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Ionospheric electron density retrieval from FORMOSAT-3/COSMIC occultation data for a period of more than half a Solar Cycle

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The disposability of information about the atmospheric electron density distribution plays an important role in a variety of application areas such as space weather monitoring and prediction, in ionosphere modeling and in general for numerous aspects in radio science. In this context, the ionospheric region constitutes a key component in the system of Sun-Earth interactions due to its high concentration of charged particles, especially electrons. One prevailing method for the exploration of the Earth's ionosphere is the application of GPS radio occultation measurements onboard Low Earth Orbiter (LEO) satellites to derive electron density values below the LEO orbit where an advanced retrieval method shall be described in this work. Besides, we present a comprehensive analysis and validation of the electron density information retrieved by GPS satellite occultation measurements taken from the FORMOSAT-3/COSMIC constellation.

A signal, transmitted by a GPS satellite and tracked on a LEO in occultation geometry, becomes delayed on its way through the atmospheric medium which allows for the determination of the refractivity indices based on the solution of an inverse problem with observations at different elevation angles. A classical Abel inversion algorithm may be applied to solve this inverse problem but goes along with mainly two drawbacks related to (1) the consideration of a spherical symmetry assumption for the electron density implying that electron density and accordingly the refractivity indices only depend on height and (2) the negligence of electron density data above the LEO orbit. Instead, a modified Abel inversion based on an algorithm developed previously at UPC will be considered in this work. It includes the supposition that electron density measurements can be described by the vertical total electron content, e.g. determined from terrestrial GNSS networks, in combination with an additional shape function (separability hypothesis) for the description of the vertical dependency.

FORMOSAT-3/COSMIC has been commissioned in 2006 with a configuration of six satellites deployed on separate orbital planes in around 800 km altitude. The availability of associated occultation measurements for more than half a Solar Cycle and with a global coverage thus yields an excellent opportunity to validate (against ionosonde data) and characterize the ionospheric electron density.