GCOS Reference Upper Air Network: Toward Characterizing Uncertainty in Atmospheric Profile Observations Associated with Collocation of Measurements

Dian J. Seidel[1], Alessandro Fassò[2], Franz Immler[3], Tony Reale[4], Bomin Sun[4,5]

(1) NOAA Air Resources Laboratory, Silver Spring, Maryland, USA (2) Dept. of Information Technology and Mathematical Methods, University of Bergamo, Dalmine, Italy

(3) GRUAN Lead Center, Deutscher Wetterdienst, Lindenberg, Germany (4) NOAA Center for Satellite Applications and Research, Camp Springs, Maryland, USA (5) I.M. Systems Group, Rockville, Maryland, USA

Problem

How should we combine multiple instrument uncertainties and collocation uncertainty to obtain overall uncertainty in atmospheric profiles?

Underlying issues:

•The cornerstone of GRUAN is complete characterization of uncertainty in atmospheric profile measurement (Immler et al. 2010).

•No one instrument provides best-quality observations through the troposphere and stratosphere.

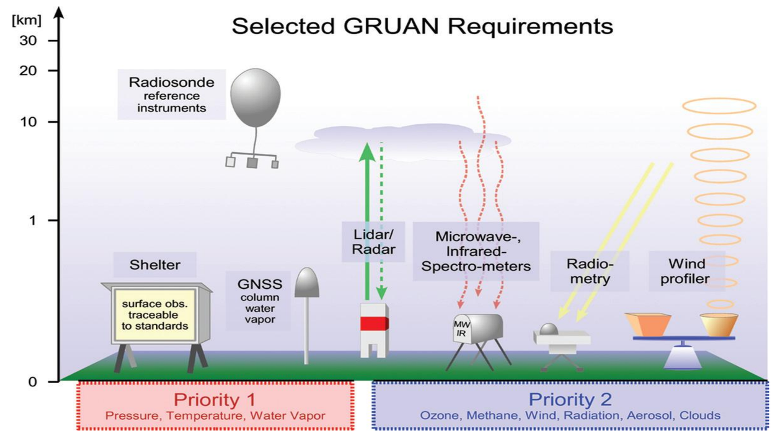
•Overall uncertainty estimates must account for the uncertainties in each measurement system.

•Observations from different sensors do not sample identical air parcels, which complicates the estimation of overall uncertainty.

•There is no well-established methodology for combining uncertainties of imperfectly collocated observations.

GRUAN sites have redundant measurements of a given parameter by different instruments, with different uncertainties, and with imperfectly matched spatial and temporal sampling.

(Figure from Seidel et al.. *Bull. Amer. Meteorol. Soc.*, 2008)



Approach

The GRUAN Analysis Team for Network Design and Operations Research (GATNDOR) has undertaking a series of studies, with the ultimate goal of developing a tool for estimating overall uncertainty in GRUAN observations.

1. Quantify uncertainty in temperature and humidity observations from radiosondes, using profiles from Global Navigational Satellite System Radio Occultation (GNSS/RO) as a reference. (Sun et al. 2010)
2. Develop statistics of uncertainties associated with space and time collocation differences. (Sun et al. 2010)
3. Develop radiosonde balloon drift statistics for estimating collocation mismatches. (Seidel et al. 2011)
4. Develop a tool to obtain overall uncertainty by combining (radiosonde and other) instrumental uncertainties with collocation uncertainty. (In progress)

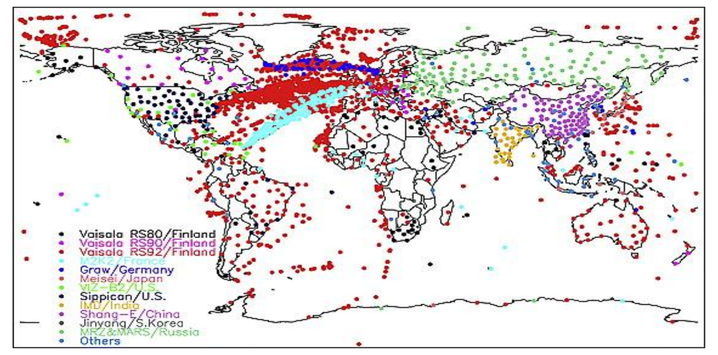
References

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, doi:10.5194/amt-3-1217-2010.

