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Intercalibration of the plasma density measurements in the topside ionosphere of the Earth

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1 Extended Abstract

The Earth's ionosphere represents a part of the upper atmosphere where the concentration of charged particles is high enough to affect the propagation of electromagnetic signals, most notably, those of the Global Navigation Satellite Systems (GNSS). Therefore, the accurate specification of the plasma density in the ionosphere is critically important both for scientific and industrial applications. The ionosphere is becoming increasingly data-rich, with the total number of plasma density observations in the order of billions of points. However, the data coverage in the topside remains highly non-uniform, especially in altitude. In order to create improved models of the ionosphere, it is crucial to use all of the available observations in modeling. Therefore, it is crucial to intercalibrate all of these observations and adjust the data sets to the same reference frame. As a reference data set, we use the Gravity Recovery and Climate Experiment (GRACE) K-Band Radnging (KBR) observations, which were previously found to be in excellent agreement with the incoherent scatter radar data. We compare the Radio Occultation (RO) density profiles provided by the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) mission to GRACE-KBR observation, and find a very good agreement between them with a relative bias of $< 2\%$ (for details, see [1]). COSMIC-RO provides the 3D data set of electron density in the topside ionosphere and due the fact that these observations agree with the reference, COSMIC-RO are used further on as a secondary reference frame to calibrate in-situ plasma density measurements by CHAllenging Minisatellite Payload (CHAMP), Swarm, and Communications/Navigation Outage Forecasting System (C/NOFS) missions. CHAMP electron densities are lower than COSMIC-RO observations by $\sim 11\%$, and the simple inter-calibration factors between them are introduced. C/NOFS full ion densities agree well with COSMIC having a relative bias of around 6%. Swarm Langmuir probe ion densities are lower at daytime and higher at nighttime compared to COSMIC, and this difference is strongest for Swarm-B (see [1]). Furthermore, these differences are mainly observed at low latitudes and during low solar activity. We discuss potential reasons for such effect, including influence of the spacecraft potential and variations in upper transition height. The cross-calibration factors introduced here can help to eliminate differences between the most prominent and widely used ionospheric data sets and allow using these observations together in a variety of ionospheric applications.

References

[1] Smirnov, A., Shprits, Y., Zhelavskaya, I., Lühr, H., Xiong, C., Goss, A., Prol, F.S., Schmidt, M., Hoque, M., Pedatella, N. and Szabó-Roberts, M., 2021. Intercalibration of the plasma density measurements in Earth's topside ionosphere. *Journal of Geophysical Research: Space Physics*, **126(10)**, p.e2021JA029334, doi: 10.1029/2021JA029334.