

Replies to the reviews of our manuscript “First results from the GPS atmosphere sounding experiment TOR aboard the TerraSAR-X satellite”

We appreciate the effort and time that the reviewer has invested in our manuscript and thank him/her for his/her work.

Below we answer the reviewer's questions and describe the changes of the revised manuscript. The reviewer's comments are quoted in italics, our replies are indented and set in straight font.

Reviewer #4, comments for the Authors:

[...]

Specific comments:

p.1, line 4-5:

'Standard deviations are...'. There are three 'abouts' in that sentence and the logic concerning what is decreasing is unclear. Consider to e.g. write: Standard deviations are about ... at 5 km and about ... at 10 km altitude.

Corrected, the revised sentence read: “Standard deviations are about 0.8% to 1.8% at 5 km and about 0.5% to 0.8% at 10 km altitude.”

p.7, line 175, 179:

an assumption is made that a subsequent analysis shows is not valid. Isn't it possible to obtain a more detailed explanation of the behavior of the instrument such that one doesn't have to speculate about the behavior?

Unfortunately, more detailed explanations of the instrument's behavior are not found in the existing IGOR user documents.

What are the implications for the paper if the assumption is not valid?

We expect that lack of knowledge about the exact start of open-loop tracking on the 20 ms level has no significant impact on the derived bending angles or refractivity profiles. Whether this expectation is indeed correct can only be answered on the basis of a realistic receiver simulation model; this type of simulation, however, is beyond the scope of this paper.

p.9, line 222:

Thanks for adding such a table. I'm a little confused about what you refer to as 'first processing step' and 'second processing step'. E.g. the table seems to indicate that the first step is raw data to excess phase but in the caption it is said that the first step is to bending angles. Please check table, caption, and text and make them consistent.

Caption of table 1 has been corrected. In the revised manuscript it reads:

“Occultation events statistics for 39,987 raw observations recorded between 24 July and 17 November 2008. $39,987 - 20,833 = 19,154$ events are removed in the first processing stage (derivation of excess phase paths from IGOR raw data), another $20,833 - 15,327 = 5,506$ events are flagged as deficient in the second processing stage (derivation of bending angle and refractivity profiles from excess phase profiles).”

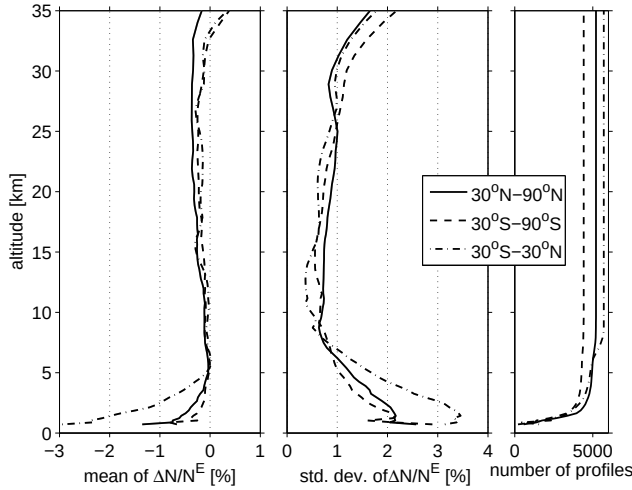


Figure 1: Statistical comparison of 15,327 IGOR (TerraSAR-X) refractivity profiles with collocated ECMWF analysis results. The observation period is 24 July to 17 November 2008. The data is processed by GFZ's experimental processing system POCS-X using single differencing. Left: mean fractional refractivity error for three meridional zones, 90°S-30°S (dashed lines), 30°S-30°N (dashed-dotted), 30°N-90°N (solid). Center: standard deviation of the fractional refractivity error. Right: number of data points.

p.11, fig.5:

There seems to be some skew structure of the biases, mainly for the Northern data set. Around 5-10 km all the biases are very close to 0 but at 25 km the solid line is at -0.5%. The corresponding biases for UCAR's processing of COSMIC data and M. Gorbunov's processing of COSMIC data are about -0.2% at 25 km. The data in Fig. 11 shows GRACE-A data and here the bias at 25 km seems to be smaller than for the TerraSAR-X data. I think this point needs to be addressed in the current paper. If the cause of this difference cannot be found it should at least be carefully discussed in the paper.

The average refractivity bias of the POCS-X data set is about -0.3% in the altitude range between 25 and 30 km. Whilst we cannot exclude the possibility that the observed refractivity bias is (to some degree) induced by ECMWF, we should also point out that N^{RO} is sensitive to the particular choice of parameters characterizing the polynomial derivative filter which is used to smooth the excess Doppler profile. As discussed in the answer to reviewer #1, the revised manuscript shows the POCS-X result for the same filter parameter as used by POCS (figures 3 and 2). In addition, the refractivity error statistics for filter degree two and a reduced filter order is shown in figure 3; the modification reduces the average refractivity bias from about -0.3% to about -0.085% in the altitude range between 25 and 30 km.

p.11, line 260:

refer to section 4.4 for the description of the ECMWF fields and extracted profiles.

