

# Opportunities and Challenges in Designing a Reference Upper-Air Network in Support of NWP

**GRUAN**



Global Climate Observing System (GCOS)  
Reference Upper Air Network

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*On behalf of GRUAN Network Design Workshop's organizing committee:*

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William Lahoz, NWP white paper leader.

## Outline:

- What is GRUAN?
- What can GRUAN do for the NWP community?
- How can the NWP community help?

# What is GRUAN?

- Network for ground-based **reference** observations **for climate** in the free atmosphere in the frame of GCOS
- Initially 15 stations, envisaged to be a network of 30-40 sites across the globe when GRUAN becomes fully operational in 2013.



See [www.gruan.org](http://www.gruan.org) for more detail

# The goals of GRUAN

The purpose of GRUAN is to:

- Provide long-term high quality climate records;
- Constrain and calibrate data from more spatially-comprehensive global observing systems (including satellites and current radiosonde networks); and
- Fully characterize the properties of the atmospheric column.

Four key user groups of GRUAN data products are identified:

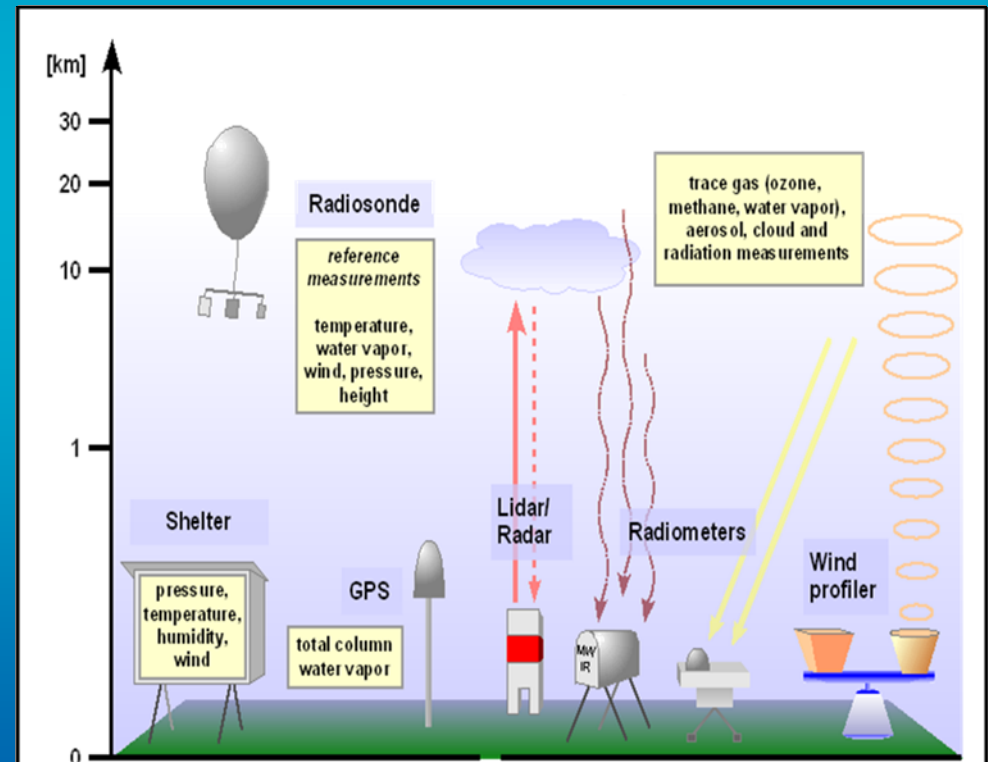
- The climate detection and attribution community.
- The satellite community.
- The atmospheric process studies community.
- The numerical weather prediction (NWP) community.

