The GCOS Reference Upper-Air Network

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What is GRUAN?

The Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) is an international reference observing network, designed to meet climate requirements and to fill a major void in the current global observing system. GRUAN observations will provide long-term, high-quality climate records from the surface, through the troposphere, and into the stratosphere. These will be used to determine trends, constrain and validate data from space-based remote sensors and to provide accurate data for the study of atmospheric processes. GRUAN is envisaged as a global network of 30-40 stations, where possible building on existing observational networks and capabilities.

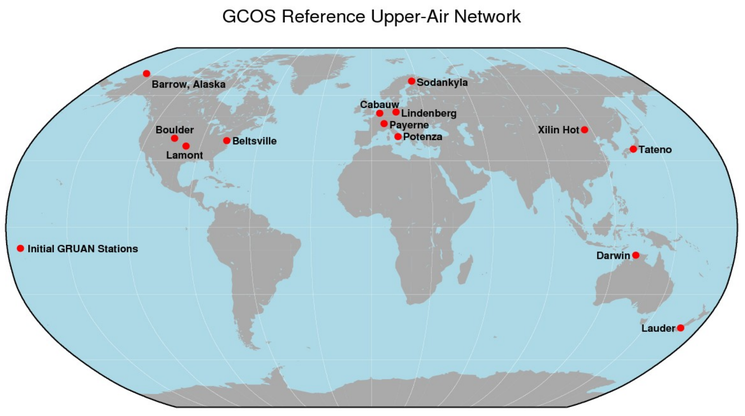
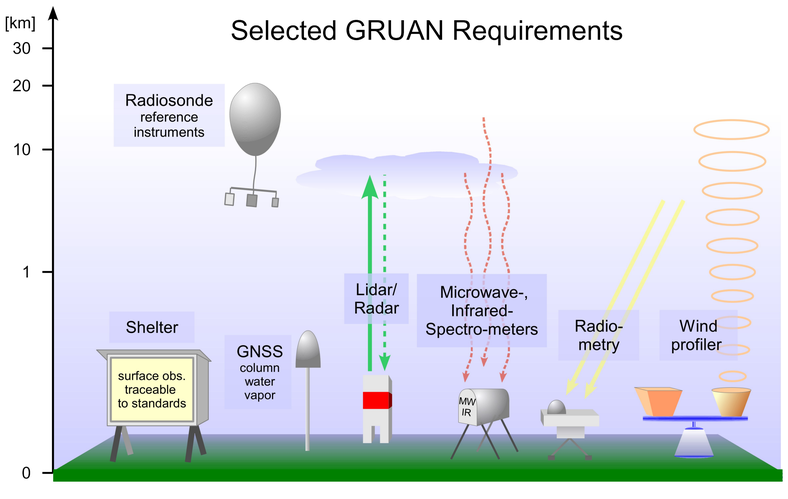


Figure 1: The GRUAN network, initial sites.

GRUAN goals:

- Provide long-term high-quality upper-air climate records
- Constrain and calibrate data from more spatially-comprehensive global observing systems (including satellites and current radiosonde networks)
- Fully characterize the properties of the atmospheric column and their changes (fig.2)
- Measure a large suite of co-related climate variables with deliberate measurement redundancy
- Focus efforts on characterizing observational biases, including complete estimates of measurement uncertainty (fig. 3)
- Ensure traceability of measurements by extended metadata collection and comprehensive documentation of observational methods (fig.4);
- Ensure long-term stability by managing instrumental changes
- Tie measurements to SI units or internationally accepted standards
- Ensure that potential gaps in satellite programs do not invalidate the long-term climate record, thus leading to improved satellite data products
- Further the understanding of climate variability and change.

