Extended heating of the nighttime *D* region by very low frequency transmitters

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Very low frequency (VLF, 3−30 kHz) signals propagating in the Earth-ionosphere waveguide are used to probe the heated nighttime *D* region over three keyed U.S. Navy VLF transmitters. The keyed VLF transmitters are turned on-off in periodic formats for thirty to sixty minutes each day over the course of several months each, providing sensitive measurements of their heating effect on the surrounding ionosphere. On several occasions, the heating effect is observed on probe signal pathways at distances greater than 1500 km from the keyed transmitter. It is proposed that the heating effect of VLF transmitters extends over very large distances through the subionospheric propagation of its radiated signal. General statistics are presented on the observed extent of the heating region over the course of the experiments, and a combination of propagation, heating, and scattering models are used to analyze the results.

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