Location of the Dominant ELF/VLF Source Region for Ground-Based Observations

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A novel technique was employed during the 2008 PARS Summer School using ground-based ELF/VLF observations to determine the location of the dominant ELF/VLF source region above the HAARP HF transmitter in Gakona, Alaska. Receivers were located between 30 and 100 km ground-distance from HAARP and measured the radial and azimuthal magnetic field components at 100 kHz with GPS timing accuracy and 16-bit precision. We employed the dual-beam capabilities of the HAARP array together with a specific modulation frequency-time format to provide bounds for the location of the ELF/VLF source region that dominates the signal observed by each receiver. These bounds are estimated using a modified time-of-arrival technique. Previous ELF/VLF wave generation studies have approximated the altitude of the dominant ELF/VLF source region assuming the location is directly above the HF heater, but the calculated altitudes varied widely both as a function of modulation frequency and as a function of time.

During the dual-beam experiment presented herein, a CW wave is used to probe the modulated ELF/VLF source region, and the resulting ground-based ELF/VLF observations indicate that different portions of the spatially distributed HF-heated region dominate the ELF/VLF signals observed at different radial distances from the HF transmitter. Furthermore, by accounting for this receiver-dependent dominant off-zenith heating angle, the altitude of the dominant ELF/VLF source region may be determined more accurately in previous experiments.

In this paper, we experimentally determine (with ± 1.8 km ranging accuracy) the location of the dominant ELF/VLF source region within the larger HF-heated ionospheric patch and analyze its dependence on receiver location.