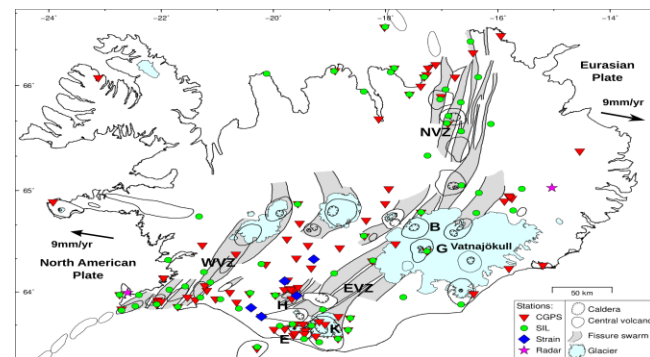

Monitoring volcanoes in Iceland, improvements over the past three to four years

Sigrún Karlsdóttir¹, Kristín Vogfjörð¹, Sara Barsotti¹, Melissa Anne Pfeffer¹, Þórður Arason¹, Benedikt G.Ófeigsson¹, Baldur Bergsson¹, Bergur H. Bergsson¹, Vilhjálmur S. Kjartansson¹, Kristín Jónsdóttir¹, Tómas Jóhannesson¹, Sigrún Hreinsdóttir², Matthew J. Roberts¹, Sibylle von Löwis¹, Ingvar Kristinsson¹, Halldór Björnsson¹, Guðrún Nína Petersen¹, Richard Yeo¹, Hermann Arngrímsson¹, Emanuele Marchetti³, Costanza Bonadonna³ and Ármann Höskuldsson⁵

¹Icelandic Meteorological Office, ²GNS Science New Zealand, ²iTEM s.r.l. – Integrated Technologies for Environmental Monitoring, ⁴Group de Volcanologie, Université de Genève, ⁵Nordic Volcanological Center, Institute of Earth Sciences, University of Iceland

Overview

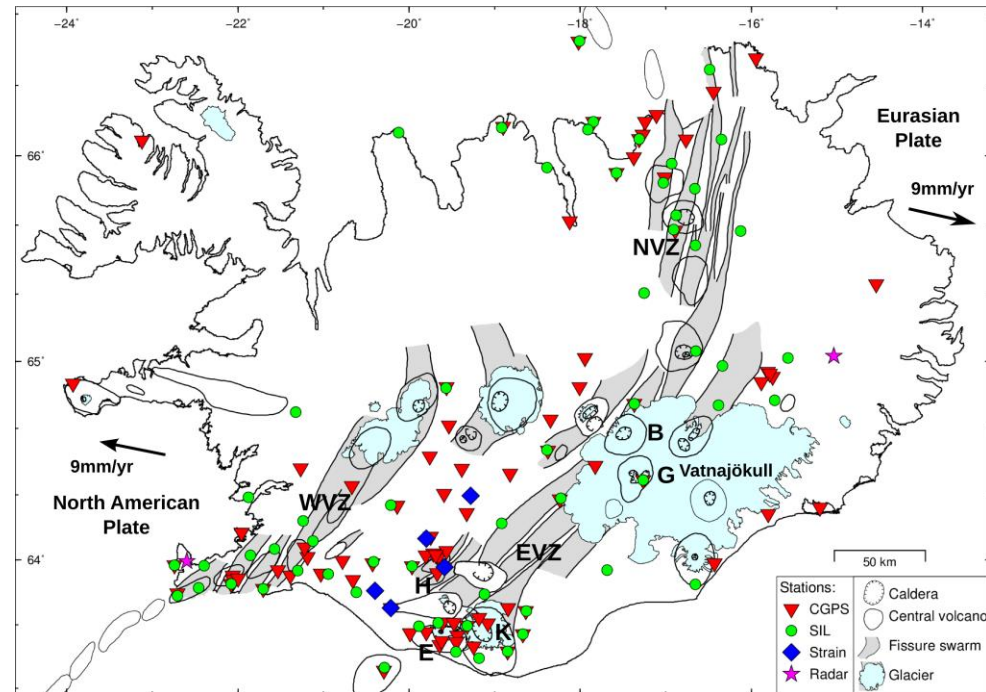
Overview of monitoring tools
Supporting tools needed in difficult conditions
How can these be used for Early Warning Systems



