# Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN)

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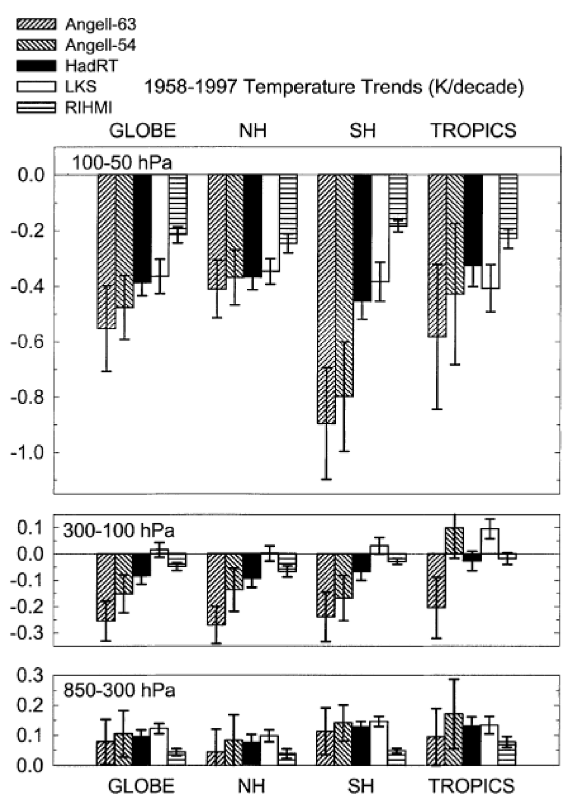
## History

1970s – ARL pioneers monitoring upper-air climate and stratospheric ozone, primarily using radiosonde and ozonesonde data archives.

1990s – Recognition of data quality and continuity problems, particularly for humidity but also for temperature and ozone, by ARL and others

2000s – ARL and others advocate for reference upper-air instruments and a reference upper-air climate network




**Uncertainty in global upper-air temperature trends due to lack of reference observations.** Plots compare radiosonde-derived temperature trends from different datasets and research teams. The wide spreads and large error bars are prime arguments for establishing a reference upper-air network.

Seidel, D.J., J.K. Angell, J. Christy, M. Free, S.A. Klein, J.R. Lanzante, C. Mears, D. Parker, M. Schabel, R. Spencer, A. Sterin, P. Thorne, and F. Wentz, 2004: **Uncertainty in signals of large-scale climate variations in radiosonde and satellite upper-air temperature datasets**, *J. Climate*, 17, 2225-2240.

## GRUAN Goals

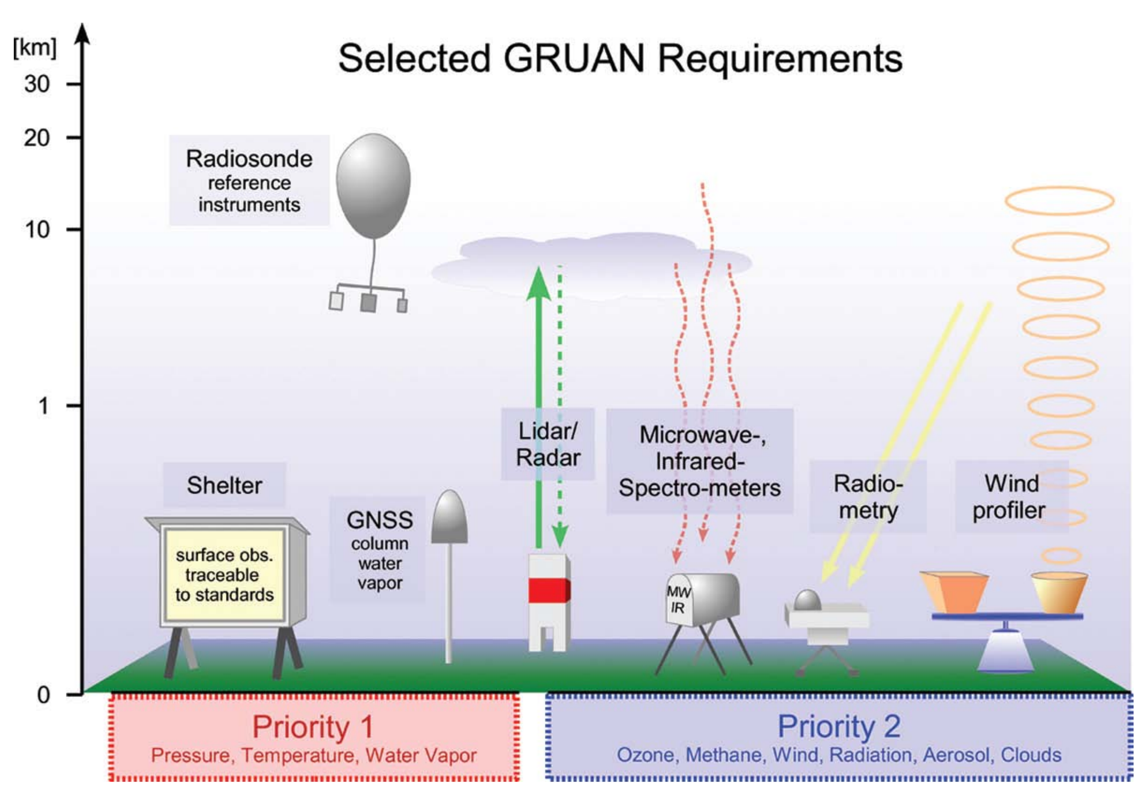
➢Develop and sustain an international reference network designed specifically to meet climate requirements