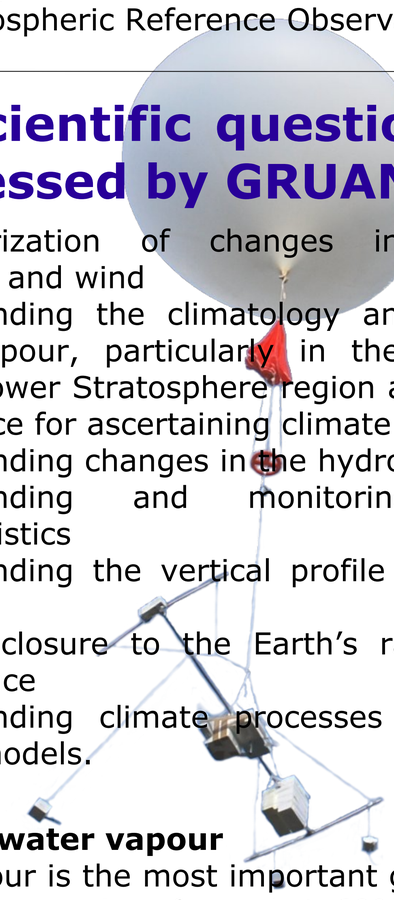


Priority 1: Temperature, Water Vapor, Pressure
Priority 2: Ozone, Wind, Radiation, Clouds, Aerosols, …

Figure 2: Schematic set-up of a GRUAN station

Key scientific questions to be addressed by GRUAN:

- Characterization of changes in temperature, humidity, and wind
- Understanding the climatology and variability of water vapour, particularly in the Upper Troposphere/Lower Stratosphere region as it is of crucial importance for ascertaining climate sensitivity
- Understanding changes in the hydrological cycle
- Understanding and monitoring tropopause characteristics
- Understanding the vertical profile of temperature trends
- Bringing closure to the Earth's radiation budget and balance
- Understanding climate processes and improving climate models.



Example: water vapour

Water vapour is the most important greenhouse gas, as it is responsible for about 60% of the natural greenhouse effect. There are vigorous discussions within the research community whether stratospheric humidity has changed and whether any further change is expected to influence the effect of global warming. At the same time, water vapour measurements, particular in the upper troposphere/lower stratosphere (UTLS) region, are afflicted with high measurement uncertainties. Even key mechanisms are not fully understood, leading to significant deficiencies in the predictive skill of global climate models. Currently, satellites and special research-quality instruments on aircraft and balloon platforms are the main sources of information about UTLS water vapour, and differences among these measurement systems have been difficult to reconcile.

What does reference quality mean?

A GRUAN reference observation:
✓is traceable to an SI unit or an accepted standard
✓provides a comprehensive uncertainty analysis
✓is documented in accessible literature
✓is validated (e.g. by intercomparison or redundant observations)
✓includes complete meta data description

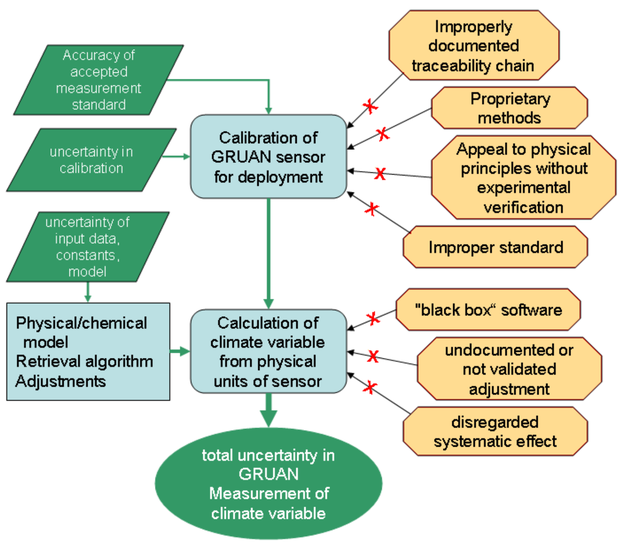


Figure 4: Schematic for establishing reference quality by calibrating to a standard, describing all sources of uncertainty (green) and recording all important meta data. The red boxes contain components jeopardizing traceability (Immler et al., AMT, 2010).

Uncertainty, redundancy, and consistency between observations from different systems provide the tools to continuously evaluate the quality of the observations and are key in the management of system changes. Laboratory studies and field intercomparisons will maintain the high quality of observations and minimize the impact of systematic errors on long term observations.

