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Manuscript Title: **The FengYun-3C radio occultation sounder GNOS: a review of the mission and its early results and science applications**

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We thank the referee very much for the constructive comments and recommendations. We thoroughly considered all comments and carefully revised the manuscript accounting for most of them. In addition, we carefully complemented these revisions with a couple of further improvements throughout the manuscript text in the spirit of the comments.

Please find below our point-by-point response (in form of italicized, blue text) to the referees' comments (in form of upright, black text), *inserted below each comment. Line numbers used in our responses refer to the original AMT Discussions paper and text updates in the revised manuscript are quoted below with yellow highlighting.*

Response to Anonymous Referee #3's Comments

Anonymous Referee #3

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The paper provides an overview of the Radio Occultation mission on board the FengYun 3C satellite. It shows a summary of the system architecture and instrument characteristics, processing characteristics, results/validation of neutral atmospheric products (basically refractivity), ionospheric profiles (but only some results on the estimated NmF2 is provided here), on the applications of derived products (thus applications related to assimilation into NWP models, ionospheric products).

The paper is quite well structured, but it is a summary of something presented in other more detailed papers. Nice to have a summary, but the summary should include all the aspects. In this paper, and in particular in the sections related the discussion of products and their validation, only very few examples are provided. For the atmospheric profiles, the discussion is done only at the refractivity level (nothing is said about bending angles and their validation results, which are also very important in the RO community).For the ionosphere monitoring, it is only provided a scatter plot with estimation of correlation between NmF2 derived by processing GNOS data and ionosonde data. All the results presented are taken by other papers (a reference is always provided), which contains a lot of other interesting information worth to be presented in a summarizing paper like this one. This is the most critical point I'd like to address to the authors. In this form I'd reject the paper, encouraging the authors to submit a more complete one.

Thank you for your constructive comments and suggestions, we have revised this paper according to your suggestions and the state-of-the-art status of FY-3C GNOS mission and related publications. It should be a relative complete review paper now; for some interesting points, which still cannot meet your requirements, they are our ongoing research work and they will be explained and published in separate papers.

As you know, FY-3C GNOS is a relatively new GNSS RO mission launched in September

2013. On the one hand, its data validation and scientific application studies have been done and relevant papers have been published. On the other hand, so far there is no review paper like this one to give an overall introduction of FY-3C GNOS mission. Therefore, be think it is the right time to write this review paper to introduce FY-3C GNOS mission, which will help reader to know FY-3C GNOS mission more comprehensively and in a "one-stop-shop paper" in all its aspects.

For the major comments of (1) the atmospheric profiles; (2) the ionosphere monitoring; and (3) All the results presented are taken by other papers (a reference is always provided), our responses are as following:

(1) You are right, bending angles and their validation results are very important, so they are discussed in the revised manuscript now.

(2) Indeed, the GNSS RO technique can provide both TEC and ionospheric electron density product. However, the RO ionosphere data are validated mainly by the comparison analysis of NmF2 with that from ionosonde data, because there is no proper reference electron density profile. So far, the NmF2 also is used to validate COSMIC ionosphere products as a main index. Please refer to the following references:

Hu L. H., Ning B. Q., Liu L. B., Zhao B. Q., Chen Y. D., Li G. Z. 2014, Comparison between ionospheric peak parameters retrieved from COSMIC measurement and ionosonde observation over Sanya, Adv. Space Res., 54, 929- 938.

Krankowski A., Zakharenkoiva I., Krypiak-Gregorczyk, A., Shagimura- tov, I.I., Wielgosz, P. 2011, Ionospheric electron density observed by FORMOSAT-3/COSMIC over the European region and validated by ionosonde data, Journal of Geodesy, 85, 949-964.

Lei J., Syndergaard S., Burns A. G., et al. 2007, Comparison of COSMIC Ionospheric Measurements with Ground-Based Observations and Model Predictions: Preliminary Results, Journal of Geophysical Research, 112, 1-6.

(3) Actually, we wrote this paper mainly according to the state-of-the-art status of FY-3C GNOS mission and related publications. To give an overview of FY-3C GNOS mission, we did not only summarize its related papers, but also describe its system architecture, instrument characteristics, data processing characteristics, and our ongoing studies like FY-3C GNOS data NWP applications, which we think are worthy to be published.

All in all, we consider this paper should be published in the interest of the community, to give readers an overview of FY-3C GNOS mission in difference aspects, and also some new knowledge that could not be got from other papers.

Then there are other major points that I'd like to put in evidence.

Sect 2.4: here you provided some hints on the Geometric Optics (GO) approach to estimate bending angles. But you are using the ROPP software, where also a more efficient wave optics (WO) approach is implemented. Not clear why you provided details on the GO one only. Are you using also the WO retrieval in the lower troposphere or not?

Yes, both the GO and WO have been used in our data processing, via the ROPP software. Specifically, the GO has been used above 25 km, while the WO has been used below 25 km. Now, the WO approach also has been described in the revised paper.