➢Provide long-term, high-quality, upper-air climate records, with complete estimates of measurement error

➢Constrain and adjust data from more spatially comprehensive global observing systems (including satellites and radiosonde networks)

➢Fully characterize the atmospheric column and its changes

➢Ensure that potential gaps in satellite programs do not invalidate the long-term climate record




Seidel,D.J., F.H. Berger, H. Diamond, J. Dykema, D. Goodrich, F. Immler, W. Murray, T. Peterson, D. Sisterson, M. Sommer, P. Thorne, H. Vomel, J. Wang, 2009: **Reference upper-air observations for climate: Rationale, progress, and plans.** *Bull. Amer. Meteorol. Soc.*, 90, DOI: 10.11752008BAMS2540.1

## Accomplishments

### ➢Foundational Workshops to Define GRUAN (2005-2008)

•Feb 2005 Boulder, CO – identified the climate observation requirements of a reference upper-air network

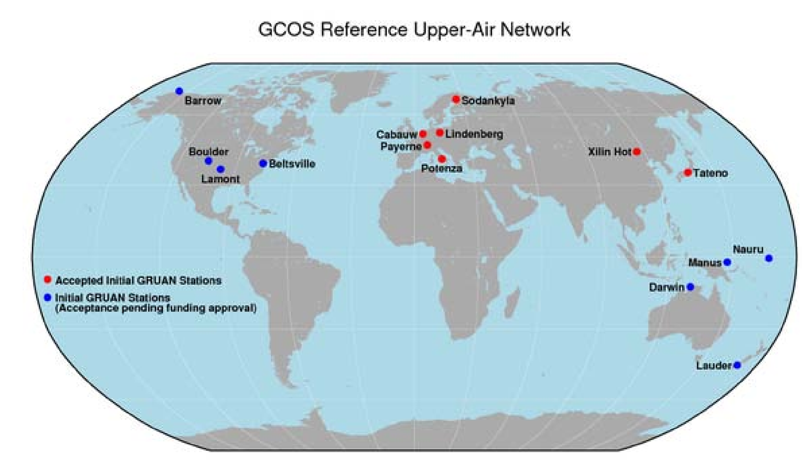
•May 2006 Seattle, WA – explored potential technologies and networks that could meet the stated requirements

•Feb 2008 Lindenberg, Germany - reached decisions on instrumentation, observing protocols, management issues

### ➢Establishment of GRUAN Lead Centre at Lindenberg (2008)

### ➢Development of Reference Radiosondes by Commercial Manufacturers

### ➢Growth of the Network (2008-2011)

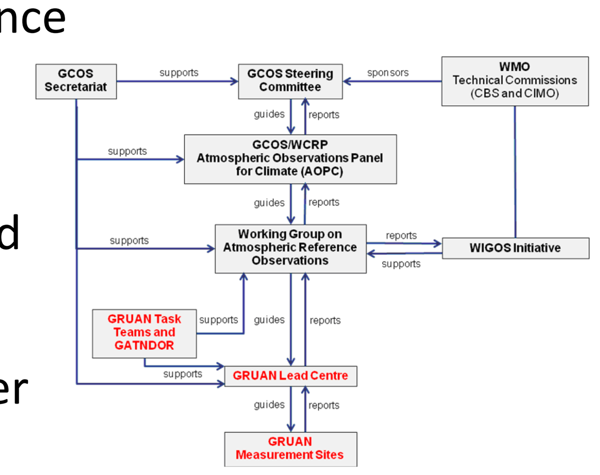



## ARL Leadership in GRUAN

➢GCOS Working Group on Atmospheric Reference Observations, which provides oversight and guidance to GRUAN (Member 2006-2011)