# GRUAN Measurements and Signatures

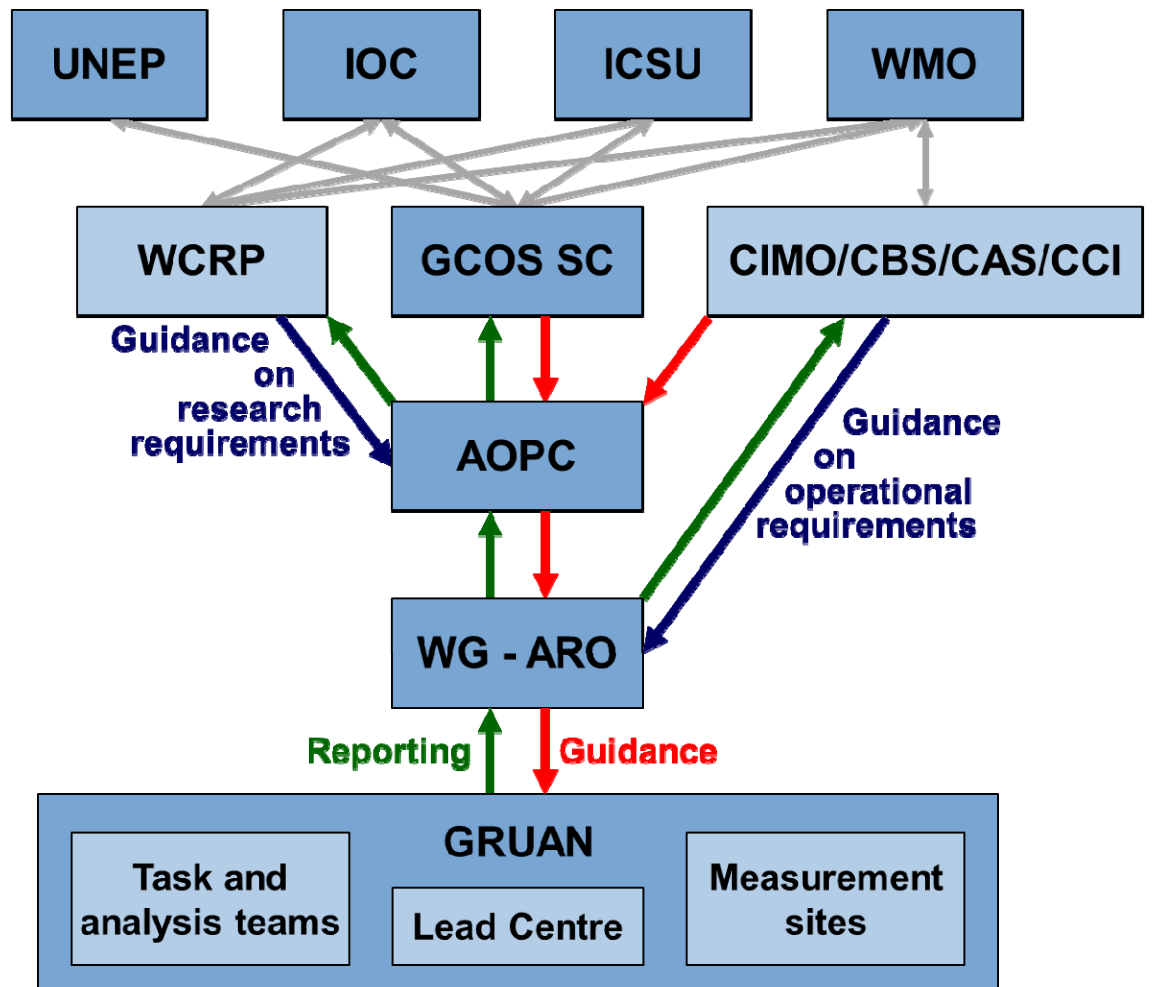
**Priority 1:** Temperature, pressure, water vapour

**Priority 2:** Ozone, methane ...

- ✓ Reference quality
- ✓ Management of change
- ✓ Long-term stability
- ✓ Long-term suitability
- ✓ Redundancy
- ✓ Co-related climate variables



# GRUAN governance



## Notes

1. WCRP identifies scientific and research requirements for GRUAN. WMO identifies operational requirements.
2. Composition of WG-ARO determined in short term by Chair of AOPC in consultation with WMO. Includes representative from each of CIMO, CBS, CAS and CCI. These representatives will be responsible for reporting back to their respective Technical Commission.
3. WG-ARO reports to AOPC
4. GRUAN measurement sites are contributed by member countries of WMO.



# GRUAN focuses on reference observations

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

*Immler, F. J.; Dykema, J.; Gardiner, T.; Whiteman, D. N.; Thorne, P. W. and Vömel, H., Reference Quality Upper-Air Measurements: guidance for developing GRUAN data products. Atmospheric Measurement Techniques, 2010, 3, 1217–1231.*

