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IONOSPHERE INDUCED HIGHER ORDER EFFECTS ON GPS RADIO OCCULTATION MEASUREMENTS

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Abstract: We have investigated higher order ionospheric effects on GPS radio occultation measurements onboard Low Earth Orbiting (LEO) satellites. Due to long ionospheric limb paths, GPS measurements are strongly affected by ionospheric refraction during radio occultation. Since the ionospheric refractive index depends mainly on the electron density, the inversion of the measured total electron content (TEC) from the radio occultation or limb sounding data provides the vertical electron density profile from the LEO height down to the bottom side of the ionosphere. In general, the TEC along a GPS-LEO path is calculated using the GPS dual frequency measurements. However, in the common practice only the first order ionospheric term in the expansion of the refractive index is taken into account for the TEC estimation, i.e., higher order ionospheric terms such as the second and third order terms, and ray path bending effects are ignored. The resulting error in TEC estimation leads thus to an erroneous reconstruction of the vertical profile of electron density. Additionally, due to the bending, the tangential height of the curved path deviates from that defined by the straight line of sight propagation. This leads to an erroneous determination of the reference height in the retrieval technique.

A schematic view of GPS frequencies geometric paths during radio occultation is shown in Fig. 1 (not scaled). When the GPS signal approaches the Earth, the closest point of approach to the Earth's surface is defined as the tangential point and the altitude corresponding to this point is defined as the tangential height. The perpendicular distances of the signal path from the straight line of sight (LoS) or vacuum path are defined as the ray path deviations.

Using a two dimensional ray tracing program, higher order ionospheric terms such as the second and third order ionospheric phase delays, and ray path bending related terms such as the ray path deviation, excess path length of the signal and TEC difference between the GPS L1 and L2 signal paths have been computed. In addition, higher order

propagation effects on the dual-frequency range estimation and TEC estimation during occultation will be presented.

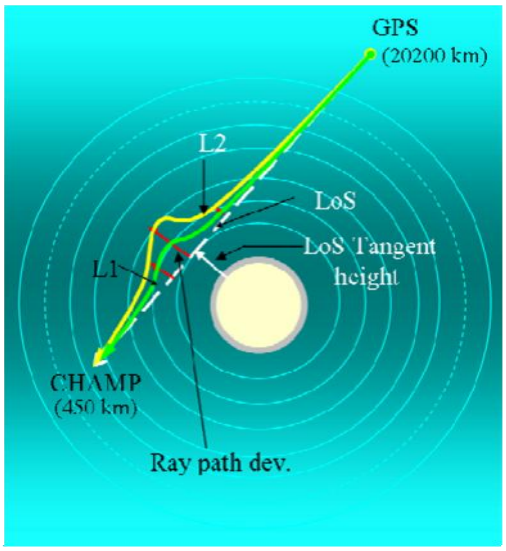

Fig. 1: A schematic view of GPS frequencies geometric paths during radio occultation(not scaled).

We have found that during radio occultation the separation between the GPS L1 and L2 ray paths approaches the kilometer level if TEC exceeds 160 TECU. In this case the differences between the tangential heights of the curved path and LoS path exceed the kilometer level for both the L1 and L2 signals. Conclusions are drawn how to mitigate such higher order effects in radio occultation retrievals.