# ELF/VLF WAVE-INJECTION ADN MAGNETOSPHERIC PROBING WITH HAARP

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## ABSTRACT

Located at L=4.9, most of the time on closed field lines in the vicinity of the plasmapause, the High-frequency Active Auroral Research Program (HAARP) HF Heater is the first ionospheric heating facility that allows the conduct of ELF/VLF wave-injection experiments to investigate coherent wave growth and emission triggering phenomena. HAARP allows the excitation of waves in the frequency range of a few Hz to 30 kHz, with highly flexible amplitude, phase, and frequency modulation capabilities. Measurements of HAARP generated ELF/VLF signals at ground-based sites (in Alaska) and on satellites (both high-altitude ones such as CLUSTER, and low altitude spacecraft such as DEMETER) indicate robust generation of fields with intensities ranging from <1 pT to several tens of pT as measured on the ground. ELF/VLF signals are generated under a wide range of conditions, both quiet and disturbed, daytime and nighttime, and are found to be at detectable levels >80% of the time. In recognition of the particular location of HAARP in the vicinity of the plasmapause and on closed field lines on which ducting of whistler-modes is commonly observed, several ELF/VLF magnetocspheric wave-injection campaigns have recently been carried out. The objective of these campaigns have been the measurement of coherently amplified one- or two-hop whistler-mode signals, and any associated triggered emissions. For measurements of the one-hop signals in teh HAARP-conjugate region (Southern Pacific Ocean), ship-board observations are conducted, while teh two-hop signals are measured at a constellation of sites in Alaska. Amplified ELF/VLF signals and triggered emissions have been observed in at least one case, on April 20, 2003, with the HAARP-injected ELF/VLF signals reflecting back-and-forth between conjugate points up 10-12 times, exhibiting evidence of wave-particle inetarction, wave-growth, and emission triggering in each traverse of the equatorial interaction regions. While extensive ELF/VLF wave-injection experiments were carried out with the Siple Station VLF transmitter in the 1980s, that facility was only designed to efficiently excite wave frequencies in the range of 1.5 - 15 kHz. The HAARP facility can be used to excited waves at several hundred or tens of Hz, thus allowing the possibility of probing the ion modes, and even field line oscillations. Also, Siple was located at L=4.2, typically just inside the plasmasphere, whereas HAARP is located at L=4.9, and is thus better suited to the probing of the plasmapause boundary, including the irregular regions immediately outside of it. With the cold plasma densities being typically an order of magnitude lower, cyclotron resonance interactions with few kHz HAARP-induced signals would involve energetic electrons with >50 keV energy, raising the possibility of detectable HAARP-induced disturbances of the nighttime D-region. In this talk, we present recent results of ELF/VLF wave-injection experiments carried out with teh HAARP facility.