Solar Activity drivers in empirical ionospheric models: Validating E-CHAIM and exploring intermediate timescales in the high latitude topside

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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. 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. 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.

These results are consistent with the vertical distribution of F2-peak-normalized errors presented in Themens et al. [2018, *doi:10.1002/2017JA024817*] with respect to the E-CHAIM fitting dataset, where E-CHAIM demonstrated largely unbiased errors in altitude and the IRI demonstrated overestimation in the near-peak topside and underestimation in the upper topside. It appears from these comparisons that the IRI's overestimation errors due to the topside shape function, demonstrated in Themens et al. [2018, *doi:10.1002/2017JA024817*] are somewhat mitigated by a tendency for the IRI to underestimate F2-peak density (NmF2) at high latitudes. This same underestimation of NmF2 appears to exacerbate the IRI's underestimation errors in the upper topside related to the topside shape function.

Finally, we will address the behaviour of the high latitude topside at intermediate time scales (1-30 days) and propose improvements upon the current E-CHAIM parameterization to better reflect topside variations at these timescales. Specifically, we will address the behaviour of various components of E-CHAIM's electron density parameterization with respect to intermediate time-scale solar activity variability and examine the need to adjust the solar activity drivers of empirical electron density models to reflect the differing sensitivity of various electron density profile components to solar activity variability.