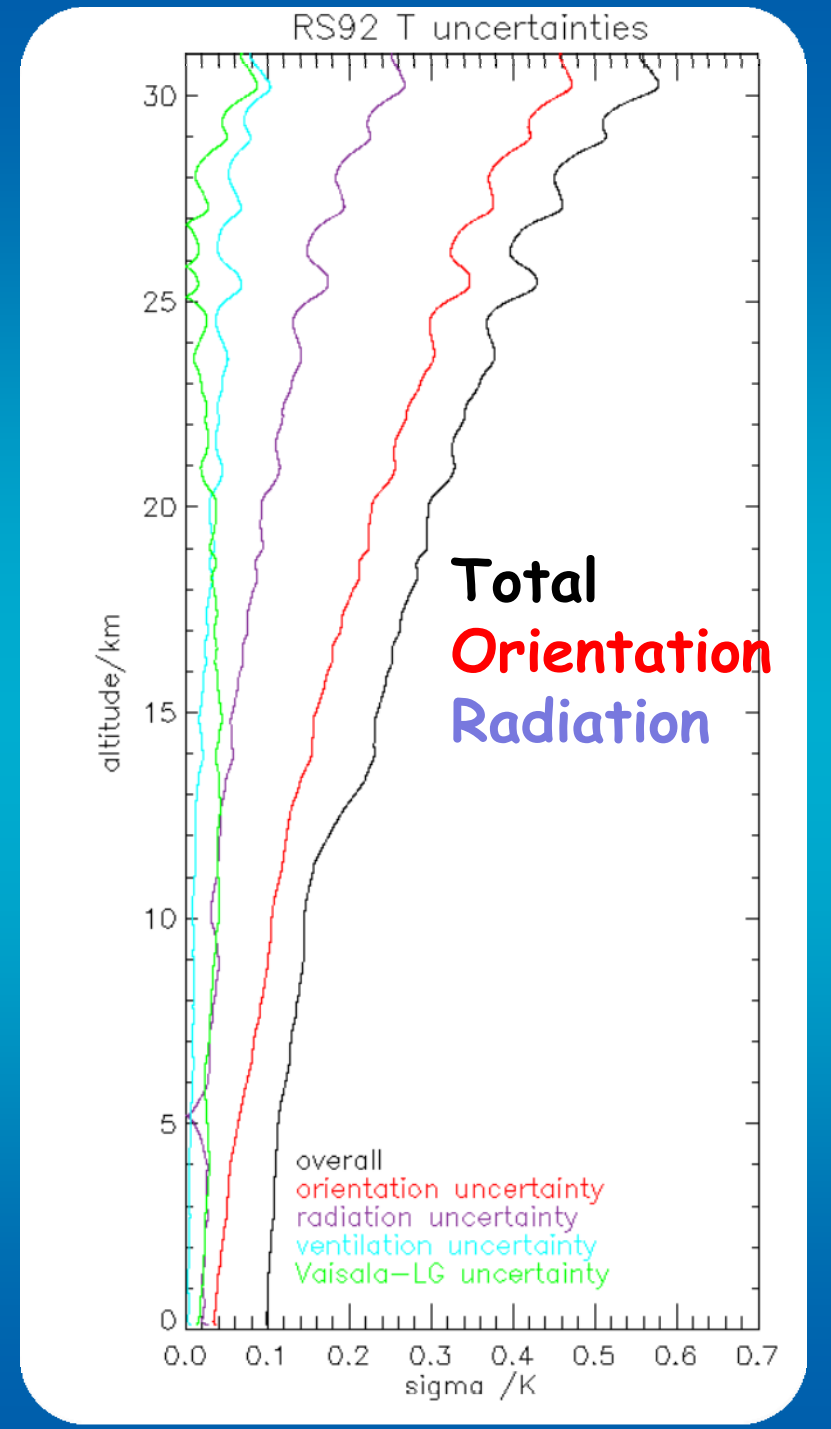
# Uncertainty example: Daytime temperature Vaisala RS92

Steps for uncertainty estimate:

- ✓ analyze sources
- ✓ synthesize best estimate
- ✓ verify in redundant observations

Sources of measurement uncertainty

- Sensor orientation
- Radiative heating of sensor
- Unknown radiation field
- Ventilation
- Ground check
- Calibration
- Time lag





# What can GRUAN do for the NWP community?

How useful are the GRUAN data (the bias correction, uncertainty analysis, high resolution, redundancy, correlated variables)?

