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

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The D-region of the ionosphere is a region of the ionosphere that is highly inaccessible because it is too high for continuous in-situ measurement techniques and too low for satellite measurements. Very-Low Frequency (VLF) signals have been developed and used as a diagnostic tool for this region of the ionosphere and are favorable because of the low ionospheric attenuation rates, allowing global propagation – but this also creates an ill-defined multi-mode propagation problem to solve. As an alternative, Low-Frequency (LF) and Medium-Frequency (MF) signals could be used as a diagnostic tool of the D-region. These higher frequencies have a higher attenuation rate, and thus fewer modes propagate in the Earth-ionosphere waveguide, creating a much simpler problem to analyze.

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 Differential Global Positioning System (DGPS) 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 whether these transmitters can be used as a diagnostic tool for characterizing 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 DGPS 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, preliminary methods for extracting the sky-wave components from the groundwave are discussed.