The road towards a globally distributed network of reference observations of temperature and water vapor

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GAIA-Clim workshop

Rome

6 October 2015

Motivation for GRUAN (GCOS Reference Upper Air Network)

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:

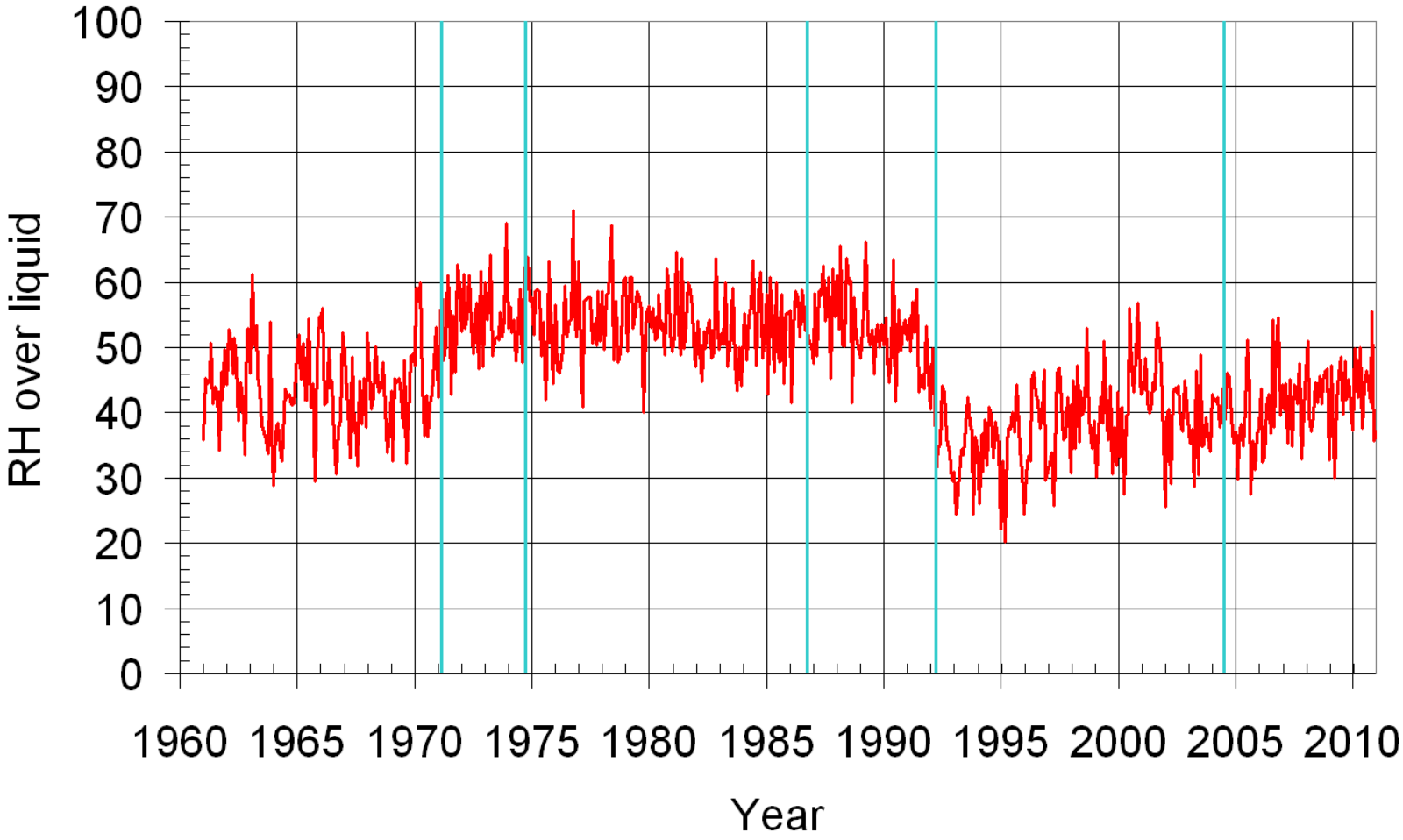
"Because of the large variability and relatively short time series, confidence in long-term stratospheric H_2O trends is low."

- Lack of good reference measurements for climate observations

Water vapor trends in the troposphere?