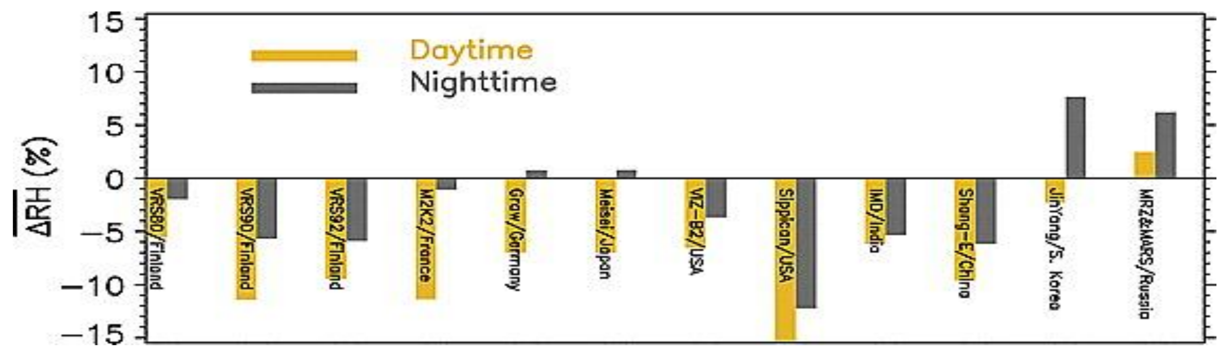
Seidel, D. J., B. Sun, M. Pettey, A. Reale, 2011: **Radiosonde balloon drift statistics**. *J. Geophys. Res.*, 116, D07102, doi:10.1029/2010JD014891.

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.

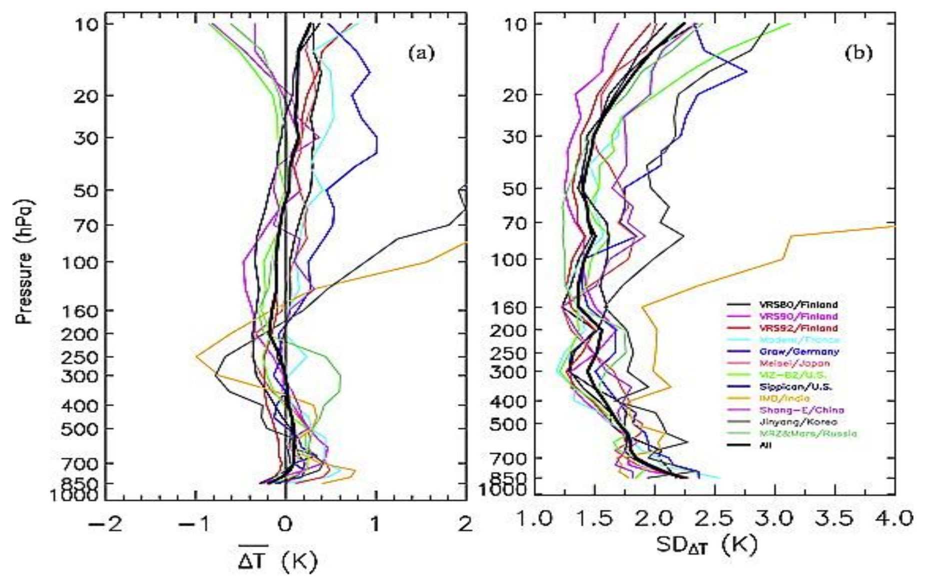
Uncertainties in Radiosonde Observations Derived via Comparison with GNSS/RO Profiles



Radiosonde observations collocated with COSMIC soundings (± 7 h, 250 km), 4/2008-10/2009.



Raob-minus-COSMIC 300 hPa **relative humidity** differences for different radiosonde types for daytime and nighttime



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; similar methods could be applied to GRUAN observations.

