Ionospheric Assessment for Satellite Navigation over the Australasian Region

Characterizing the ionosphere over any geographic region is a multi-faceted problem. Techniques such as tomographic decomposition and TEC modelling measure ionospheric delay and density characteristics whereas S4 and σ_{Φ} metrics measure scintillation behavior. Other ionospheric properties include TIDs, plasma bubbles, ionospheric drift velocities and disruption in the earth's magnetic field components, to name a few. While much work has been devoted to academic investigations of the ionosphere, other work in recent years have investigated ionospheric properties as they relate to satellite navigation systems and specifically to the design of single frequency ionospheric delay and GIVE algorithms. These characteristics include deviations from planarity, Ionospheric Perturbation Metrics (IPMs), and undersampled ionospheric threats and gradients.

The Australasian region presents a challenging yet manageable problem for satellite navigation. While most of the continent enjoys benign ionosphere, the northern region lies under the lower portion of the equatorial anomaly. The curvature imposed by this feature makes ionospheric delay estimation and error bars more difficult to model, and so the question remains, to what extent can the Australasian region be modeled such that a single frequency satellite navigation system can provide both coverage and integrity? It is this question which we hope to support with the ionospheric assessment of the Australasian region.

In this paper, we characterize the ionosphere in the Australasian region in terms of relevant quantities for a Space Based Augmentation System. The single frequency satellite navigation system uses a bilinear interpolation algorithm defined in the MOPS to generate the user's ionospheric delay. Errors in this model are effectively the only quantity of importance for signal frequency satellite navigation systems. Statistics on deviations from the bilinear interpolation represent the initial errors to be modeled. These deviations have strong dependence on distance from the fit center, magnetic latitude as well as day/night variations. To this end, statistics for these deviations are used to create the models for the weights applied to the IPPs used in creating an ionospheric delay estimates. After the weights are created and the fits are applied at IGPs, ionospheric threats are assessed. Ionospheric threats are simply any real ionospheric deviation from the bilinear model which is not able to be observed using the station network. These threats are highly dependent on the actual network of stations used, since sparse and/or offset IPP distributions lead to more severe threats. The accumulation of these threats, categorized by geometric metrics, is known as an ionospheric threat model.

The two characterizations described above, that is the statistics of the deviations from a bilinear model and the ionospheric threat model are sufficient to allow us to estimate the performance and integrity of a single frequency satellite navigation system. While the algorithm performance discussed in this paper is not definitive, this work represents a detailed approach to assessing the behavior of ionospheric algorithms in the Australasia region.