Geophysical Research Abstracts
Vol. 21, EGU2019-1559, 2019
EGU General Assembly 2019

Volcanic lightning: a remote monitoring tool for volcanic eruptions

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Fragmentation and collision of ash particles in explosive volcanic eruptions cause plume electrification, which often results in electrical discharges. This has been observed at many volcanoes around the world, such as Eyjafjallajökull (2010), Colima (2015), Krakatau (2018) and Sakurajima (frequently). The volcanic lightning can be detected up to several hundred kilometres away from the volcano, which allows for a safe and remote near real-time monitoring tool for volcanic eruptions.
Here, electrical discharges were recorded in situ during explosive eruptions of the Minamidake crater at Sakurajima volcano, Japan, using two Biral Thunderstorm Detectors (BTD-200) within a few kilometres from the volcano. They have a lightning detection range of 35 kilometres. In addition, field measurements using Thermal Infrared (TIR) imaging, high-speed camera imaging and Doppler radar were carried out. These observations were combined with detections from three wideband electrical field sensors from the Earth Networks Total Lightning Network (ENTLN), which were located at much greater distances than the BTDs. Lightning interferometry was applied to the data of ENTLN to enhance detection of the signals originating from the volcano.
The BTDs were able to detect almost all eruptions at Minamidake regardless of weather conditions and plume height, which indicates that this is an effective monitoring tool for proximal volcanic eruptions. Lightning interferometry revealed to be a successful method in detecting volcanic lightning at greater distances, even when the signals were not clearly visible in the raw data. Cross-correlation shows strong correlated pulses shortly after the start of major eruptions. Also the peek velocity of particle ejection measured by the Doppler radar corresponds well to the timing of electrical discharges and allows to distinguish between separate pulses during one greater event. The TIR images show a positive correlation between the magnitude and plume height of the eruptions and the amount and size of electrical discharges. These findings show that volcanic lightning can be used as a monitoring tool and to give a first-order estimation of the magnitude of the eruption.