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

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



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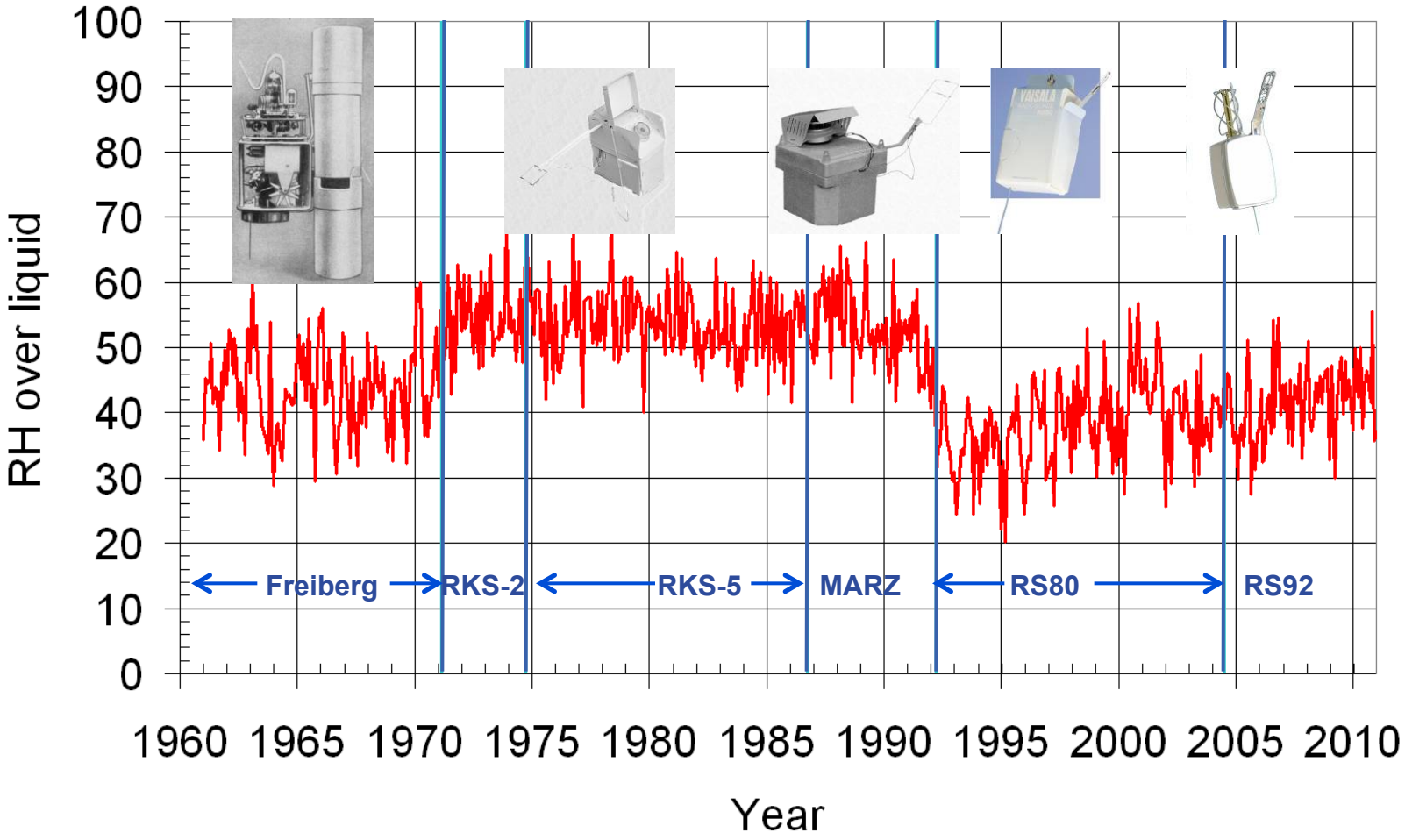


What is GRUAN?

The GCOS Reference Upper Air Network (GRUAN):

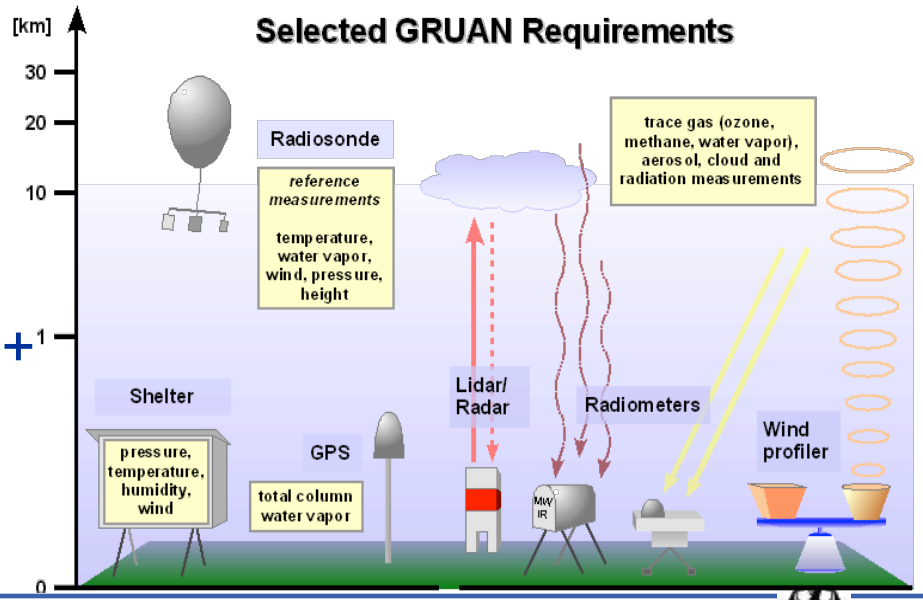
- Started in 2008
- GRUAN is response to the need of WMO and the Global Climate Observing System (GCOS) for the highest accuracy data possible
- Ground based network for reference upper air observations for climate under GCOS and integrated into WIGOS
- Currently 22 sites, with the aim to expand to 30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

