To what extent can E-CHAIM be used as a model of total electron content?

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The Empirical Canadian High Arctic Ionospheric Model (E-CHAIM) is designed as a full-featured alternative to the use of the International Reference Ionosphere (IRI) in the representation of ionospheric electron density at high latitudes. The model, detailed in Themens et al. [2017, *doi:10.1002/2017JA024398*], [2018, *doi:10.1002/2017JA024817*] and [2019, *doi: 10.1029/2018RS006748*], features an improved representation of high latitude characteristics in peak electron density (NmF2) and a refinement of the IRI's NeQuick topside function to better characterize the shape of the high latitude topside electron density profile. Here we will explore to what extent E-CHAIM may be used as a climatological model of high latitude total electron content (TEC). To this end, we compare ground-based Global Positioning System (GPS) receiver data from the Canadian High Arctic Ionospheric Network (CHAIN) to that generated using E-CHAIM.

Themens et al. [2016, *doi:10.1002/2016JA022664*] demonstrated that the IRI tends to significantly underestimate TEC at high latitudes, primarily due to the model's underestimation of foF2 and underestimation in the IRI topside. This study will use the same dataset to evaluate the performance of E-CHAIM.

Through this study, we show that E-CHAIM performs well as a TEC model within the Polar Cap and Auroral Oval region, where monthly RMS TEC errors are shown to remain below 1.5TECU at low solar activity, peaking at 4.5 TECU during solar maximum. For context, the IRI's monthly RMS errors remain below 3 TECU at solar minimum but increase to up to 12 TECU during solar maximum. It is a different story in the North American sub-auroral region, where E-CHAIM demonstrates monthly RMS errors ranging from 2.0 TECU to 7.0 TECU. The IRI, however, sees a significant improvement in performance with monthly RMS errors ranging from 1.5 TECU to 8.0 TECU, performing better than E-CHAIM during the winter and at solar minimum. The reduction in performance of E-CHAIM in the North American sub-auroral region appears tied to an overestimation of the Main Ionospheric Trough (MIT) depth stemming from a severe lack of fitting data available from that region when E-CHAIM was developed. This results in the underestimation of TEC at night in this region, particularly during the winter. Combined comparisons with DMSP and Swarm-B suggest that these errors are likely due to an underestimation of the F2-peak electron density (NmF2).