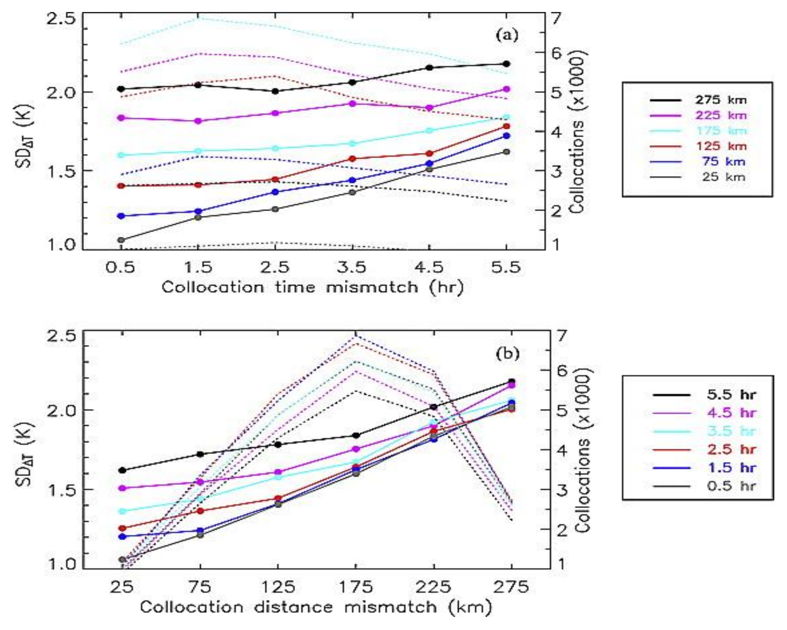
Mean (left) and standard deviation (right) of radiosonde-minus-COSMIC temperature difference.

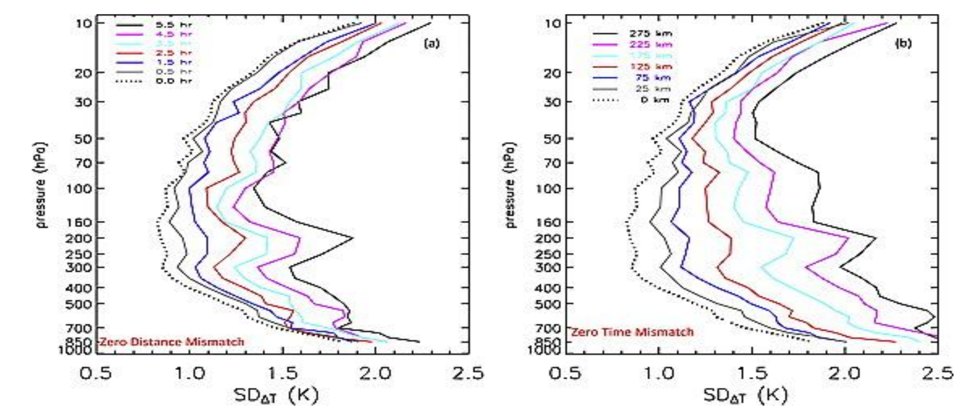
Uncertainties Associated with Collocation Mismatch

The standard deviation of raob-minus-COSMIC temperature difference ($SD_{\Delta T}$) is a measure of uncertainty associated with the mismatch in the collocation of the two observations.

Dependence of 300 hPa $SD_{\Delta T}$ on time and distance collocation mismatch shows that collocation uncertainty increases as mismatch time or distance increases, due to atmospheric variability.

Dotted curves show the number of collocations used to compute $SD_{\Delta T}$.





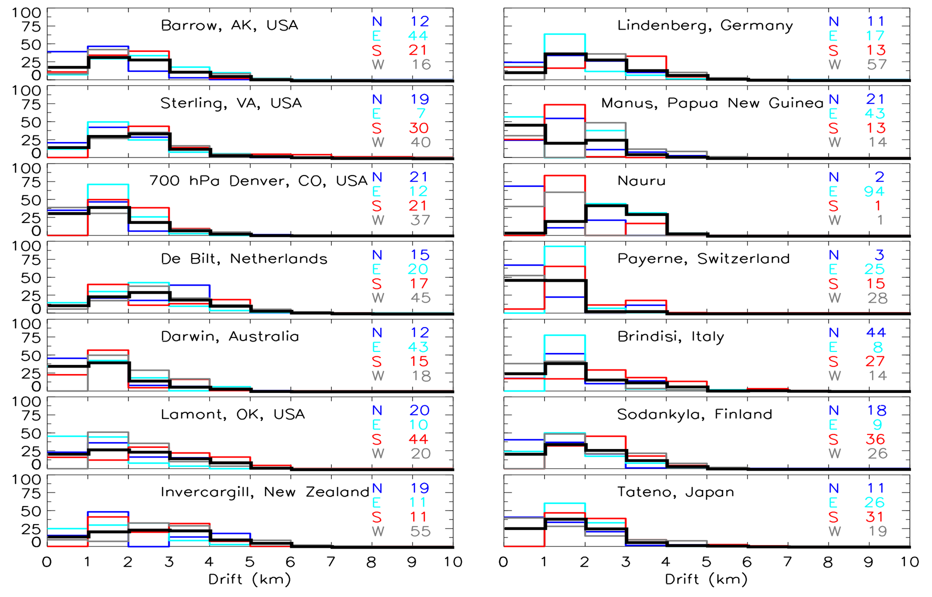
Vertical profiles of $SD_{\Delta T}$ show greatest mismatch uncertainty in the lower troposphere (where atmospheric variability is high) and stratosphere (where sonde measurement uncertainty is large).

