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Atmospheric Measurement Techniques Discussions

Interactive comment on "Meteorological information in GPS-RO reflected signals" *by* K. Boniface et al.

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The authors examine two inversion procedures used to retrieve the refractivity profiles, but do not discuss explicitly why or whether two are even necessary. It would be useful to summarize what was learned from this aspect of the work.

This was actually commented in the paper, but since both reviewers ask this question we will modify the text to emphasize it further. The main focus of the paper is to indicate that reflected signals contain geophysical information that can be exploited. The demonstration of the presence of the information is done extracting it, although we do not claim that the extraction is optimal, and we do not attempt in this work to merge it with standard inversions from direct signals. We use one inversion procedure (perturbation inversion). Since it operates in a multidimensional vector space of solution profiles, we illustrated it with a simpler case where this vector space is one-dimensional. They are therefore not two procedures, but a more general one, plus a simplified case intended as an illustration.

Similarly, it is not discussed why the sensitivity study leading to the results of Fig. 5 represents a realistic assumption, that is to say why 1% is a useful number. In principle the authors should consider the impact of the retrieval uncertainties on the error in determining ultimately temperature and water vapor.

Again, this is not an inversion, but a one-dimensional illustration of the vector space where the solution is searched. The short-term forecast error of refractivity in the low troposphere, for all state-of-the-art NWP systems is in the range 1%-10%, which is why the 1-dimensional space was explored each 1% around a short-term forecast. This also is in line with the estimation of errors in refractivity profiles from the inversion of direct signals found in the litterature (e.g. Lauritsen et al., 2011; Kursinski et al., 2001). Observation minus forecast comparisons improve to about 0.5% agreement at higher altitude (notably, 10-25 km) but this is not the focus of this manuscript. Errors comparing GPSRO and ECMWF refractivity profiles are expected to be roughly estimated with a few percent accuracy at sea-level. We will add an estimate of the equivalent in terms of temperature and water vapor. A variation of 1% on refractivity is equivalent to a relative change on humidity ranging from 0.2 to 0.5g/kg. The mean temperature equivalent error would be equal to 0.5 K.

Figure 6 is intriguing: what happens at the lowest heights, where the $\frac{\Delta n}{n}$ has a significant jump? Was this height near the surface, do we have a topographic feature, or was this a loss of track ?

The refraction index correction has been provided using a multidimensional solution. Below a certain level the solution was not well constrained by the data, as noticeable in the error bars. We therefore show only the results whose solution was well

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constrained. The objective of the paper is not to show that a full profile can be derived from reflection data, but that there is information to provide useful data of at least some portion of the profile. There is no topographic feature (open ocean) nor loss of track. We will mention it in the interpretation of this Figure.

My pdf file of the article contains 7 figures, but the authors seem to refer to two additional figures (at the end of page 1219) where the comparisons between the two approaches are discussed. These figures appear key to the paper but they were not provided here and I feel that I cannot properly assess this work.

We apologize for this confusion. There are no other figures after the 7th. The comment (at the end of page 1219) was related to both approaches: the pertubation approach and the simpler inversion method. We will modify the sentence to avoid the ambiguity.

Is the method presented above suitable to handle strong gradients of refractivity, such as those found in the boundary layer? The paper leaves the impression that the refractivity is assumed as a smoothly varying field, and first order variations are considered. A discussion of this aspect would be very helpful.

The procedure is in principle applicable to any profile, and can be applied iteratively. However, we consider it practical only if the perturbation inversion is sufficiently accurate after one iteration of raytracing, perturbation, inversion. This of course constrains to cases where the a priori information is already close to the solution, and strong gradients reduce the convergence radius for these inversions. However, we expect the procedure to be particularly useful in cases of strong gradients, as the reflected signal may probe the gradient at a different angle as the direct signal, providing information difficult to extract from the direct signal (e.g. Ahmad et al., 1999). This, however, requires merging both sources of data, which was beyond the scope, and is still underway.

Initially, we found this to be too forward looking. However, we will include a discussion in the conclusions.

Only one COSMIC occultation, containing a reflection, was examined. This makes it difficult to assess the usefulness of the methodology presented here. I would strongly recommend that the authors consider expanding the set of tests with additional measured occultations. Ideally, I would like to see a test where retrievals with and without the reflected signal are produced, using interferometric phase in one case and not in the other, and the improvements are discussed as they relate to the lower troposphere.

The reviewer is right. We chose the word "assess" inappropriately, as it was closer to an initial exploration before launching a wider research. We are conscious that only one study case is not sufficient to generalize the results. We are cautious in the conclusions and will add some comments in the perspective related to the more general study that is still ongoing. We propose to redefine the objectives of the manuscript clearer in the introduction. As we mention to Reviewer 2, we try to determine whether there is geophysical information that can be accessed and be potentially useful. We do conclude that there is geophysical information, that it can be accessed, and we outline how. We do not pretend to give a universal methodology to retrieve meteorological information thanks to GPSRO reflected signals, and we do not provide a practical procedure, as we are not merging this data source with the much richer profiles from direct signals.

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