GRUAN goals

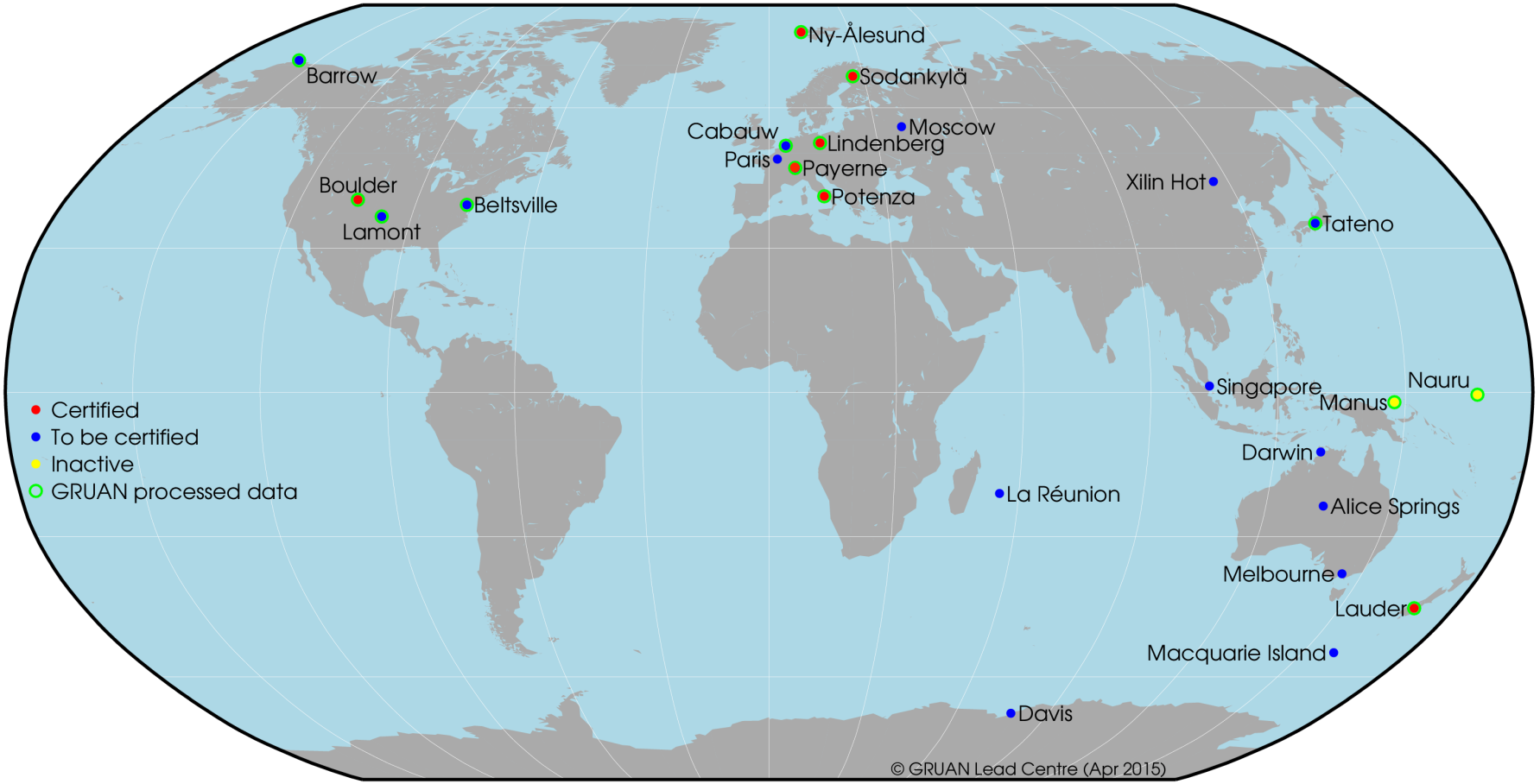
- Maintain consistent observations over decades
- Validation of satellite systems
- Numerical weather prediction
- Deliberate measurement redundancy
- Standardization and traceability
- Quality management and managed change
- Full documentation: collect raw + meta data

