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A Neural Network based foF2 model for a single station in the polar cap

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1. Extended Abstract

The importance of the F2 layer critical frequency (foF2) in high frequency (HF) communication studies and applications has been a driving force in the development of various ionospheric and HF propagation models. For instance, empirical models have been developed to predict the behavior of foF2 over different timescales using various approaches including the nonlinear least square, Neural Network (NN) and AdaBoost techniques [1, 2, 3]. Particularly, the NN approach has proven to be a promising tool in modeling of ionospheric characteristics. Most of the available empirical models have been developed with an aim to improve on the International Reference Ionosphere (IRI) model predictions of the various ionospheric parameters. Inspite of such tireless efforts, recent studies by [4, 5]) still show persistent limitations of the IRI at high latitudes especially in the polar cap, in addition to a previously emphasized problem of data scarcity in this region.

With the persistent limitations of the IRI at high latitudes and an improvement in data availability from various sources including the Canadian High Arctic Ionospheric Network (CHAIN) [6], it is necessary to develop alternatives to the IRI for the polar regions. This paper attempts to empirically model foF2 at a single station located in the polar cap using both historical and new data obtained from the Space Physics Interactive Data Resource (SPIDR) and the CHAIN, respectively.

A Neural Network (NN) model has been developed for the critical frequency of the F2 layer (foF2) using data from Space Physics Interactive Data Resource (SPIDR) and the Canadian Advanced Digital Ionosonde (CADI) at Resolute (74.75° N, 265.00º E). The NN model predictions (NN-foF2) were compared with foF2 values obtained from the IRI model (IRI-foF2) and CADI (CADI-foF2) for the period of 2009 - 2013. The NN and IRI models were able to reproduce the diurnal variations observed in hourly CADI measurements. While the IRI underestimates the nighttime monthly median foF2 variation observed in CADI-foF2. The models are also able to demonstrate the seasonal variation in foF2, specifically the NN is able to reproduce the enhancements in the foF2 observed in CADI measurements during the equinoxes. IRI underestimates foF2 values in winter and the equinoxes during low solar activity. The NN model also shows an improvement in foF2 predictions during disturbed days. Root Mean Square Errors (RMSE) were computed between hourly and monthly median model predictions and observations. RMSE values seem to increase with solar activity, and are lowest in summer. On the whole, the NN model seems to perform better during low solar activity and the equinoxes. The IRI shows an improvement in its predictions as solar activity increases especially in winter.

2. References

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