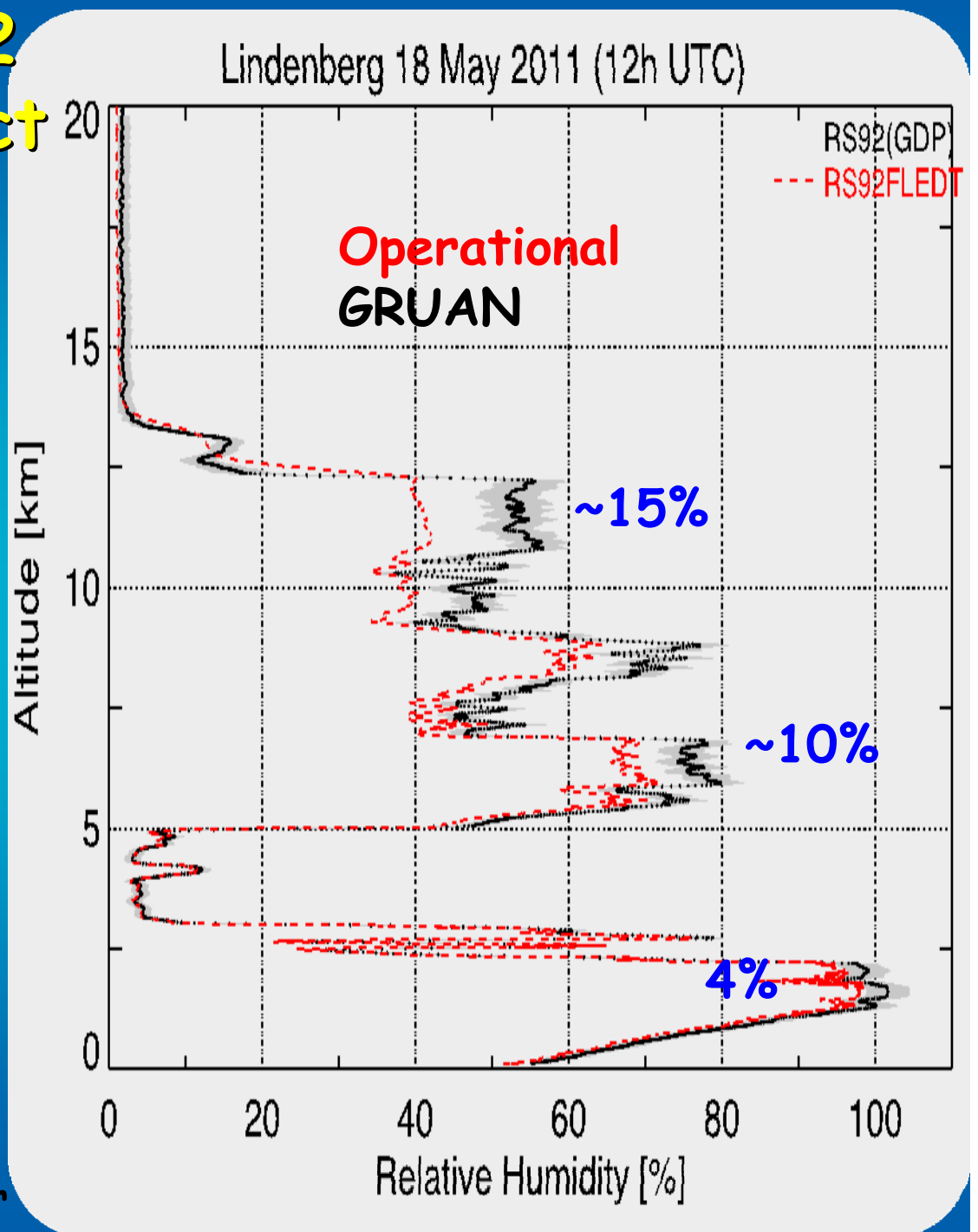
- ✓ To be directly assimilated into NWP models;
- ✓ To verify NWP model outputs;
- ✓ To validate and correct other data being assimilated into NWP models, such as satellite;
- ✓ To assess and develop model parametrizations of key processes (e.g. clouds and, increasingly, aerosols);
- ✓ How useful are the UT/LS water vapor data?
- ✓ To select new GRUAN sites to serve the NWP.

# First: Vaisala RS92 GRUAN Data Product

- ✓ Known biases removed for all variables;
- ✓ Uncertainty values for each data point;
- ✓ Consistency through a single data processing center;
- ✓ Detailed metadata;
- ✓ Correlated multiple variables.

