Volcanic Lightning on Earth and Beyond

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We present a review of our current understanding of the electrification of volcanic plumes on Earth and discuss the possible implications in terms of volcanic monitoring, early Earth evolution, planetary exploration and volcanic electrification under different planetary scenarios. We also present simple calculations to show how the global electrical circuit might be modified following a large volcanic eruption reaching the stratosphere.

Volcanic lightning is perhaps the most spectacular consequence of the electrification of volcanic plumes. Recent years have seen remote-sensing measurements of volcanic lightning used as part of a portfolio of techniques to monitor volcanic eruptions. Surface observations of the atmospheric electric Potential Gradient (PG) and the charge carried on volcanic ash also show that many volcanic plumes, whilst not sufficiently electrified to produce lightning, have detectable electrification exceeding that of their surrounding environment. Electrification has only been observed associated with ash-rich explosive plumes, but there is little evidence that the composition of the ash is critical to its occurrence. Different conceptual theories for charge generation and separation in volcanic plumes have been developed to explain the disparate observations obtained. Beyond the local electrification of plumes, the higher stratospheric particle concentrations following a large explosive eruption may affect the global atmospheric electrical circuit, which might present another, if minor, way by which large volcanic eruptions affect global climate.

Volcanic lightning has been implicated in a number of ways in the origin of life on Earth, and may also exist in other planetary atmospheres where measurements of its occurrence might give clues about the nature of volcanism on other planets. Understanding the electrification of emissions associated with volcanic activity on other planetary bodies in the solar system may also prove a key part in understanding the electrical properties of their atmospheres.

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