

Dear Reviewer,

Thank you very much for providing the valuable comments and suggestions. We do appreciate it. After checked all the comments and suggestions carefully, we'd like to respond them item by item as well.

List of Responses

As to the abstract:

1. **More attention will be paid to the reference to the ECMWF reanalysis.**
2. **Sorry for my mistake to mix two tables.-{**

As to the introduction:

1. "The use of RO in operational NWP actually started after the papers of Hajj and Kuo. The authors should consult e.g. the papers by Healy and Thepaut (2006), Cucurull et al. (2007), Aparicio and Deblonde (2008), etc. for more information."

Thanks for clarifying this; the citation with respect to it will be corrected.

2. "Lines 13ff: A refractivity profile could be considered a "primary" product, but I would never call it "elementary", since it is generated after several processing steps. For the NWP community, bending angle is nowadays considered the primary RO product, and refractivity a primary or secondary product."

Yes, indeed.

3. "Most NWP centers assimilate bending angles into their global models; only a minority uses refractivity."

Thank you for reminding us.

4. "Line 19ff: Performance of the "current" radiosonde? The paper of Kuo et al. rather states that they are able to (statistically) differentiate the performance of various types of radiosondes, which is something different. Please rephrase."

Thank you.

5. "P.9012, lines 3-4: It is my impression that GPS is an "operational" system, and that development did not stop since satellites need to be replaced when they age. It is also my impression that BDS, even being developed and improved over time, is a system being "deployed", with currently roughly half of the number of planned satellites in place." **Yes, indeed. So should I rephrase as "GPS is an operational system" instead of "GPS is the fully developed system"?**

As to the section 2

1. **We'd like to accept all the comments on languages.**

2. "Line 14: What does "At length" mean in that context?"

The phrase used there is the intention of expressing "at last".

3. "Line 9ff: The authors claim that "below 25 km there are ... complicated multipath effects." This number sounds unusually high. Multipath is usually expected to occur more likely in moist tropospheric conditions, less so in the stratosphere. Can the authors be more specific on the reasons for their choice?"

From my understanding, 25km is the maximum height for wave optics processing. Although multipath effects are a phenomenon of the troposphere, an extended height is kept for transition from WO to GO processing. SAF ROPP also sets the 25km as the maximum height for wave optics. Therefore, it is

drawn on the experience of ROPP and set 25km.

4. "Lines 23ff: Question: is $n(r)$ calculated on a fixed grid, i.e. same grid for all profiles, or is the grid different for each profile?"

It is calculated on a fixed grid.

5. "P.9015, line 4: There is no "moisture ambiguity", it is the decomposition of refractivity profiles into temperature and humidity that is ambiguous." **This phrase was the literal translation of the Chinese meaning, sorry for that.**

6. "Line 7: Which "T639 forecast model" is being referred to?"

T639 is the global Medium-Range Weather Forecasts of Chinese, which started to be operational at CMA in 2009.

7. "Line 13ff: Is the full profile rejected if any ray has a bending angle larger than 60 mrad, or only part of the profile?"

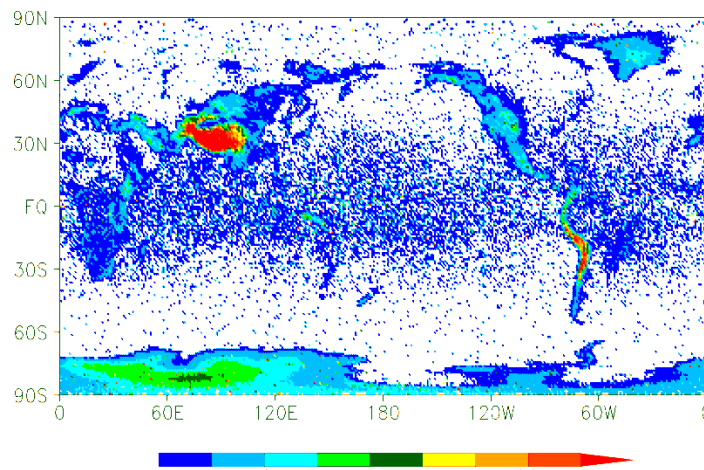
Only part of the profile.

8. "P.9016, line 5ff: There is some confusion here. I think that the authors wanted to express that GNOS does support open-loop tracking for GPS L1, but not for BDS B1. I am not aware of a problem with the GNSS signal design. Please check and reformulate."

Thank you for reminding. At present, open-loop tracking has not been implemented for BDS B1 signals yet. In the next generation of GNOS, B1 will be received by open-loop tracking, like GPS L1.