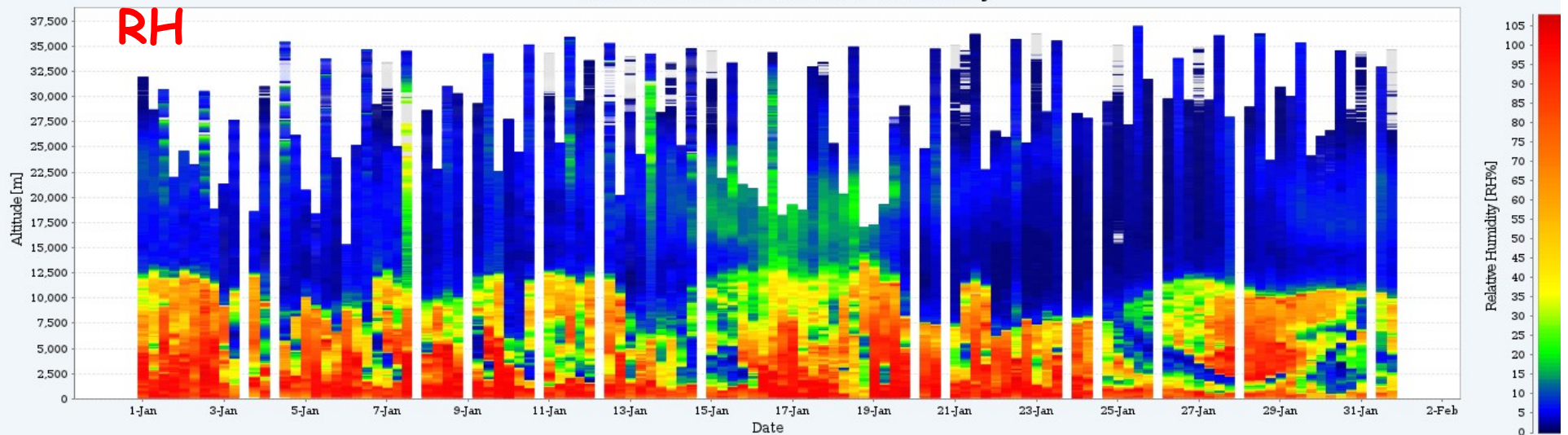
Next: GRUAN Lidar &  
GPS-PW Products

Courtesy of Michael Sommer

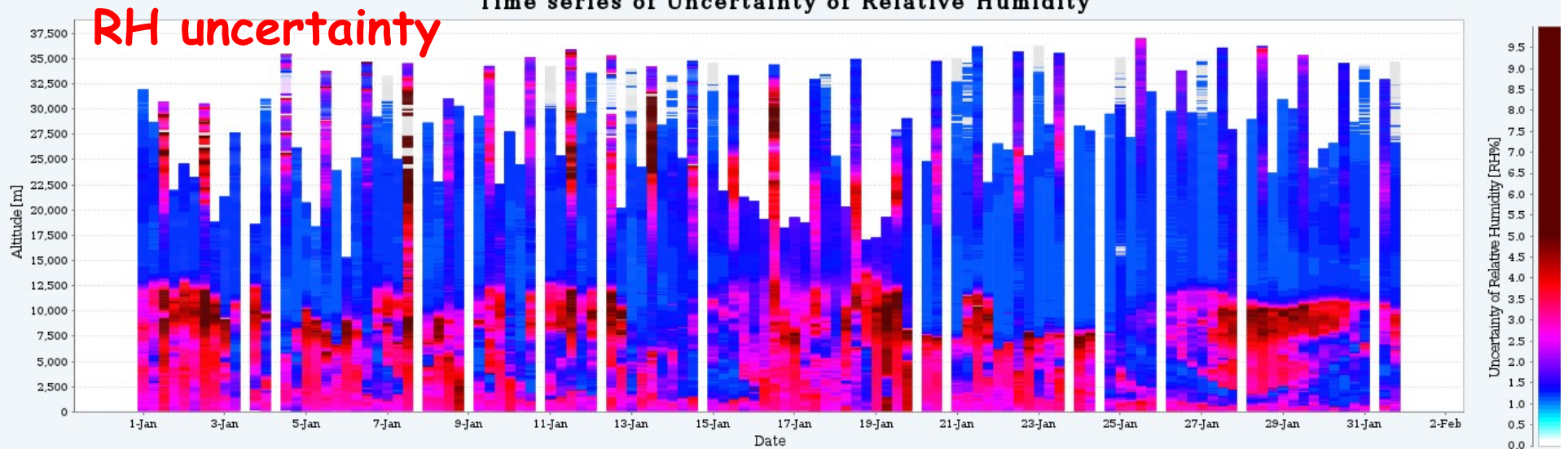


# Vaisala RS92 GRUAN Data Product (01/2012, Lindenberg)

Time series of Relative Humidity



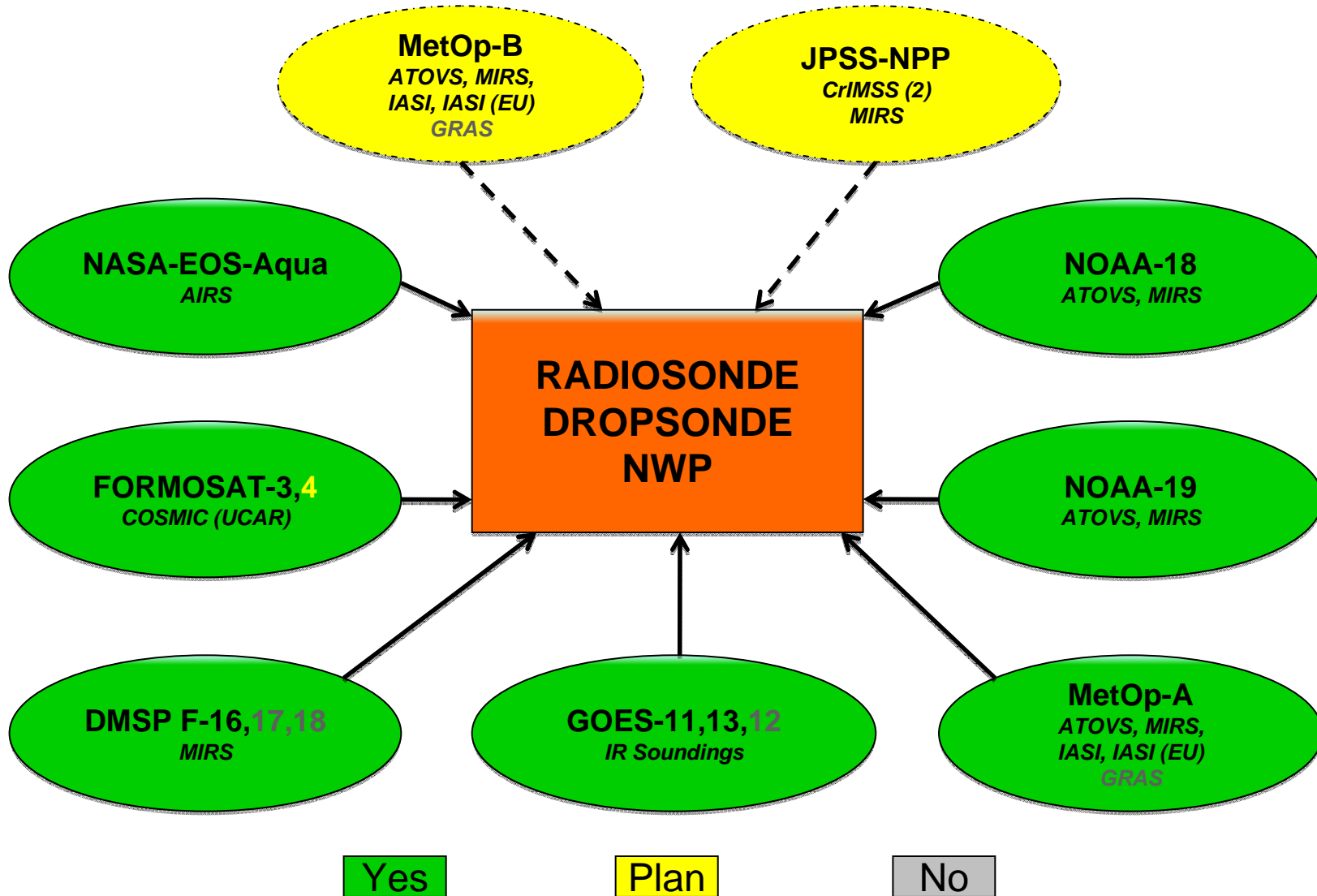
Time series of Uncertainty of Relative Humidity







