Resonating eruptive flow rate during the Grímsvötn 2011 volcanic eruption

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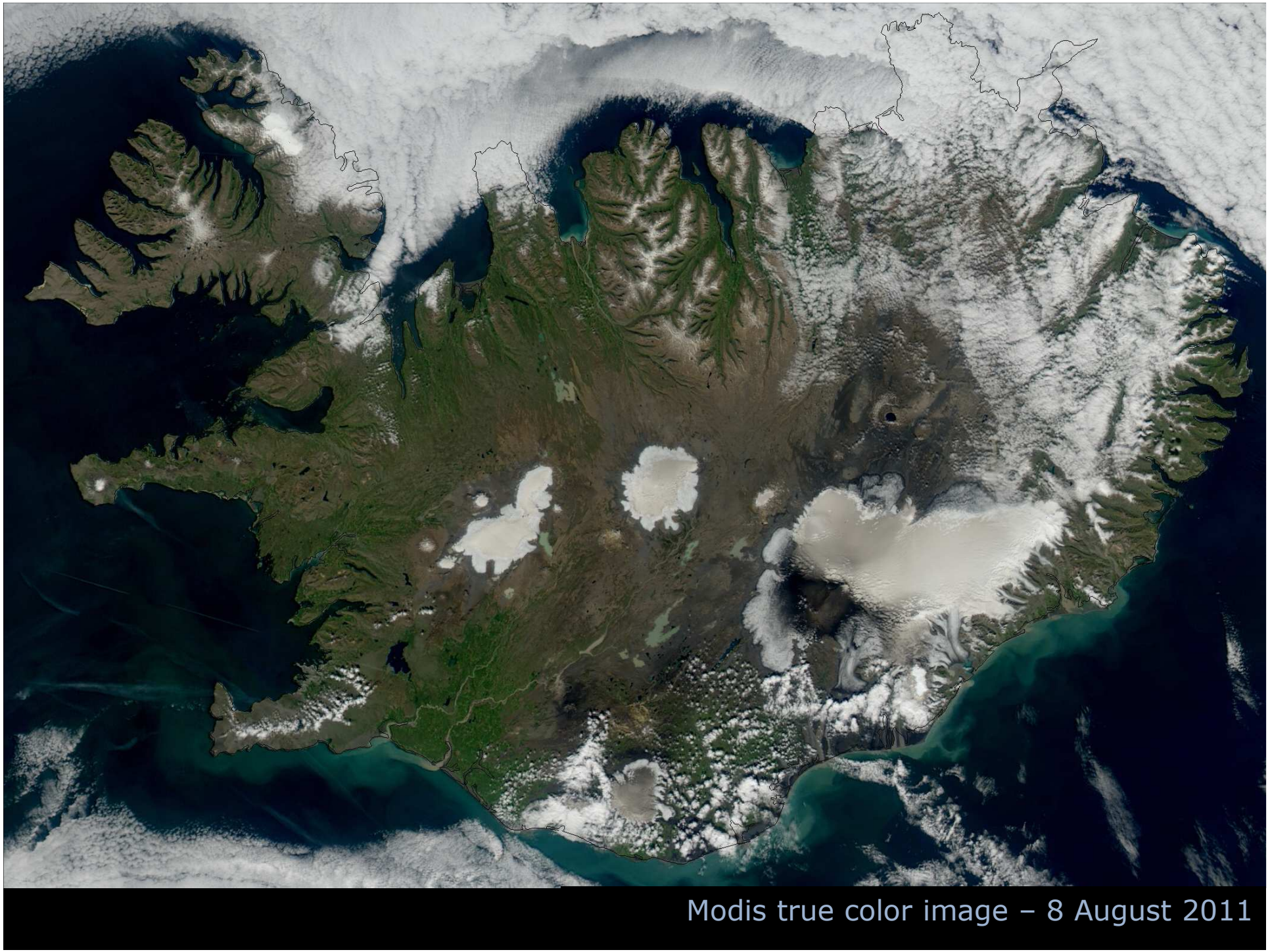
UV4-04 – 30th Nordic geological winter meeting, Reykjavík, 9-12 January 2012

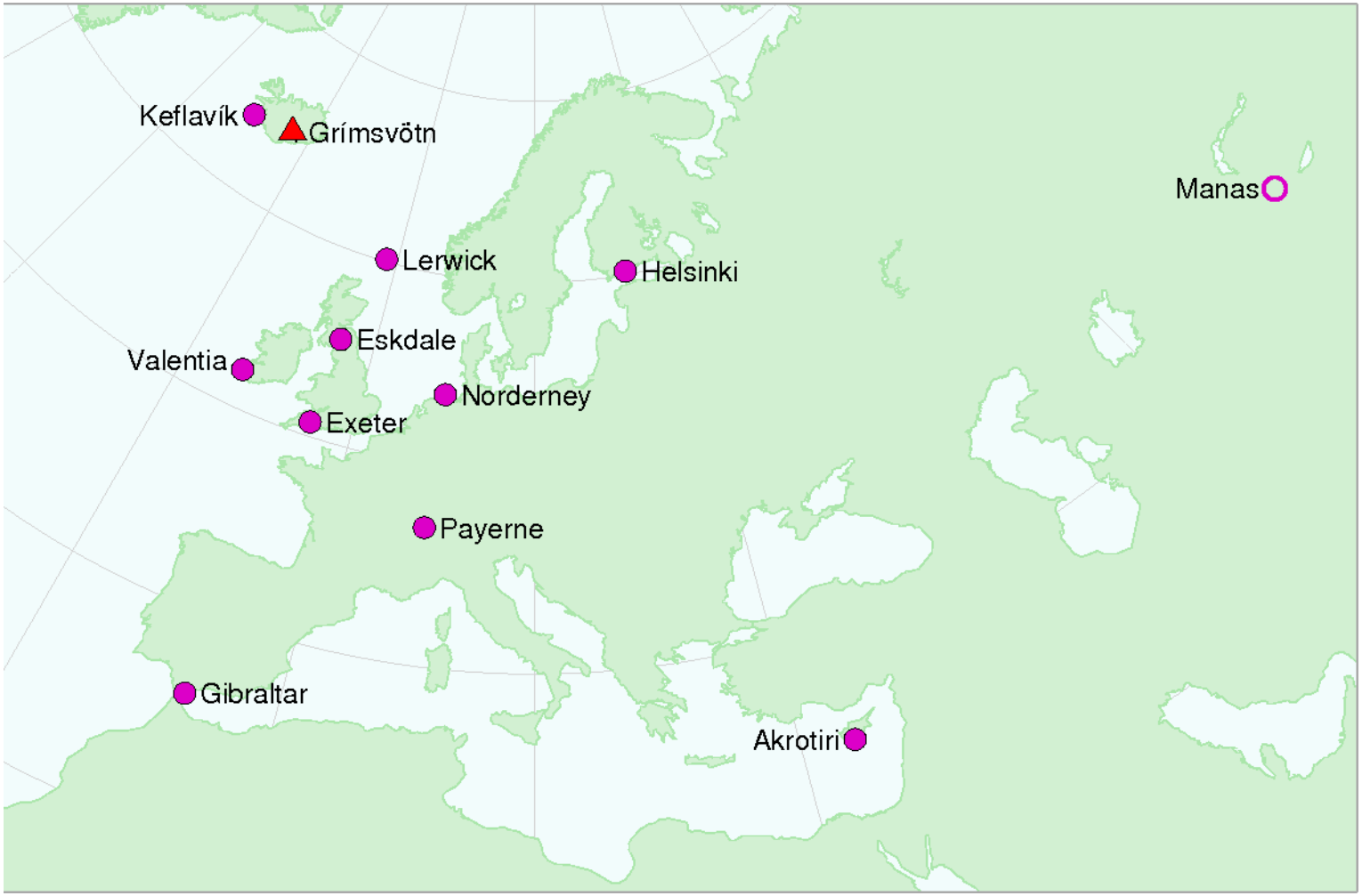
Grímsvötn eruption plume. Photo Gunnar Sigurðsson 21 May 2011



