

Estimation and Evaluation of COSMIC Radio Occultation Excess

Phase Using Non-Differenced Measurements

Dear Reviewer,

First of all, we would like to thank the anonymous reviewer very much. All the comments helped us improve the manuscript a lot. We are very appreciative of that. For each comment, we have carefully examined and answered with our best efforts. The paper is significantly revised and structured based on the reviewer's valuable comments and suggestions. Thank you! Please kindly find enclosed our updated manuscript and our responses to each comment below.

The article titled 'Estimation and evaluation of COSMIC radio occultation excess phase using non-differenced method' presents the non-differenced technique to calculate atmospheric excess phase (AEP), and compare the refractivities using these AEP to those obtained from UCAR/CDAAC, which uses single differenced method. Overall, the article has scientific merit and needs minor grammatical corrections for clarity. It is suitable for publication after minor corrections.

General comments and suggestions:

- The references need to be reorganized. They are not listed in alphabetical or chronological order, and in-text citation of the reference is ambiguous in some cases.

Response: Thank you very much! Revision has been made. The references are reorganized and listed in alphabetical order. Moreover, the in-text citation of references which are ambiguous or not used in the text are corrected.

- In the 'Results validation and analysis' section, the authors compare collocated measurements and retrievals with UCAR/CDAAC. Does the collocated imply that the same pair of GNSS transmitters and LEO receivers are used? If the same transmitter-receiver pair is used, then it would be easier to the reader if this information is mentioned in the text instead of just stating collocated measurements.

Response: Yes, the collocated imply that we used the same pair of GNSS transmitters and LEO receivers. We had added this information in the text. "We used the same transmitter-receiver pair to compare the collocated measurements and retrievals with UCAR/CDAAS."

- A comparison of the AEP from ND technique with 'atmPhs' would be interesting because it looks like refractivity difference between Ref_ND and Ref_Phs has a positive bias of ~0.5 % in setting occultation case (Fig 1) and a negative bias of ~ -0.5% in the rising occultation case (Fig 2). Is there a similar bias in the AEP from the ND method and 'atmPhs'?

Response: It is very difficult to obtain the absolute value of AEP using ND method or

SN method. Because of the AEP usually contains ambiguity and time-independent error terms. However, we are interested in deriving the atmospheric Doppler (the time derivative of the atmospheric excess phase) from AEP.

And the atmospheric Doppler obtained from the ND method and “atmPhs” has a similar bias with the refractivity derived from Ref_ND and Ref_Phs.

- The average differences (Table 4) show >1.5% difference between refractivities derived using AEP from ND technique and AEP from ‘atmPhs’ using the ROPP software for the retrieval. In the troposphere, the difference is $\sim \pm 0.5\%$ in both the rising and setting cases (Fig 4 and Fig 5). What can be the contributing factor for this difference? Just by comparing the figures, one of the factors seem to be the excess phase difference. However, the difference between the ROPP and UCAR retrievals for the same excess phase also have differences of 0.51 and 0.93 % for setting and rising occultations, respectively, indicating the role of factors other than the excess phase.

Response: The main sources of error above 30km are the incomplete ionospheric correction and the receiver tracking error, and the error below 10km (in the troposphere) is mainly due to the fact that atmospheric water vapor ambiguity can’t be determined. The ROPP software and CDAAC software used different methods to deal with these these problems.

Specific comments:

P6L148 – acronym ‘COD’ is not defined in the text.

Response: We defined the acronym ‘COD’ (Center for Orbit Determination in Europe).

P6L157 – ‘experience force’ is this typographical error?

Response: Thank you very much! Revision has been made. ‘experience force’ is modified to ‘empirical acceleration’.

P6L169 – Replace ‘3th’ with ‘3rd’.

Response: Revision has been made.

P13L295 – ‘ecmPrf’ is repeated. One of them should be changed to ‘echPrf’.

Response: Thank you very much! Revision has been made.

P18L384 – Reference is not used in the text.

Response: Thank you very much! Revision has been made.

P18L386 – Reference is not used in the text.

Response: Thank you very much! Revision has been made.

P19L412 – This reference is already listed in P18L408, with less co-authors.

Response: Revision has been made.

Rocken, C., Anthes, R., Exner, M., Hunt, D., Sokolovskiy, S., Ware, R., Gorbunov, M., Schreiner, W., Feng, D., Herman, B., Kuo, Y.-H., Zou, X.: Analysis and Validation of GPS/MET Data in the neutral atmosphere, *Journal of Geophysical Research.*, 102(D25), 29849-29866, 1997.

P20L442 – This reference does not appear in the text.

Response: Thank you very much! Revision has been made.

P20L448 –This reference does not appear in the text.

Response: Thank you very much! Revision has been made.