

Comment on essd-2021-136

Anonymous Referee #1

Referee comment on "The cooperative IGS RT-GIMs: a reliable estimation of the global ionospheric electron content distribution in real time" by Qi Liu et al., Earth Syst. Sci. Data Discuss., <https://doi.org/10.5194/essd-2021-136-RC1>, 2021

This paper describes the four real-time GIM products by CAS, CNES, UPC, and WHU, as well as the real-time IGS GIM combination. The results are analyzed for one month at the beginning of 2021 by means of a comparison with Jason3 VTEC data and by the differential STEC technique. In particular, the paper focuses on the update of the UPC solution and its impact on the combined IGS solution.

The topic is highly relevant, and the new UPC and IGS solutions justify publishing this contribution. The GIMs of the combined IGS solution are provided in the commonly used and well documented IONEX format and are therefore easily usable by the community.

The data set including only one month is a bit limited, especially considering that it starts only one day before the switch of the UPC solution on January 4. In my opinion, the content of the manuscript is worth publishing, but the presentation requires substantial improvement concerning language, clarity of presentation, and consistency of mathematical expressions and equations, for which examples are given below.

- 1) The mathematical expressions throughout the entire paper are very inconsistent, incomplete, and also incorrect, e.g.:
 - The parameters should have consistent indexes, e.g., in (1) P, L, and STEC have no indexes in the first two lines, but then P and L have a time index k in the last line (whereas STEC and Phi do not). The biases, however, have a satellite and receiver index. Later in (4), the STEC has indexes for r and s, and depends on latitude, longitude, time, and zenith angle (which doesn't make sense by itself, as receiver+satellite and time uniquely define the STEC parameter, the other dependencies are superfluous). In (7), the observations and VTEC values explicitly depend on time via ...(t), which is again a different representation compared to a subscript.
 - (2) is just a copy of the second line of (1), so why is it repeated?
 - c is used as the speed of light in L86, but in (4) it is a different constant that is not defined.
 - The symbol for the VTEC is mostly VTEC, but sometimes V (5,7).
 - In (6) in the last line the authors summarize over i, which means the result cannot depend on i, so this equation cannot be correct.
 - In (7), the VTEC depends on t, so delta should also depend on t.

- N is used in the paper as the number of ACs, the number Jason3 VTEC points during one day, the number of dSTEC points, and the maximum degree of the spherical harmonics, which should be avoided to facilitate the readability.
- Why is the phase wind-up term Phi introduced in (1) and (2), when it is simply ignored afterwards? This is an a-priori correction similar to antenna PCVs and not a parameter, and should therefore not be listed, or at least it should be explained how it is treated.
- Taking the SQUARE of the ROOT-mean-square in (6) is a bit pointless and simply is the mean-square.

2) The presentation generally is too unclear and unprecise, and should be revised in this regard, e.g.:

- L10 'after the transition of interpolation technique': This cannot be understood at this point, as this is only explained later.
- L25 'due to the good performance and global distribution of VTEC': What is the performance of VTEC?
- L57: RTK over medium and long baselines can also achieve centimeter level without any ionospheric information, it might just take longer.
- It is often stated that the 'STEC is extracted from the GF combination'. This is not correct. This is the STEC biased by ambiguities or DCBs. The unbiased STEC can only be obtained by fitting an ionospheric model to the observations. This should be made more precise.
- L96 'Since ... adopts spherical harmonic expansion...': This is not the reason that some ACs use the spherical harmonic model.
- The description of the CAS method should be more clear. What I currently understand is that they compute local VTEC models, then transform the VTEC to STEC, then back to VTEC, and then estimate a global model. Is this really the case?
- I cannot follow the description of the UPC method in L148 and following, maybe this could be presented in a more intuitive way. In (5) it is stated that 'G_t is the generated RT-GIM'. G_t seems to be a vector, but a GIM is a set of grid points characterized with latitude, longitude, time, and VTEC value. D_t is simply defined as 'dictionary matrix'. Either all of this should be explained or simply described in a clear way, since the reference is given.
- Figure 5 is difficult to read, maybe a smoothed representation would help?
- L296 'RT-weighting ... turns out to be effective': What does this mean? Effective for what?

3) The language of the paper as well as some technical aspects should be carefully revised, e.g., missing articles should be added, sentences that are only equations (L86) should be avoided, and abbreviations have to be defined at first use (GIM in L10, but used in L3, VTEC is used in L23, but TEC is defined in L26, SHE is defined in L166 but only used within this paragraph, outside the full expression is used,...).