1. Objective
We seek to document the practical precision of GPS RO tropospheric and lower stratospheric temperature measurements.

2. GPS RO and COSMIC
Global Positioning System (GPS) Radio Occultation (RO) is an innovative method for global, precise, consistent sampling of atmospheric temperature. RO data have been used to improve observational understanding, increase forecast skill, and are expected to be a valuable resource in long-term climate studies. COSMIC, launched in 2006, includes six GPS receiver satellites and produces between 1500 - 2500 globally distributed temperature every 24 hours.

3. Methods
We begin by comparing all of the pairs of COSMIC moisture-corrected temperature measurements taken from March 30, 2006 to March 31, 2008 by latitude and geometric altitude. We then examine how the differences between pairs increase with distance and separation in time (see Figure 1), similar to [Staten and Reichler, 2008].

In Figure 1a, the noise in the differences where $\Delta t$ nears zero is due to the sharply decreasing number of measurements. This decrease makes it difficult to obtain a statistically meaningful estimation of the RMS differences at the smallest space and time separations. However, in Figure 1b we show a planar, second-order best-fit polynomial to the contour shown in Figure 1a. This figure makes use of all the data points used in Figure 1a, and produces what appears to be a reasonable approximation of the differences between pairs as their temporal and spatial separation goes to zero.

To produce the profiles and confidence intervals in the following section, we run a Monte-Carlo simulation in which we resample the data 10,000 times, with replacement.

Figure 1. RMS differences between COSMIC 12 km temperature measurements from 20° to 60° latitude (a) by separation in space $\Delta x$ and time $\Delta t$, and the second-order best fit to the observed differences(b). Color scales are identical between plots.

4. Previous Estimates

Estimates
- Kursinski et al. [1997] predict RO temperature precision as high as 0.3 – 0.4 K at altitudes between 12 – 18 km.
- Hajj et al. [2004] estimate RO temperature precision to be within 0.5 between 5 – 18 km, using data from the CHAMP and SAC-C instruments.
- Anthes et al. [2008] use the COSMIC dataset to estimate RO temperature precision to be ~0.25 K from 10 – 20 km altitude.

Drawbacks
- Kursinski et al. [1997] is theoretical.
- Hajj et al. [2004] estimate an upper bound on RO uncertainty using reanalyses.
- Anthes et al. [2008] estimate COSMIC refractivity precision, and infer temperature precision based on this result.

5. Precision Profiles

(a) $(-90°, -60°)$  
(b) $(-60°, -20°)$  
(c) $(-20°, 20°)$  
(d) $(20°, 60°)$  
(e) $(60°, 90°)$

Figure 2. Profiles of RMS temperature differences between profiles with height, for the latitude bands shown. The red shading represents the 95% confidence interval of the RMS differences, based on our Monte-Carlo method.

Our results agree well with those predicted by Kursinski et al. (2007) above 10 km, but we find notable differences between ours and those from Anthes et al. [2008]. Our altitudes of highest precision are generally narrower than 10 km, and our precision rarely reaches the 0.25 K level quoted in their study. We attribute this fact two additional sources of uncertainty which are inherent in the temperature retrieval, and to the more conservative nature of our estimation. These precision estimates include contributions to uncertainty due to satellite tracking errors, differing occultation planes, the inversion process, temperature retrieval, and moisture correction. Thus, these precision errors represent a practical, useful precision values for RO data users. “Dry temperature” precision is expected to be similar, but higher below 10 km.

6. Conclusion

- Profiles of COSMIC temperature precision are presented.
- Results agree well with those predicted by Kursinski et al. [1997], but do not reproduce the high precision estimated by Anthes et al. [2008].
- Results are latitude-dependant.
- Use of less-processed data products should result in increased precision.

References

Practical GPS RO Temperature Precision
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