Climate considerations for Upper Air Reference Network Operating Strategies

Kevin E. Trenberth
NCAR

February, Lindenberg, Germany

NCAR

A vision for the future:

- ✓ Fewer regular radiosonde stations
- ✓ GPS RO for temperatures above 500 mb
- ✓ IR and microwave soundings (T and water vapor)
- ✓ Winds from AMDAR, profilers
- ✓ Ground based GPS column water vapor network continuous in time
- ✓ Sparse network of "reference sondes" for satellite calibration and climate monitoring, and UT water vapor
- ✓ Co-locate new sondes with regular sonde sites to replace them at appropriate times
- ✓ Integrate with ozone sondes and/or GAW, SRB etc?
- ✓ Co-locate with CEOP reference sites?

Recommendation: Establish a new global baseline network of "reference" radiosondes

From Trenberth 2002.

NCAR

Purpose of Reference Sondes

- To create an anchor and baseline reference point that does not require bias correction for assimilation and comparison with all other observations.
- To create a climate data record in its own right at that location.
- The latter can be achieved only for a fixed schedule of regular synoptic observations.

NCAR

Sondes vs satellite soundings

- A typical sun synchronous satellite has a retrograde orbit with period about 96 to 100 minutes.
- It does not pass over the same spot again for several weeks
- It moves at a rate of over 400 km in one minute
- The entire orbit is about the time of one sonde sounding
- Many satellite soundings are not made at nadir and do not sample the same vertical profile.
- Satellite soundings have a finite sized footprint

NCAR

Sondes vs satellite soundings

- Sonde soundings have an ascent of order 5 m/s (300 m/min) and take over 90 minutes to get to 10 hPa.
- During this time they drift with winds by 100 to 200 km. (0 to 100 kt in 1 hour is 90 km).
- Sondes are typically launched about an hour ahead of nominal synoptic time, so the midpoint of ascent coincides with actual NWP analysis time

NCAR

Sondes vs satellite soundings

- To best utilize satellite soundings, they should be inserted in 4DDA at exact time and place they are made (asynoptically)
- To best utilize sondes, they should similarly be inserted at the time and place they are made, allowing for time of launch and displacement by winds
- The comparison of analysis vs observations can probably provide the best calibration and bias correction for radiances

NCAR

Sondes vs satellite soundings

- For any place, the signal in a sounding is made up of:
- The value at the point
- The perturbation in time from nominal
- The perturbation due to displacement
- Any errors in the sonde

NCAR

Sondes vs satellite soundings

- Except perhaps for one point and time, all other sonde measurements will not match those of any satellite sounding.
- The offset in time consists of a systematic component associated with the diurnal cycle and a synoptic component related to weather.
- Comparisons of sondes with satellites should **always** include a systematic adjustment for diurnal cycle time offsets.
- It may also include an adjustment for displacement (relative location).

NCAR

Conclusions

- It makes no sense whatsoever to try to collocate reference sondes with satellite overpasses.
- It makes a lot of sense to develop better ways to compare the two, taking proper account of random and systematic errors, which has NOT been done yet.
- Global 4DDA may provide the best source of radiance calibration and bias, although radiation transfer code errors are also present.

NCAR

Conclusions

THE COSMIC/FORMOSAT-3 MISSION

Early Results

BY R. A. ANTHES, P. A. BERNHARDT, Y. CHEN, L. CUCURULL, K. F. DYMOND, D. ECTOR, S. B. HEALY, S.-P. HO, D. C. HUNT, Y.-H. KUO, H. LIU, K. MANNING, C. MCCORMICK, T. K. MEEHAN, W. J. RANDEL, C. ROCKEN, W. S. SCHREINER, S. V. SOKOLOVSKIY, S. SYNDERGAARD, D. C. THOMPSON, K. E. TRENBERTH, T.-K. WEE, N. L. YEN, AND Z. ZHANG

The COSMIC radio occultation mission represents a revolution in atmospheric sounding from space, with precise, accurate, and all-weather global observations useful for weather, climate, and space weather research and operations.

