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Assessment of ionosphere models from the combination of GNSS and LEO constellations

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Global Navigation Satellite Systems (GNSS), as a very useful tool for ionosphere sounding, have been widely used in space weather research. Although GNSS have various advantages, e.g., high precision, high-resolution and all-weather suitability, the accuracy of GNSS-based ionosphere models is still depending on the number and the distribution of the terrestrial receiver stations. Especially in some areas, in particular the oceans and the polar regions, the accuracy of ionosphere modeling is not very satisfactory.
Low-Earth-Orbiting (LEO) satellites are characterized by the potential to solve the above-mentioned problems. As we know, there are several famous companies and organizations having planned to launch respective LEO constellation missions with hundreds or thousands of satellites. Since the velocity and the number of LEO satellites are much larger than in case of GNSS, not only the number of ionospheric pierce points (IPP) will significantly increase, but also the onboard receivers on the LEO satellites will cover the oceanic areas rather well.
In this contribution, we design a LEO constellation with 192 satellites, and then simulate the onboard LEO and the ground-based slant total electron content (STEC) measurements by applying the International Reference Ionosphere (IRI) model. In the following step, we develop an integrating method and a mathematical model to make full use of the GNSS and LEO observations. Finally, we employ these generated datasets and the developed methods to test the modeling accuracy of different solutions, namely GNSS-only as well as the joint evaluations of GNSS and LEO (bottomside), GNSS and LEO (upside) as well as GNSS, LEO (upside) and LEO (bottomside). The results of these experiments demonstrate that the LEO-augmented GNSS ionosphere model has a higher accuracy than the GNSS-only model, especially over specific regions such as the oceans.