Priority 1:
- temperature
- water vapor
- pressure and wind

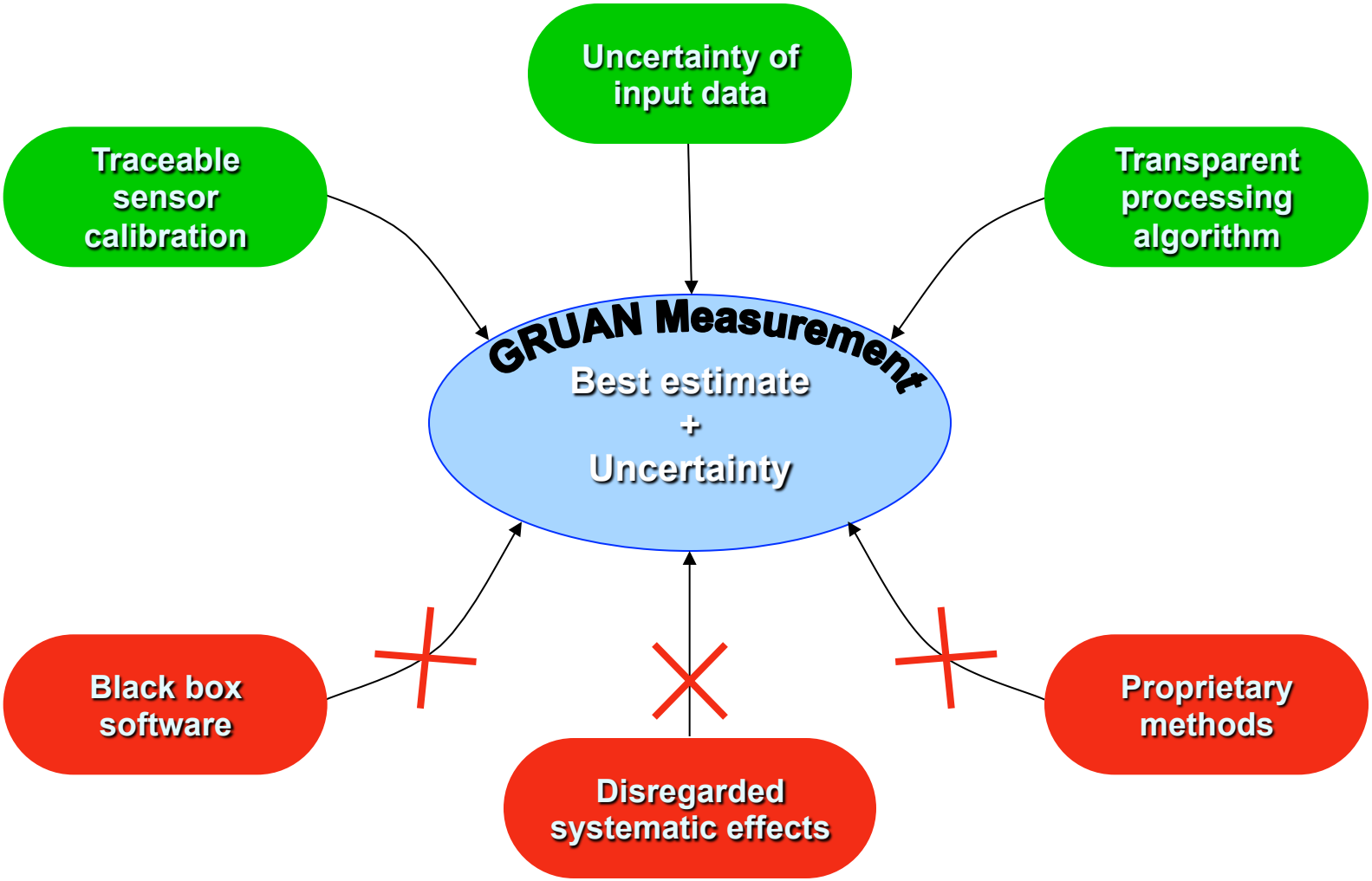
Priority 2: Ozone, …



GRUAN sites


Ny-Ålesund
Barrow
Sodankylä
Cabauw
Moscow
Lindenberg
Paris
Payerne
Potenza
Xilin Hot
Boulder
Beltsville
Lamont
Tateno
Singapore
Nauru
Manus
Darwin
La Réunion
Alice Springs
Melbourne
Lauder
Macquarie Island
Davis
Certified
To be certified
Inactive
GRUAN processed data
© GRUAN Lead Centre (Apr 2015)

Establishing reference quality



GRUAN data product for RS92

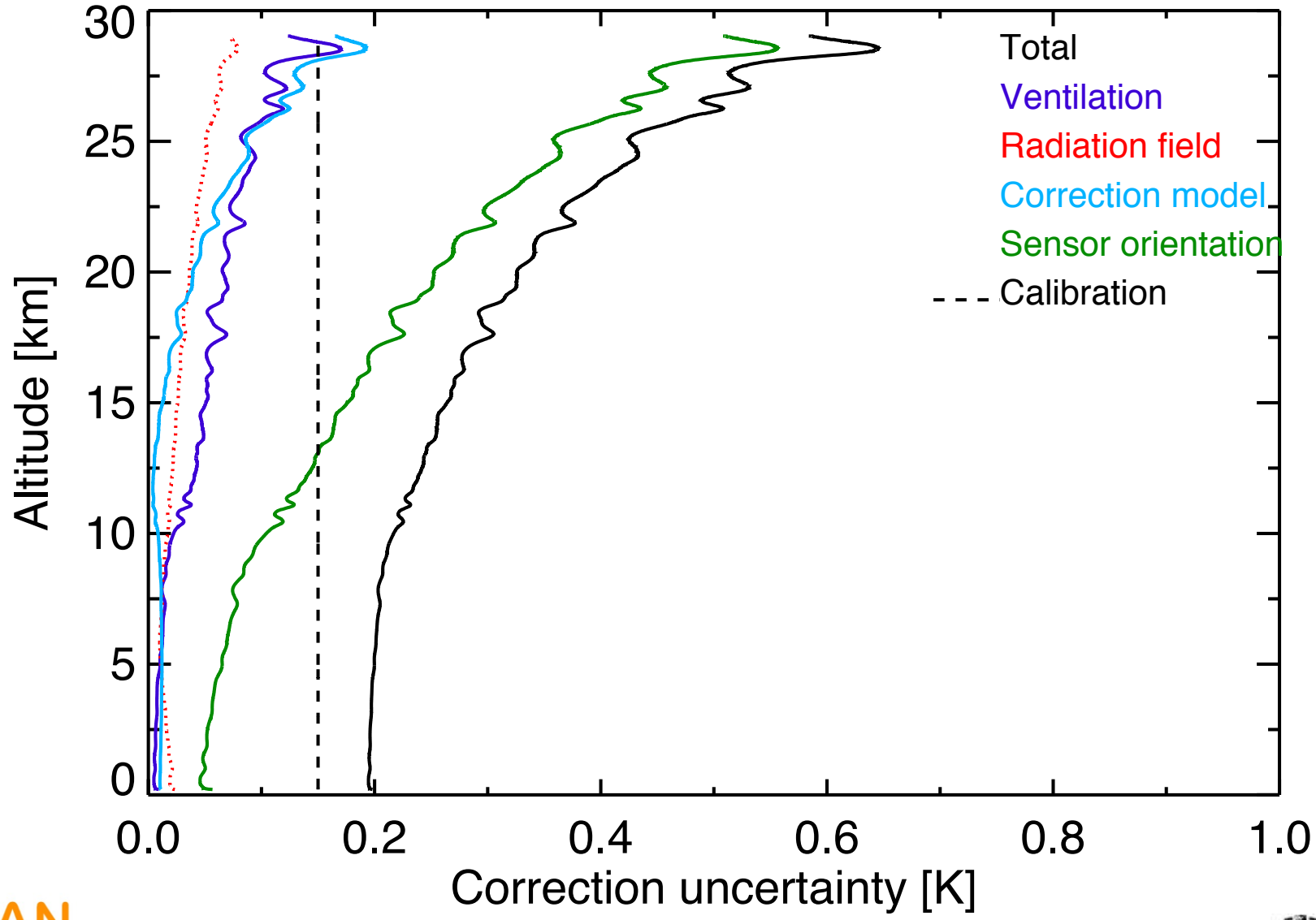
Characterization & correction of instrument errors/biases
Well-documented
Vertically resolved error estimates

