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Examining the use of the NeQuick bottomside and topside parameterizations at high latitudes

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The NeQuick electron density model, similarly to the IRI, provides a global 3D representation of ionospheric electron density. The model uses a series of semi-Epstein layers with single thickness parameters to represent electron density from the lower E-region up to the upper topside at 2000km. While the model can be considered reasonably accurate at mid latitudes, its application at high latitudes remains untested. This study addresses the high latitude representation of the F2 peak by the NeQuick model; specifically, this study looks at the method used to parameterize the thickness of the bottomside and topside of the F2 peak, focusing on the use of the NeQuick topside parametrization for the topside extrapolation of ionosonde-derived bottomside profiles and its use in the IRI model.

For the bottomside, we present a comparison between modeled and measured B2Bot thickness parameter. In this comparison, we show that the use of the NeQuick parameterization at high latitudes results in significantly underestimated bottomside thicknesses, regularly exceeding 50%. We show that these errors can be attributed to two main issues in the NeQuick parameterization: 1) through the relationship relating foF2 and M3000F2 to the maximum derivative of F2 electron density, which is used to derive the bottomside thickness, and 2) through a fundamental inability of a constant scale thickness, semi-Epstein shape function to fit the curvature of the high latitude peak electron density region.

For the topside, a comparison is undertaken between the NeQuick topside thickness parameterization, using measured and IRI-modeled ionospheric parameters, and that derived from fitting the NeQuick topside function to Incoherent Scatter Radar-measured topside electron density profiles. Through this comparison, we show that using CCIR-derived foF2 and M3000F2, used in both the NeQuick and IRI, results in significantly underestimated topside thickness during summer periods, overestimated thickness during winter periods, and an overall tendency to underestimate diurnal, seasonal, and solar cycle variability. These issues see some resolution through the use of measured foF2 and M3000F2; however, there remains a significant tendency for the parametrization to produce a declining trend in topside thickness with increasing solar activity, to produce damped seasonal variations, and to produce significantly overestimated topside thickness during winter periods, particularly during the nighttime.