Fixed; on page 11 the revised lines read:

" $N^E(z)$ is the corresponding refractivity value extracted from the ECMWF meteorological field; the procedure is described in section 4.4".

p.14, Fig.8:

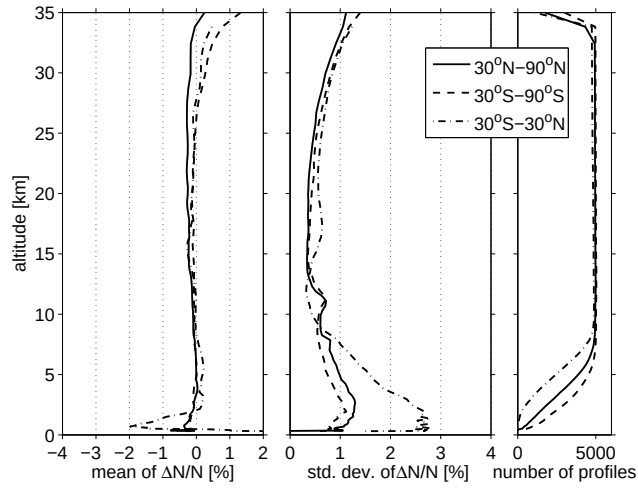


Figure 2: Same as figure 1 but for 15,159 GRACE-A GPSRO observations recorded during the same time period and processed by GFZ's operational processing system POCS.

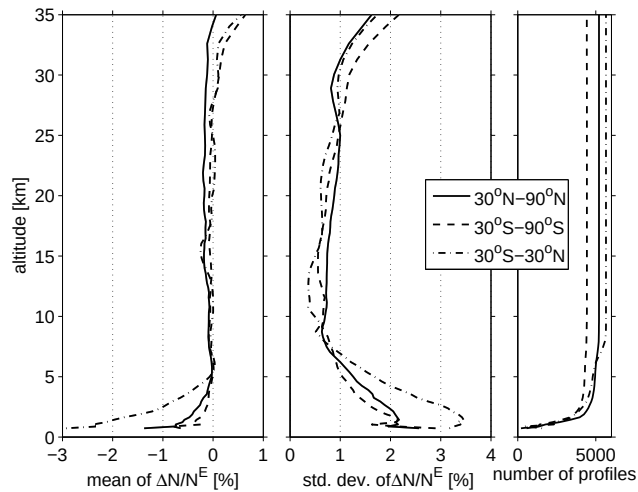


Figure 3: Same as figure 1, but derivative filter parameters reduced from degree three to two and filter order reduced from 101 to 41 (for details see text).

please clarify if this is SD data (in caption and text).

Fixed.

p.16, line 380:

what is the reason that 29 ECMWF profiles are missing?

As described in the reply to reviewer #1 the full data set has been re-processed and for each observation a corresponding ECMWF refractivity and bending angle profile has been determined. I.e. in the revised data set there are no missing ECMWF profiles.

p.17, Fig.10:

please clarify if this is SD data (in caption and text). Editorial: '.' missing after 'results' in caption.

Corrected.

p.17, line 391:

There are new results by Sokolovskiy et al. and Gorbunov et al. that indicate that at least part of the negative bias for COSMIC data is due to the way the data are cutoff and filtered. By carefully adjusting these parameters the bias can be reduced to less than -1% for non-tropical and about -2% for tropical occultations all the way down to the surface. I think this point should be added to the discussion.

In the revised manuscript the following sentences are added:

"Recently Sokolovskiy et al. (2010) describe a significant correlation between the lowest line-of-sight altitude and the mean fractional refractivity error in the lower troposphere. By adjusting the cut-off height for each individual occultation event the tropospheric bias can be successfully reduced to less than -1% for non-tropical and about -2% for tropical observations (Sokolovskiy et al., 2010). We note that these advanced methods for retrieval parameter adjustments are not implemented in GFZ's RO processing systems."

The corresponding reference was added:

Sokolovskiy, S., Rocken, C., Schreiner, W., and Hunt, D.: On the uncertainty of radio occultation inversions in the lower troposphere, J. Geophys. Res., 115, D22111, doi:10.1029/2010JD014058, 2010.

References

Sokolovskiy, S., Rocken, C., Schreiner, W., and Hunt, D.: On the uncertainty of radio occultation inversions in the lower troposphere, J. Geophys. Res., 115, D22111, doi:10.1029/2010JD014058, 2010.