Examining the use of the Empirical Canadian High Arctic Ionospheric Model (E-CHAIM) using in situ measurements

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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*] and [2018, *doi:10.1002/2017JA024817*], features 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. This study uses in situ measurements of electron density from the Defense Meteorological Satellite Program (DMSP, 830 - 880km altitude) and Challenging Minisatellite Payload (CHAMP, 350km - 450km altitude) satellite missions to undertake the first independent validation of E-CHAIM's performance in the representation of high latitude topside electron density.

We first compare E-CHAIM- and IRI-modeled electron density to that measured by DMSP. We will demonstrate that E-CHAIM provides a marked improvement over the IRI at these altitudes, constituting a 70% or more reduction in RMS error during summer periods, particularly at high solar activity. We will also show that E-CHAIM is able to capture the general seasonal, solar cycle, and spatial variations in electron density at DMSP altitudes, while in general, the IRI underestimates electron density at DMSP orbit by as much as 80% during summer periods and particularly at high solar activity.

Comparing the models to CHAMP in situ electron density measurements, we note a somewhat different story. At CHAMP E-CHAIM performs better than the IRI during morning and daytime periods by as much as 65%; however, outside of these periods, both models tend to perform comparably, with slightly larger RMS errors at high solar activity but universally below 1.2e11 e/m^3.

Based on the results of Themens et al. [2014, *doi:10.1002/2014JA020052*] and [2016, *doi:10.1002/2016JA022664*] we were led to suspect a tendency for the IRI to underestimate electron density at the DMSP orbit, while performing reasonably in the near-peak topside, measured by CHAMP. For E-CHAIM, based on the fitting statistics of the model, we expected largely zero-mean Gaussian error behaviour. Examining the comparisons using these two datasets, we assess these expectations, finding that they are largely correct, confirming our prior suspicions of the cause of observed IRI Total Electron Content (TEC) errors at high latitudes.