Error sources

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

Dirksen et al. AMT2014

Temperature: uncertainties



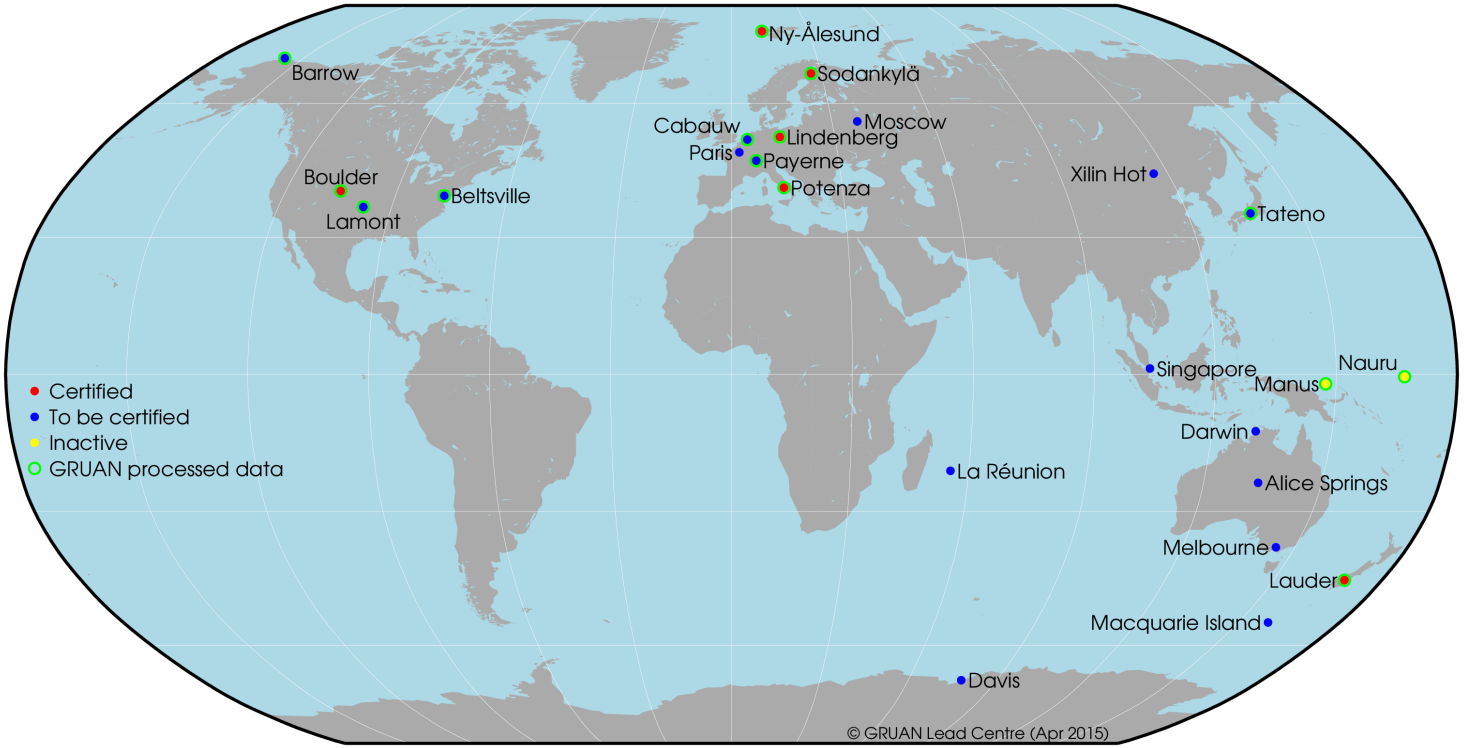
GRUAN data products

- GRUAN data product for Vaisala RS92 radiosonde
- Other RS products under development (Modem M10, Meisei RS11-G, Meteolabor SRS34, Frost point hygrometer)
- Other products & data streams:
  - GNSS total water vapor column [Dick, GFZ]
  - Lidar (T, U) [Le Blanc, JPL]
  - µ-wave radiometer (T, U) [Cimini, CNR]

