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An over bounding model of higher order ionospheric residuals for dual-frequency SBAS

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Extended Abstract

Future space based augmentation systems (SBAS) will support dual-frequency GNSS receivers onboard airplanes. Therefore, about 99% of the ionospheric refraction effects can be mitigated by combining signals at two different frequencies without additional SBAS corrections. However, higher order ionospheric effects such as the second- and third-order terms in the refractive index, ray-path bending related errors such as the curvature effects will be reduced in the dual-frequency combination but not completely mitigated [1, 2, 3]. The second-order effect is due to the interaction between the signal and the Earth's magnetic field [3]. Due to ionospheric gradients electromagnetic signal propagates along a curved path instead of a straight line of sight (LoS) path. Again due to the frequency dispersive nature of the ionosphere two GNSS signals follow two slightly different curved paths. In one hand the length of a curved path is slightly bigger than the LoS path and on the other hand the total electron content (TEC) along a curved path is larger than that along the LoS path [2]. Thus the curvature effect leads to propagation errors which are different at two frequencies. For estimating different higher order ionospheric effects we used a ray tracing tool to trace signals from GNSS satellites down to the receivers using three dimensional ionosphere and geomagnetic field models. Our simulation study varying ionospheric profile parameters shows that the higher order ionospheric effects can be several tens of centimeters in worst case situations especially for a thin profile. The worst case situations are derived based on history of ionospheric and geomagnetic storms and maximum TEC values from current and previous solar cycles. In this paper we developed and justified an over bounding model for ionospheric residuals that remain after the application of the ionosphere-free linear combination. The model takes into account the second- and third-order ionospheric refraction effects, excess path and increased TEC along the signal path due to ray bending. The model is elevation dependent, easy implementable in the receiver software, and provides a conservative estimate of the worse-case residuals with a risk probability beyond 10^{-7}. The model is designed to fit the needs of the dual-frequency multi constellation (DFMC) Minimum Operational Performance Standard (MOPS) for the next generation dual-frequency SBAS.

References

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