EPSC Abstracts
Vol. 6, EPSC-DPS2011-53, 2011
EPSC-DPS Joint Meeting 2011

Lightning on Venus and Earth

C.T. Russell (1,2), J.T.M. Daniels (1,2) R.J. Strangeway (2), and T.L. Zhang (3)
(1) ESS, UCLA, Los Angeles, CA 90095-1567 USA, (2) IGPP, UCLA, Los Angeles, CA 90095-1567, (3) Space Research Institute, Schmiedlstr. 6, A-8042, Graz, Austria (ctrussell@igpp.ucla.edu / Fax: 310-206-8042)

Abstract

Collisions between solid particles in clouds can transfer electric charge between particles of differing sizes. When this occurs in a vertically convecting cloud, the lightest particles will rise and the heaviest particles sink, creating an electrical potential difference between the top and the bottom of the cloud. If this potential difference produces an electric field sufficient to "break down" the neutral state of the atmosphere, an electrically conducting path may form allowing the flow of electric charge. This electric current often flows in short, irregularly-directed paths. On Earth, lightning occurs in rain clouds and dust clouds. Approximately one third of lightning flashes are cloud-to-ground. On Venus, the clouds consist of sulfuric acid particles at heights of 50 to 60 km. The high pressures at low altitudes make it unlikely that any active volcanoes will produce lightning or that there will be cloud-to-ground discharges. The discharge channel carries an electric current of sufficient strength to generate significant heating, causing the air to increase in pressure and temperature. This facilitates non-local thermodynamic equilibrium chemistry such as nitric oxide production as well as the aural phenomenon thunder. Nitric oxide is found in both the atmospheres of Venus and Earth.

On Earth, lightning is sensed by the optical flash it creates which can be seen for great distances above and below the cloud, but not necessarily for great distances within. On Venus, there are reports of visible flashes seen from orbit on Venera 9 and from Earth-based observations but not from within the cloud deck as probed by the VEGA balloons. The most sensitive detection of lightning on Earth is achieved through the analysis of electromagnetic waves in the ELF to radio frequencies. These signals can propagate around the planet beneath the clouds trapped in the Earth-ionosphere wave guide. On Venus, the Venera 11, 12, 13, and 14 descent probes sensed these signals in the atmosphere as did the Pioneer Venus orbiter when it descended beneath the ionosphere. On Earth, most of the lightning studies take place in the atmosphere while on Venus most of the studies are performed on platforms in the ionosphere. On both planets, the electromagnetic waves that are generated by lightning refract vertically when they reach the atmosphere. Over much of the surface of the Earth, this refraction aligns the wave propagation vector with the magnetic field vector. On Venus, however, this refraction orients the wave vector perpendicular to the magnetic field in the ionosphere. The former facilitates entry of the electric magnetic wave energy into the ionosphere, while the latter mitigates this entry.

In this paper, we examine the similarities and differences of the observed signatures of lightning on the Earth and Venus and the possible sources of these electrical discharges.