9. "Line 25: "...comparable to the GPS occultation". Did the authors try to compare to other RO missions?"

It has been qualitatively compared with a picture shown below, which is the penetration depth of COSMIC.



As to the section 3:

1. "P.9017, lines 10f: "...while GNOS BDS is obtained from the experiment system as it does not become operational." Does this imply that there will never be an operational GNOS BDS product stream?"

No, if the BDS ephemeris could be delivered in near-real time, the GNOS BDS products will be operational and open to public.

2. "Lines 14-16: To the best of my knowledge, COSMIC and GRAS are actually quite

different types of GPS receivers.”

Yes, they are not the same. Actually, I intent to express they are both occultation sounders, and their products can be compared with each other.

3. “Lines 19-20: The ERA-Interim website and the ERA-Interim publication clearly state that the model top of the atmosphere is at 0.1 hPa, not at 1 hPa.”

Sorry for not explaining this clearly. The data we used is from pressure levels, not model levels, it gets only 37 levels and up to 1 hPa. See the data link: <http://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=pl>

4. “Lines 21-22: Is there a reason not to compare to COSMIC, which has more total occultations than a single Metop/GRAS?”

Sorry, I was misleading by a paper which says “The COSMIC satellite system consists of a constellation of six low-earth-orbit (LEO) microsattellites and was launched on 15 April 2006 into a circular, 728 inclination orbit at 512-km altitude”. Actually, 512km is just the initial altitude. I didn’t realize this mistake until the manuscript was uploaded. Therefore, COSMIC will also be used in the next revise, just as reviewers recommended.

5. “P.9018, lines 10ff: Instead of "forwarded", use "modeled" or something similar. How shall I understand "vertically logarithm interpolated"? Does it mean that the logarithm of refractivity is vertically interpolated in some way, or something else?”

Yes, it means the logarithm of refractivity is vertically interpolated. It will be rephrased.

6. “Lines 18ff: There is excessive and unconventional use of the word "statistics": "through statistics", "during the process of statistics". Please reformulate.”

Thank you for reminding.

7. “How many profiles are rejected by the "extra quality controls"? Looking at figures 1 and 3, one expects approx. 450 profiles/d for GNOS GPS before quality control. The procedures described in section 2.1.5 reduce this by roughly 20%, leaving roughly 360/d or 21600 for 2 months of data. Line 23 has 17509 profiles (290/d) before extra QC, roughly 20% less than the naive estimate. So where did this 20% go? And yet there is another 27% rejected by the extra QC?”

As to this phenomenon, it is related to data transmission system of Chinese. The data we used in this manuscript is from near-real time stream. However, in the near-real time stream, some data can’t be completely transmitted when pass-by the ground receiving station, as there are globally only 4 stations. With too much satellite data and relatively few receiving stations, some GNOS RO data are delayed, and their corresponding products can’t be produced in near-real time. When the next satellite FY-3D, carried GNOS, is launched, an extra ground station will be deployed at the South Pole. Besides, the data storage and transfer strategy will be changed to ensure the priority of GNOS. Therefore, this kind of delay will be mostly resolved. Back to this manuscript, the 15 days data used in figure 1 is from 3 Oct., which is the period of least delay. Sorry for a mistake labelled for figure 3, after another check, there should be 6 months data. From my point of view, although there are some data

missed per day, it should not have significant impact for the statistical analysis.

As to section 4:

1. "P.9019, lines 12-16: As explained above, the ERA-Interim analysis is available up to 0.1 hPa, which is more like 65 km rather than 46 km (for 1 hPa), and no extrapolation seems necessary. I therefore do not understand the discussion here. Maybe the authors made some mistake?"

The data we used is pressure levels, not model levels, it gets only 37 levels and up to 1 hPa.

2. "P.9020, lines 5-10: I think that part of the apparent differences in the performance of GNOS GPS versus GNOS BDS is a genuine sampling issue. This can already be seen from figures 2 and 11: the more difficult tropical lower troposphere is less covered by GNOS BDS. In my opinion this has little to do with "representativeness error"."

Thank you very much for your new prospect to explain this phenomenon. That's really a reasonable explanation.

3. "Line 18: Which "fluctuant features" are the authors talking about? Assuming that the ECMWF model used in the reanalysis is not perfect, there will be biases in the analysis. Maybe the authors can clarify."

Sorry for using this unsuitable words. The original intention is to give a description of bias characteristics. According to reviewer's comment, if I could draw an impression that the bias between RO profiles and ECMWF reanalysis would be from both of them. If GRAS, COSMIC and GNOS get similar bias characteristics compared with ECMWF reanalysis in the altitude range of 5-30km, where RO profiles perform best, does it attribute more confidently to ECMWF reanalysis?