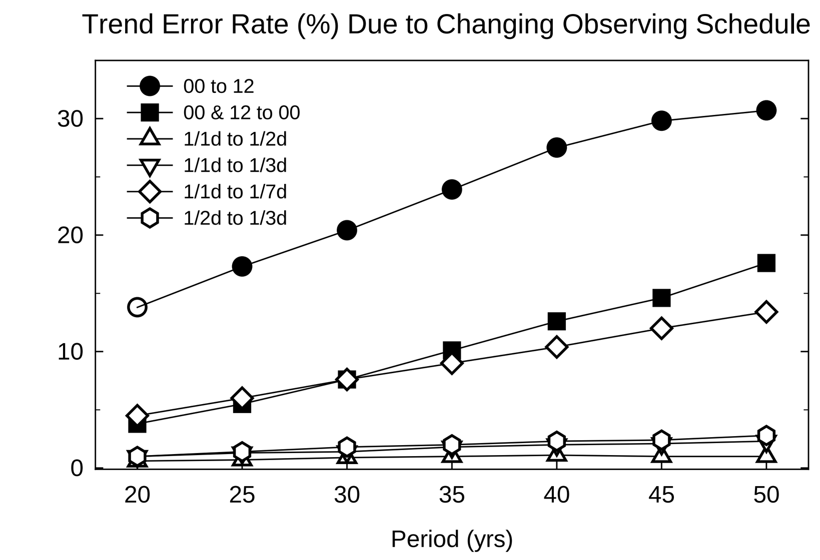
➢GRUAN Analysis Team for Network Design and Operations Research (Chair 2009 -2011 )

➢GRUAN Task Team on Site Evaluation (Member 2010-2011)



**Participants in Workshop on the Implementation of the GCOS Reference Upper Air Network, February, 2008.** Scientists and program managers pose in the balloon launch shed at the historic Richard Assmann Observatory in Lindenberg, Germany.

## ARL Research in Support of GRUAN



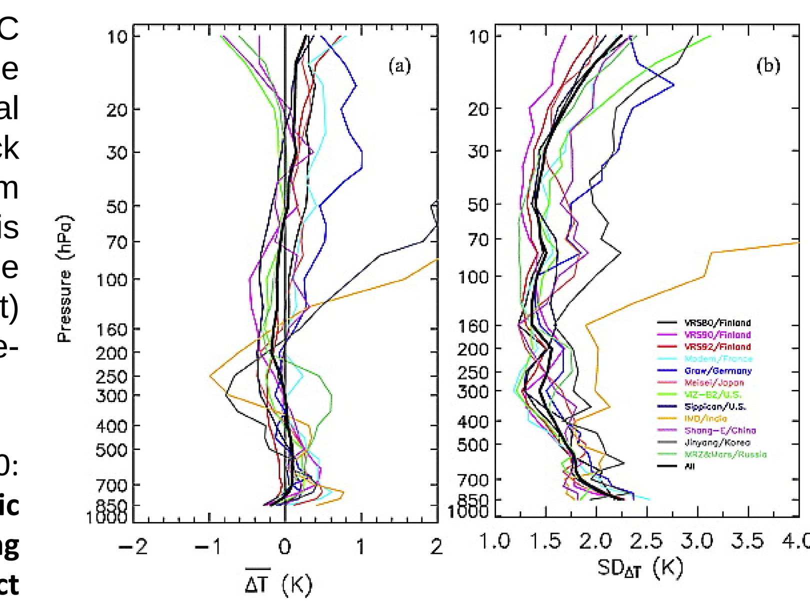

**The importance of consistent methods of observation**

Plot shows the effects of changes in observation schedule on temperature trend detection. Reanalysis data were manipulated to simulate the effects of schedule changes on multi-decadal temperature trends. Schedule changes can introduce inhomogeneities in time series that result in trend errors (when trends in altered time series are statistically significantly different from trends in unaltered time series) for trend periods ranging from 20 to 50 years. Effects of changes in the time of observation (from 00 to 12 UTC or from 00 and 12 UTC to 00 UTC only) are shown by filled symbols, and changes in the number of days per month sampled are shown by open symbols.

