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Discussions

Interactive comment on "Analysis of ionospheric structure influences on residual ionospheric errors in GNSS radio occultation bending angles based on ray tracing simulations" by Congliang Liu et al.

Anonymous Referee #2

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Summary: The authors perform a study of residual ionospheric error (RIE) in radio occultation simulations. They build on a past study to focus on 26 events with anomalously large RIEs that appear at the 1 to 10 micro-rad level. The authors analyze how the residual error changes along the raypath. Asymmetric ionospheric conditions are found to play a primary role in the largest RIEs, more than the ionization level driven by solar activity and other factors. Another factor is technical ray tracer effects due to occasionally imperfect smoothness in ionospheric refractivity model derivatives, but not the main one. Mesospheric RIEs are generally found to be higher than in the upper

stratosphere, likely due to proximity of the tangent point to the source region of largest asymmetry, the ionospheric E layer.

Review summary:

The authors successfully build on prior work to create a useful and interesting article on what causes the largest residual ionospheric errors. As far as I know, there is no other work of this kind, and it provides useful knowledge on the effects of spherical asymmetry. Certain aspects of the presentation should be improved before publication. These are described in this section and in the detailed comments.

It would be very useful to the conclusions if the authors could show that the regions of largest RIE are also regions of large asymmetry. Perhaps they are regions of large ray-tracer error also, due to the NeUoG algorithm? This is unlikely, but it is also not clear why large ionospheric asymmetry is found in the regions highlighted by this study. The authors should consider this point more carefully. What would be useful is a metric of asymmetry for each occultation, and then showing that for nearly all the occultations of small to moderate RIE, the asymmetry is smaller than for nearly all of the occultations of large RIE studied here. Without this additional information one runs the risk of ascribing asymmetry as the cause of large RIE by coincidence. It might be the case that the large RIE differences between symmetric and asymmetric conditions is correlated with some other reason the RIEs are so large in the highlighted regions. Are the regions of large RIE also the regions where ionospheric asymmetries are largest, based on fundamental ionospheric considerations independent of the raytracing?

The authors should consider citing a recent publication that is related to their work: Coleman, C. J., and B. Forte (2017), On the residual ionospheric error in radio occultation measurements, Radio Sci., 47(3), 653–20, doi:10.1002/2016RS006239.

In the spirit of remarks made by co-author Kirchengast at IROWG-6 on referencing unpublished work, the authors might consider referencing the presentation by Mannucci et al., at OPAC-2010, on the role of ionospheric asymmetry in the magnitude of the RIE.

If the authors of this paper believe that Mannucci et al.'s presentation is not sufficiently relevant, no reference is needed.

The authors tend not to emphasize ionospheric asymmetry in their 2015 published study, whereas it factors into this study in a major way. A remark or two on why this study found asymmetry as important given the prior 2015 study is recommended.

Detailed Comments:

Page 4, Line 14: The term "quasi-realistic" is somewhat vague. It is understood that simulations are approximations of reality, so what is meant by this phrase?

Page 4, Line 20: I believe unpublished work by Mannucci et al. (OPAC 2010) contained an initial analysis of the role of ionospheric asymmetry. Certainly, the present work is more comprehensive than was presented then.

Page 6, Line 16: "clustered"

Page 6, Line 17: How is standard deviation defined for the bottom panels of Figure 2?

P6, L19: how is spherical symmetry (SS) achieved in the model? Please provide a brief description.

P7, L6: what is meant by "geographical dependencies" as separated from SS conditions or similar? Pure geography (latitude and longitude) would not be a factor, in general.

P11, L19: are out-of-occultation-plane refractive gradients ignored or included? Please clarify.

P17, L5: to bolster this conclusion and its applicability to real observations, it would be useful to see a metric of ionospheric asymmetry in other regions, to show that in the regions highlighted here, ionospheric asymmetry is largest. If ionospheric asymmetries are large in other regions also, but RIE is not so large, then how robust is this conclusion?

C3