Modis true color image – 8 August 2011

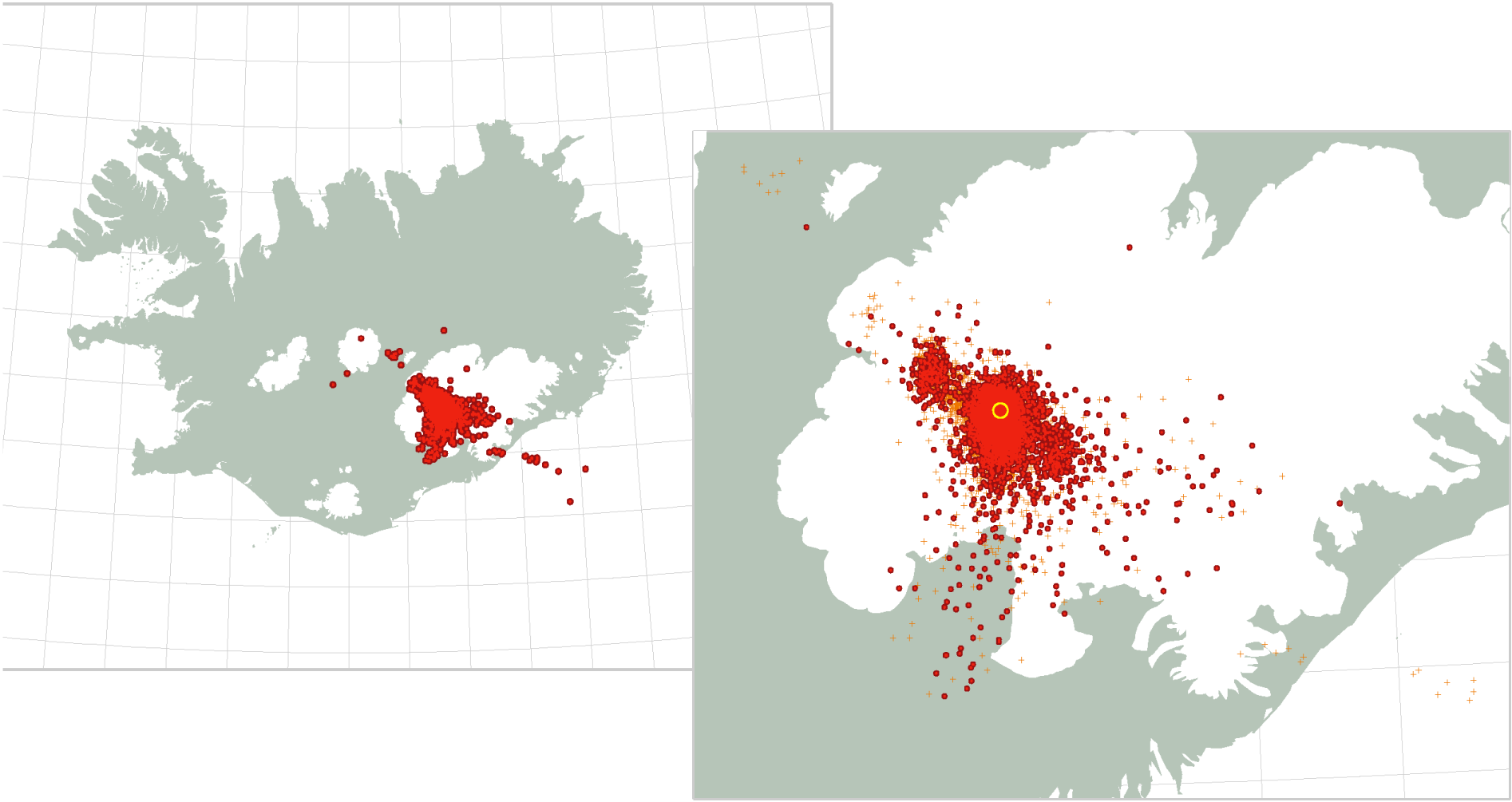
Out-stations of the ATDnet lightning location system