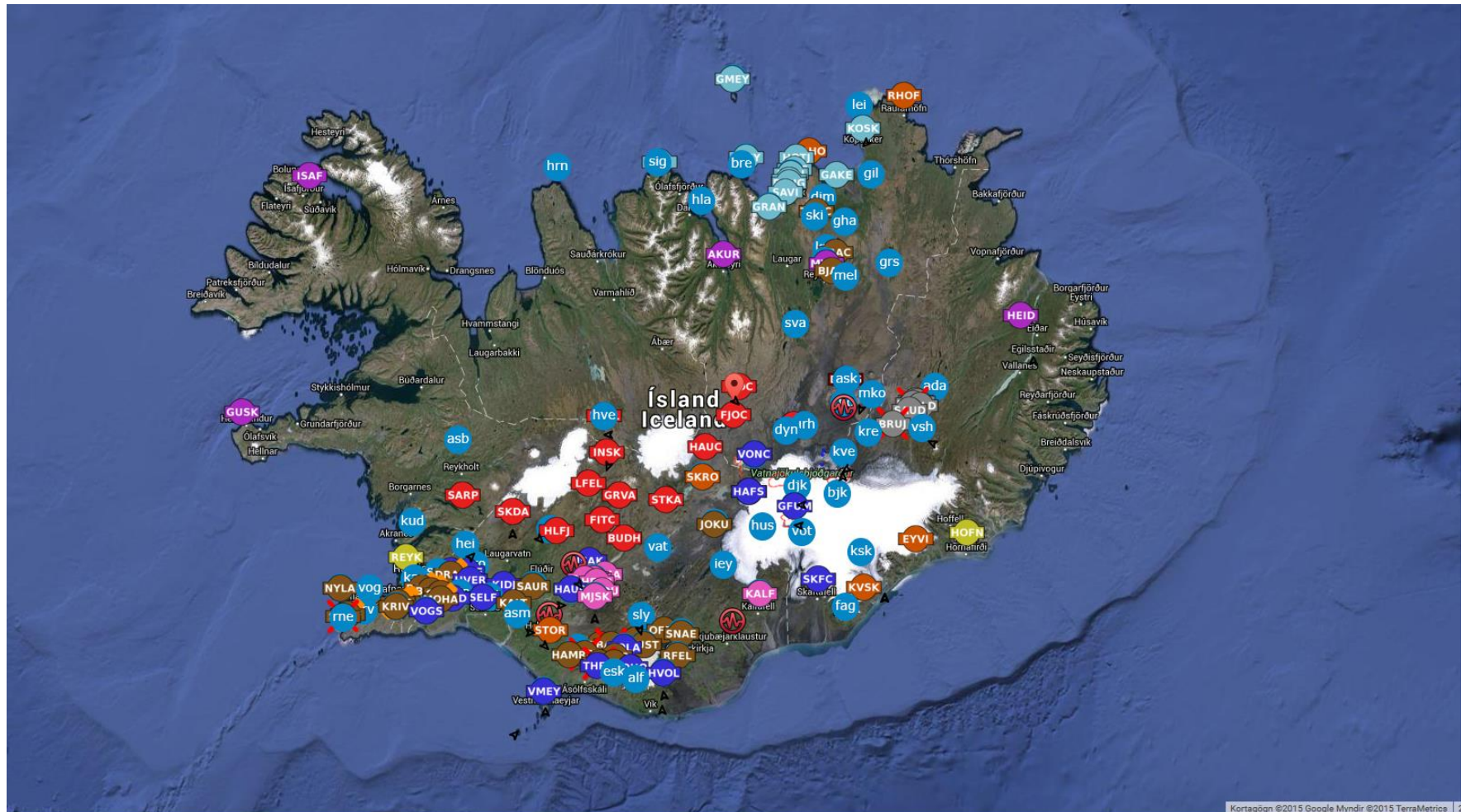
Photos by Vilhjálmur S. Kjartansson

Monitoring and Research: Pre-eruptive monitoring → EWS

- ▶ ~69 seismic stations
- ▶ 2 seismic arrays
- ▶ ~70 GPS instruments
- ▶ 5 strain-meter stations
- ▶ 4 infrasound arrays
- ▶ 145 hydrological gauging stations
- ▶ Conductivity sensors (Glacial outlet rivers)
- ▶ 3 multigas device
- ▶ 7 continuous DOAS (SO₂)
- ▶ Water chemistry sensors (dissolved CO₂)
- ▶ Osmotic water samplers
- ▶ FTIR

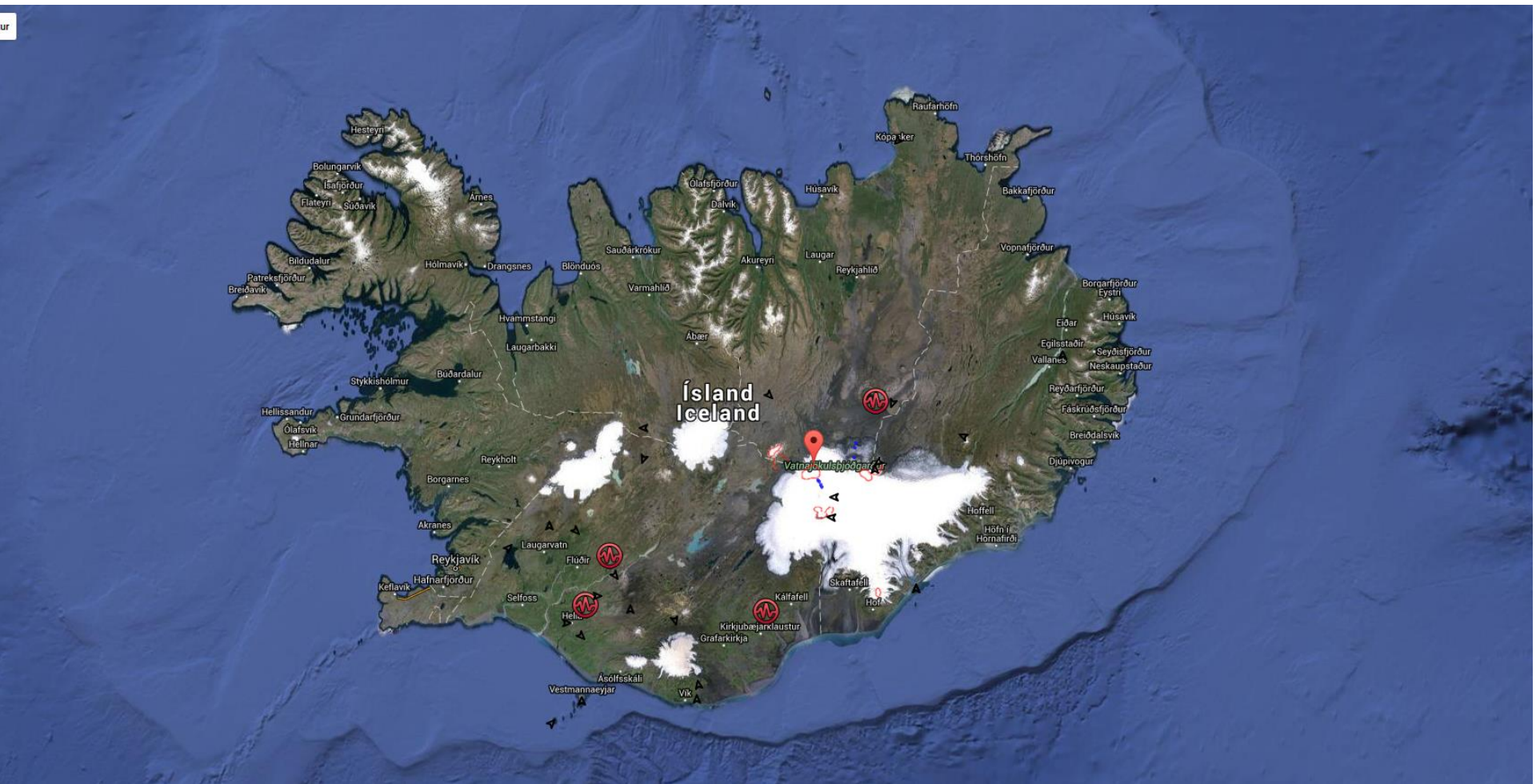


Geophysical station network and web-cams



Kortagögn ©2015 Google Myndir ©2015 TerraMetrics

Infrasound array and web-cams



Challenges in difficult conditions

- ▶ Create a system to run seismic station in ice/glacier all year around
- ▶ Minimum maintainance
 - ▲ Secure electricity
 - ▲ Communication
 - ▲ Snow accumulation



Photos by Vilhjálmur S. Kjartansson



GPS installed in calderas

<http://en.vedur.is/earthquakes-and-volcanism/gps-measurements/bardarbunga/caldera/>

Photos by Benedikt G. Ófeigsson



Mounting the station in the Middle of the caldera of Bárðarbunga in Vatnajökull.

