Geophysical Research Abstracts, Vol. 7, 05355, 2005
SRef-ID: 1607-7962/gra/EGU05-A-05355

Volcanogenic lightning during the Grímsvötn 2004 subglacial eruption

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On 1 November 2004 a volcanic eruption began in the Grímsvötn caldera beneath the Vatnajökull ice cap in Iceland. The eruption lasted six days, but it was most vigorous during the first 36 hours. The eruption was preceeded by both a long term increase in seismicity and a short term earthquake swarm, which enabled successful prediction of the eruption by the staff of the Icelandic Meteorological Office. The ash plume was first detected by a weather radar at 23:10 UTC on 1 Nov. During the initial phase of the eruption, numerous lightning were observed in the ash plume. The interaction between magma and water is considered responsible for the electric charge separation, leading to positively charged vapor and negatively charged ash. Fortunately for our data collection, no "weather" thunderstorm activity was occurring close to Iceland during the eruption. Our lightning data was recorded by three systems. The LLP Icelandic lightning location system was not successful in locating the lightning, but was able to give useful polarity and intensity measurements, from which we were able to calculate peak electric current estimates of 149 cloud-to-ground lightning. The first lightning was at 01:37 UTC on 2 Nov and the last one at 08:40 UTC on 3 Nov. Real-time access to the ATD sferics lightning location system of the UK Met Office enabled the location of over 250 lightning strikes over Vatnajökull in the first 36 hours of the eruption. Our EFMS wave recording station is located in Reykjavík, 220 km from the volcano. This station records variations in the vertical electric field with a sampling interval of 200 ns. We were able to record the waveforms of 152 lightning with the EFMS system from 23:23 UTC on 1 Nov to 08:37 UTC on 3 Nov. About half of these waveforms indicate cloud-to-cloud lightning and about half of the waveforms show negative polarity cloud-to-ground lightning. A good correlation exists between the lightning activity and the intensity of the eruption as indicated by the height of the ash plume observed by weather radar. The lightning data collected during this brief

volcanic eruption gives valuable insight into the character of volcanogenic lightning and how they differ from weather lightning.