LIGHTNING ON VENUS CONFIRMED BY FREQUENT OBSERVATIONS OF WHISTLER-MODE WAVES. R. A. Hart[1], C. T. Russell[1], and T. L. Zhang[2], [1]Earth Planetary and Space Sciences, University of California, Los Angeles, CA (rhart@igpp.ucla.edu), [2]Austrian Academy of Sciences, Vienna, Austria.

Introduction: Lightning produces an extremely low frequency (ELF) radio wave that propagates along magnetic field lines to higher altitudes in the ionosphere [1]. Venus lacks an intrinsic magnetic dipole, so the interplanetary magnetic field (IMF) drapes around the planet forming a comet-like tail. The IMF induces currents in the ionosphere that generate an opposing field. The field lines tend to be nearly horizontal to the surface around much of the planet, except in the tail where it is more radial. There must be a dip to the field in order for waves to be guided to higher altitudes on the dayside. Therefore, on the dayside a wave is less likely to enter the ionosphere at the zenith of its source and more likely to enter at angles toward the horizon, where the field lines and wave path are more aligned.

Signal Analysis: The dual fluxgate magnetometer onboard VEX was able to detect ELF signals up to 64 Hz at various altitudes throughout the mission [2]. We searched all available data within the ionosphere for lightning-generated whistler-mode waves. Figure 1 illustrates an example of the waves seen. We show first the ellipticity of the waves. Whistlers are right-hand circularly polarized waves, giving a red color to the dynamic spectrum. Next is the angle of the wave propagation relative to the magnetic field. Blue indicates the waves are propagating along the magnetic field. Whistlers are also transverse waves, which is illustrated by the bottom two panels of the figure. This event is just one example of 1000's of events each confirmed to be of the whistler-mode by the same analysis.

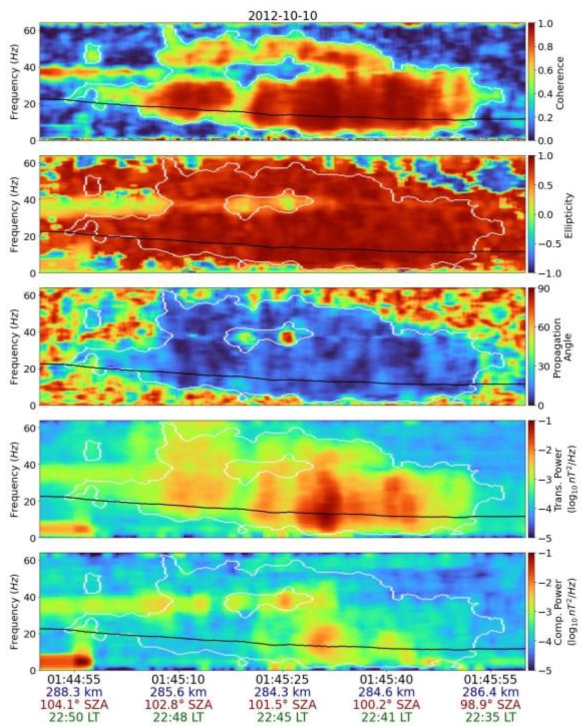

Figure 1. Spectra of coherence, ellipticity, propagation angle, transverse and compressional powers, highlighting the criteria used to classify whistler-mode waves in this study. The white contour is the outline of the waves. The black line is the magnetic field strength with nT on the same scale as Hz.

Statistics: The mission was in orbit from 2006-2014 and in that time there were nearly 17 cumulative hours of whistler observations below 400 km. In some cases, there was continuous activity for over a minute, implying a connection to an electrical storm below. These signals were most frequently seen when the spacecraft was at ~250 km altitude. Most signals were observed within 200-300 km altitude with a rate of ~7% of the time the spacecraft spent at these altitudes. The median Poynting flux of the signals was 1.4 x 10-9 W/m^2 and the peak values occurred at low altitudes, suggesting a lightning source from below. Whistlers-mode waves may propagate significant distances in the ionosphere before detection, so the observation region may be 1000's of kilometers from the source. Therefore, it must be emphasized that these observations alone do not tell us where the lightning itself is occurring. If a typical wave propagates between 30º and 60º around the planet from its source, then we calculate a global flash rate to be 320 s^{-1} - 1200 s^{-1}.

References:

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