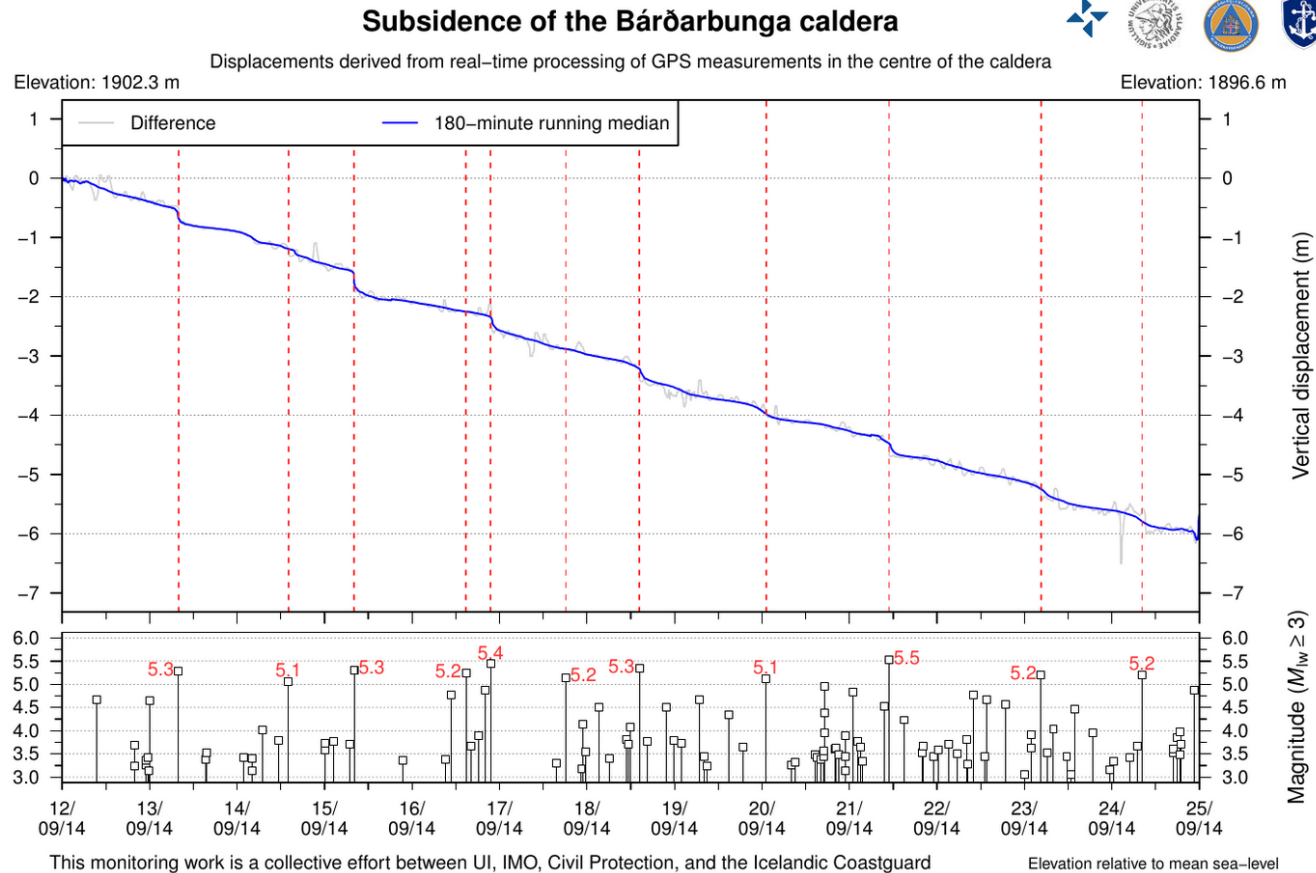


The repeater on the caldera rim, Which communicates with the GPS Station in the middle of the Bárðarbungu caldera an with the distant relay Station in Kverkfjöll.

GPS stations installed in calderas

Bárðarbunga 2014-2015

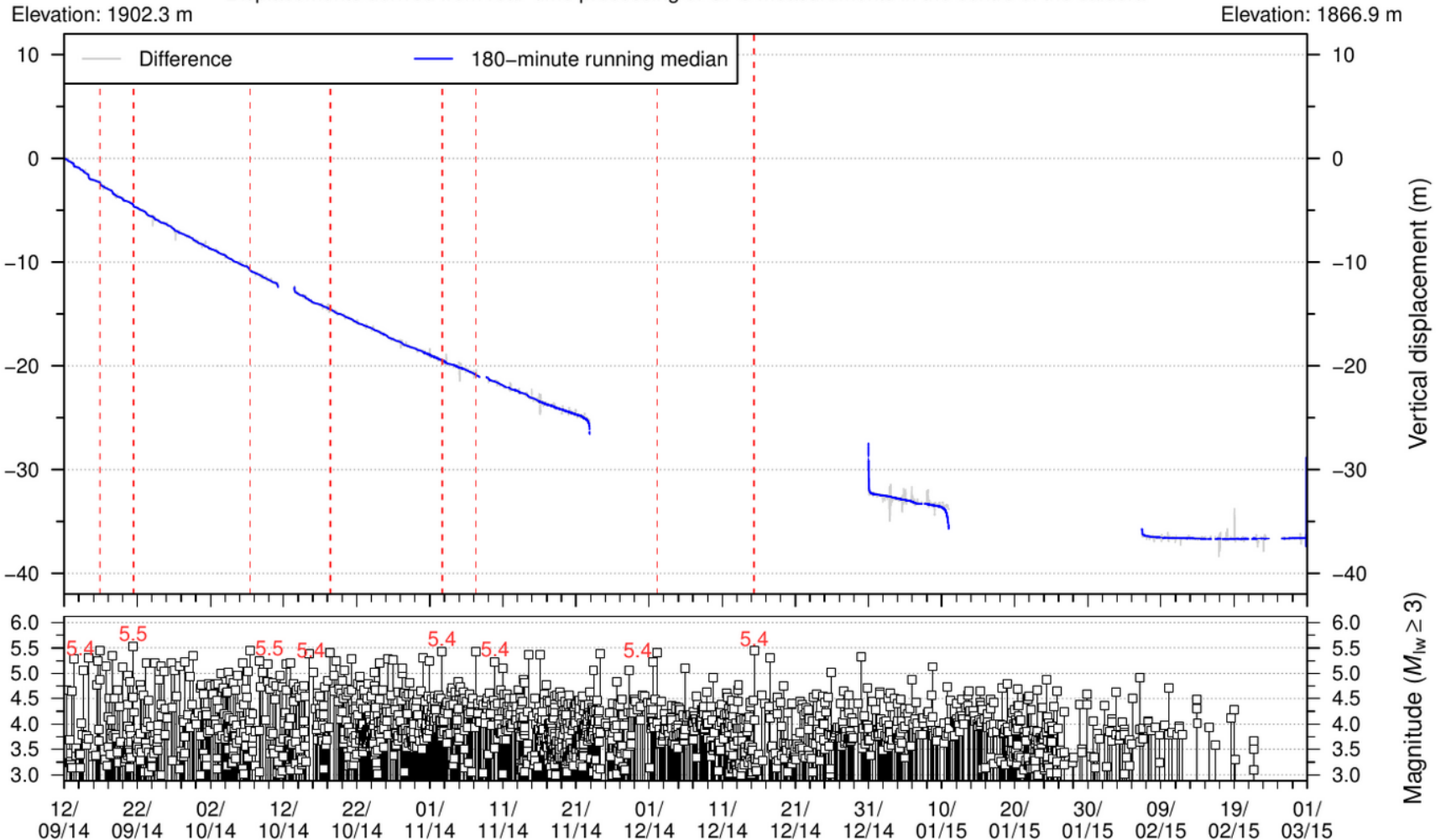
GPS station was installed in the middle of the Bárðarbunga caldera