Icelandic Met Office



Located lightning 21-28 May 2011

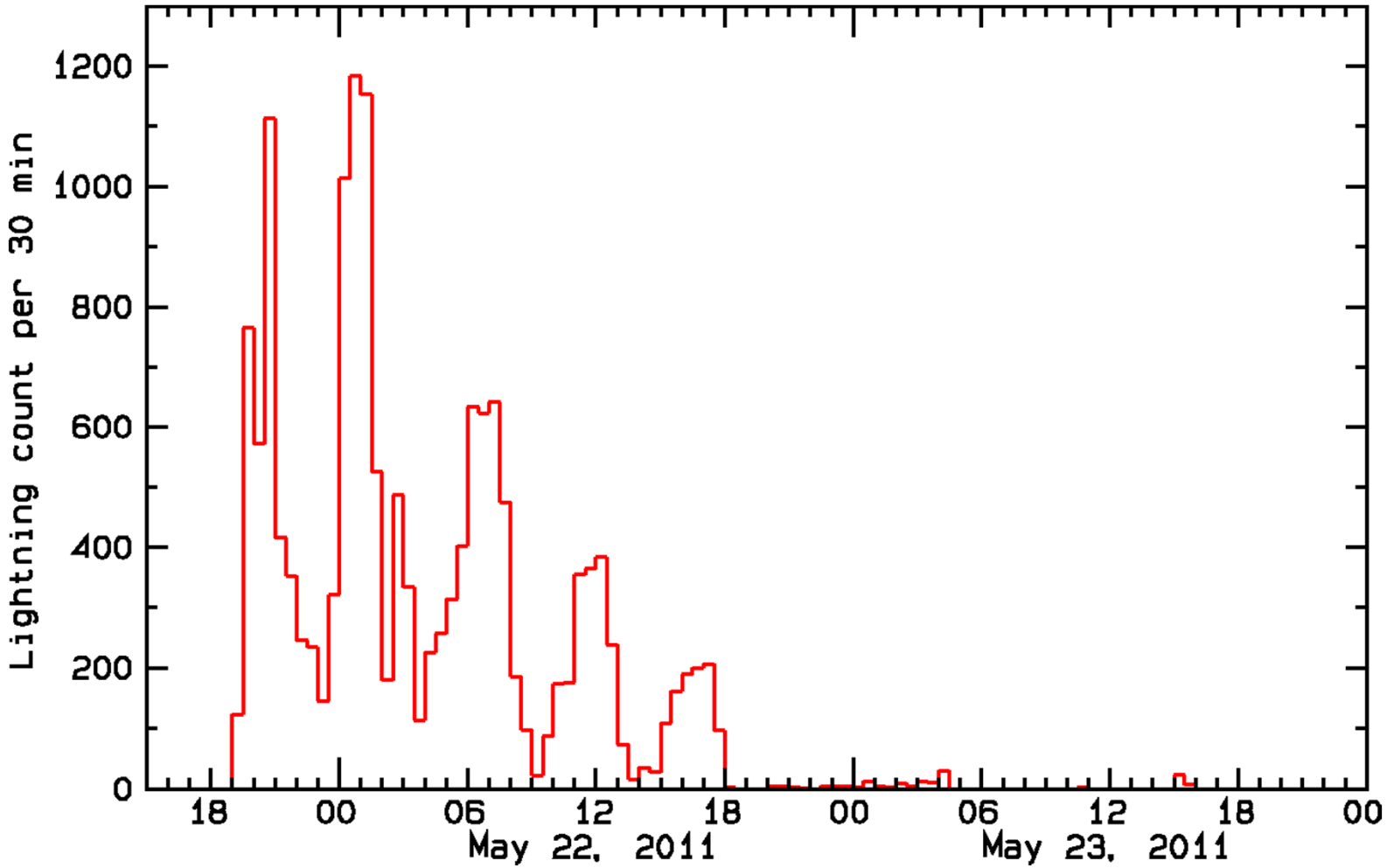
Icelandic Met Office



Lightning rate

Oscillations became evident during real-time monitoring

Icelandic Met Office



Resonance period of about 5 hours

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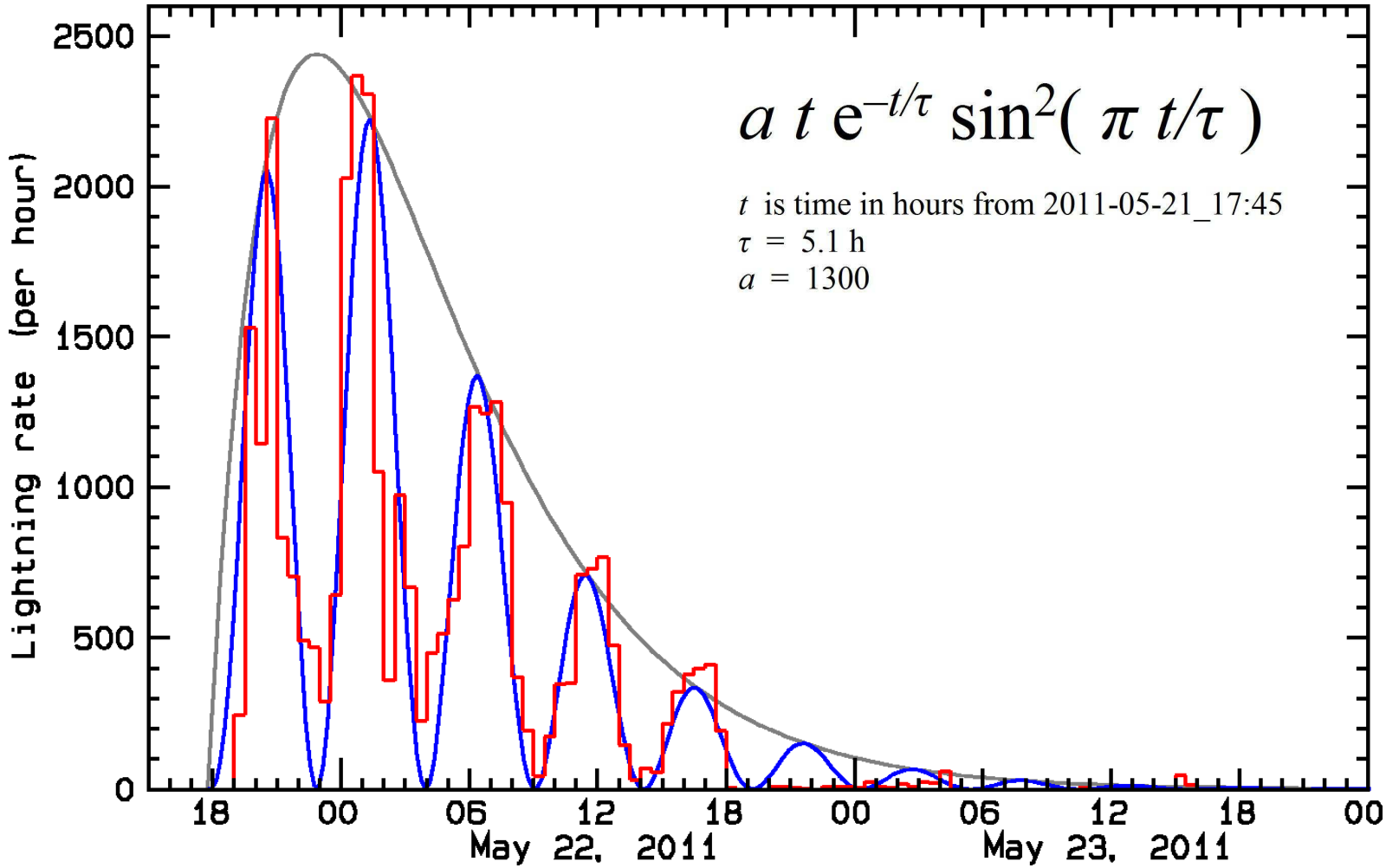


