32nd URSI GASS, Montreal, 19–26 August 2017

D-Region Ionospheric Remote Sensing with LF/MF Signals of Opportunity

Marc A. Higginson-Rollins* (1) and Morris B. Cohen (1)
(1) School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, Georgia, USA.

1 Extended Abstract

The D-region ionosphere (60−100 km altitude) is of great importance for long distance terrestrial communication and for studying many geophysical phenomena. Modern remote sensing methods used to study the D-region are predominately in the Very-Low Frequency band (VLF, 3−30 kHz, using VLF beacons and natural lightning emissions.) Other workers utilized the High Frequency band (HF, 3−30 MHz) including partial reflections, radars, and rockets. VLF based remote sensing is favorable because of the low ionospheric attenuation rates, allowing global propagation, but this also creates an ill-defined multi-mode propagation problem to solve. HF remote sensing methods are typically more simple and accurate, but restricted to making measurements in a single location. Low Frequency (LF, 30−300 kHz) and Medium Frequency (MF, 300 kHz−3 MHz) waves have not been extensively utilized as a diagnostic tool for the D-region, specifically near the middle of the two bands, but may serve as an effective middle ground. Radio waves propagating at LF and higher frequencies reflect off the ionosphere, and the earth, but at much higher attenuation rates, which reduces the propagation range but also simplifies the modal complexity of the signal.

The United States Coast Guard (USCG) operates a national network of radio transmitters that serve as an enhancement to the Global Positioning System (GPS). This network is termed Nationwide Differential Global Positioning System (NDGPS) and uses fixed reference stations as a method of determining the error in received GPS satellite signals and transmits the correction value using low frequency and medium frequency radio signals between 285 kHz and 385 kHz.

In this presentation, we evaluate the use of these transmitters as a diagnostic tool for the D-region of the ionosphere. We present the data collected from several LF AWESOME receivers located throughout the United States and find diurnal trends in the signal from these transmitters, as well as observations of geophysical phenomena. The Finite-Difference Time-Domain (FDTD) method has been implemented to model the groundwave radiated by the NDGPS beacons and account for environmental effects, such as changing ground conductivities and terrain. We compare data collected from the LF AWESOME receivers to simulated propagation in the FDTD model to demonstrate the impact of terrain on the propagating signal. In addition, the skywave component of the propagating signal, or the component of the wave that reflects off the ionosphere, is analyzed using an FDTD model. Comparisons are made to real data and discussed.