Subsidence of Bárðarbunga caldera 12. September 2014 – 1. March 2015

Subsidence of the Bárðarbunga caldera

Displacements derived from real-time processing of GPS measurements in the centre of the caldera



GPS in Skaftárketill eystri → Glacial outburst



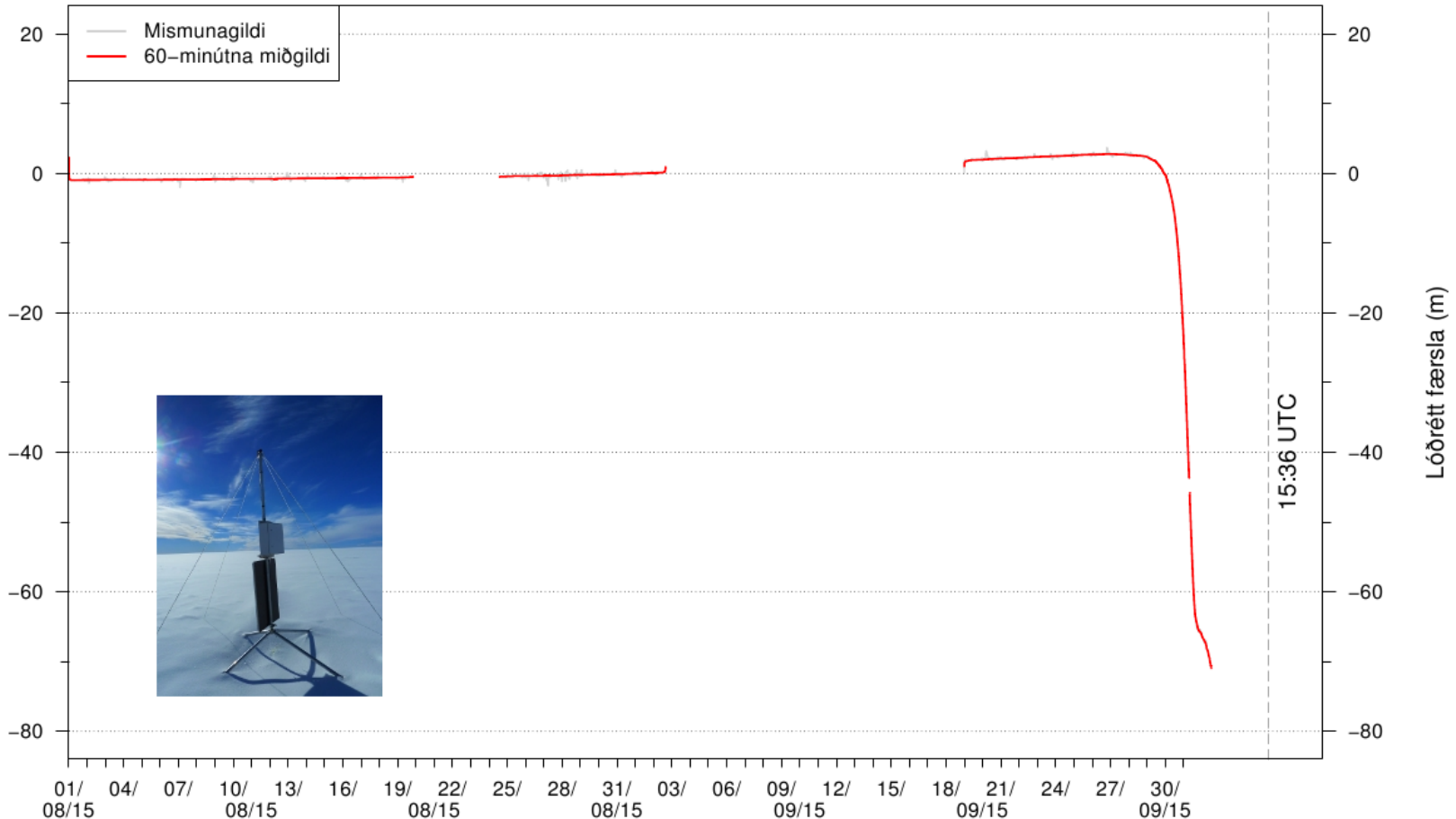
Hæðarbreyting í Eystri Skaftárkatli

Lóðrétt færsla fengin með rauntímaúrvinnslu úr GPS tæki staðsettu í Eystri skaftárkatli

Uppfært: 05.10.2015 15:36 UTC

Hæð: 1588.9 m

Hæð: 1509 m



Mælingarnar eru styrktar af Samevrópska verkefninu FutureVolc, Orkurannsóknasjóði Landsvirkjunar og rannsóknasjóði Vegagerðarinnar

