Ann. Geophys. Discuss.,
https://doi.org/10.5194/angeo-2019-131-AC2, 2019


Annales Geophysicae Discussions

ANGEOD

Interactive comment

# *Interactive comment on* "Ionosonde Total Electron Content Evaluation Using IGS Data" *by* Telmo dos Santos Klipp et al.

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Received and published: 4 November 2019

Reviewer #2 Comments:

Report on the paper "Ionosonde Total Electron Content Evaluation Using IGS Data"by Telmo dos Santos Klipp et al. angeo-2019-131 The manuscript compares the "Ionosonde Total Electron Content, ITEC", derived from ground based ionogram measurements, with the "International GNSS Service (IGS) vertical-TEC, vTEC" for a low latitude/equatorial region. The authors use two years of ionogram data from a 5-station Digisonde network in Brazil. Avoiding the mistake made by some of the previous analyses, the authors made careful use of the "confidence level" information contained in the Digisonde ionograms to filter out questionable ionogram data. This careful analy-



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Discussion paper

sis of the difference between ITEC and vTEC focussing on the equatorial ionosphere anomaly (EIA) region should be published if appropriate revisions and corrections can be made.

Here are the major concerns. 1. The authors state that "they noticed" that ITEC systematically underestimates vTEC, and they explain this by claiming that the ITEC profile integration stops at 900 km. Both claims are not quite correct. Firstly, the original ITEC paper by Reinisch and Huang [2001], which the authors have cited, shows that the height integration for the ITEC calculation goes to infinity, and is not stopped at âĹij900 km. The Digisonde calculations of ITEC assume an ðİŻij-Chapman topside profile with constant scale height Hm. Secondly, extensive studies by Belehaki et al. [e.g., 2004, 2012] had shown as early as 2004 that the Digisonde ITEC systematically underestimates vTEC; Belehaki's explanation was that a constant scale height Hm (calculated from the bottomside profile for heights near hmF2) makes the topside profile decay too rapidly with height. They concluded that the plasma above about 900km is practically not included in the Digisonde's ITEC value. Instead of saying "they noticed" the underestimate, it might be more correct to say that the Belehaki et al. results were "confirmed" to also apply in the equatorial region.

Authors: We would like to thank the reviewer for providing very interesting and important suggestions to improve the manuscript. The modifications made are in blue color.

Considering the discussion where reviewer #1 reply to this reviewer #2 comment: "This is not true. For the time window (2016-2017) considered by the authors the ITEC (Ionospheric - not Ionosonde - Total Electron Content) given as output by digisondes is the one calculated to approximately 1000 km of altitude." Reviewer #2 added: "The ionosonde TEC calculation in the Digisonde is performed as part of the NHPC program, and Reinisch and Huang [2001] state that the analytic integration for the topside goes from 0→inf. The DIDBase and SAO characteristic #38 contain this TEC value. In the literature this ionosonde-derived TEC value is occasionally referred to as ITEC. It could of course be that the authors have numerically recalculated the topside content up to 900 or 1000 km with the alpha-Chapman profile and constant scale height Hm. But even if they did, it could not explain the observed underestimation by the ionosonde technique. The reason is not an abrupt cutoff at 900 km, but an invalid scale height Hm (of ∼75km) that is way too small a value for heights above ∼700 km as discussed in several papers since 2001." And also the reviewer #1 wrote: "The authors cannot consider what the reviewer is claiming, especially "the Belehaki et al. results were "confirmed" to also apply in the equatorial region" because the situation here is completely different from that faced by Belehaki et al. I repeat, ITEC values considered by the authors for the time window 2016-2017 are those calculated till 1000 km of altitude and not beyond." Reviewer #1 added: "Please see my response above for the 1000 km upper integration limit. You are right, the Belehaki et al. papers are for a completely different situation. This is why I recommended that your paper be published since it applies to the equatorial region."

