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Resonating eruptive flow rate during the Grímsvötn 2011 volcanic eruption

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The Grímsvötn volcano in Iceland erupted 21-28 May 2011 at a similar place (64°23.9'N, 17°23.1'W, about 1450 m a.s.l.) under the SW caldera rim as the last eruption in November 2004. The eruption started at or just before 19:00 UTC on 21 May. During the first night the plume reached 20-25 km altitude over a 10 hour period, after which the strength of the eruption appeared to decrease exponentially. Two weather radars monitored the plume during the eruption; a fixed C-band radar in Keflavík and a mobile X-band radar at Kirkjubæjarklaustur, 257 and 75 km from the volcano, respectively. The plume height of the radar time-series was used to calculate the mean eruptive flow rate. The calculations indicate that about 90% of the total mass erupted during the first 21 hours. The estimates of eruptive flow rate show very strong regular oscillations with periods of about 5 hours. During the first 12 hours the 1 hour mean dense rock equivalent flow rate oscillated between about 1000 and 8000 m³/s (2 and 20 million kg/s). During the eruption, over 16 000 lightning strikes were recorded near Grímsvötn by the ATDnet (Arrival Time Difference) network of the UK Met Office. Peculiar variations in the rate of lightning occurrence became evident during real-time monitoring of the ATDnet lightning data during the first night of the eruption. The calculated flow rate oscillations agree well with the observed lightning oscillations, both in phase and relative amplitude. The same oscillations can also be seen in tiltmeter data from Grímsfjall, about 6 km East of the vent. In hindsight, there also appear to have been some regular long period oscillations in lightning rate and plume height during the Grímsvötn 2004 eruption. We can only speculate on the causes of the apparent volcanic resonance. (a) The magma chamber and feeding dykes of the volcano might act like a Helmholtz cavity resonator. However, the observed period is considerably longer than one might expect. (b) The oscillations might reflect an interaction between quenching of the feeding dykes to the surface and boiling of the geothermal fluids in the geothermal system above the magma chamber. (c) A small shallow magma chamber might be emptied in a few hours and a larger deeper source might take similar time to refill the shallow magma chamber. Possibly, such a two chamber system might resonate with the observed period.