Grímsvötn crater. Photo Þórður Arason 11 June 2011

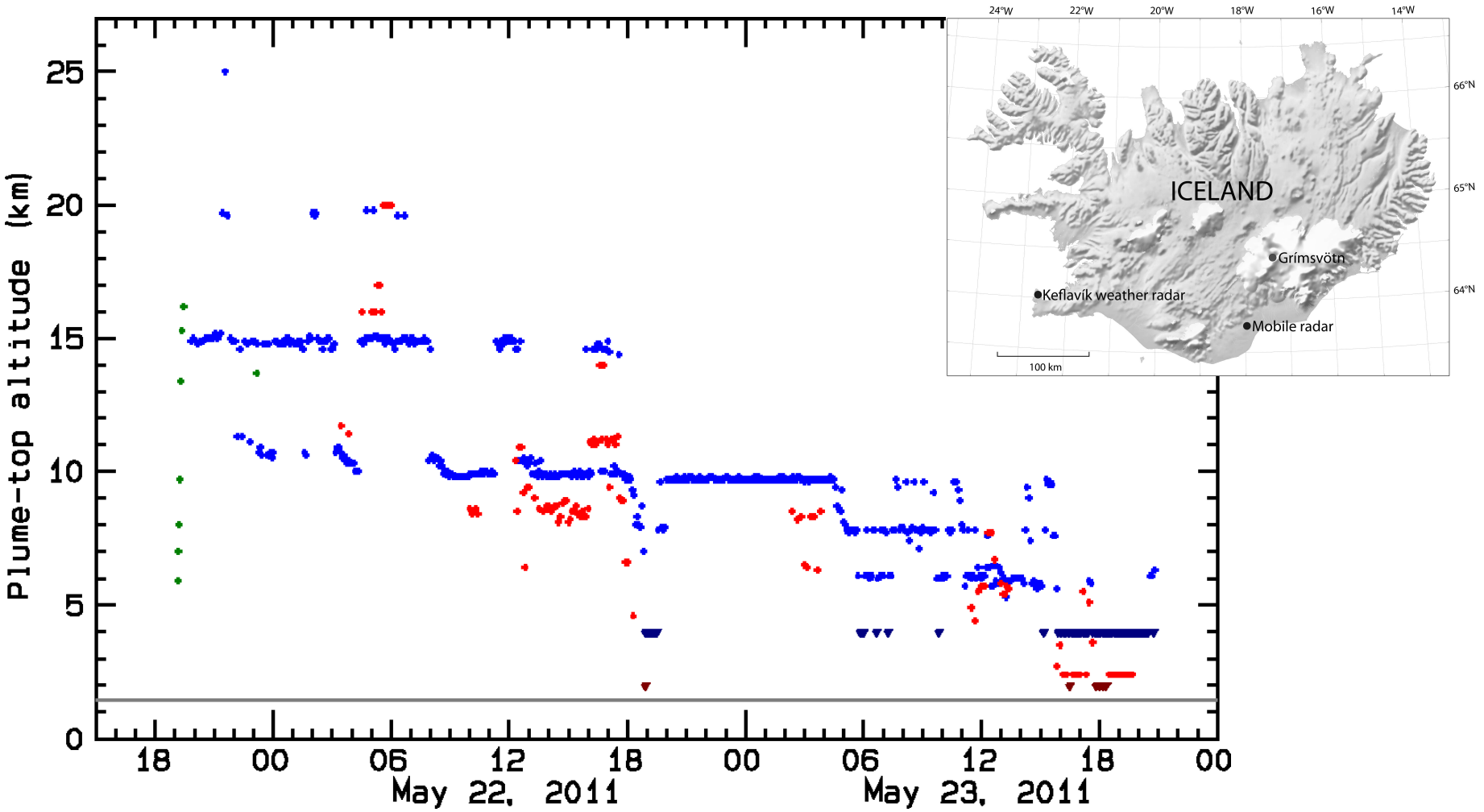
Ash-infused hail

Icelandic Met Office

Photos Þórður Arason 11 June 2011

mm scale

Plume-top altitude



Plume-top altitude

30 minute mean values

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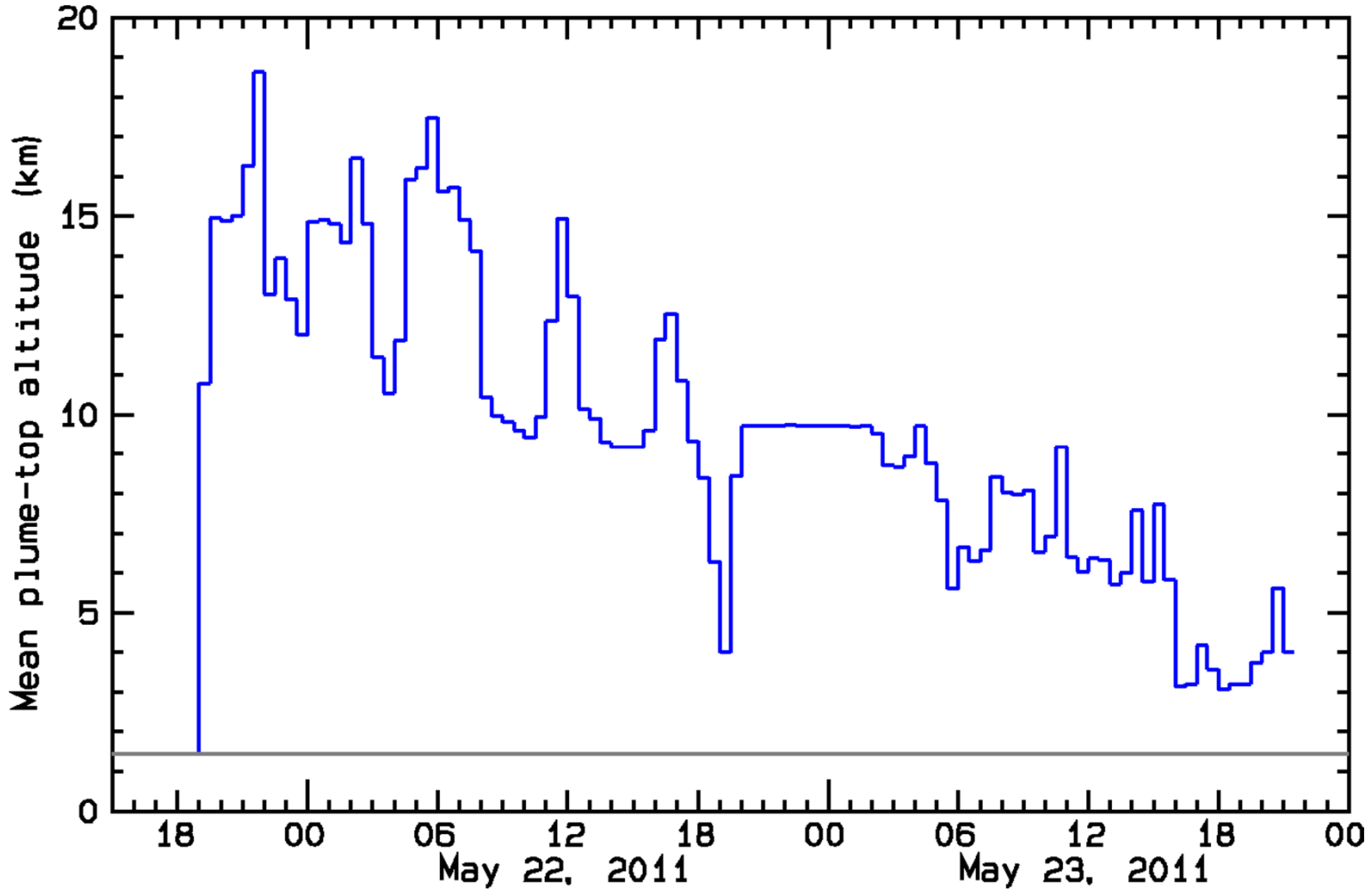

Flow rate

Calculated using Mastin et al. (2009)

