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Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "Sodankylä ionospheric tomography dataset 2003–2014" *by* J. Norberg et al.

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This paper reports total electron content (TEC) estimated from tomographic technique using beacon signals transmitted from low-earth-orbit satellites. The estimated TECs are compared with TEC taken from the IRI model. The authors show that the IRI- TEC is 40% larger than the TEC obtained from the tomography. Based on this result, however, the authors do not obtain any conclusions

which could contribute to scientific and/or technical studies. Consequently, this paper is no suitable to be published as discussion paper. This reviewer recommends this paper to be rejected. The authors need to discuss reasons of the discrepancy. Does the IRI overestimate TEC? If so, the IRI model needs to be improved.

We agree that the paper lacks conclusions and discussion on the factors that cause the reported discrepancies between the IRI model and tomographic total electron content (TEC) values. If we were provided a possibility to revise the manuscript we would be extremely grateful to improve it, especially by considering the mentioned quantitative differences between the tomographic TEC and TEC provided by IRI model in a more detailed manner.

We think that the Sodankylä tomographic measurements and analysis results provide a unique data set for the Fennoscandian high latitude ionospheric electron densities (Ne). The visibility of the solar cycle in the dataset and the qualitatively similar behaviour with IRI model demonstrates the overall long-time performance. Whereas, the performance for individual reconstructions with the method have been validated with EISCAT incoherent scatter radar measurements (ISR) by Markkanen et al. (1995).

The overestimation of high latitude Ne has been widely reported for different versions of IRI model. Zhang et al. (2006) reported that IRI-2001 overestimates Ne at the peak altitude and above, especially in winter time compared to ISR measurements.

One of the main improvements for IRI-2007 was the topside Ne modeling (Bilitza & Reinisch 2008). Lühr and Xiong (2010) compared the IRI-2007 model results to orbital averages of CHAMP and GRACE satellite measurements from 2000-2009, with the satellite height range from 300 to 500 km. Especially during the solar minimum period the overestimation was up to 60%. The overestimation was concentrated on the lower latitudes, but in Xiong et al. (2011) a 20% overestimation also for trough area was reported. Xiong et al. (2011) utilized CHAMP and GRACE satellite based Ne measurements from 2005 to 2010.

These studies then suggest that despite the development, the modelling of F peak and topside Ne still carries some problems. The improvements for IRI-2012 were made for the thickness and the shape of the bottom-side F2 layer, as well as for the description of storm effects in the auroral E region (Bilitza et al. 2014).

We have found it difficult to find out a comprehensive account on the different measurements used in the IRI model. In Altadill et al. (2008) a network of 27 ionosondes were used for the enhanced bottom-side modelling of Ne. The closest ionosonde measurements to Fennoscandia in the network were from Chilton, UK. In all, the network comprises two high latitude ionosondes, both located in Greenland.

The Sodankylä tomographic set-up employs numerous measurements from the high-latitude area which is poorly populated by ionosonde stations. However, ionospheric tomographic inversion is well-known to be an unstable inverse problem, and its performance, especially in small scale details in vertical structures, can be argued. The Bayesian approach (Markkanen et al. 1995.) utilized here assumes zero electron density a priori, and variations from zero background are then controlled with a Chapman profile shaped standard deviation. The approach is hence more likely to underestimate than overestimate the electron densities. Then again, as mentioned in the Introduction of our manuscript, improved inversion methods for this measurement concept are under development. The upgrading work includes also better methods to estimate the quality of inversion results. Therefore, we believe that beacon-based tomography could be used more intensively in future research, perhaps even in IRI-validation and upgrading.

Interactive comment on Geosci. Instrum. Method. Data Syst. Discuss., 5, 385, 2015.