Sect 2.4: regarding TEC estimation. Eq 4 provides you the uncalibrated TEC. For two reasons:

first, using only L1-L2, the effect of initial ambiguities is not removed.
The TEC is thus completely biased. You should level it to the P2-P1 pseudorange based TEC; second, the leveled TEC should then be corrected by the receiver and transmitter differential code biases. I don't see any description of this standard way to process ionospheric observations.

You are right. We just retrieve the ionosphere electron density as final GNOS ionospheric product. The relative TEC in our data processing is only a intermediate variable but not product, so the ambiguities and DCB are not removed; we did not calculated the absolute TEC.

Sect 2.4: always on the retrieval of ionospheric data. One problem in using the Abel inversion to obtain Ne(h), Eq 5, is the initialization at the LEO height. You should have an estimate of TEC at the LEO height. Could you discuss this?

The orbit of FY-3C satellite is 833 km height, and we get the ionosphere information above the LEO orbit by using the exponential extrapolation method. Our simulation indicated that the ionosphere above the LEO satellite effect the accuracy of the retrieved results slightly, but less than 0.1%. Therefore, the ionosphere above the LEO satellite can be neglected in the FY-3C GNOS case with its relatively high orbit altitude.

Sect 3.1: Please use tables to summarize results/validation of POD results. The entire section presents results in a way that is really difficult to be followed. Moreover, being this a summary, I'd like to see some results also regarding LEO velocities and clock bias estimations.

Ok, done. Please refer to the revised paper.

Sect 3.2: the same here. Use tables to present the results. Define clearly what is the background (true) for evaluating your relative errors. And show/discuss results also at the bending angle level

The background ("true") data is ECMWF reanalysis data, which has been used as reference data for RO data validation also in other of studies. It is clarified in the revised manuscript now.

A preliminary comparison study of GNOS GPS raw bending angles with COSMIC and MetOp RO data has been conducted; and the results also presented in Liao, et al., 2016 AMT paper. We have input the bending angle valuation results and discussions in the revised manuscript, for details, please refer to Liao, et al., 2016 AMT paper.

Sect 3.3: same here. Use tables and try to be more complete in the description of results obtained related the ionospheric monitoring.

Ok, done. Please refer to the revised paper.

Sect. 4.2: I don't understand the difference between this section and Sect 3.3. Here you should have been discussed Application of ionospheric products. Probably something more is done or will be done regarding space weather activities.

Right, Sect. 3.3 is on validation of the ionosphere data, while Sect. 4.2 describes GNOS *ionosphere data application for a geomagnetic storm monitoring and analysis.*

I found some typos and bad written sentences. Here a (not exhaustive) list (# shows the row number)

page 2, #10-16: reformulate, it is bad written

Ok, done.

page 8, #6: is the open loop baseband signal sampled at 100 kHz or 100 Hz as stated in Table 1?

It is 100 Hz, thank you. Revised.

page 10, #8: are the ground stations used also for computing GPD/BDS orbits and clocks?

The ground stations are mainly used to receive the observed data from FY-3C satellite, and then transmit it to the data processing center in Beijing. And their functions are clarified in the revised manuscript now.

page 12, #4-8: bad written. Could you please clarify is you are using single or zero differencing? If BDS and GNOS clock stability is enough, why you have to use single differencing?

Currently, all the GPS/GNOS RO events and part of the BDS/GNOS RO events use single-differencing algorithm. For the other part of the BDS/GNOS RO events, which do not have a proper BDS reference satellites to implement the single-differencing, we use the zero-differencing algorithm. As we know, the single-differencing algorithm is commonly used in different RO data centers, and for different RO missions, so we mainly use it in operational data processing system.

We conducted a comparison study/analysis of the single- and zero- differencing to validate whether the zero-differencing can be used for the BDS/GNOS RO events that do not have a proper BDS reference satellite.

Thank you for your valuable suggestion; reprocessing our data by using zero-differencing is part of our next plans and on-going work.

page 11, #15: What are GNSS position package data and satellite precision ephemeris data? Bad written. Why you insisted with using "precise ephemeris"? Maybe you wanted to say "precise positions and velocities"?

The GNSS position package we use contains the raw pseudo range and carrier phase observations from positioning antenna, the satellite precision ephemeris data is in GPS SP3 format, which can be obtained from IGS stations. These raw data were used as inputs to calculate the precise positions and velocities.

page 20, # 17: could you please provide further details or define better this ACC?

An approach to measure the quality of a forecast system is to calculate the correlation between forecasts and observations. However, correlating forecasts directly with observations or analyses may give misleadingly high values because of the seasonal variations. It is therefore established practice to subtract the climate average from both the *forecast and the verification and to verify the forecast and observed anomalies according to the anomaly correlation coefficient (ACC), which in its most simple form can be written:*

$$ACC = \frac{\overline{(f-c)(a-c)}}{\sqrt{\overline{(f-c)^2}\,\overline{(a-c)^2}}}$$

The ACC can be regarded as a skill score relative to the climate. It is positively orientated, with increasing numerical values indicating increasing "success".

We thank the reviewer again for the valuable comments that helped to improve the paper.