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Radio Occultation Modelling in Complex Ionospheres

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1. Extended Abstract

Radio occultation measurements are an established technique for probing the structure of the atmosphere. They achieve this by observing the bending of radio waves between a GPS and a low Earth orbiting (LEO) satellite and then using these observations to infer the distribution of atmospheric refractive index. The major problem with this technique, however, is that there can be a substantial contribution to the bending from the Earth's ionosphere and this needs to be removed before the behaviour of the atmosphere can be inferred. Fortunately, because of the dispersive nature of the ionosphere and the dual frequency transmissions of GPS, we can produce a suitable correction. Unfortunately, however, the correction is asymptotic in nature and only works to the leading order in frequency. Consequently, there is a residual ionospheric error (RIE) and we need to understand the impact of this upon the refractive index we infer from occultation measurements. For a spherically symmetric ionosphere, the RIE is well understood [1]. What is less well understood is the effect of complex ionospheric structures (the equatorial anomaly for example) upon the RIE. Mannucci et al. [2], Liu et al. [3] and Danzer [4] have simulated the effect of large scale structure upon the RIE and have all concluded that it can have a significant impact. Unfortunately, a major problem that has been encountered in such work is the numerical noise that arises during such simulations. This has two major sources, the first is the fact that we are working near the limit of the achievable accuracy of the ray tracing and the second is the low degree of smoothness in the global ionospheric models that are used. Calculations of the RIE require the differencing of calculations at the two GPS frequencies (L1 and L2) and this amplifies the effect of the noise. The current paper addresses the issue of this noise and looks at techniques for overcoming the problem. The simulations require a classic point to point ray trace and we first address this through a homing approach [5]. The major problem with this approach is the low order of smoothness in the ionsopheric models that are available and the breakdown that occurs when the L1 and L2 rays are located either side of a discontinuity in electron density gradient. We develop a technique for detecting and eliminating such anomalies and find that the remaining simulations produce well behaved results. As an alternative, we also investigate a direct variational approach to the problem [6] since this approach is less sensitive to the low differentiability of the ionospheric model. We demonstrate the effectiveness of the above approaches through simulations involving a variety of ionsopheric structures.

2. References

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