

Anonymous reviewer #1

This paper investigated the distribution of bubbles as a function of longitude, latitude, altitude, local time, and year (solar cycle) using the FormoSat-3/COSMIC radio occultation data acquired in 2008-2016. Their results show an agreement with the occurrence climatology of bubbles derived by other observations.

On the scientific aspect, this paper does not deliver any new findings regarding bubbles; the behaviour of bubbles (dependence on the geographic and geophysical parameters) is well established, even if this paper does not report. However, the paper demonstrates that GPS RO signal can be a good proxy for the detection of bubbles. The results are acceptable, but writing is so bad, so I recommend resubmission of the paper.

For most sentences, I could not progress to the next sentence without pointing out a problem. Below are some examples.

- We like to thank reviewer #1 for taking the time to read and comment on our paper. We are grateful for the valuable comments which will help us to improve our paper distinctly. Regarding the writing of the paper, we have taken your comments into consideration and made appropriate modifications.

Title

May change "Occurrence climatology of equatorial plasma bubbles derived using the FormoSat3/COSMIC GPS radio occultation data"

- Thank you for suggesting the title. We will replace the existing title with the suggested one, as the latter is more appropriate with the topics discussed in the paper.

Abstract

We are grateful for the constructive inputs for improving the abstract and will consider all of them in the revised manuscript.

The whole sentences should be revised.

- Rewrote the abstract as follows:
"The GPS Radio Occultation technique is used to detect the equatorial plasma bubbles in the F-region, which are characterized by depleted regions of electron density. The occurrence climatology of bubbles is derived using the vertical GPS radio occultation data in 2008-2016 by the FormoSat-3/COSMIC mission. The plasma bubbles are identified based on the S4 index, derived from the signal-to-noise ratio of the radio occultation profile. The analyses revealed that, the F-region irregularities associated with plasma bubbles occur mainly post sunset close to Earth's geomagnetic equator. The distribution of bubbles shows the dependence on season, longitude, and solar cycle. Through this paper, a modest attempt is made to show that GPS Radio Occultation can be used as complementary technique to investigate plasma bubbles. Additionally, the advantage in using radio occultation data is

that, we do not only get information on the occurrence of the equatorial bubble events but also on its altitude distribution.”

Line 2-3: The words “emerging”, “prominent” are not necessary.

→ The words “emerging”, “prominent” are removed in the revised abstract as suggested and agree that it was simply unnecessary.

Line 4-5: “For investigating the plasma bubbles, a nine-year (2008-2016) long time series of signal-to-noise ratio data are used from the vertical GPS radio occultation profiles.” This is bad structure. I would write “The occurrence climatology of bubbles is derived using the vertical GPS radio occultation data in 2008-2016 by the FormoSat-3/COSMIC mission.”

→ Thank you very much for the ideal structure of the sentence. The existing sentence is replaced with the suggested sentence in the revised abstract.

Line 8-9: “Dependence on the solar cycle as well as distinctive seasonal variation is observed when analyzed for different years.” -> The distribution of bubbles shows the dependence on season, longitude, and solar cycle.

→ According to reviewer suggestion, the changes are incorporated in the revised abstract and we agree that it improves the quality of the sentence

” The words “depreciated” and “personifies” do not sound good expressions.

→ The words “depreciated” and “personifies” are removed from the abstract and agree that inclusion of such words did not make expressions sound good.

Sections 1-3 There are many awkward expressions. Too much work to point out all of them.

→ Thank you very much for going through the section in-detail. We agree that sections 1-3 are not well written and therefore we will rephrase it to avoid awkward expressions to the best of our ability in our revised manuscript.

Conclusions

→ We are grateful to reviewer #1 for his in-detail review on the conclusion of the paper and included it in our revised manuscript in line with your suggestion.

Page 10 Line 28: “ a nine-year comprehensive study of equatorial plasma bubbles ...” It sounds that the authors have studied bubbles for nine years.

→ Thank you for providing the perspective to the sentence. We have rewritten and made changes to the phrase as: “In this paper, a nine-year global climatology of EPBs is presented using GPS-RO measurements obtained from the FormoSat-3/COSMIC mission.”

Page 10 Line 32: There is no “striking” finding of this study. The solar cycle dependence of the bubble activity is already very well known, and this study just has identified the known phenomenon using the RO data.

- According to the reviewer suggestion, we agree that solar cycle dependence of the bubble activity is already well known. However, we tried to show it from the perspective of RO data and agree the unnecessary of the word ‘striking’. Therefore, the word is removed from the manuscript according to authors suggestion.

Page 10 Line 33-Page 11 Line 1: The concentration of bubbles near the magnetic equator is already well known fact, and it is not an intriguing characteristic at all.

- Thanks a lot for this hint. Yes, the bubble climatology is already well known from other measurement techniques. In this paper we like to show the time statistical distribution of this phenomenon based on GPS RO data. We added some sentences comparing our results with those from former publications (Carter et al.,2013, Liu et al.,2016) and also with publications that are not based on GPS RO data like (Stolle et al.,2006, Xiong et al.,2010). The main finding portrays the shifting of the peak EPB occurrence from South American to African sector along geomagnetic equator as we proceed from solar minimum to solar maximum and we intend to include this in the revised manuscript.

Page 11 Line 1: “The rapid depletion of E-layer post sunset cause...” -> The rapid plasma loss in the E layer after sunset causes ...

- We are thankful for different formulation of the sentence which is more crisp and clear. Therefore, changes are done in line with the reviewer suggestion.

Page 12 Line 1: “The study reveals the influence of solar cycle, which facilitates the contraction and expansion of plasma bubbles across the complete altitude range.” Does the solar cycle contract or expand bubbles? What does this mean?

- Thank you for providing your perspective on this sentence. The study falls in line with the different conditions of solar activity, wherein during solar minima the scintillation activity contracts, whereas as we proceed the solar maxima, the scintillation activity expands along the altitude range. Taking your view into consideration the rephrased sentence is:” The study reveals that the periodic variation in the solar cycle has an indirect role in the vertical occurrence range of the plasma bubbles, that covers a large range during solar maximum and lower altitude range during solar minimum condition.
- Finally, we would like to appreciate reviewer #1 for his time in reviewing this paper comprehensively. We have included the suggestions and the changes which will significantly improve the quality of the paper.

References:

- Carter, B. A., Zhang, K., Norman, R., Kumar, V. V., & Kumar, S. (2013). On the occurrence of equatorial F-region irregularities during solar minimum using radio occultation measurements. *Journal of Geophysical Research: Space Physics*, 118(2), 892-904.
- Liu, J. Y., Chen, S. P., Yeh, W. H., Tsai, H. F., & Rajesh, P. K. (2016). Worst-case GPS scintillations on the ground estimated from radio occultation observations of FORMOSAT-3/COSMIC during 2007–2014. *Surveys in Geophysics*, 37(4), 791-809.
- Stolle, C., Lühr, H., Rother, M., & Balasis, G. (2006). Magnetic signatures of equatorial spread F as observed by the CHAMP satellite. *Journal of Geophysical Research: Space Physics*, 111(A2).
- Xiong, C., Park, J., Lühr, H., Stolle, C., & Ma, S. Y. (2010). Comparing plasma bubble occurrence rates at CHAMP and GRACE altitudes during high and low solar activity. *Annales Geophysicae*, 28(9), 1647-1658.