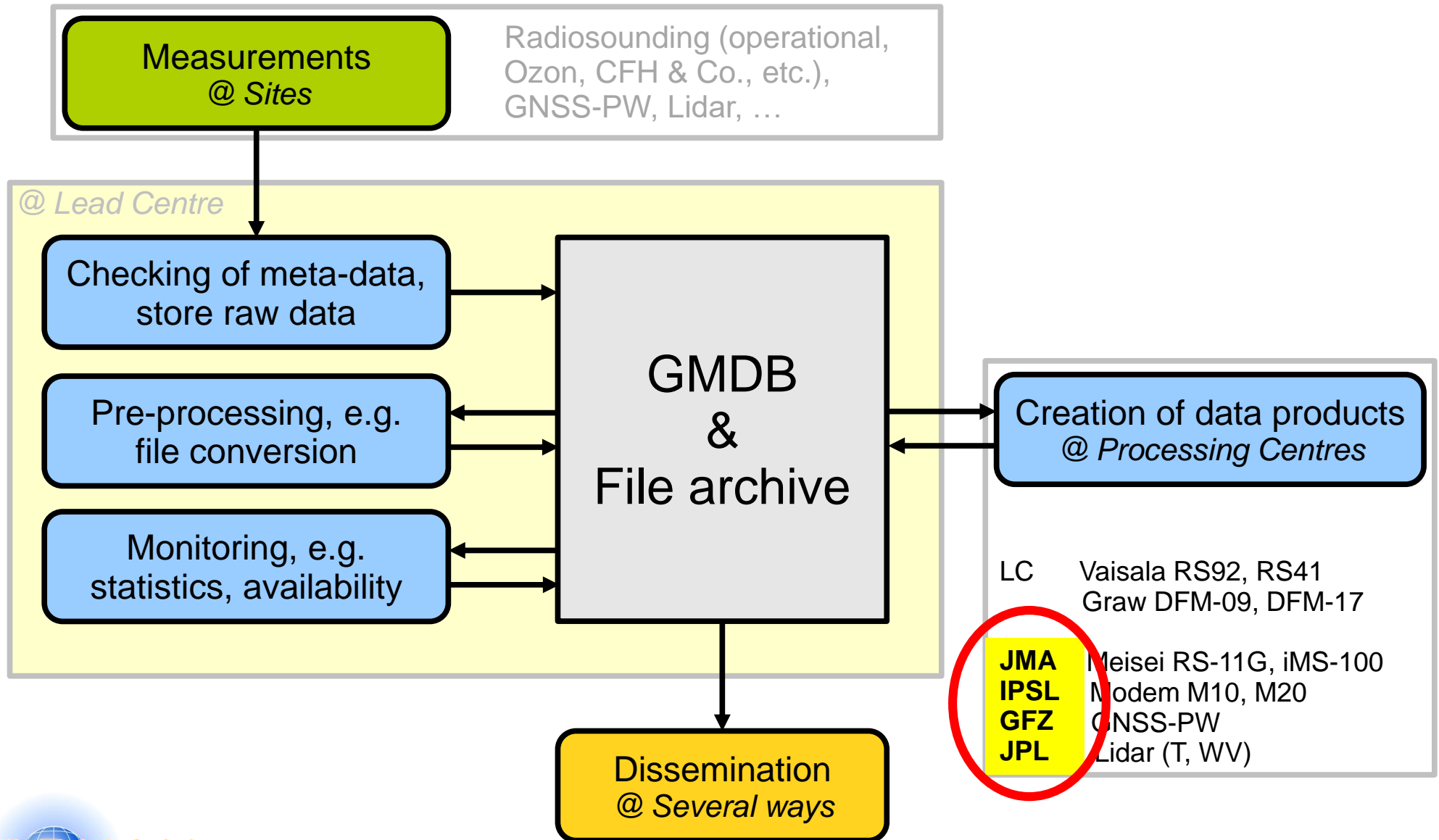
POT



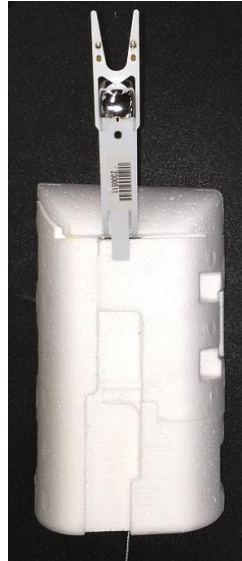
SOD



GRUAN data flow – processing centres



- GRUAN Dataproducts for Radiosondes:
 - Vaisala RS92, RS41, Meisei RS-11G, iMS-100
 - Modem M10, Graw DFM-9, DFM-17
- Other products & data:
 - GNSS-PW (total water vapor column)
 - Lidar (T, U)
 - Microwave-Radiometer (T, U)
- Archive of >160k Radiosonde-profiles
- > 100 GRUAN-related publications



ICM-1



Lindenberg Meteorological Observatory
Richard-Abmann-Observatory



- Providing long-term reference observations of upper air essential climate variables
 - Quantified uncertainties
 - Well documented
 - Verify in redundant observations
 - Change management
 - Traceability

- Being a network
 - Gaining & sharing knowledge (task teams, lab-facilities)
 - Relying on collective effort by sites, processing centres, experts
 - Interaction with user community (ICM)