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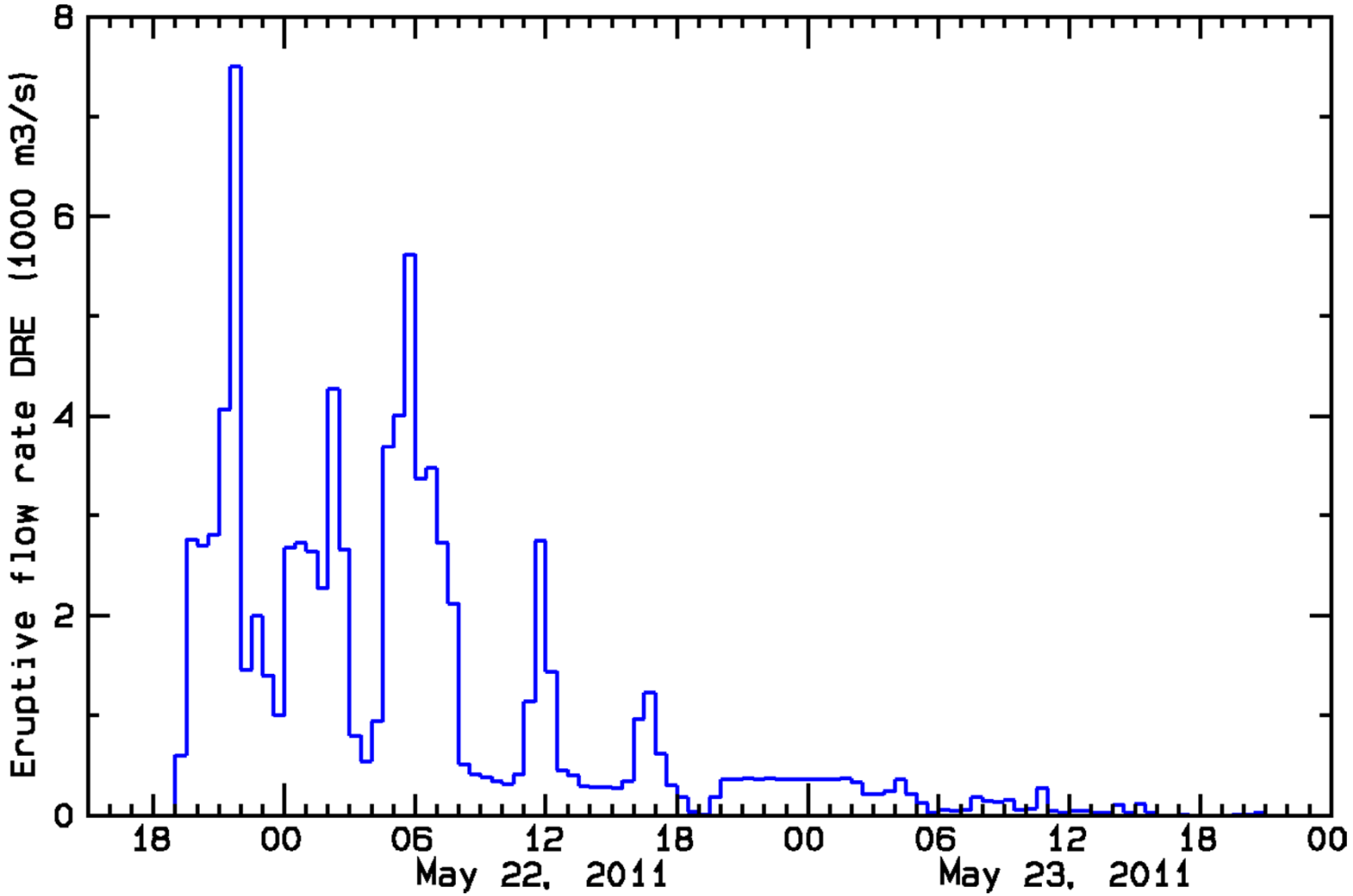

Cumulative erupted volume

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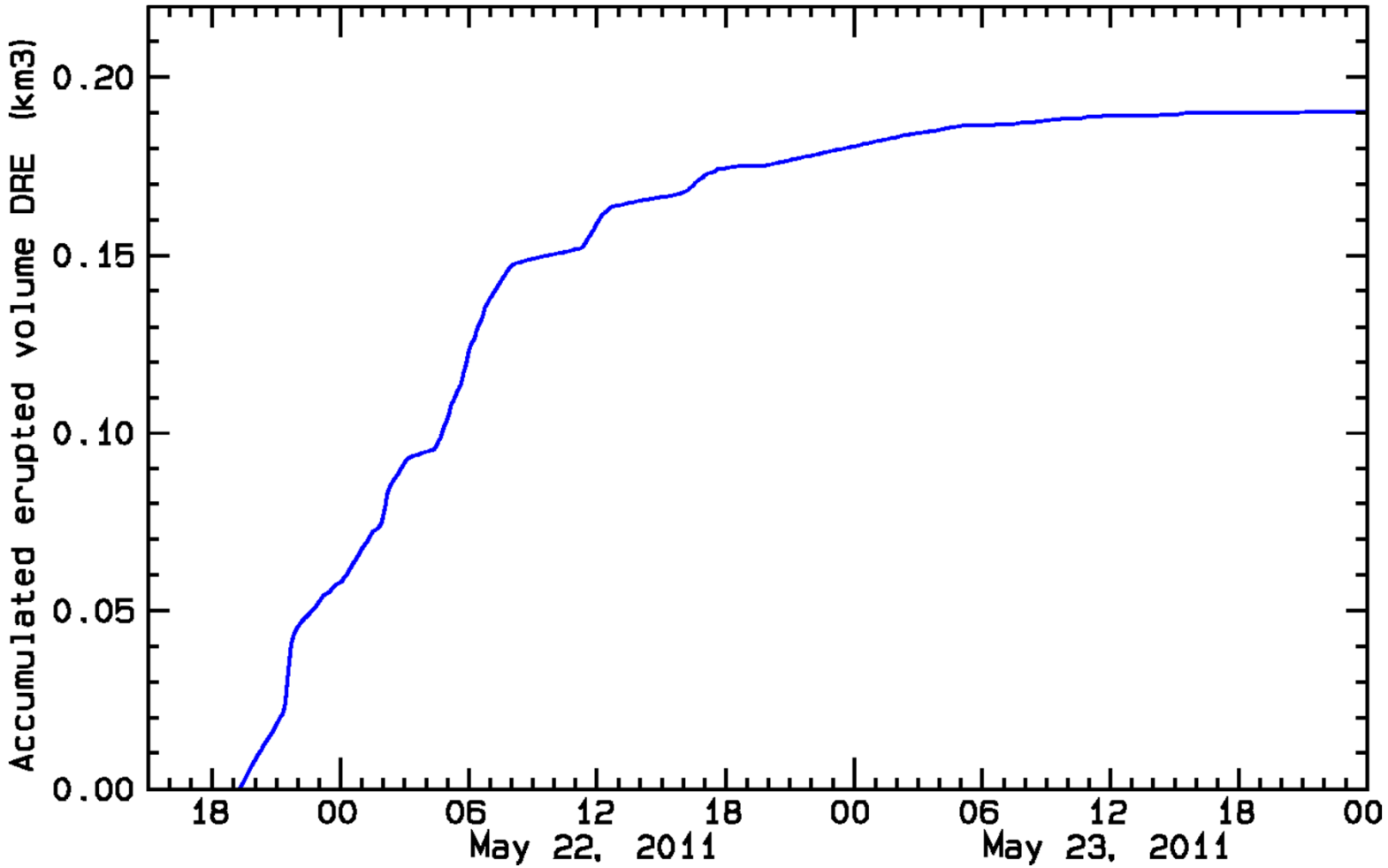