Current gaps in reference observations

Geographic distribution of GRUAN sites

Wish-list: Africa, Asia, South America, Antarctica, Tropics, Oceans



Current gaps in reference observations

Continuity of measurement programs

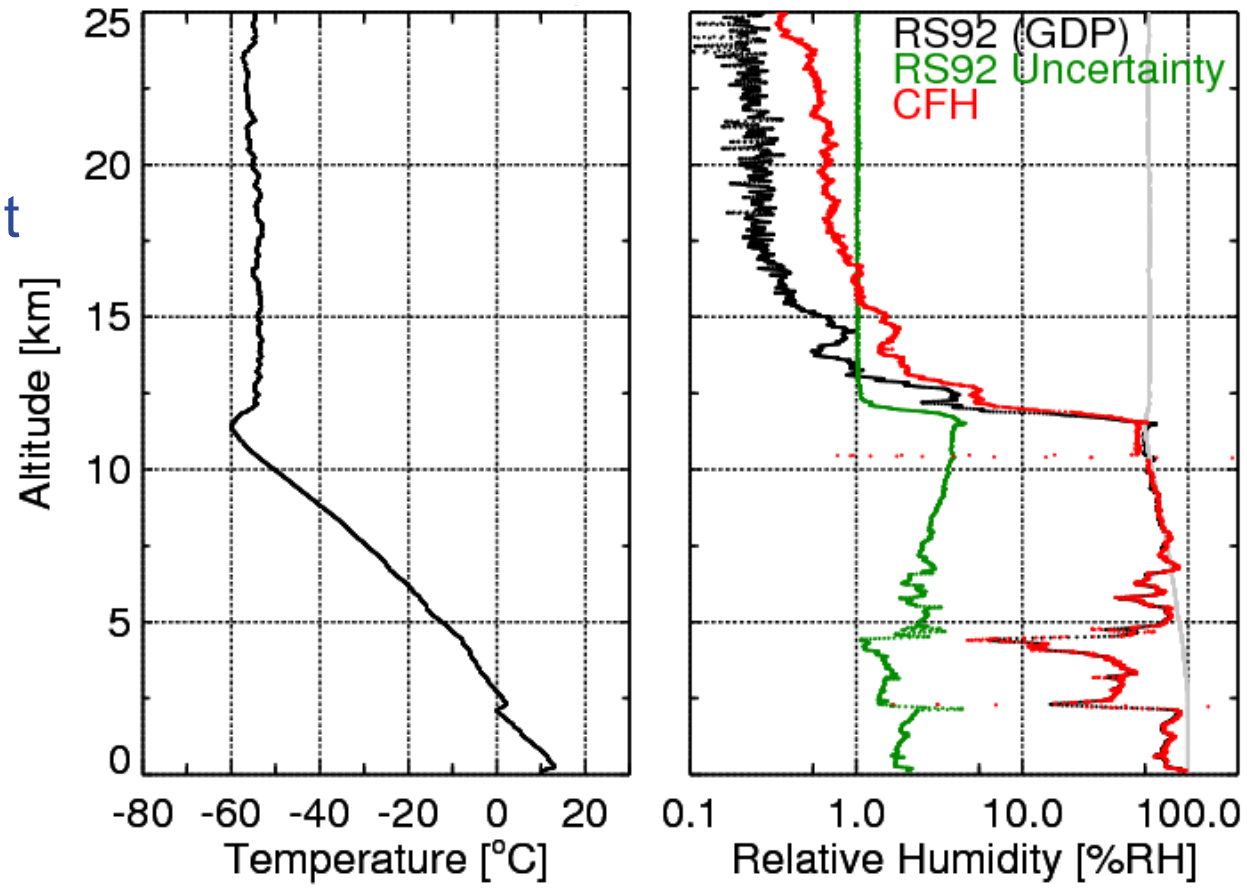
Change management (upcoming RS92-RS41 transition)

Additional radiosoundings coincident/collocated with satellite overpasses (budget)