# NOAA Products Validation System (NPROVS)

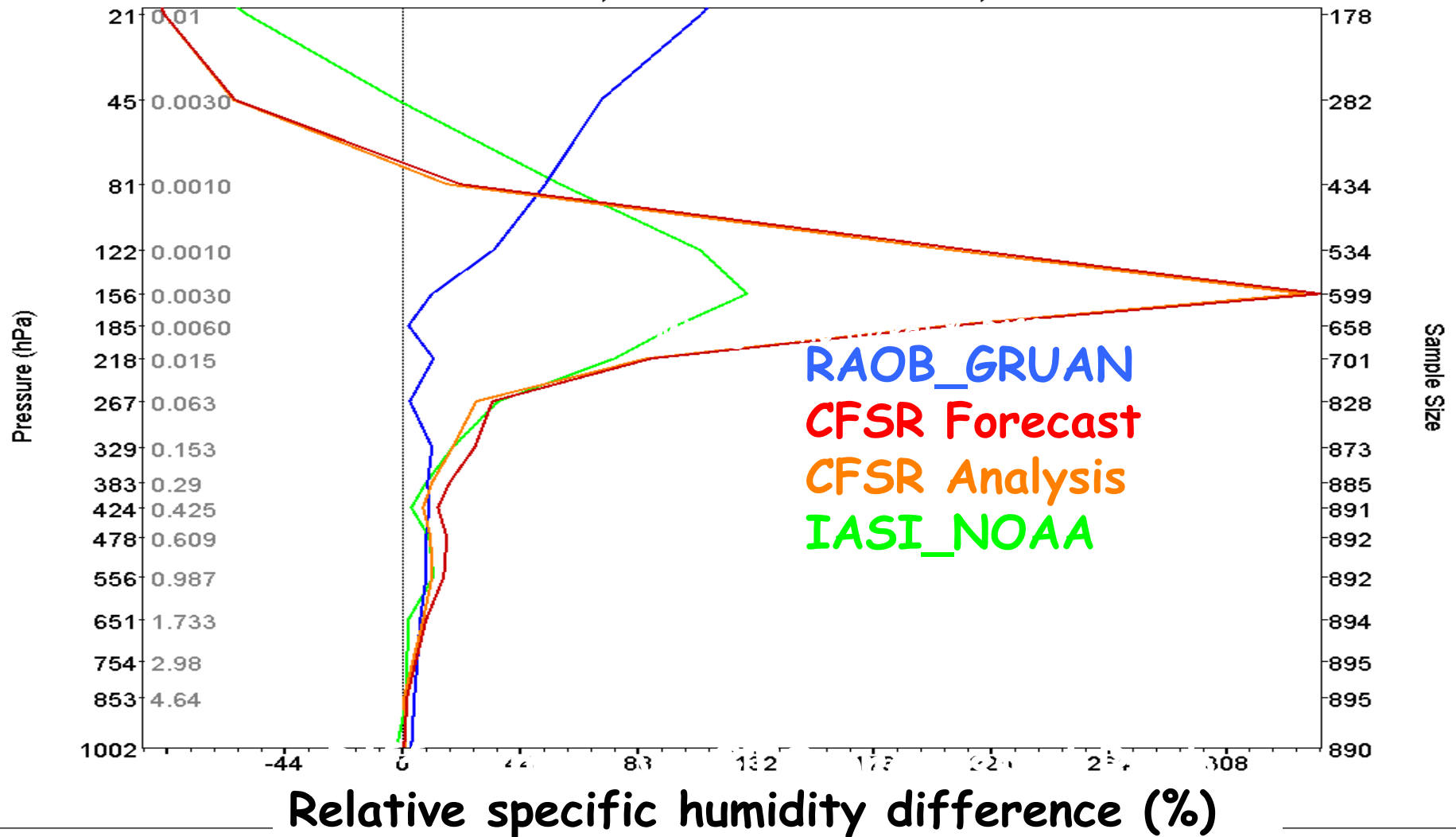


Tony Reale, NOAA/NESDIS



# Comparisons of humidity (CFSR/RAOB\_GRUAN/IASI – RAOB\_GTS) (Lindenberg, Germany; Tateno, Japan; 2011)

December 31, 2010 to December 30, 2011





# How can the NWP community help?

- ✓ To help us answer the question of how useful the GRUAN data (and analysis methods) is to NWP, (verification, directly assimilation, ...)?
- ✓ To perform experiments (OSSEs, ...) both for network design and evaluation of the value of accurate uncertainty measures on NWP;
- ✓ To provide advices on what GRUAN data are needed for real-time assimilation;
- ✓ To select new GRUAN sites to serve the NWP;
- ✓ TO GET INVOLVED!