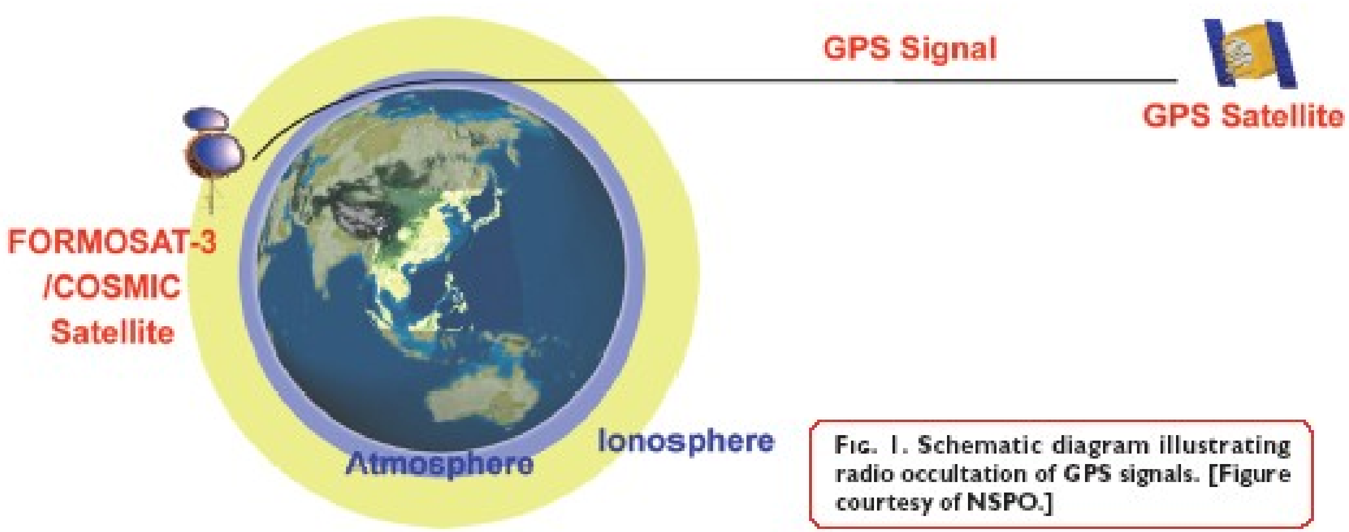

FIG. 1. Schematic diagram illustrating radio occultation of GPS signals. [Figure courtesy of NSPO.]

Another form of MSU calibration is from GPS Radio occultation (cf COSMIC): see BAMS article 2008

