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Multi-Dimensional Modeling of Electron Density Using Spherical Harmonics and Chapman Function

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Ionosphere, the upper part of Earth's atmosphere is a dispersive medium with respect to microwave signals. This means that in the first approximation, signals traveling through this medium are affected proportional to the square of their frequencies. This phenomenon allows gaining information about the parameters of the ionosphere in terms of the electron density or the Total Electron Content (TEC). Space geodetic techniques, such as the Global Navigation Satellite System (GNSS), satellite altimetry, and Low Earth Orbiting (LEO) satellites allow the observation and modeling of the ionosphere, but each have their specific characteristics that affect the derived ionosphere parameters. The combined model makes best use of the advantages of each particular method, has more homogeneous global coverage, and is more accurate and reliable than the results of each single technique.
This study aims at developing a multi-dimensional model of the electron density, by combining measurements from different space geodetic techniques. In order to model the electron density in longitude and latitude, a two-dimensional spherical harmonics expansion is applied. To model the electron density in height, a Chapman function is used. The parameters of the Chapman function, e.g., the maximum electron density and the height of the maximum electron density above the Earth's surface will be modeled by series expansions in appropriate base functions, such as trigonometric functions or splines. Finally, the unknown parameters can be estimated by least-squares adjustment from the combination of the measurements from space geodetic techniques, such as GNSS and satellite altimetry.