# Multi-Station Observations of Frequency dependence of Amplitude and Polarization of the ELF Waves generated via Ionospheric Modification

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Generation of Extremely Low Frequency (ELF) and Very Low Frequency (VLF) signals through ionospheric modification has been practiced for many years. In ionospheric heating with high power HF waves, the electron temperature of the lower ionosphere is increased thereby changing the particle collision frequency and conductivity of the medium. Modulating the conductivity allows modulation of natural current systems.

Our experiments were carried out at the High Frequency Active Auroral Research Program (*HAARP*) facility in Alaska, USA. In this experiment, the ionosphere was heated with a vertical amplitude modulating signal and the modulation frequency was changed sequentially within an array of 40 frequencies.

The observed magnetic field amplitude and polarization of the generated ELF/VLF signals were analyzed for multiple sites and as a function of modulation frequency. Our three observation sites: Chistochina, Paxon and Paradise are located within 36km (azimuth 47.7°), 50.2km (azimuth -20°) and 99km (azimuth 80.3°) respectively.

Based on the experimental results, we can show that the highest magnetic field strength was observed at 2.1 kHz which is the resonance frequency of the ionosphere, and the next highest peaks are observed at 4.1 kHz, 6.1 kHz respectively for all three sites. Out of the three sites Paxon shows the highest circularity in the magnetic field polarization, compared to Chistochina and Paradise which show highly linear polarizations.

The experimental results were compared with a theoretical simulation model results and it was clear that in both cases, Hall current dominates in Chistochina and Paradise sites and Paxon is dominated by the Pedersen current.

The Chistochina site shows the highest magnetic field amplitudes in both experimental and simulation environments. Depending upon the experimental and simulation observations at the three sites, a radiation pattern for the HAARP ionospheric heater can be mapped.