Spatial and Temporal Ionospheric Mapping with Outlier and Missing Samples

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Abstract

Ionospheric mapping is required by various users for forecasting and nowcasting. Here we are concerned with the case of providing a real-time ionospheric model (RTIM) for applications such as coordinate registration in the Jindalee Operational Radar Network (JORN) HF skywave radar. In this situation coordinate registration is the act of transforming the position of a target detected in radar coordinates to ground position. To do this an accurate description of the HF skywave propagation path is required. A means to do this is to form a parametric model of the ionosphere. The parameters typically include estimates for each ionospheric layer of height, thickness and critical frequency. Propagation paths are then calculated using Chapman or quasi-parabolic electron density height profiles. The parameters to drive the model are derived from real-time measurements from vertical incidence and oblique incidence sounders that are positioned sparsely across the Australian continent.

Ionospheric mapping requires interpolation of the parameters between the sounder sites. A means to do this is by a spatial (site to site) correlation model for each parameter and performing the interpolation (a methodology referred to as Kriging in the geo-physical literature). This result is only optimal in a LMS sense if the covariance matrix is true. However, the estimate may be improved with use of the sample covariance matrix provided the samples form an homogenous set. A non-homogeneity test is provided to select samples. This same test may be used to address the problem of poor derivation of parameters from sounder measurements (the outlier problem). We also derive a robust solution to the catastrophic failure of sounders (the missing sample problem).