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VLF triggered emissions excited by the HAARP HF Ionospheric Heater

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ELF/VLF wave generation by heated modulation of the ionospheric auroral electrojet currents is used for controlled magnetospheric wave injection experiments. The High Frequency Active Auroral Research Program (HAARP) facility in Alaska (L = 4.9) has been used to efficiently generate electromagnetic radiation in the 500 Hz - 5 kHz frequency range for several years. In an on-going experiment the HAARP facility is used to inject ELF/VLF waves into the magnetosphere to trigger wave-particle interactions that result in the non-linear amplification of the wave, known as the coherent whistler mode instability. Amplified and triggered waves called 'echoes' are observed on the ground at both ends of the magnetic field line and also on the DEMETER satellite. The amplified signals show temporal growth rates 15-30 dB/sec and triggering of free running emissions. The amplification process is shown to be sensitive to select frequency bands and to selectively amplify specific frequency-time formats in these bands. Dispersion results indicate that HAARP induced echoes are excited primarily directly above the heated region and propagate inside the plasmapause. The efficiency of exciting echoes is explored for various generation techniques and transmitter parameters. Accurate phase and amplitude measurements allow for the determination of the spatial average of the magnitude and phase of the nonlinear resonant current vector that drives the non-linear amplification.