Fitting Ionospheric Models Using Real-Time HF Amateur Radio Observations

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Introduction
Using novel, spatially distributed data sources, we have begun an investigation into ionospheric morphology over wide observational areas, with a goal of improving ionospheric and radio propagation models. These data sources also have information density that is ideal for advancing knowledge on high time cadence radio propagation trends at shortwave frequencies in ways that are difficult to obtain by other means. The initial investigation reported here focuses on transmissions in the 7 MHz (40 M) radio band.

Research Questions
• Using RBN propagation data, can we identify significant space weather events that affect ionospheric structure?
• How well do RBN observations agree with IRI HF Raytracing predictions?

Data and Methodology
The data used during this analysis comes from the Reverse Beacon Network (RBN). The Reverse Beacon Network is an automated radio (1.8 – 144 MHz) receiving network created and maintained voluntarily by ham radio operators that has been shown to be sensitive to ionospheric effects [Frissell et al., 2014]. We ignored all communication paths observed by the RBN over 4000 km. This was done to remove multi-hop ionospheric propagation from the data to more easily highlight variations in reported signal to noise ratio (SNR) data. The Ap and 10.7 cm indices were obtained from CDAWeb’s hourly OMNI data set and were smoothed over a 3 month period.

We simulated the communication paths seen by the Reverse Beacon Network using PHaRLAP [Cervera and Harris, 2014]. This provided us with a baseline for comparison of ionospheric model predictions with observations derived from the RBN.

Coverage
This plot shows midpoints for all communication paths observed by the Reverse Beacon Network where the transmitter and receiver are less than 4000 km apart. Most communications observed by the Reverse Beacon Network come from the United States and Europe with only minor participation from China and Japan. Our analysis focuses on communication from the United States and Europe for this reason.

Summary
• We can see space weather effects on radio propagation as seen by the RBN. RBN observations reveal large-scale propagation signatures inconsistent with HF raytracing through the IRI.

Acknowledgements and References

All simulated data in this paper was obtained using the HF propagation toolbox, PHaRLAP created by Dr. Manuel Cervera, Defence Science and Technology Group, Australia (manuel.cervera@dsto.defence.gov.au). This toolbox is the result of more than a decade of research into HF propagation at the University of New Hampshire and is supported by the ionospheric rummages project, which is funded by the National Science Foundation (NSF). The work presented here was supported by the National Science Foundation Office of Polar Programs. The authors would like to thank the ionogram database providers: RBN, RBN, and the Washington University in St. Louis for their support on the propagation database.

7 MHz Global Communications

Diurnal Effects

Regional Effects

European Effects

Night

Day

All

Sunet

Night

Day

All

0300 LST, and Sunset are defined as not being Day or Night. Within these time bins we can see the 7 MHz propagation at night favors long distance communications while day favors shorter range communications.

European Effects

In these plots we are comparing observed and simulated spots from Europe. We have simulated all observed communications seen by the Reverse Beacon network over the entire duration of the network. PHaRLAP does not predict the large variations in SRNs that we see in the observed data. Most of PHaRLAP’s predictions seem to be grounded in month-to-month variations.

RBN

PHaRLAP

European Effects