Tilt measurements at Grímsfjall

about 6 km East of the vent

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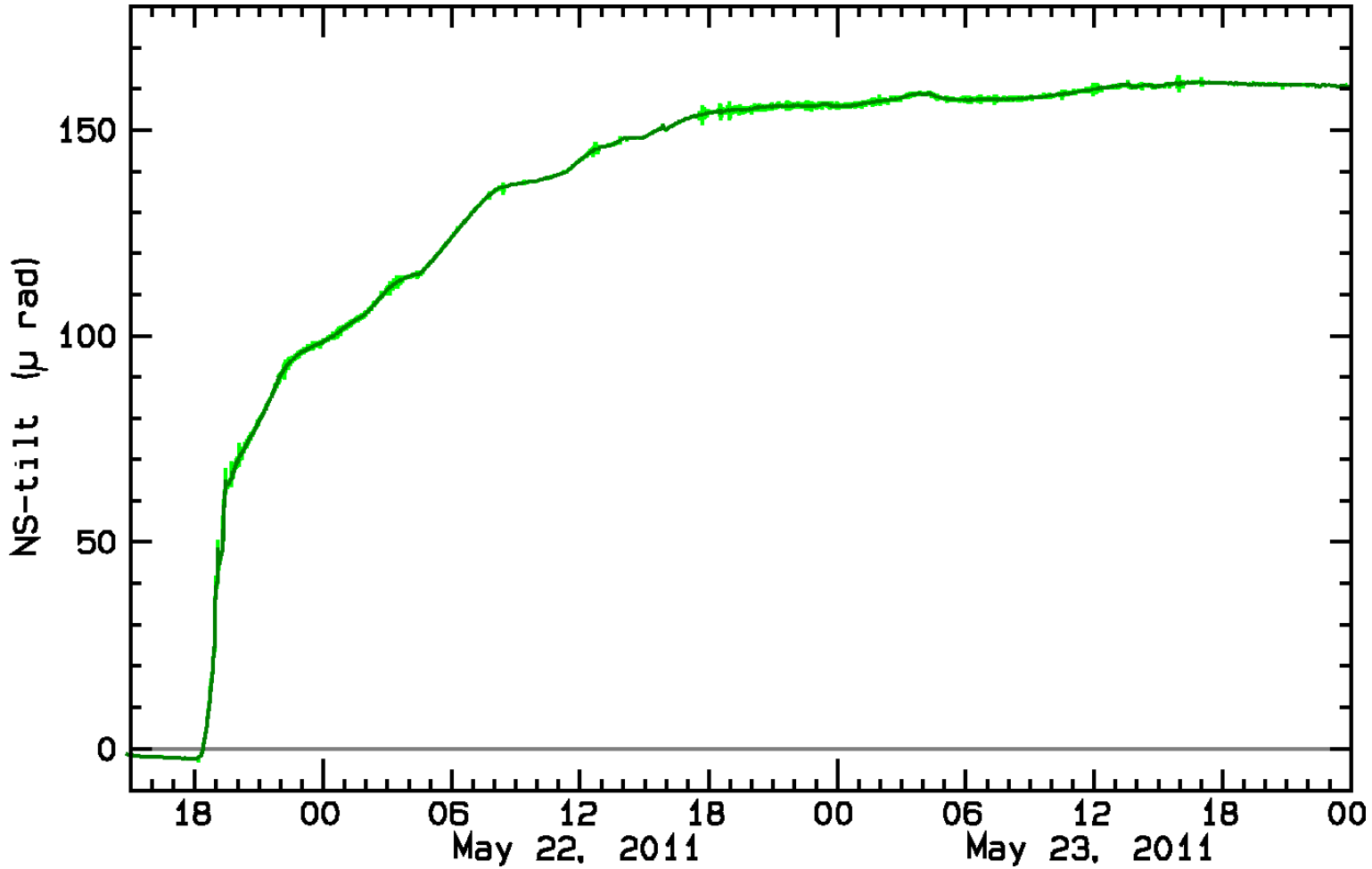
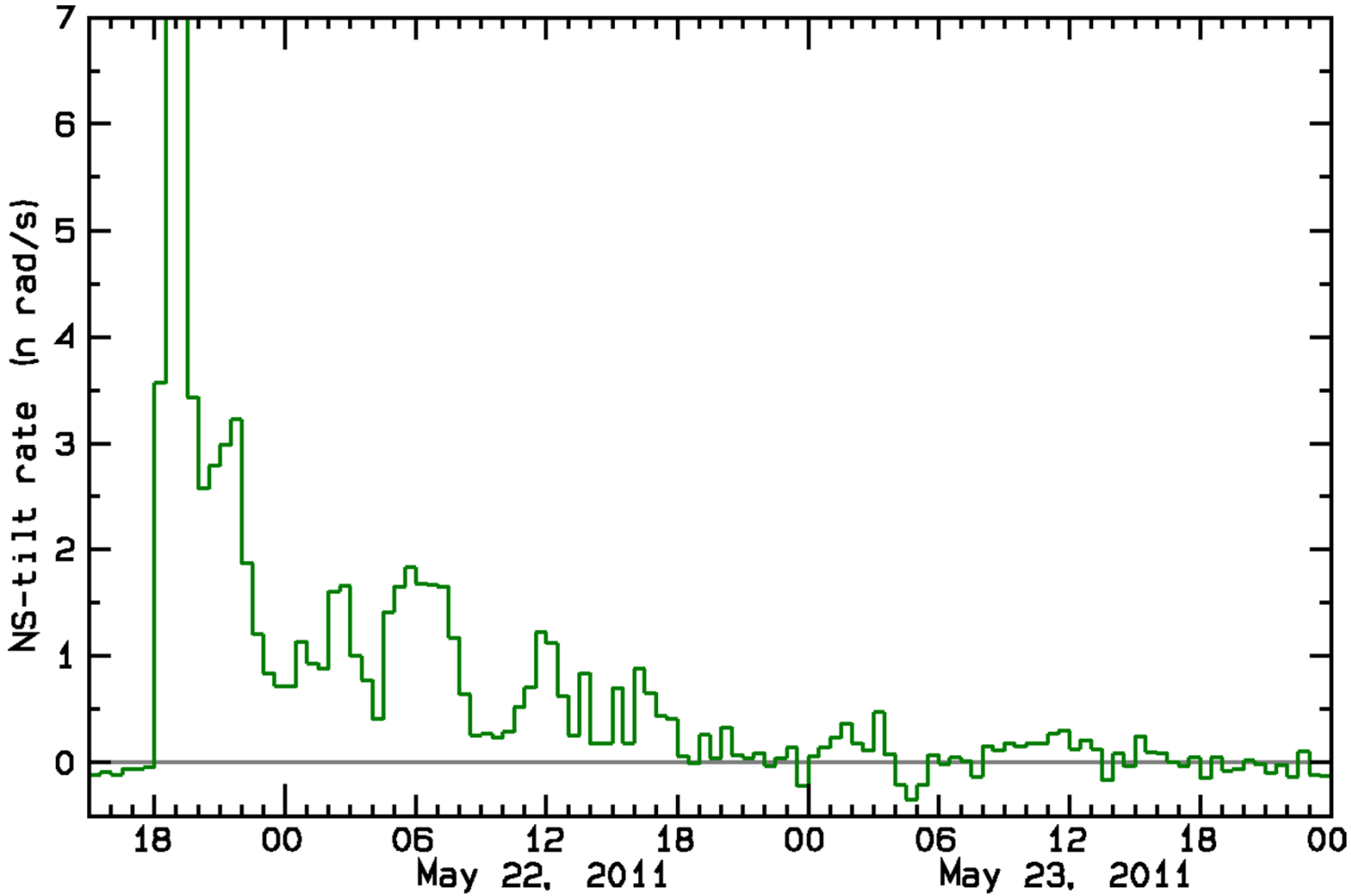
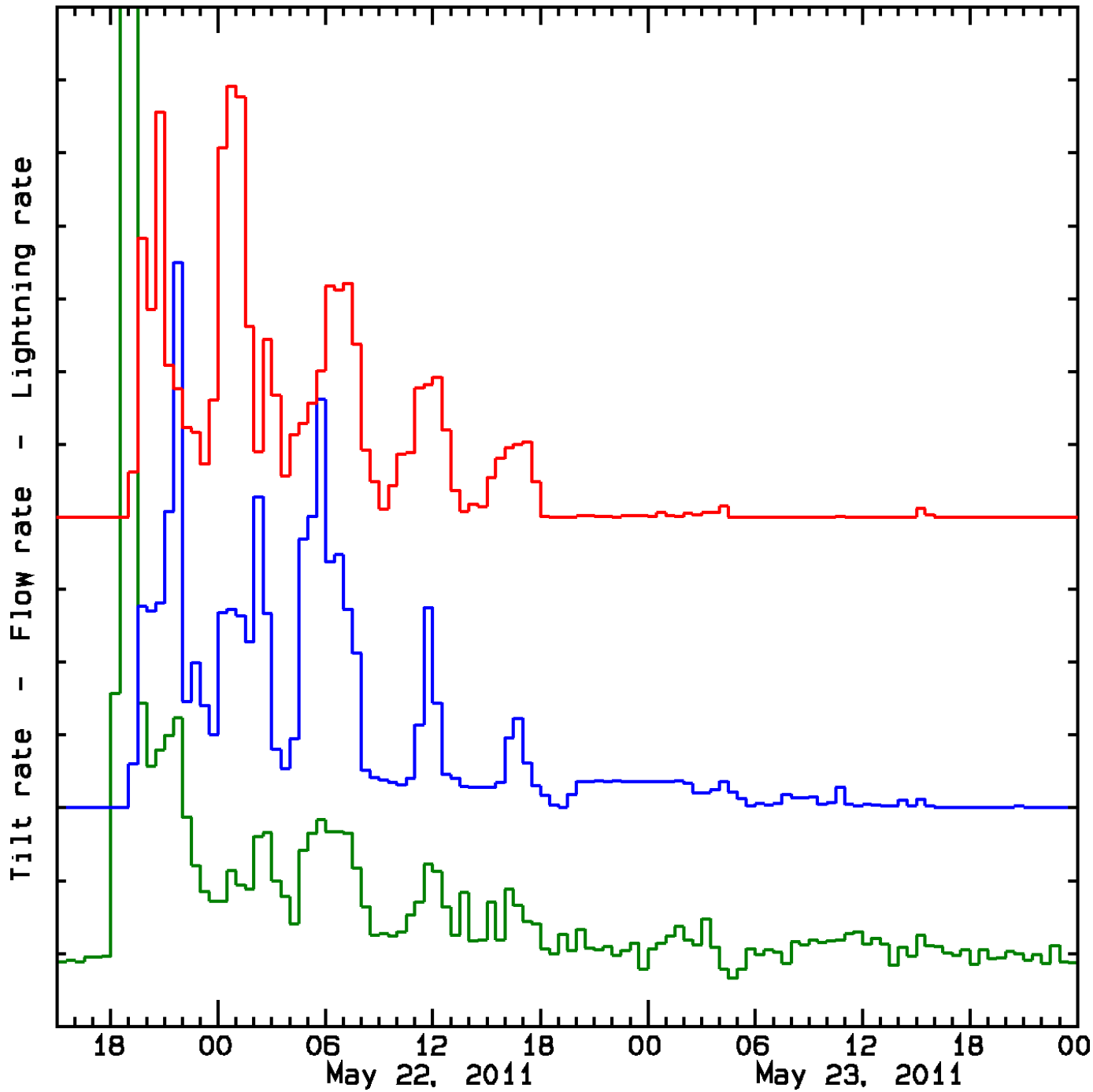