Global Radiosonde Balloon Drift Statistics

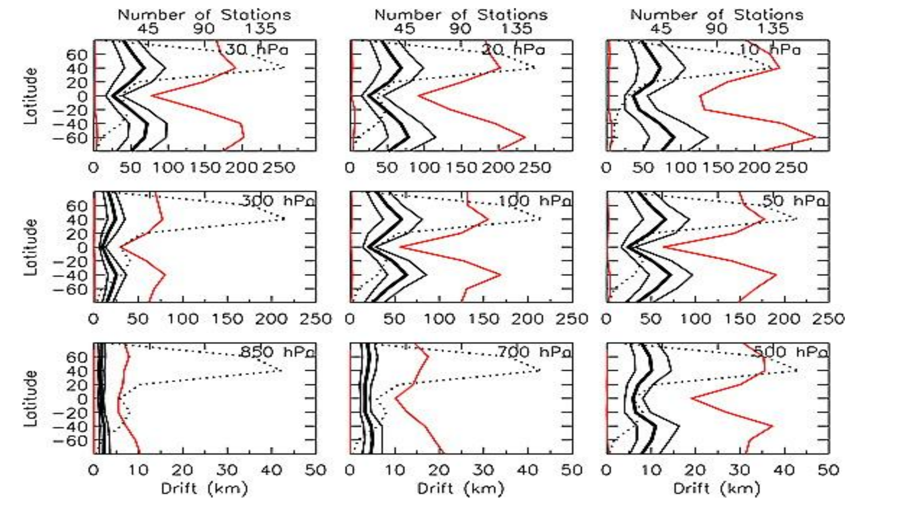
Radiosondes launched at GRUAN sites will drift with prevailing winds, which impacts:

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.

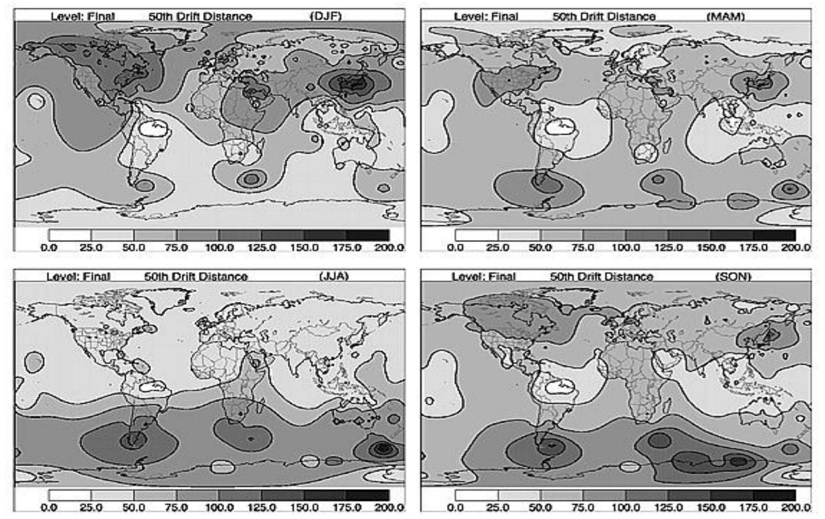
For these applications, we have developed a global climatology of balloon drift, including its variability with height, season, and latitude.



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).



Zonal average values of minimum and maximum (red lines), and 25th, 50th, and 75th percentile (black lines) balloon drift distances at 300 hPa for each of the four seasons.



Global contour maps of median values of final balloon drift distance (kilometers) for each season.

Next Steps

•Develop methodology for characterizing total uncertainty of imperfectly-collocated observations.

•Model uncertainty as the distribution of measurements differences, with two main components:

(1) stochastic model of spatial and temporal correlations

(2) smooth component defining the true environmental trend

•Both components may involve several terms, require some assumptions, and be based on historical data.

For more information on this poster: dian.seidel@noaa.gov

For more information on GRUAN:

Email: gruan.lc@dwd.de

Internet: www.gruan.org

GCOS GLOBAL CLIMATE OBSERVING SYSTEM