Correlation Between ELF Signal Intensity and Magnetometer Deviations in Modulated Ionospheric Heating Experiments

George Jin[(1)], Maria Spasojevic[(1)], and Umran S. Inan[(1)]
(1) STAR Laboratory, Stanford University, USA

The High Frequency Active Auroral Research Program (HAARP) facility is used to generate waves in the Extremely Low Frequency (ELF) range via modulated ionospheric heating. This HF heating modulates the electron temperature in the D-region ionosphere and leads to modulated conductivity and a time-varying current at the modulation frequency. In this paper, we investigate the relationship between the intensity of the HAARP generated ELF signal and deviations in the horizontal component of the local magnetic field strength (ΔH). ΔH is proportional to the east-west current density of the auroral electrojet. The ELF waves are measured by a receiver located in Chistochina, Alaska roughly 37 km northeast from HAARP while the magnetometer (part of the Geophysical Institute Magnetometer Array) is located at HAARP. We analyze data spread across 12 days of transmissions and thus are able to analyze several substorms and compile statistics on the relationship between ELF amplitude and ΔH variation, including both the correlation coefficient and the relative change in ELF amplitude per unit change in ΔH. We find that the generated ELF wave intensity is in general linearly correlated (with high statistical significance) to the strength of ΔH. However, the nature of the correlation differs drastically from quiet to active magnetic conditions. During quiet magnetic periods (peak $|\Delta H| < 50$ nT), the slope of the linear least squares fit of ELF strength versus ΔH is higher than during active magnetic periods (peak $|\Delta H| > 50$ nT). That is, during quiet periods, small changes in ΔH can result in relatively large changes in ELF signal intensity. While strong electrojet intervals can result in ELF amplitudes of 2-3 pT, a weak electrojet can regularly result in amplitudes of 1.5 pT. At times during periods of weak magnetic activity, the ELF signal intensity is anti-correlated with magnetic activity. That is, ELF signal strength decreases with increasing electrojet current. We interpret these experimental results in terms of the physics of modulated ionospheric heating.