Higher Order Ionosphere Error

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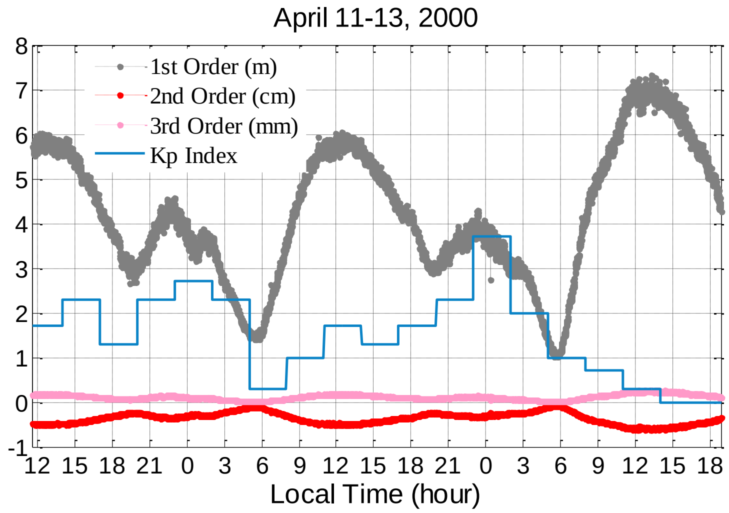

Fig.1 First, second, and third order ionosphere error for signals arriving from zenith during a typical quiet period (as indicated by the Kp index in the figure).

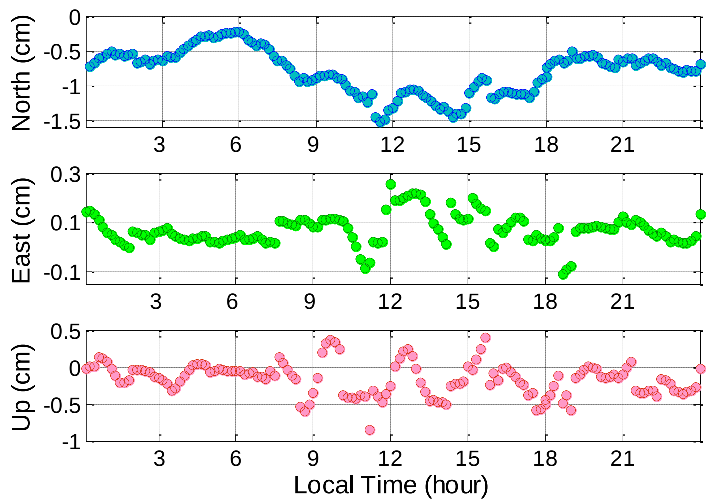

Fig.2 Receiver position error in local tangential coordinates for April 11, 2000 at Arecibo, Puerto Rico, assuming there is no satellite failure in the baseline 24-satellite constellation.

Ionosphere error is the most dominant error source in GPS range observables. Dual frequency GPS receivers have been widely used to mitigate the first order ionosphere error which can range up to several tens of meters under quiet conditions and over 100m during geomagnetic storms. However, there are residual higher order ionosphere error that remain in the dual frequency corrected range measurements. The two key parameters required to compute the error are the electron density distributions and the projection of the Earth geomagnetic field onto the satellite signal propagation direction along the signal path. Previous theoretical and modeling studies have shown that the higher-order ionospheric error residuals could reach up to ~10 centimeters during geomagnetic storms, but should remain less than 1~2 cm under quiet conditions. These works used simplified ionospheric electron density distributions, simple dipole field model, or mean constant to approximate the Earth geomagnetic field. While these approaches can be simple and appropriate in obtaining the bounds of the ionosphere higher order error, they are not suitable in helping to understand the temporal and spatial variations of the error.

Our recent study overcomes the limitations of the simplified ionosphere model by using electron density profiles obtained from the incoherent scatter radar (ISR) measurements at Arecibo Observatory. The geomagnetic field vector is computed using the 10^{th} generation of the International Geomagnetic Reference Field (IGRF) model. Combining the ISR measurements and the IGRF model B field, we were able to obtain a quantitative understanding of the second order error behavior at Arecibo (Latitude: 18^{o}20’37”N, Longitude: 66^{o}45’11”W), Puerto Rico (Morton et al, 2008). There are, however, many questions remain to be answered in order to develop a reliable mitigation scheme for the higher-order ionosphere error. This proposed project involves joint ISR and multi-frequency GPS receiver experiment for comprehensive understanding of the ionosphere higher order error and its relationship to the background ionosphere state.

References:

[1] Morton, Y. T., Q. Zhou, and F. van Graas, “Assessment of second order ionosphere error in GPS range observables using Arecibo incoherent scatter radar measurements,” *Radio Sci.*, 44, RS1002, doi:10.1029/2008RS003888, 2009.

[2] Morton, Y. T., F. van Graas, Q. Zhou, and J. Herdtner, “Assessment of the higher order ionosphere error on position solutions,” accepted, *Navigation*, 2009.