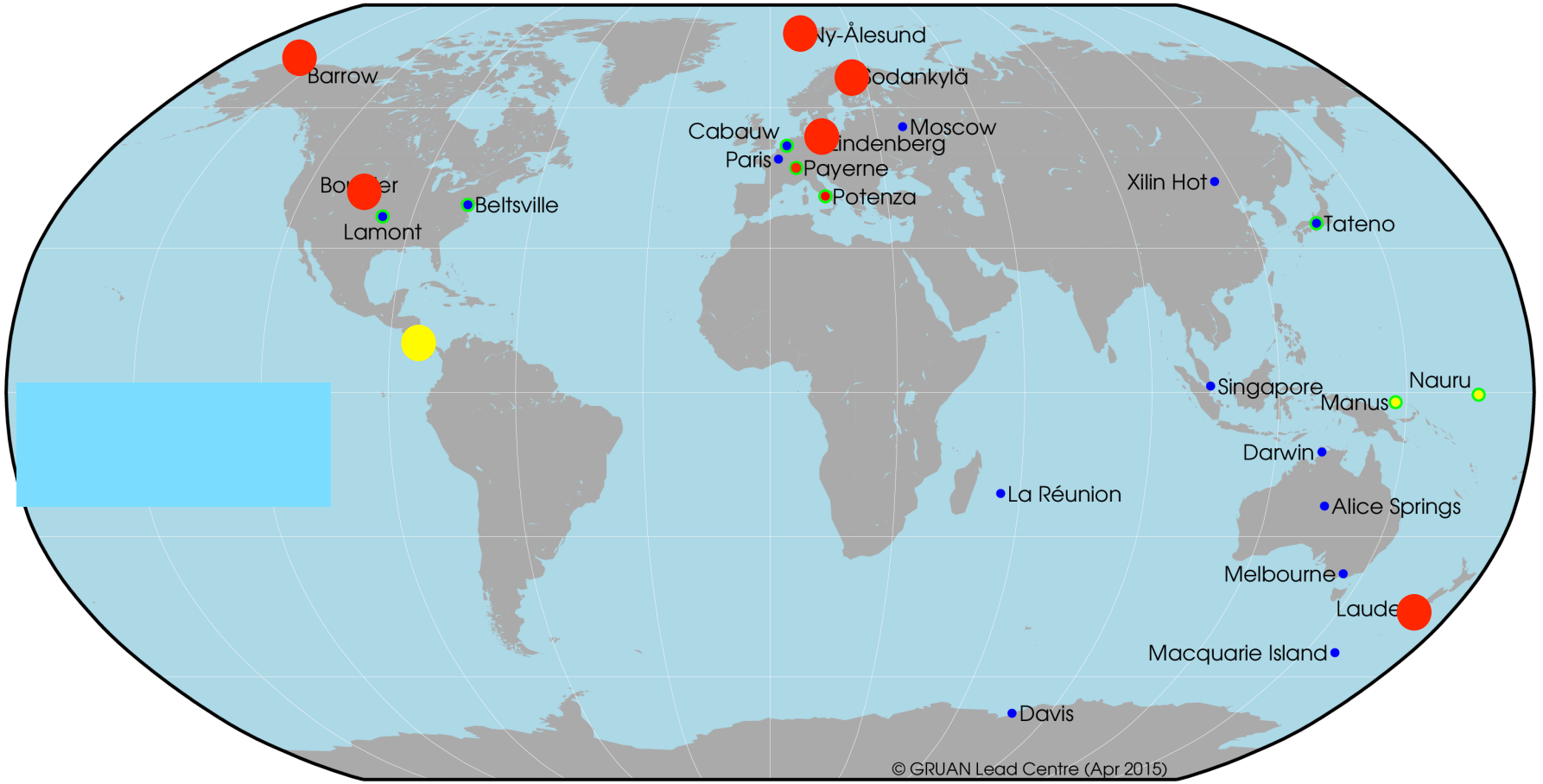
Stratospheric water vapor soundings

- RS92: reliable RH profiles up to UTLS
- Above UTLS: reference instrument (e.g. frost point)