4. "Lines 24-26: "As seen in previous studies, the radio-occultation-data spreads from the middle troposphere to the lower stratosphere play a key role in numeric weather prediction (Kuo et al., 2000)". Sorry, but I do not understand this. Clarify or remove."

RO profiles perform best in the altitude range of 5-30km (from the middle troposphere to the lower stratosphere), where it could play an important role in NWP.

5. "P.9021, lines 27-28: What is "non-optimal statistics"? Why only GNOS vs. GRAS, not vs. COSMIC?"

"non-optimal statistics" means ionosphere-free bending angles without/before statistical optimization. The reason for not using COSMIC can be found in the fourth answer of "as to the section 3".

6. "P.9022, lines 17-18: "It should not be excluded that the systematic representative error due to time and space gaps." Sorry, but I do not understand this."

This unsuitable description will be removed.

7. "P.9023, lines 3-4: "As the analyses are based on the non-optimal statistical bending angles...". Do the authors refer to the ionosphere-free bending angles without/before statistical optimization, or something else? Please clarify."

Yes, it means the ionosphere-free bending angles without/before statistical optimization.

8. "P.9024, line 3: "below the lower troposphere." Where exactly is that?"
Especially below ~5km. however, in the original plot, it is not obvious to notice the sample differences. It will be put together in the next revise.

9. "Line 13: "for the next generations." Should this rather read "for the next generation of GNOS.?"

YES

10. "Is it possible to redo figure 10 in the same way as figure 3, with the same color scale for the penetration depth?"

That's no problem.

11. "Lines 26-28: "The Northern Hemisphere and Southern Hemisphere can be considered as data-rich and data-sparse regions, respectively." This is maybe relevant for the discussion of the quality of ERA-Interim for those periods when there were fewer satellite data available, but I fail to see why it is relevant for the present discussion. Clarify or remove."

Thank you, it will be removed.

12. "Lines 6-7: "These comparisons give evidences to say that radio occultations perform better at middle and high zones." As it is written, I think this is a too general and misleading statement. The conditions in the tropics are more challenging for both NWP models and RO than in the extra-tropics. Rephrase or remove."

Thank you, it will be removed to avoid misleading.

13. "Lines 8-9: "showing that the wavy structures are real." This is not really clear and obvious. What do the authors mean by "real"? Are they talking about structures in the bias and/or the stdv? Are they sure that there is no potential problem in their calculation of the profiles and/or statistics?"

Yes, the intention is to talk about structures in the bias. "Wavy" can be interpreted as "fluctuant". Maybe, there is problem in the calculations; it will be checked once again. I read a paper written by Rocken, et al.,(1997,JGR), which says "Based on the relatively strong signal to noise ratio in the 10 to 40 km height range, it is likely that these fluctuations are real, perhaps caused by gravity waves" in the page 11, part 4. It's the description of dry temperature, is it also applied to refractivity?

14. "Lines 11-12: The reference to the Alexander et al. paper here is not really clear to me. Do the authors want to express the potential for measuring gravity waves or something different? Please clarify or remove."

Thank you, it will be clarified.

15. "I find it difficult to reproduce the findings of the authors. Could they please verify that e.g. the differences in the bias between COSMIC and GRAS agree with the differences between COSMIC and GRAS as shown in the ROM SAF monitoring?"

From my knowledge, bias could be affected by different interpolations or outliers screening. If within a certain fault-tolerance, the bias differences

between COSMIC and GRAS from different sources would be compared for analysis. Anyway, I will check and give the differences in the bias between COSMIC and GRAS. That would be great if ROM SAF monitoring could provide their differences. If not, only qualitatively comparison can be done.

As to section 5:

1. "P.9026, lines 4-5: "As to different zones, GNOS GPS can reflect the superiority of middle and high latitude zones over the tropics, due to less multipath propagation in the moist atmosphere especially in the lower troposphere." As I explained above, I consider this judgment misleading, and recommend to remove it."

Thank you, it will be removed.

2. "I would rather recommend to add a summarizing sentence about the comparison of the raw bending angle profiles in section 4.2, as it is more relevant to the NWP community."

Thank you for your recommending.

As to the technical corrections:

We will keep in mind to avoid these basic issues. For my first foreign language paper, your suggestions really help me a lot to improving the writing.

As to the language:

I am not a native English speaker, although I have used the copy-editing service for improving the languages, the problems still remain. In the next revise, we will use another language service to avoid those problems.

At last, really appreciate your kind work.