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Atmospheric Measurement Techniques Discussions

Interactive comment on "Dynamic statistical optimization of GNSS radio occultation bending angles: an advanced algorithm and its performance analysis" *by* Y. Li et al.

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Review of Li et al: Dynamic statistical optimization of GNSS radio occultation bending angles: an advanced algorithm and its performance analysis, Atmos. Meas. Tech. Discuss., 8, 811-855, 2015.

Context and general comment

The paper deals with the problem inherent in the RO technique on how to handle the observational errors in the bending angles that remain after ionospheric correction. The errors increase upward from around 25-30 km. The subsequent retrieval of refractivity and temperature profiles, through the application of Abel and hydrostatic integrals,

propagates these errors to lower altitudes. Hence, retrievals of geophysical information in the mid- to upper stratosphere is fundamentally dependent on our ability to handle this problem.

A standard approach is to combine the observed bending angle profile, α_o, and a background bending angle profile, α_b, into an optimized bending angle profile, α_{SO}, using a generalized least squares method. The two bending angles are weighted by the inverse of their error covariances, C_o and C_b, respectively. Since this method, referred to as statistical optimization, was introduced for RO data in the mid-1990's, many improvements have been suggested, with a focus on how to determine an unbiased background bending angle profile, and how to determine accurate co-variances, including correlations, for both background and observation.

The present study is an extension of the work described in Li et al. [JGR, 2013], in which they described a dynamic approach for obtaining better background bending-angle profiles, α_b, and background error covariance matrixes, C_b. Here, "dynamic" means that the covariance matrix is updated on a daily basis based on ECMWF short-term forecast and analysis fields, and the observed data itself. The uncertainties have geographic latitude-longitude dependence, while the correlations are described in terms of a global mean, both of them updated on a daily basis.

What is new in this study is the extension of the dynamic approach to include also the observation error covariance matrix, C_o. Like the background error covariances [Li et al., 2013], the observation error covariance matrices have geographic latitude-longitude dependence, and a global-mean correlation matrix estimated on a daily basis.

The manuscript is very well-written and easy to follow. The presentation quality is good, as is also the scientific quality of the manuscript. The scientific significance is fair: for those working within the same field it may give ideas on how to improve on the statistical optimization schemes. It should be seen as a part II of Li et al. [JGR, 2013] and is well worth to be published in AMT.

Questions/comments to the authors

The results described in the paper seem to show that the new method performs somewhat better than comparable methods (i.e., the Li et al. “b-dynamic” method, the Wegener Center standard method OPSv5.6, and the statistical optimization scheme used by UCAR/CDAAC), when compared to co-located ECMWF analysis profiles.

1) The method incorporates a background bias-calibration step. Could the general conclusions concerning the efficiency of this step be changed if you used a completely different reference data set (i.e. not ECMWF analyses, but some other comparable non-ECMWF model data)?

2) The observed, raw bending-angle profile, α_o, is almost exclusively the linear combination of the L1 and L2 bending angles. It is quite strongly affected by the preceding smoothing and filtering steps in the retrieval chain. Do you expect the same efficiency of the new method irrespective of the preceding filtering?

3) The statistical optimization is primarily a method to reduce the impacts of random upper level bending-angle errors being propagated to refractivity and geophysical variables at lower altitudes. Could you say something about the ability to handle observational biases caused by remaining ionospheric errors.

4) The method described adds quite a lot of complexity to the “optimization” of the observed, raw bending angles. If one was to speculate a bit: could further developments of ionospheric correction methods, e.g. by applying more physically realistic assumptions concerning the ionosphere, reduce the need for this type of very complex statistical-optimization step?

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 811, 2015.