Lindenberg, 22 September 2015



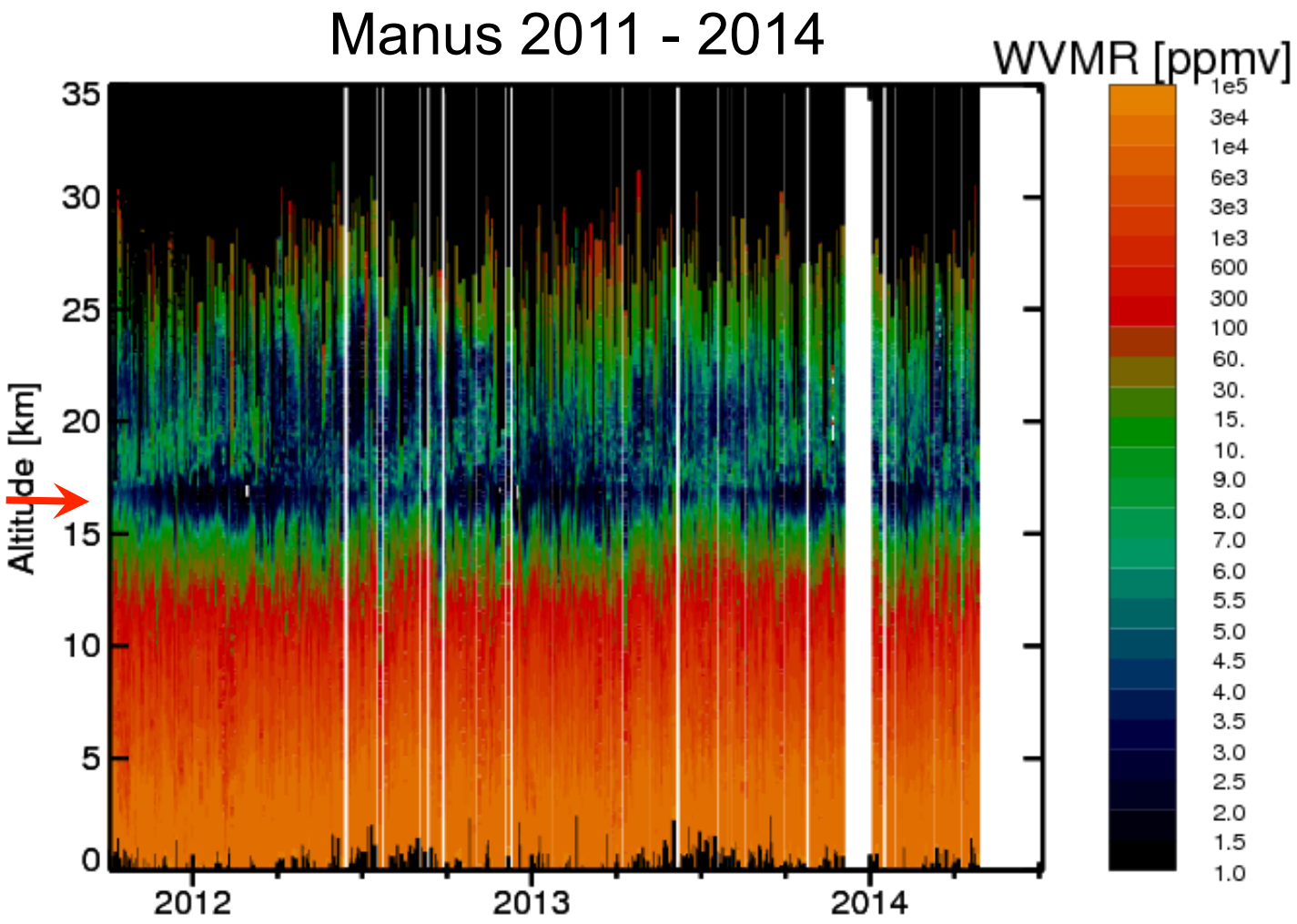
Sites with CFH/FPH soundings



FPH = Frost point hygrometer
CFH = Cryogenic frost point hygrometer

Pushing the limit: RS92 WV profiles

Tropopause



Summary, Gaps & GRUAN products

Instrument	Parameter		Remark
	Temperature	Water vapor	
Radiosonde	0-35km	above tropopause reference instrument needed	
GNSS	--	total column	
lidar	up to ~80km	0-15km	limited global coverage
MWR	up to ~10km	up to ~10km	no reference product yet (uncertainty, traceability)

GRUAN wish list:

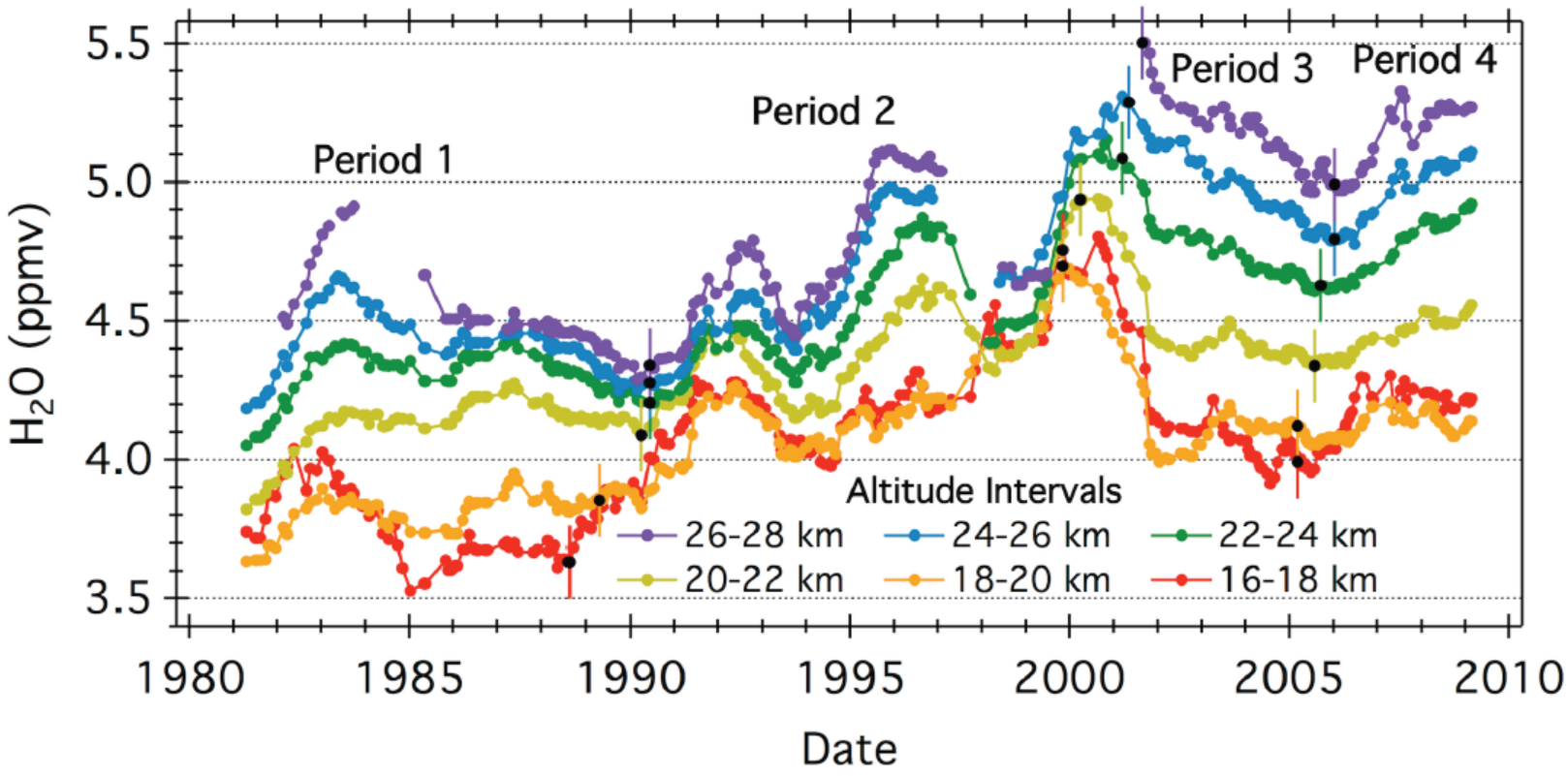
- Expansion in underrepresented areas
- More data products
- Measurements of stratospheric WV profiles

GRUAN is about…

- 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)

www.gruan.org

Stratospheric water vapor over Boulder



Hurst et al. JGR2011

Traceability of humidity measurements

Check in SHC at 100% RH
Instrumental change: 4% over 6 years