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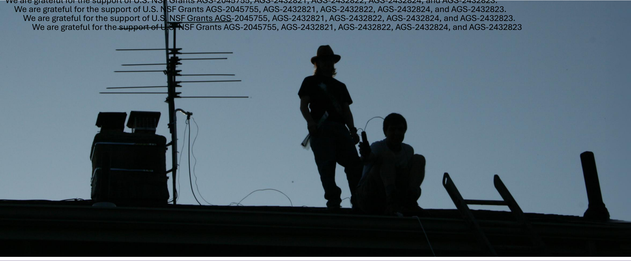

What is the ITU-R-HF Model and How Could it Be Used in a HF Contesting Dashboard?

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Abstract

The ITU-R HF propagation model is a method for mathematically determining the chance as a percentage of being able to reach a given performance criterion. It can be used to model an expected Signal to Noise Ratio (SNR), Maximum Usable Frequency (MUF), or Field Strength over a given month. It uses known mathematical models of the ionosphere to determine generalized propagation through the E and F2 layers of the ionosphere and gives considerably accurate predictions. Our goal is to use this method with a currently existing HF contesting dashboard that utilizes the Personal Space Weather Station (PSWS) to determine if appropriate conditions exist for making a contact in real time. Through ITU-R recommendations and with programming assistance from Anthropic's Claude.ai, we are working to integrate these scientific modeling methods with real-time data with the PSWS. After successful implementation of the ITU-R HF model, we can use model assimilation techniques to achieve higher accuracy predictions. Using the technology, we will be able to achieve more accurate band opening prediction, DX propagation prediction, and ionospheric modeling.

Background

The ITU-R-HF model is an empirical model for HF radio wave propagation over a given month. It is an empirical model based on ionospheric measurements. It works by:

- Determining control points (TX site, RX site, hop locations) and then using those points to create a ray path along the Great Circle and find the distances of the path
- Determining reference critical frequencies (foE and foF2), and reference measured ionospheric coefficients
- Determining the type of signal (modulation) being used
- Determining the antenna gain

Then, all of these values are used in empirical equations to calculate:

- Basic Circuit Reliability (BCR) – Chance of the wave reaching a given area
- The Maximum Usable Frequency (MUF/OPMUF)
- The Lowest Usable Frequency (LUF)
- Signal to Noise Ratio (SNR)
- Field Strength (in dB – μV/m)

Background (cont.)

Based on the critical frequencies, control points, monthly ionospheric coefficients, and signal strength, it also determines whether the dominant propagation mode is from the E-layer or the F2-layer and uses that for calculations. Depending on the ray path, the model also accounts for losses from polar paths (aurora) and equatorial scattering; however, slight errors in prediction occur for equatorial paths in the evening.

Implementation

Over the next year, we will work to implement this model into our current HF-Contesting DX Dashboard. Based on the recommendations from the International Telecommunication Union (ITU) and with programming support from Anthropic's Claude.ai, we will implement the model into the dashboard. We will implement both point-to-point predictions (with a range of frequencies) and overall-area predictions (with a given frequency).

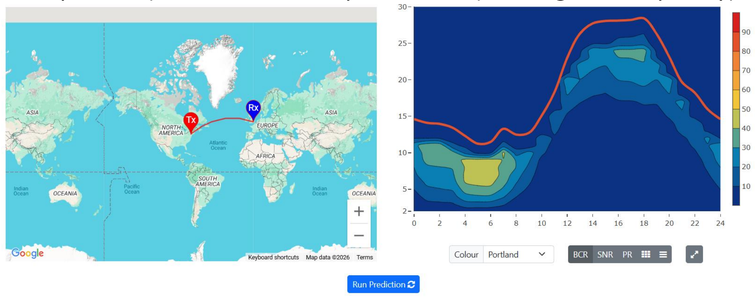

Figure 1: Point-to-Point prediction from FN21 (Scranton) to TQ38 (London). Basic Circuit Reliability is shown by color. The solid red line is the Maximum Usable Frequency. *Credit: Proppy*

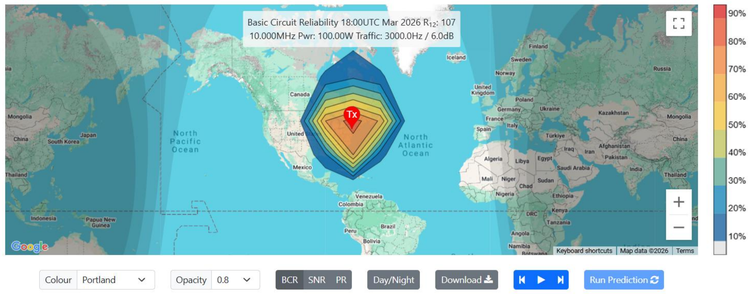

Figure 2: Area Prediction around FN21 (Scranton). The set frequency is 10MHz, and the current time shown is UTC 1800. The color represents the Basic Circuit Reliability. *Credit: Proppy*

Goals

- Fully implement the model into our current contesting dashboard
- Create a system for comparing real-time data with the model
- Ensure offline model capability with options to input current space weather
- Create online features to pull from other networks (RBN, NCDXF, NOAA Space Weather)

Future Work

- Verify ITU-R model for accuracy vs. real-time data to test model integrity
- Integrate real-time data into the predictions with model assimilation for more accurate values
- Use the new DX-Dashboard for both contesting and ionospheric study

Timeline

- Summer 2026
  - Finalize project plan and background information
  - Begin work on model development
- Fall 2026
  - Finalize model development
  - Begin dashboard integration
  - Begin prediction verification during contest season
- Spring 2027
  - Determine gaps between real-time data and model predictions
  - Compile and present results at the 2027 HamSCI Conference

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