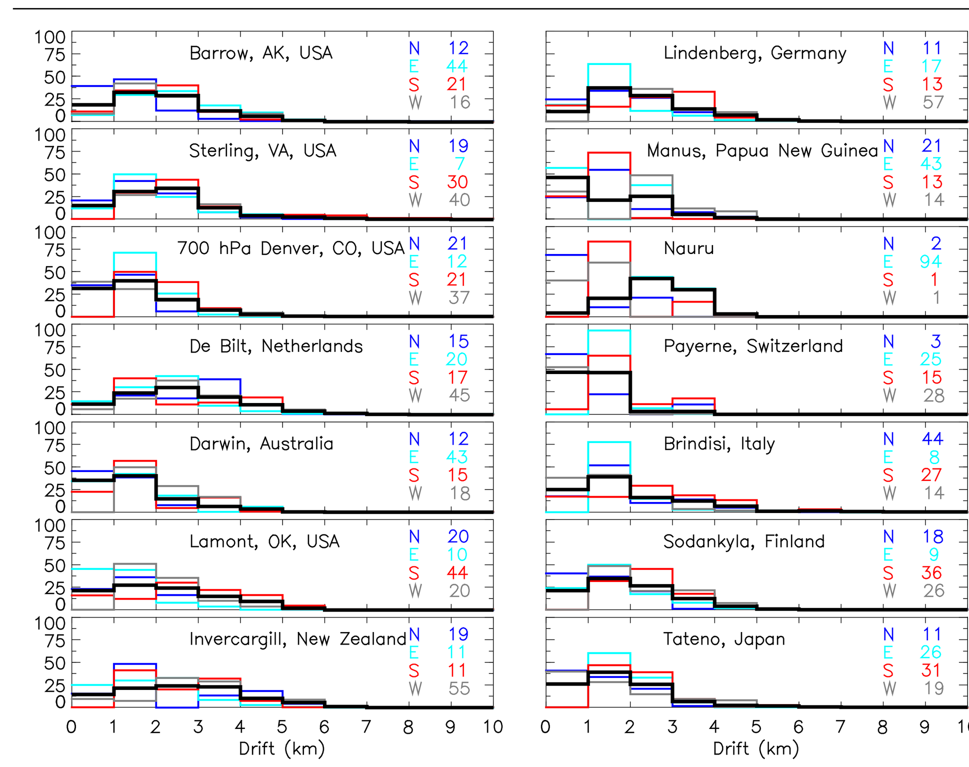
Seidel, D. J., and M. Free, 2006: **Measurement requirements for climate monitoring of upper-air temperature derived from reanalysis data.** *J. Climate*, 19, 854-871.

**The use of reference observations to characterize uncertainty**

Plots compare radiosonde and COSMIC temperature profiles, by radiosonde type (colored curves) and the average for global radiosonde network average (heavy black curves). Radio occultation observations from COSMIC served as a reference for this analysis, and similar methods could be applied to GRUAN observations. Mean (left) and standard deviation (right) of radiosonde-minus-COSMIC temperature difference.




Sun, B., A. Reale, D. J. Seidel, and D. C. Hunt, 2010: **Comparing radiosonde and COSMIC atmospheric profile data to quantify differences among radiosonde types and the effects of imperfect collocation on comparison statistics.** *J. Geophys. Res.*, 115, D23104, doi:10.1029/2010JD014457.




The figure shows histograms of the frequency of balloon drift distances (km) at 850 hPa for 14 radiosonde stations, each collocated with or near a GRUAN site. Results are based on all data (black) and data segregated by wind direction (colors).

Seidel, D. J., B. Sun, M. Pettey, A. Reale, 2011: **Radiosonde balloon drift statistics.** *J. Geophys. Res.*, 116, D07102, doi:10.1029/2010JD014891.

**Balloon Drift Climatology**

Radiosondes launched at GRUAN sites will drift with prevailing winds, which impacts:

(1) Retrieval of expensive reference sondes

(2) Comparison of radiosonde observations with those from other observing systems, and

(3) Merging observations from nearby sub-sites.

For these applications, we have developed a global climatology of balloon drift, including its variability with height, season, and latitude.