Report #1

Submitted on 28 Mar 2022
Anonymous referee #2

Suggestions for revision or reasons for rejection (will be published if the paper is accepted for final publication)

I am happy with the revisions, except one major issue: In response to my previous comment about eta in Eqs. (1) and (2), the authors have now included a new Appendix where they compare higher-order residual terms associated with single- and dual-frequency processing. In their answer they claim that the analysis shows that the dual-frequency residual ionospheric error (RIE) can significantly exceed single-frequency RIE. The appendix is very nicely written, but it does not show what the authors claim it shows. The equations in the Appendix is only about the higher order terms in the Appleton-Hartree formula, there are no equations for the raypath separation effect. In line 459 in the main text, the authors write that the dominant raypath separation effect is absent in the single-frequency processing. I agree that it is the dominant effect, but there is no proof in the Appendix that it is absent in the single-frequency processing. The authors refer to studies by Hardy et al. (1994), by Syndergaard (2000), and by Hoque and Jakowski (2010). As noted in the Appendix, the latter study finds that a bending term (or curvature correction term in Hardy et al (1994), or dispersion residual in Syndergaard (2000)) exists on both L1 and L2 and far exceeds the second order residual. I am pretty certain that this term (in different variants in the three papers) does not disappear in the single-frequency processing. In single-frequency processing only the L1 path is used, but the effect is still there since the L1 path is affected by the ionosphere, and the extra bending is contained in eta (see my earlier comments about eta in Eqs. (1) and (2)). In the dual-frequency processing, one can call it raypath separation effect, but in the single-frequency processing 'bending term' is probably a better name for it. I believe the frequency dependency in the single-frequency processing (residual after ionospheric correction) will be as 1/f1^4, whereas in the dual-frequency processing I believe it is 1/(f1*f2)^2. In both cases, the factor in front of these is so large that the bending term dominates the much smaller higher-order residual terms. It is worth noting that we are talking about single- and dual-frequency excess phase corrections here, and that the dominating term is greatly reduced in the dual-frequency bending angle correction.

I think the authors should either include the bending term in the new Appendix, and give relative estimates of its size in single- and dual-frequency excess phase processing (as nicely done with the higher order residuals), or alternatively the Appendix could be removed again if the authors disagree that this term is present also in the single-frequency processing. In any case I think the authors should remove the indications in lines 454-460, 469-473, 481-485, and 535-539 of the revised manuscript, as well as in the Appendix that the single-frequency processing has the potential to resolve the residual ionospheric bias in dual-frequency processing.

Response: we appreciate this comment from the reviewer and have modified the manuscript accordingly. The impacts due to raypath bending on the single frequency correction are now described in the appendix. The possible benefits of comparing the dual- and single-frequency correction methods now take this into account. We have accordingly modified the manuscript in the lines mentioned by the reviewer above.