Hæðartölur miðast við hæð yfir sjó

Glacial outburst in Skaftá eystri



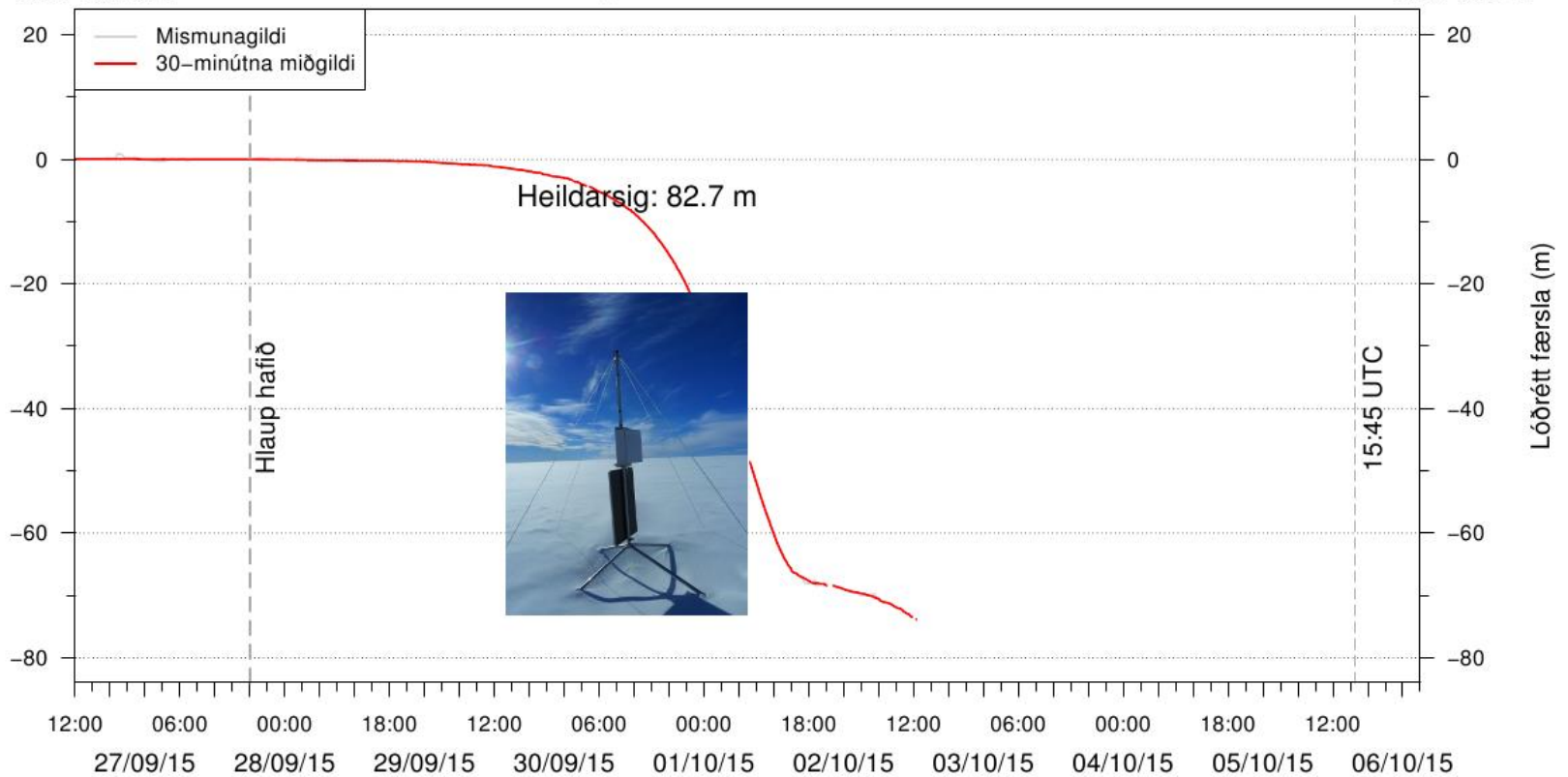
Hæðarbreyting í Eystri Skaftárkatli

Lóðrétt færsla fengin með rauntímaúrvinnslu úr GPS tæki staðsettu í Eystri skaftárkatli
Uppfært: 05.10.2015 15:45 UTC



Hæð: 1509 m

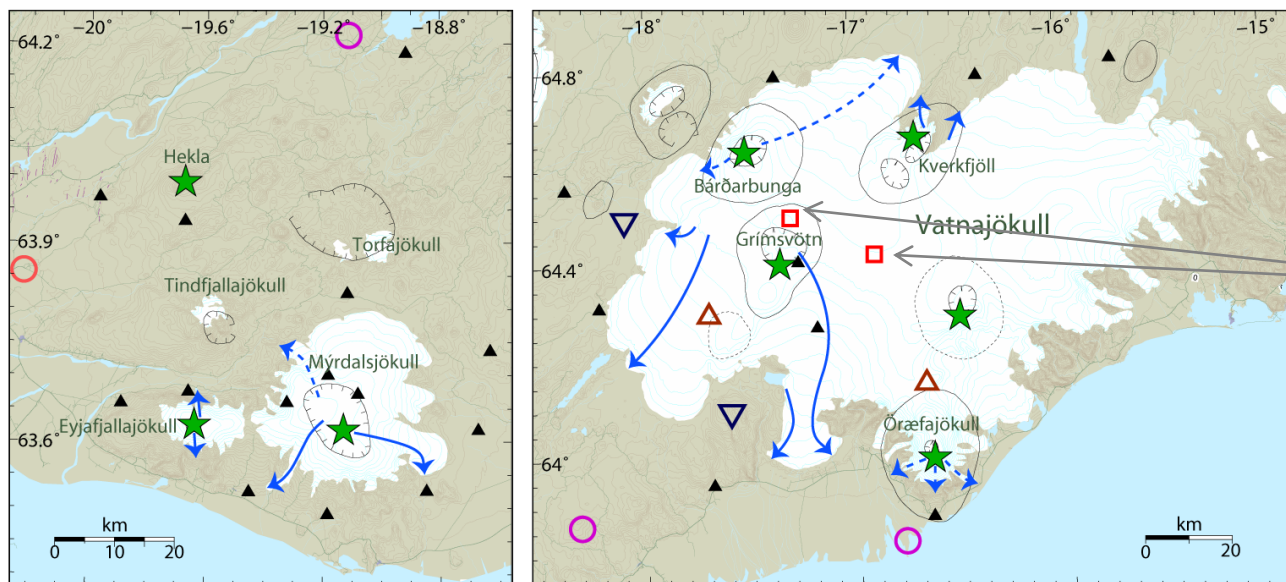
Hæð: 1591.7 m



Permanent and temporary stations monitoring subglacial volcanoes

Seismic stations and arrays installed in and around the glacier to discriminate between subglacial floods, eruptions and glacier movements