Tilt rate

Icelandic Met Office



The initial Grímsvötn eruption plume. Photo Bolli Valgarðsson 21 May 2011 at 19:20


Tilt rate - Flow rate - Lightning rate
18
00
06
12
18
00
06
12
18
00
May 22, 2011
May 23, 2011

Grímsvötn – November 2004
Lightning – Plume-top altitude – Volcanic tremor

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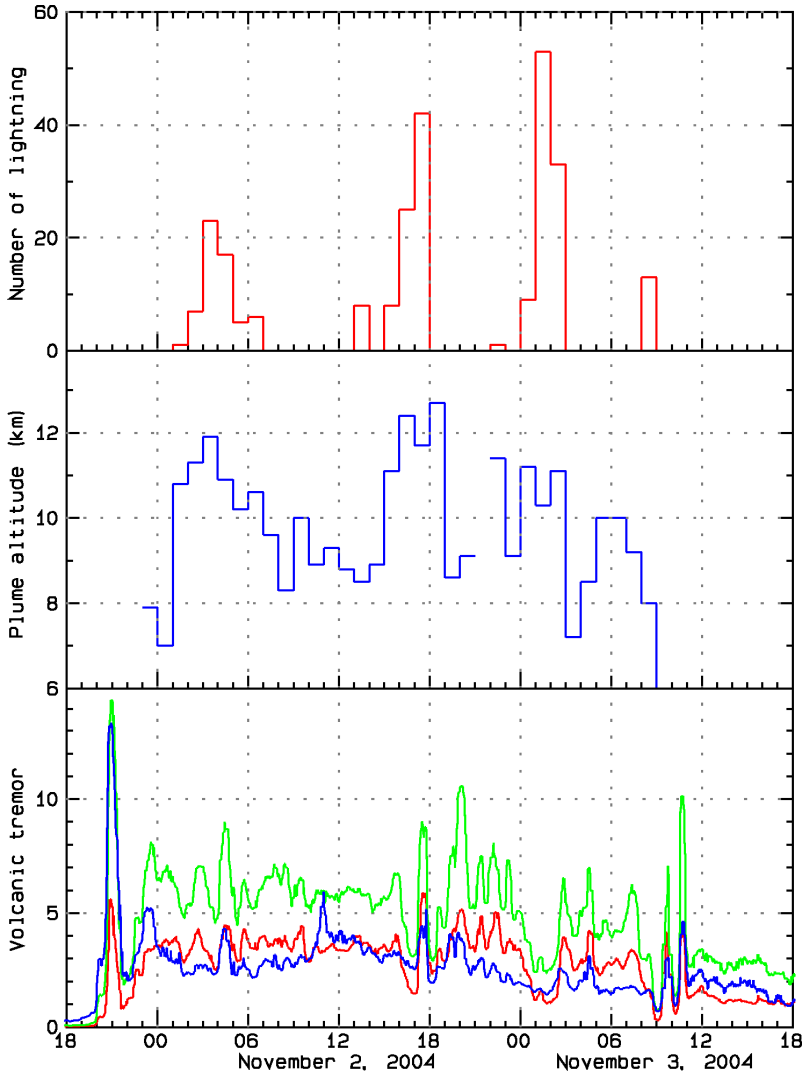

