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# Lightning Occurrence Statistics from Venus Explorer Observations of ELF Emissions

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## Abstract

Venus Express has now recorded ELF emissions (up to 64 Hz) in the low-altitude Venus ionosphere since mid-2006. These signals are most prevalent when the ionosphere magnetic field dips into the atmosphere, enabling the electromagnetic signal to enter the ionosphere. The signals can extend over the full bandwidth of the instrument, up to 64 Hz. The waves are nearly circularly polarized and are right-hand polarized, as expected for whistler-mode propagation generated by lightning. When isolated bursts of signal occur, frequently dispersion is seen in which the high-frequency waves arrive first. This is the expected signature generated by impulsive electric discharges. These observations suggest that the rate of lightning occurrence on Venus is not unlike the terrestrial rate where atmosphere chemistry is affected measurably by these discharges. When Venus Express was inserted into its 24-hour elliptical polar orbit, periapsis was near 80 degrees and later precessed up to 88 degrees. Now in the orbit, Venus Express has precessed over the pole and has reached lower latitudes than on arrival. The occurrence rate of lightning-associated ELF signals has increased. Here we report on the latest statistics of these lightning-produced signals and compare the occurrence statistics on the most recent orbits with those at orbit insertion.

## Analysis Methods

The Venus Express magnetometer can observe lightning-generated signals up to 64 Hz. Whistler-mode (ELF and VLF in the Earth's ionosphere, but only ELF at Venus) are guided well up to about ¼ of the local electron gyrofrequency. Thus, Venus Express should be able to study atmospheric lightning emissions as long as the background magnetic field in the ionosphere is greater than 10 nT and thus a magnetic pathway through the lower ionosphere. This certainly happens frequently, and below we illustrate some recent examples of the waves seen. We show first the power in the waves as a function of frequency. (The white line shows the magnetic field strength.) Beside that is the ellipticity of the waves. Whistler-mode waves should be right-handed, giving a red color to the dynamic spectrum. The third panel is the direction of the wave propagation relative to the magnetic field. Dark blue indicates the waves are propagating parallel to the magnetic field. The time series is given in the fourth panel.

## Figures

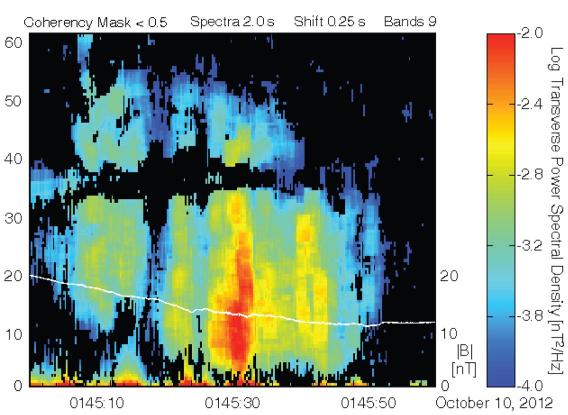


Figure 1: Dynamic spectra of transverse power.

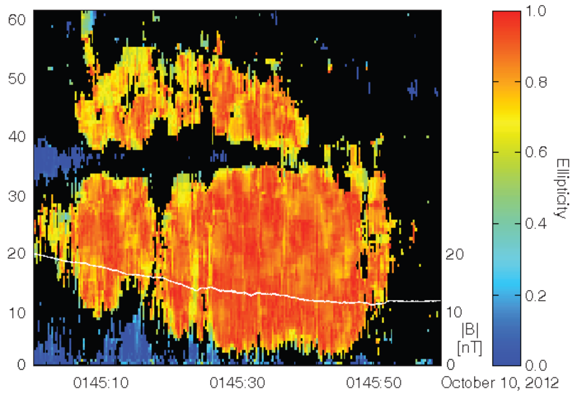


Figure 2: Dynamic spectra of ellipticity.

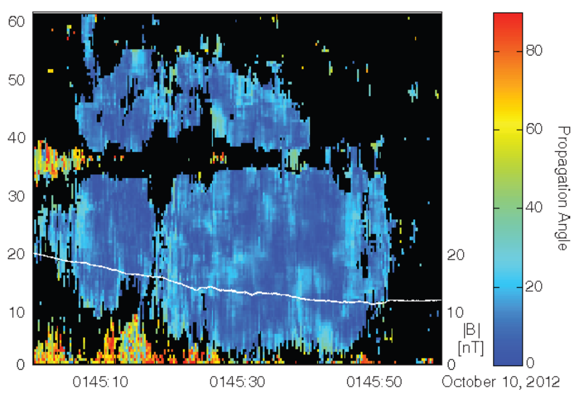


Figure 3: Dynamic spectra of propagation angle.

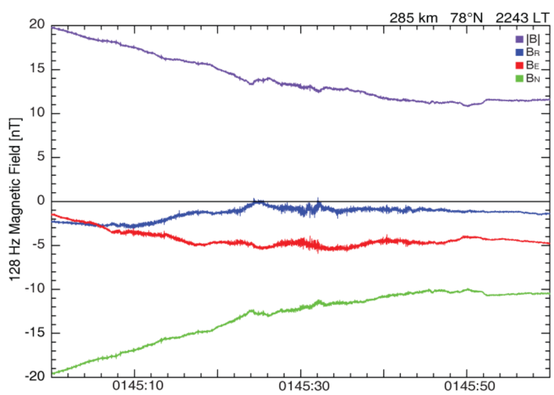


Figure 4: Time series of total magnetic field and along radial, east, and north directions.