Infrasound arrays installed to detect and locate when eruptions become subaerial

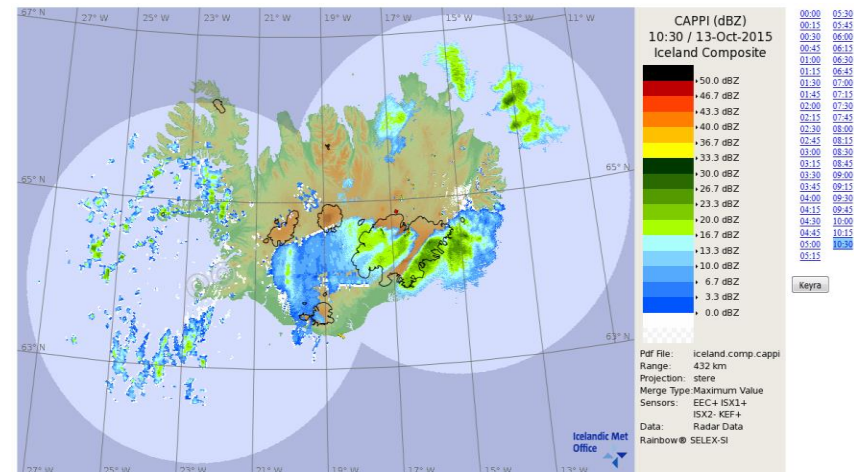
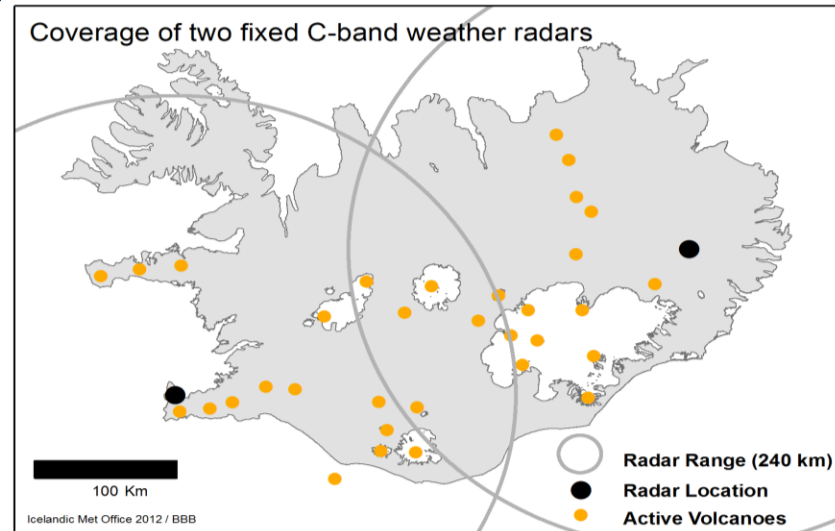


Glacier seismometer – installed 2014

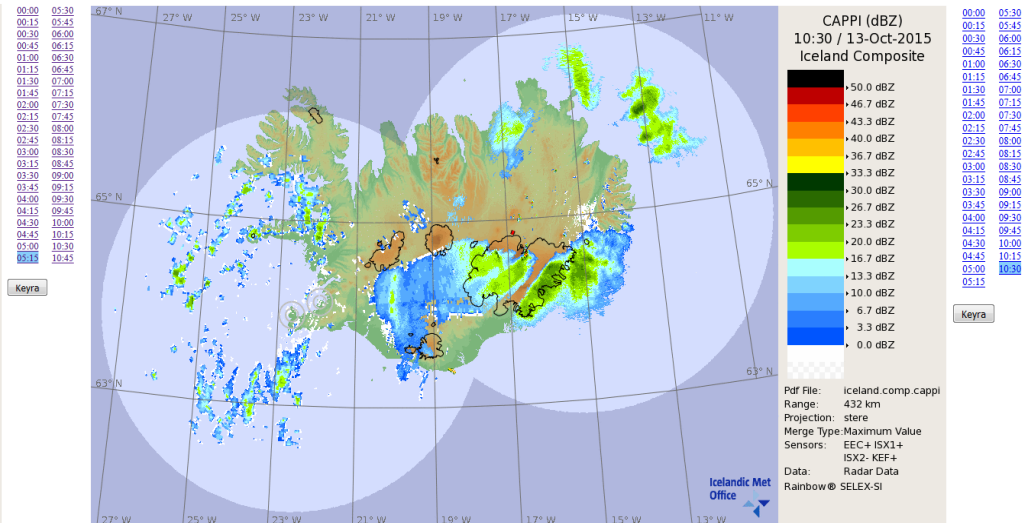
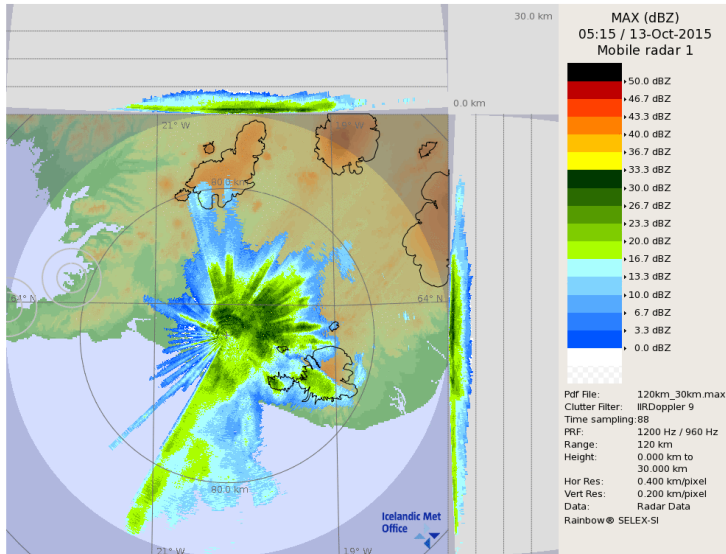
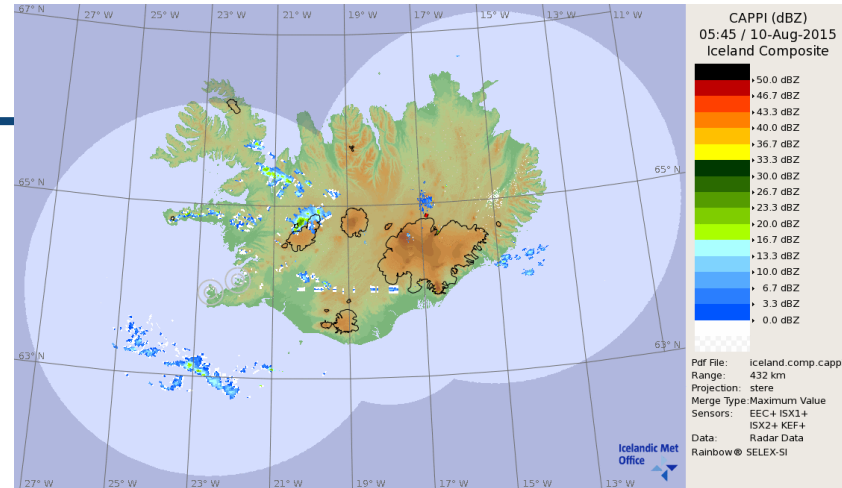
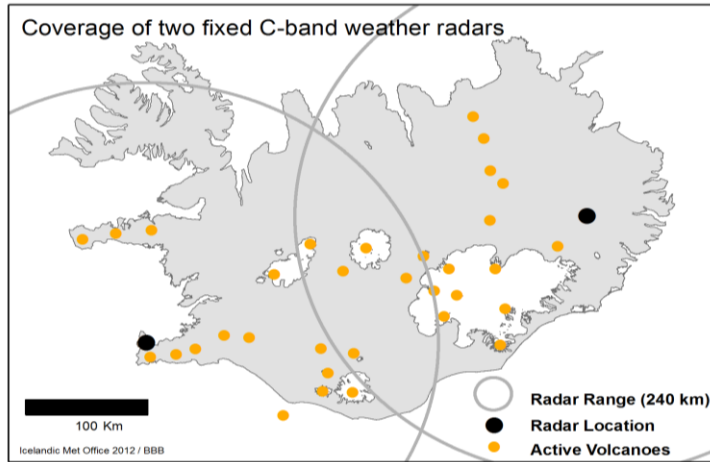
- | | | | |
|-----------------------|-----------------------------------|-----------------------------|-----------------------------|
| ★ Key volcanoes | ↔ Subglacial route for floodwater | ▲ Permanent seismic station | △ Intended seismic station |
| □ Glacial seismometer | ▽ Short-period array | ○ Existing infrasound array | ○ Intended infrasound array |

