Ionospheric refraction on GNSS radio occultation signals

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Abstract
Radio signals of Global Navigation Satellite Systems (GNSS) are refracted while travelling through the plasmasphere/ionosphere on their way to the receiver onboard a Low Earth Orbiting (LEO) satellite. Due to spatial gradients of the electron density distribution, i.e. also of the ionospheric refractive index, significant ray path bending is caused. Due to the dispersive nature of the ionosphere the deviations of the curved ray path from the straight line of sight (LoS) are different at different GNSS carrier frequencies. In case of radio occultation measurements, the signal received from a rising or setting satellite travels an extreme long distance through the ionosphere and hence experiences a significant ray path deviation. We used a two dimensional ray tracing tool to trace signals from GNSS satellites down to the COSMIC satellites for ionospheric radio occultation geometry. Our analysis reveals that the ray path bending error, i.e., the excess path in addition to the geometric path length (LoS) or true range may exceed the 1 meter level for the GPS L2 signal when a high total electron content is assumed. The corresponding deviations of the curved optical path from the straight LoS may exceed the 2 km level. In addition, we have found that the tangential heights (correspond to minimum heights) of the signal paths may deviate by more than 1 km from that of the straight LoS propagation. This might cause a substantial error in determining the reference height in the atmospheric profiles retrieval techniques.