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# Venus Lightning: A Ubiquitous Feature of the Venus Atmosphere?

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Lightning has been detected on Venus through radio, optical, plasma-wave and electromagnetic observations. The most extensive set of observations have been obtained by Pioneer Venus and Venus Express, the former detecting electrostatic plasma waves and whistler-mode waves, and the latter, the electromagnetic component of these waves. Both missions found that the access of the whistler-mode electromagnetic signals to the spacecraft in the low-altitude ionosphere was controlled by the direction of the magnetic field. This control is to be expected since the lightning-generated whistler-mode waves do not travel perpendicularly to the magnetic field in a plasma under the conditions in the Venus ionosphere. The waves are also expected to be right handed, which is consistent with observations. Whistler-mode waves can travel long distances unattenuated, so it is sometimes difficult to determine their source region. Electrostatic waves, in contrast, evanesce rapidly in the ionosphere and are good markers of the wave origins. The Pioneer Venus observations show that there is a preponderance of lightning activity near the dusk terminator, similar to the local time distribution of lightning on Earth. There are no electrostatic wave sensors on Venus Express and the whistler-mode signals it detects may have traveled far. However, the periapsis location of Venus Express is almost squarely over the North Pole and as far as possible from the Pioneer Venus low-latitude periapsis. Moreover, the signals are very strong, so the lightning source cannot be far away. Otherwise we would have expected a much weaker signal as was seen on Pioneer Venus far from the dusk terminator. It appears that while lightning is not uniform across the Venus surface, it is not restricted to a narrow source region either.