Monitoring and Research: eruption cloud detection and investigation

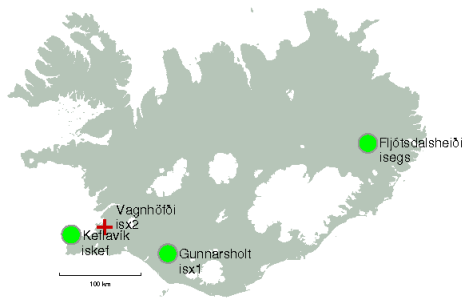
- ▶ C-band weather radar close to Keflavík airport since Jan 1991
- ▶ **has detected 7 eruptions**
- ▶ C-band weather radar in E-Iceland since April 2012
- ▶ 2 X-band mobile radars
- ▶ 2 Lidars (1 fixed; 1 mobile)
- ▶ 7 ceilometers
- ▶ Mobile radiosonde soundings
- ▶ Lightning-detection devices
- ▶ 2 mobile particle counters



Radar - measurements



Radar - performance



Skýringar

Nýjustu gögn	Eldgos
● < 3 klst	▲ Merki um virkni
● < 24 klst	▲ Aukin virkni
● > 24 klst	▲ Eldgos stendur yfir
+	Veðursjá ekki virk

Uppfært: 13. október 2015, kl. 10:09

Nýjast

DAGSETNING TÍMI RADAR TEG
 2015-10-13 10:00:00 iskef bru
 2015-10-13 09:45:00 isegs bru
 2015-10-13 09:15:00 isx1 vol