We have used ionosonde TEC provided in SAO files (digisonde outputs), now referenced in manuscript as ITEC, and the differences to IGS vTEC were observed. We reconstructed the topside profile using only alpha-Chapman and constant scale height, and it was observed, even if we extended the maximum altitude, little difference in the final density integration (TEC). It is clear a different modeling approach for the topside profile is necessary to compare with IGS vTEC. And we tried 2 different approaches in this work: the adapted alpha-Chapman (using a scale for plasmasphere), and NeQuick with variable scale height. Both procedures provided similar results and were able to consider plasmaspheric TEC and reduce RMSE. It was not considered relevant to discuss the well expected differences between ITEC and TEC. We have updated the manuscript, indicating these differences were expected, and emphasized our major contributions.

2. Since the authors try providing a comprehensive review of the ITEC technique, why do they not mention the "Vary-Chap topside profile" that was introduced by Reinisch et

al. [2007] based on a topside scale height H(h) that varies continuously with height h, see also Nsumei et al.[2012].

Authors: We included a brief overview of different topside profiles techniques, and Vary-Chap topside profile references were included.

3. What is the meaning of RMSE in eq. (1)? The "error" is defined as the "difference between TEC values". Which TEC values? Is the error defined as the deviation from a mean? The mean over what samples? It would be helpful if the authors would provide a clear description, and explain what is plotted in Figures 6 and 7.

Authors: RMSE stands for "root mean squared error", as mentioned before equation 1. The "error" is defined as the difference between 2 values, which in our work come from IGS and ionosonde. We tried to improve the text and figure captions to avoid misunderstanding.

4. The paper makes a clear point in emphasizing that any high-volume data analysis depends on the availability of automatically processed data, and of automatically generated data confidence scores, this is very good and important. The Brazilian Digisondes have used the ARTIST-5 autoscaler (as stated on p3/25), so why is there such lengthy discussion of the performance of ARTIST 4.0, 4.5, and AUTOSCALA when none of these were used for the analysis of the 2016-2017 data reported in this paper? A short note may suffice to alert the reader. (By the way, older Digisonde data can be automatically reprocessed with ARTIST-5 using SAO-Explorer. Have you checked whether AUTOSCALA determines hmF2, which is a required input for the construction of the topside profile in Eq. 2?).

Authors: The discussion about autoscaling systems was reduced. Other autoscale systems (e.g. AUTOSCALA) were not used.

5. Figures 7c and 7d introduce the "Maximum Altitude" and "Plasma Frequency". How is the Maximum Altitude defined?

Authors: The maximum altitude shown is the one provided by ionosonde SAO files. Both, the maximum altitude and the plasma frequency measured at maximum altitude were daily averaged considering all ionosondes. We tried to improve the manuscript to clear this point.

Some minor concerns: Careful proofreading of the text is required, e.g. gaped echoes traces → gapped echo traces, etc. It would be useful to systematically refer to "ITEC" (as derived from ionograms) and "vTEC" or "IGSTEC" (obtained from IGS maps), or similar notation, which would make it easier for the reader to follow the discussions.

Authors: We tried to correct the text, and adopted ITEC and vTEC to differentiate the TEC sources.

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Belehaki, A., B.W. Reinisch, and N. Jakowski (2004), Plasmaspheric electron content derived from GPS TEC and digisonde ionograms, Adv. Spac. Res., 33, 833-837. Belehaki, A., I. Kutiev, B. Reinisch, N. Jakowski, P. Marinov, I. Galkin, C. Mayer, I. Tsagouri, T. Herekakis (2012), Verification of the TSMP-assisted digisonde topside pro- filing technique, Acta Geophysica, 04/2012. 432-452, doi:10.2478/s11600-009-0052- 3. Reinisch, B.W., P. Nsumei, X. Huang, and D.K. Bilitza, Modeling the F2 topside and plasmasphere for IRI using IMAGE/RPI, and ISIS data, Adv. Space Res., 39, 731-738, 2007. Nsumei, P., B.W. Reinisch, X. Huang, and D. Bilitza (2012), New Vary-Chap profile of the topside ionosphere electron density distribution for use with the IRI Model and the GIRO real time data, Radio Sci., doi:10.1029/2012RS004989.

Please also note the supplement to this comment:
https://www.ann-geophys-discuss.net/angeo-2019-131/angeo-2019-131-AC2-supplement.pdf

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