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Higher Order Ionospheric Effects on GNSS Radio Occultation Inversion

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Extended Abstract
GNSS signals are strongly affected by ionospheric refraction during radio occultation due to long ionospheric travel paths. Inhomogeneous plasma distribution and anisotropy cause higher order nonlinear refraction effects on GNSS signals [1, 2]. However, non-linear terms such as the second and third order ionospheric terms and ray path bending effects are not generally considered when computing slant total electron content (STEC) through a linear combination of dual frequency phase observables. The STECs are used to reconstruct electron density profile along altitude using an inversion technique known as onion peeling. However, the accuracy of the inversion technique can be improved if the higher order terms are corrected for. We have investigated the second and third order terms in the refractive index and effects due to the straight line of sight (LOS) propagation assumption such as the excess path length of the signal in addition to the LOS path and the total electron content difference between the curved path and the LOS path for selected GPS - COSMIC/FORMOSAT-3 occultation events.

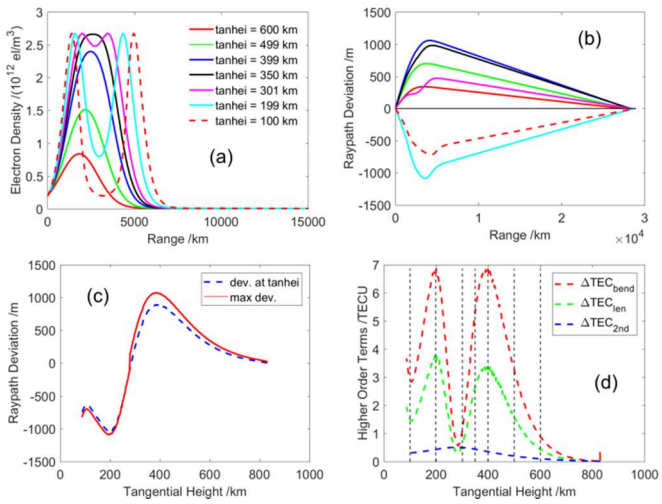

Figure 1. panel (a) shows electron density distribution experiences by signals with tangential heights 100, 199, 301, 350, 399, 500 and 600 km along GPS-COSMIC path, panel (b) shows corresponding ray path deviation from the LOS. Panel (c) shows the maximum ray path deviation and deviation at tangential height during a radio occultation event. Panel (d) shows the corresponding higher order terms in STEC computation.

We used a typical electron density profile based on multiple Chapman layers for computing ray propagation and higher order ionospheric effects. We found that the ray path bending or curvature effects as well as different higher order STEC terms [2] vary depending on the tangential height of the signal and can be several TEC units (1 TECU = 10^{16} el/m^3). We used onion peeling technique to reconstruct electron density distribution from simulated STEC measurements. Our simulation study shows that the accuracy of the electron density reconstruction improves when higher order terms are considered.

References

[1] M. M. Hoque, and N Jakowski, "Higher order ionospheric propagation effects on GPS radio occultation signals," *Advances in Space Research*, 46, 2, July 2010, pp. 162-173, doi: 10.1016/j.asr.2010.02.013.

[2] M. M. Hoque, and N Jakowski, "Ionospheric bending correction for GNSS radio occultation signals," *Radio Science*, 46, RS0D06, July 2011, doi: 10.1029/2010RS004583.