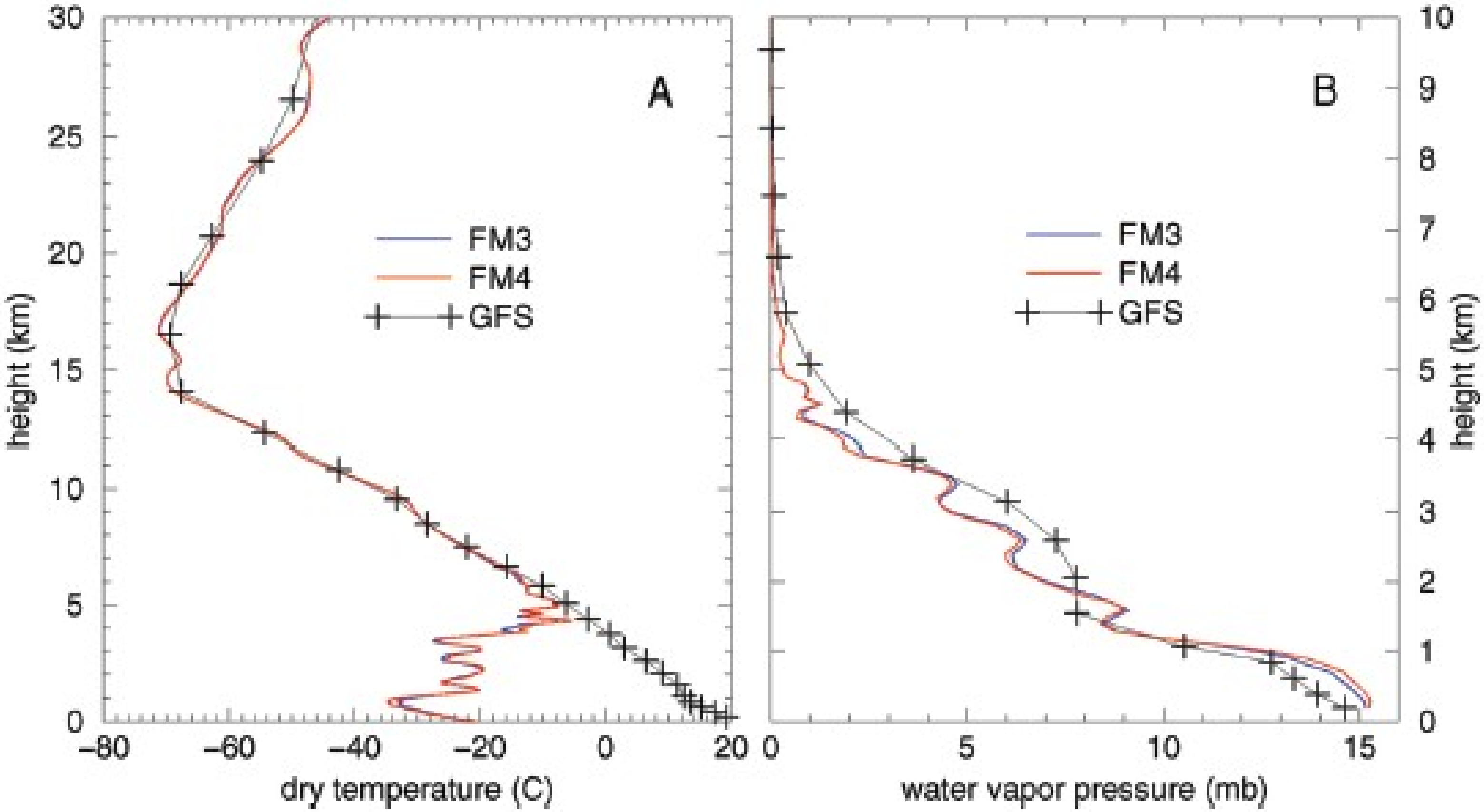

Fig. 7. (a) Vertical profiles of "dry" temperature (blue and red lines) from two independent receivers on separate COSMIC satellites (*FM-3* and *FM-4*) on 3 Aug 2006. The satellites were approximately 5 s apart, which corresponds to a distance separation at the ray tangent point of about 1 km. The soundings are at 21.8°S, 32.9°W. The black line (GFS) is the NCEP analysis of temperature interpolated to the time and location of the COSMIC soundings. (b) Same as in (a), but for water vapor pressure profiles computed from the refractivities using a 1D variational data assimilation scheme. The red and blue lines are difficult to distinguish because they coincide so closely.