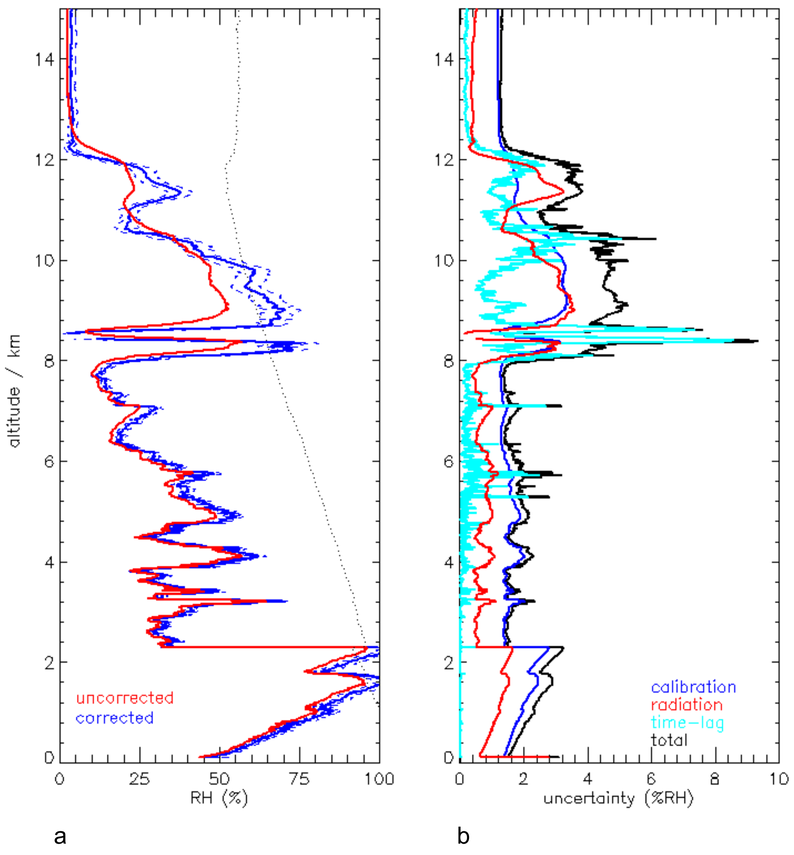


Figure 3 a: Humidity profiles from Vaisala RS92 radiosonde uncorrected (red) and corrected with uncertainties (blue), b: contribution of different sources to total uncertainty (black): calibration uncertainty (blue), uncertainty of the radiation correction, uncertainty of time-lag correction (light blue)

GRUAN Structure

- GCOS/WCRP AOPC Working Group on Atmospheric Reference Observations (WG-ARO)
- GRUAN Lead Centre at the Lindenberg Meteorological Observatory (DWD)
- GRUAN sites world wide (currently 15 to be expanded to 30-40)
- GRUAN task teams for:
  - Radiosondes
  - GNSS-Precipitable Water
  - Measurement schedules and associated site requirements
  - Ancillary measurements
  - Site representation
- GRUAN Analysis Team for Network Design and Operations Research (GATNDOR)

GRUAN Data Products

GRUAN data (beta) based on RS92 Temperature, Humidity and wind measurements available on:
ftp://ftp.ncdc.noaa.gov/pub/data/gruan

More info under www.gruan.org

Partners:

- National contributors (fundamental to success of the enterprise) currently: BoM, CMA, CNR, DOE/ACRF, DWD, FMI, Howard University, JMA, KNMI, MeteoSwiss, NIWA, NOAA, NCAR
- Existing observational networks (NDACC, ARM, GAW, BSRN, GUAN, GSN)
- The Global Space-based Inter-calibration System (GSICS) and The "Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring" (SCOPE-CM) Initiative
- The climate science community
- WMO; its Commission for Instruments and Methods of Observations (CIMO); Commission on Climatology (CCI); Commission for Basic Systems (CBS); The World Climate Research Programme (WCRP)

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GCOS GLOBAL CLIMATE OBSERVING SYSTEM