# Overview of GRUAN Network Design Workshop

**When:** 13-15 June 2012

**Where:** Fürstenwalde, Germany

**Expected number of attendees:** 25

**Purpose:** Understand the network design requirements to meet the needs of four primary users of GRUAN data, Climate monitoring, Satellite, Atmospheric processing, NWP communities.

**Goal:** Engage key representatives from each community to develop a series of 4 whitepapers that can guide decision making regarding expansion of GRUAN from 15 to ~40 sites.



# GRUAN White Paper to Develop Network Design and Expansion Criteria to meet the needs of Numerical Weather Prediction

William Lahoz, David Tan, Bill Bell, Andrew Charlton-Perez,  
Domenico Cimini, Ulrich Löhnert

1. To identify the needs of the NWP community regarding the use of GRUAN data products.
1. To discuss the use of various concepts (OSEs; OSSEs; ensemble data assimilation impact studies) to
  - help design additions to the GRUAN network,
  - test various configurations of the GRUAN network,
  - evaluate and quantify the added value of these configurations
3. To provide first order estimates of the cost of the various network configurations.

Courtesy of William Lahoz

## Conclusions

- GRUAN is a new approach to long-term reference observations of upper air essential climate variables
- Reference quality of GRUAN data makes them useful for verifying NWP model outputs, and for validating and correcting other data being assimilated into NWP models. GRUAN data can also be directly assimilated into NWP models.
- There are many ways to become involved in GRUAN activities at this very exciting stage in GRUAN development.

# Web based tool for collecting data



Name:

Email:

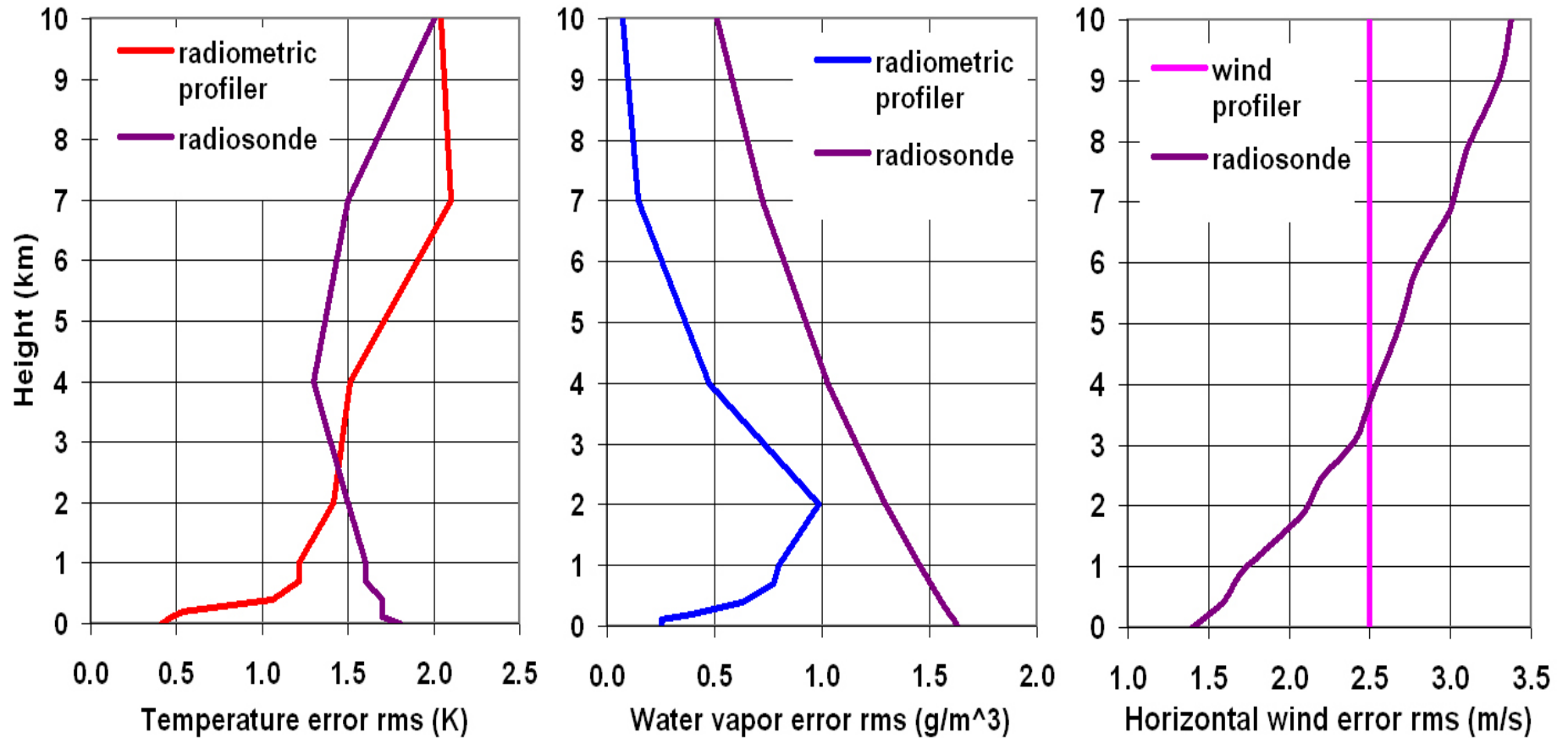
Community:

