Characterization of the D-Region Ionosphere Using ELF/VLF Wave Generation Experiments: An Interpretation and Review of Experimental Facts

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Ground-based observations of ELF/VLF waves generated by modulated HF heating of the auroral electrojet current system with the High-frequency Active Auroral Research Program (HAARP) HF transmitter in Gakona, Alaska may eventually offer a means for determining the characteristics (i.e., the ambient electron density and temperature) of the overlying lower ionosphere (at 70-100 km altitude). The detected amplitude and phase of the generated ELF/VLF signals depend on these source characteristics as a function of altitude as well as on the location of the ELF/VLF receiver in relation to the HF-heated three-dimensional ionospheric volume. In this paper, we review recent experimental observations of the ELF/VLF signals generated as a function of HF power, HF frequency, and ELF/VLF modulation frequency and present a simple theoretical framework with which to interpret these observations. Based on the analysis of the experimental observations, we discuss the difficulties inherent in resolving the ELF/VLF source region characteristics and identify experimental methods that may help overcome some of these obstacles in the future.