NCAR

Reproducibility of soundings and MSU comparison

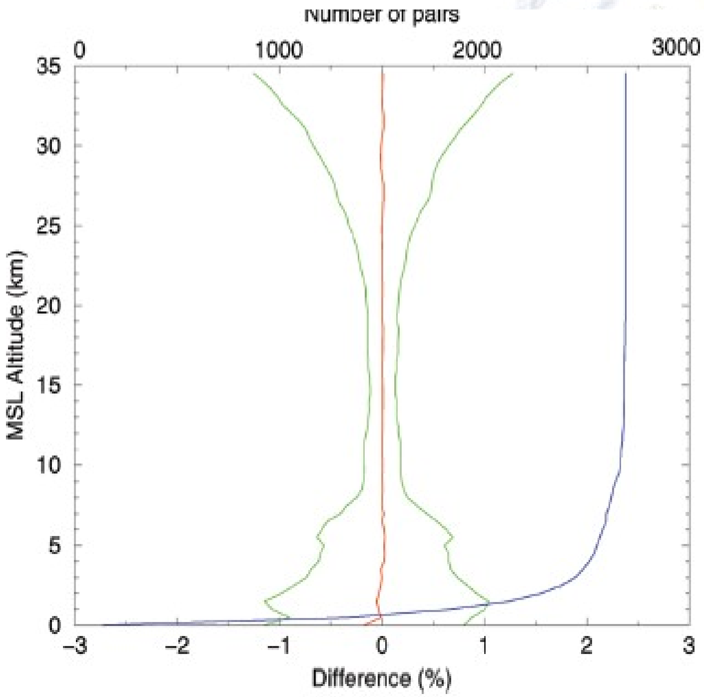

FIG. 8. Difference of pairs of GPS RO measurements (*FM3-FM4*) with tangent point separation less than 10 km. Mean difference shown by red line; standard deviations of the differences shown by green lines. The blue line shows the number of pairs of nearby soundings as a function of height.

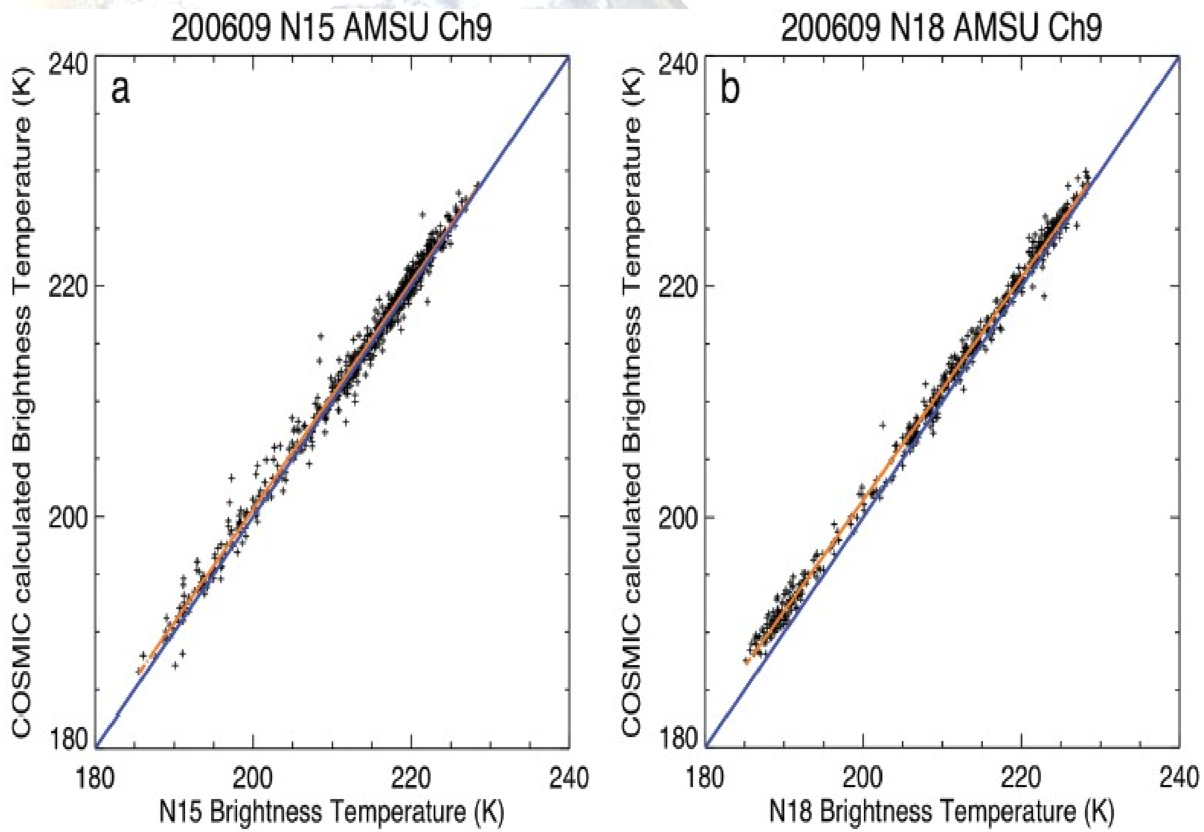

FIG. 16. Comparison of COSMIC-simulated AMSU Ch9 Tbs and (a) *NOAA-15* AMSU Ch9 Tbs and (b) *NOAA-18* AMSU Ch9 Tbs for Sep 2006.