Comments:

#### Acronyms of Networks

- ARM : Atmospheric Radiation Measurement programme
- GAW : Global Atmospheric Watch
- GRUAN : GCOS Reference Upper Air Network (shown in yellow)
- GUAN : GCOS Upper Air Network
- NDACC : Network for the Detection of Atmospheric Composition Change
- WOUDC : World Ozone and UV Data Centre

<http://notus.bodekerscientific.com/gruan/survey.html?>



Radiometric profiler, wind profiler, and radiosonde sounding error.

Profiler errors are determined by statistical comparison with radiosondes [Guldner and Spänkuch, JAOT 18, 2001; Weber and Wuertz, JAOT 7, 1990]. Radiosonde errors are provided by NCEP

<<http://lnx21.wwb.noaa.gov/oberr/reanl-obs.html>>.

From Stick Ware and Francois Vandenberghe

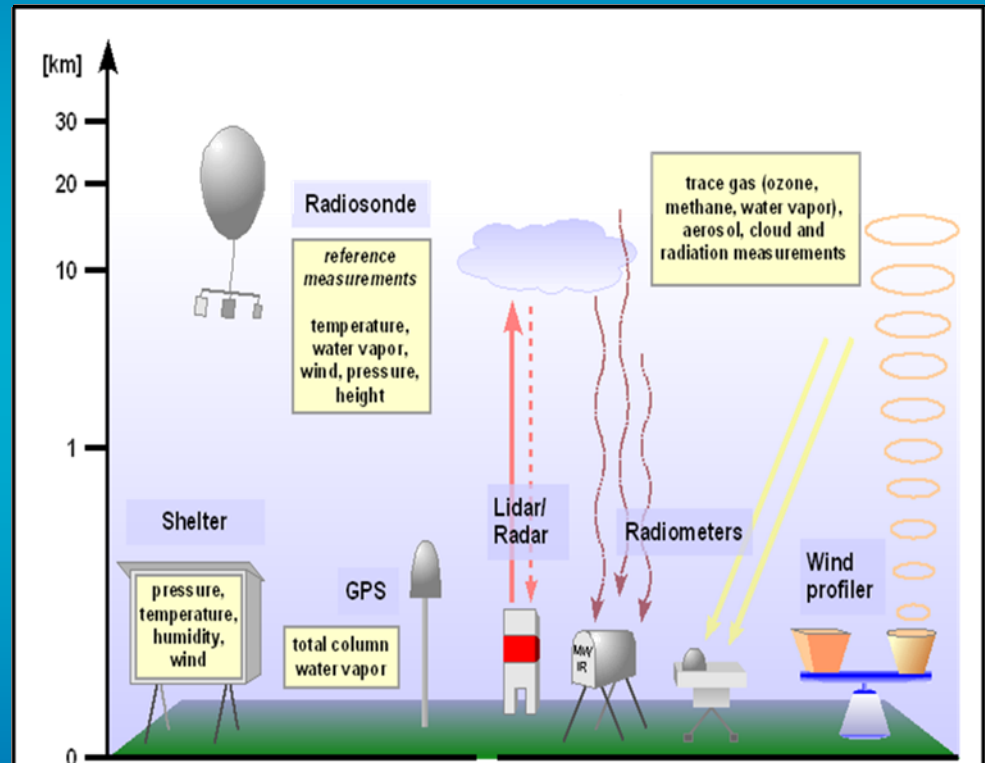


# More about goals of GRUAN

- Maintain observations over **several decades** for accurately estimating climate variability and change
- Focus on characterizing observational **biases**, including complete estimates of **measurement uncertainty**
- Ensure **traceability** of measurements by comprehensive meta-data collection, documentation, and traceability
- Ensure **long-term stability** by managing instrumental changes
- Tie measurements to **SI** units or internationally accepted standards

**Priority 1:** Temperature, pressure, water vapour

**Priority 2:** Ozone, methane ...



- Measure a large suite of **co-related climate variables** with deliberate measurement redundancy

# Vaisala RS92 GRUAN Data Product

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