Helmholtz cavity resonator

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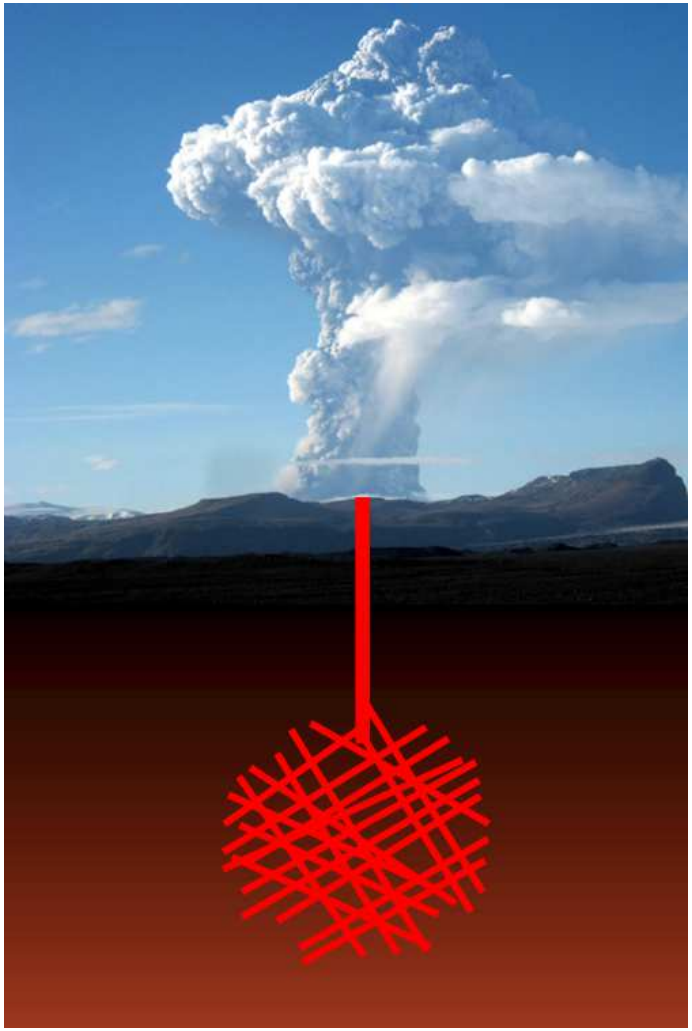
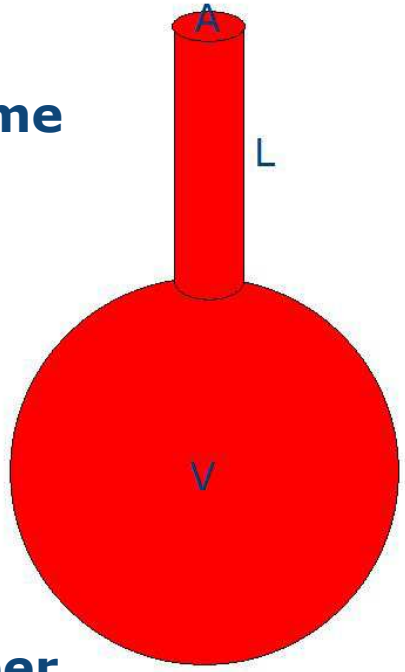


19th century physics: Acoustic resonance in some musical instruments



$$\tau = 2\pi\sqrt{\frac{L\,V}{v^2 A}}$$

Realistic values for a Grímsvötn magma chamber result in Helmholtz resonance periods of 1-10 minutes – Two orders of magnitude lower than observed

Water-dyke interaction

Quenching of feeding dykes and boiling in geothermal system

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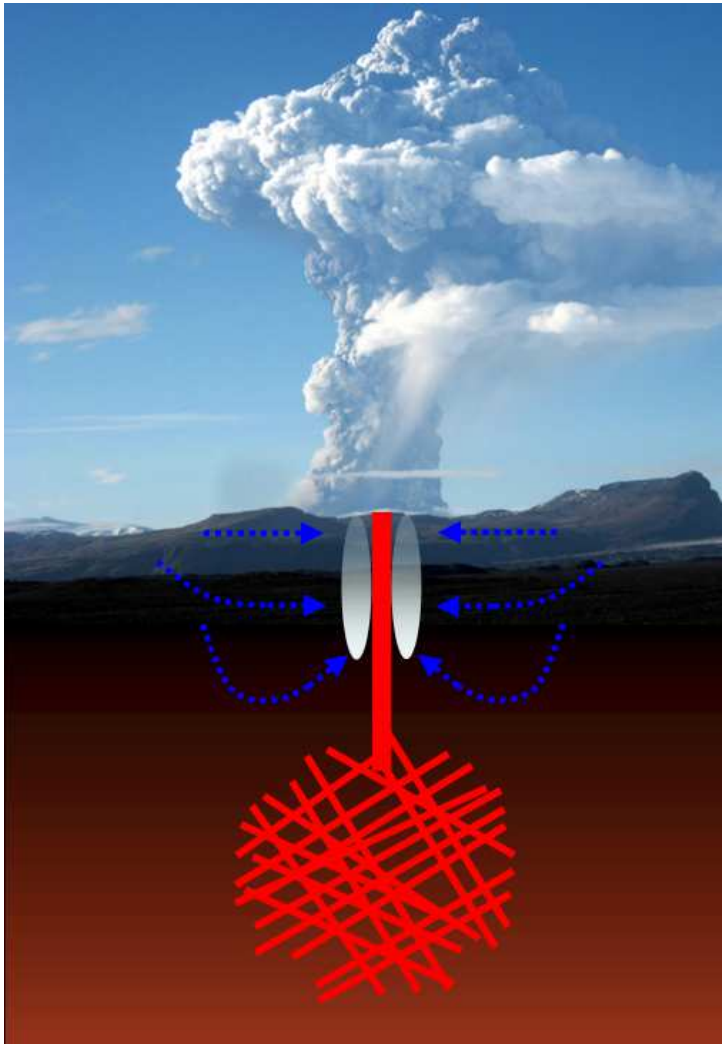

Double chamber interaction

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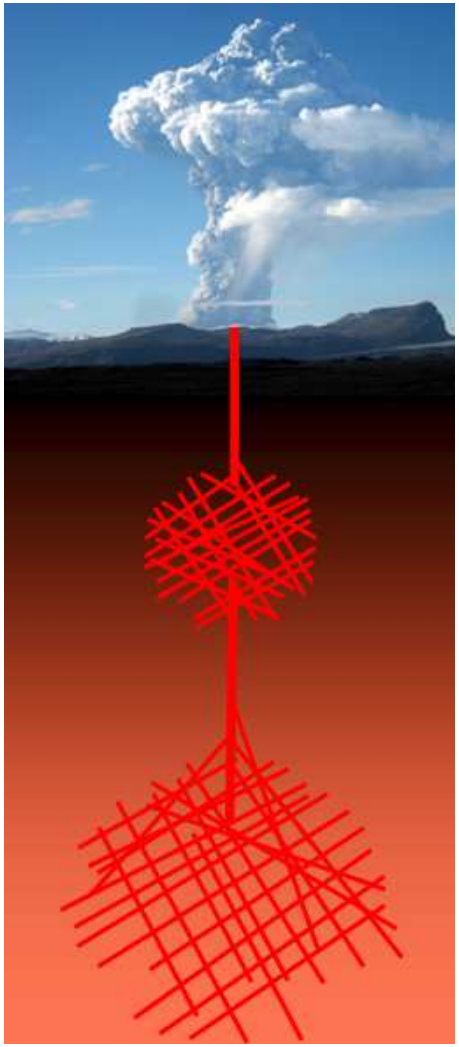

- **Shallow magma chamber emptied in a few hours**
- **Larger deeper source takes similar time to refill the shallow magma chamber**
- **Possibly, such a double chamber system could resonate with the observed period**

Conclusions

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- Very regular oscillations with a period of about 5 hours were observed in real-time monitoring of volcanic lightning during the first 24 hours of the Grímsvötn 2011 eruption
- Same oscillations are seen in plume height variations, calculated flow rate and tilt measurements
- The regularity of the oscillations indicate a resonance in the system rather than a random process
- In hindsight, some resonance (with a higher period) can be seen in data from the Grímsvötn 2004 eruption
- The causes of the observed volcanic resonance are not clear