NCAR

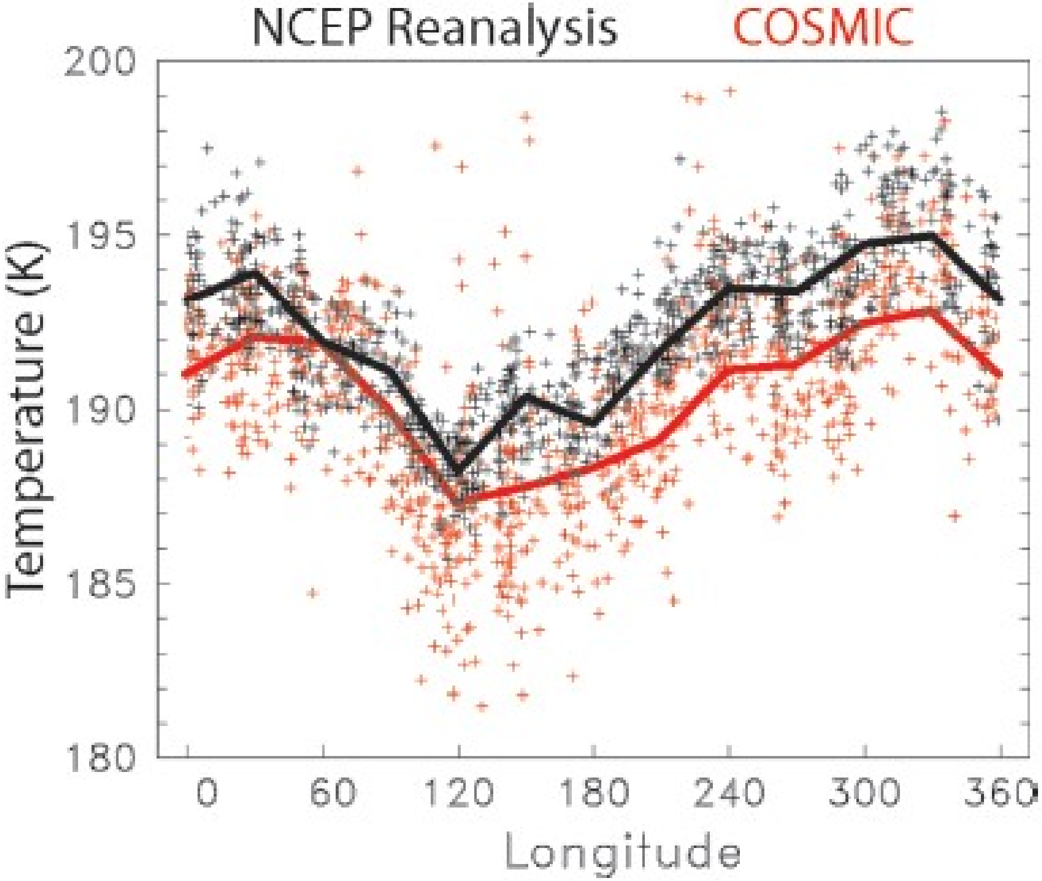

FIG. 17. Temperatures (red +) at the cold-point tropopause derived from all COSMIC temperature retrievals over 10°N–S for 20–30 Dec 2006. Each point represents one sounding, and the red line indicates the average longitudinal structure. The black line denotes the cold-point tropopause average derived from NCEP reanalysis data for the same time period, with individual points (black +) sampled identically to the COSMIC data.

Biases in NCEP reanalyses tropical tropopause

NCAR