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Interactive comment on "Analyses of different propagation models for the estimation of the topside ionosphere and plasmasphere with an Ensemble Kalman Filter" *by* Tatjana Gerzen et al.

Anonymous Referee #2

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I think this is a very interesting, and potentially, very impactful paper.

Whilst the paper would be suitable with only minor corrections, I think if a little more analysis is done as well it would substantially increase the impact of the paper.

Please see my attached marked up copy of the document correcting English spelling and grammar and embeds all of minor comments. My major comments are:

* You need to decide how "much" you want to discuss SMART+ in this work. I understand the point of using it as a reference, but your result discussion focuses heavily on the fact that SMART+ is the best model (and you give detailed analysis of the statistics). However there is no description of the model in the paper (you have to follow

the references to find out more). If you want to keep the SMART+ discussion then I suggest you give some time to describe SMART+ and in particular the way the model time propagates - which is the main focus of this paper.

* I cannot understand how the Rot + Exp method shows almost no difference from the background NeQuick version. The Rot+Exp method is assimilating data, whereas the NeQuick results are not. The results suggest that the DA is doing nothing to the background model, and changing the time propagation method shouldn't completely negate the impact of the DA.

* In a related point, I am surprised by the amount of differences between each of the methods. I would have expected the DA to be the dominate term, with the changes caused by the propagation being minor. Since this not seem to be the case I think it needs to be carefully described why this is.

* What I would most like to see, and what I think would have the biggest impact on making this paper more cite-able in the future, is clearer analysis about the propagation results. So far the results are described in a global modelling sense - which is useful. However I am interested in understanding how each of the propagation methods work in more detail. For example you have picked 20mins propagation time but it would be interesting to see a histogram of the errors, for each technique, overplotted with increasing time, say 5min, 15min, 30min, 60min (or something similar). I would expect all methods to do very well on short time scales, but perhaps one or the other would be better at the longer scales.

You have provided some rigorous statistical results between using the different methods, but it is still hard to get a "feel" for it. I would find it interesting to see the difference between t(n) and t(n+1) for each method. So following the DA step (resulting in X_a) you could apply each method separately, and show a difference from SMART+ (as that is the best model). We would then be able to see an example of the differences (and what changes there are globally). Alternatively you could show one vertical profile (after assimilation) and then show the impacts caused by the 3 propagation methods.

* In all cases comparing the methods to persistence (let $X_a^t = X_b^{t+1}$) would also help to demonstrate the models effectiveness. This would be especially useful if you include analysis on different timescales. For example we would expect that over 5 minutes the persistence assumption will likely work well. But at 60 mins not. It is not clear what happens on a 20min scale.

Overall I think further analysis of the results of the propagation methods, in terms of the differences found between them should be further highlighted. Time propagation for ionospheric models, without a physics-based model, is clearly of interest and so I think it is worthwhile trying to make this paper as useful as possible.

Please also note the supplement to this comment:
https://angeo.copernicus.org/preprints/angeo-2020-39/angeo-2020-39-RC2-supplement.pdf

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