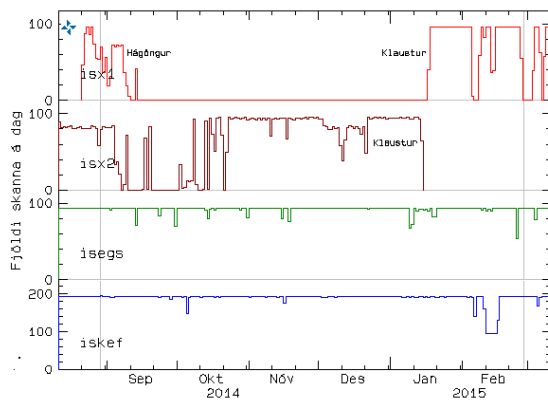


Veðursjár - staða Gagnaskil sl. viku

Forsíða > Veðursjár - Staða

Veðursjár - Gagnaskil í eldgosum

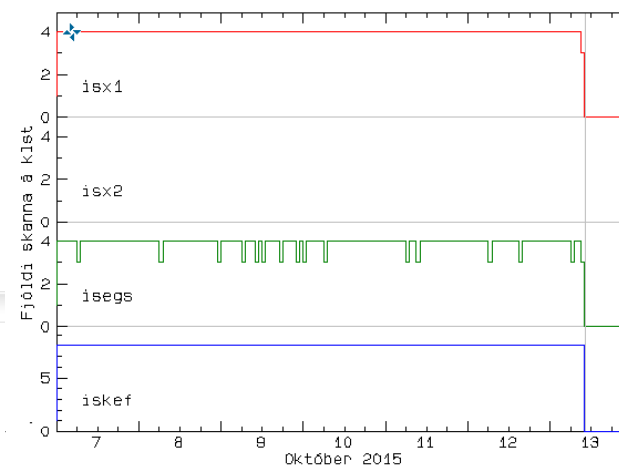
Holuhraun 2014-2015



Veðursjár - staða Gagnaskil eftir árum Gagnaskil í eldgosum

Forsíða > Veðursjár - Staða

Veðursjár - Gagnaskil sl. viku

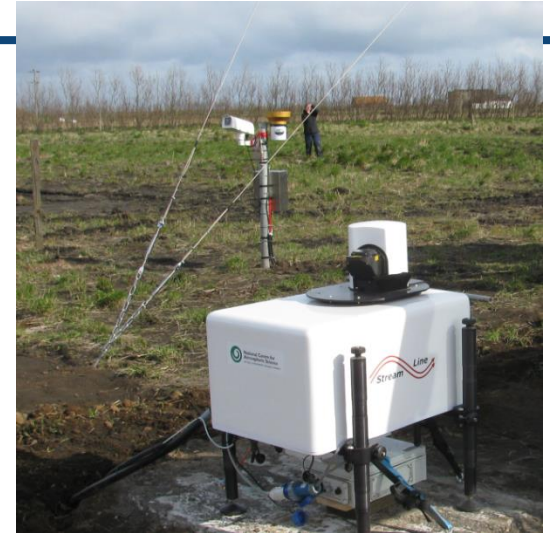


Uppfært: 13. október 2015, kl. 10:09

Ceilometers and Lidars

Lidar

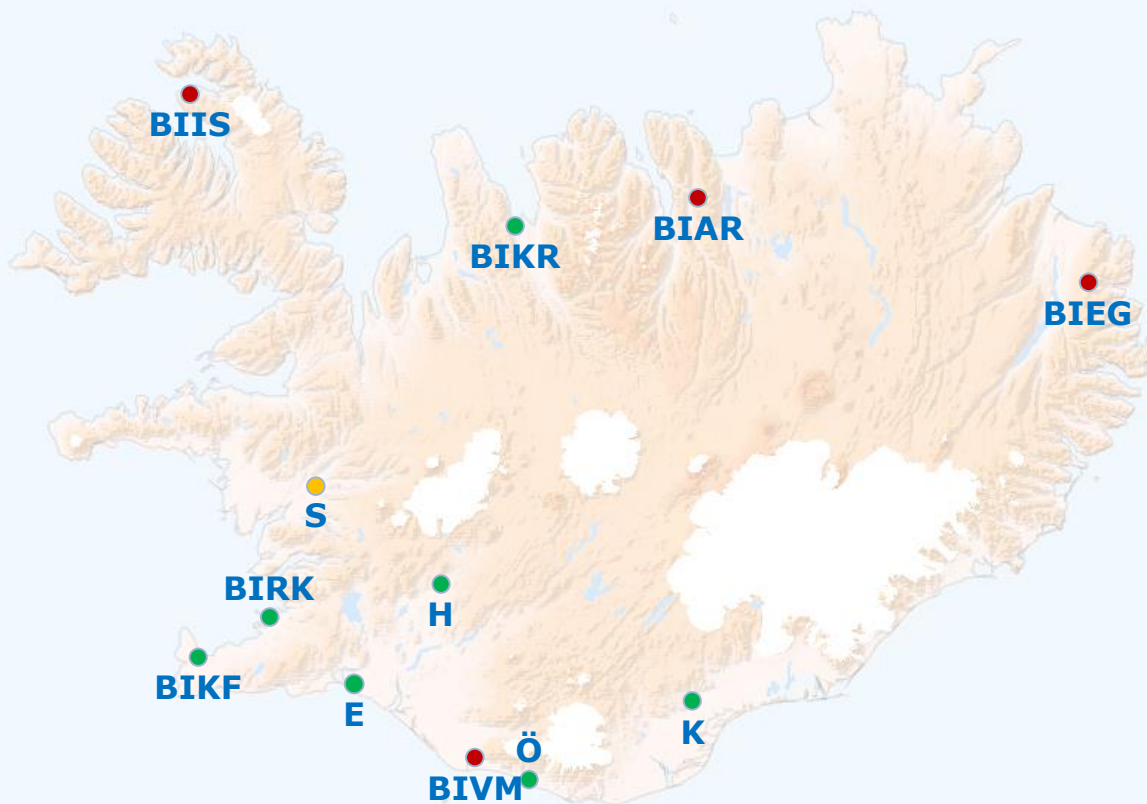
- ▶ May 2011 – June 2012 on loan from NCAS, UK. Pulsed scanning Doppler LIDAR with de-polarization channel
- ▶ In 2014 – two lidars implemented – one located in Keflavík airport and the other one mobile



7 Ceilometers



Ceilometers



Operational:

- BIKF – Keflavík Airport
- BIRK - Reykjavík
- E - Eyrarbakki
- H - Hjarðarland
- Ö- Önundarhorn
- K – Kirkjubæjarklaustur
- BIKR – Sauðárkrókur

Planned:

- S - Stafholtsey/Stóri-Kroppur

ISAVIA:

- BIIS – Isafjörður
- BIAR – Akureyri
- BIEG – Egilsstaðir
- BIVM - Vestmannaeyjar

Ceilometer – visualization

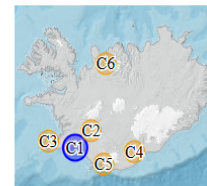
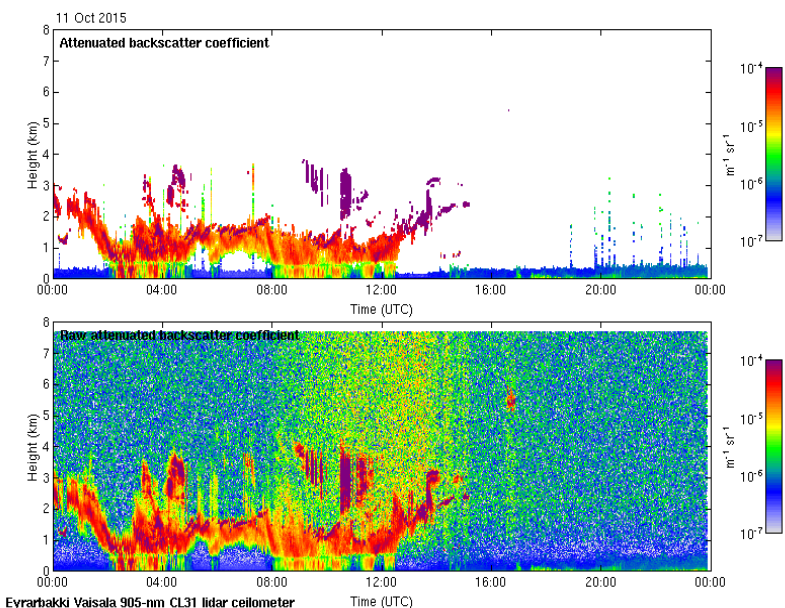
Eyrarbakki

Mælingar með agnasjár og skýjahæðamælum

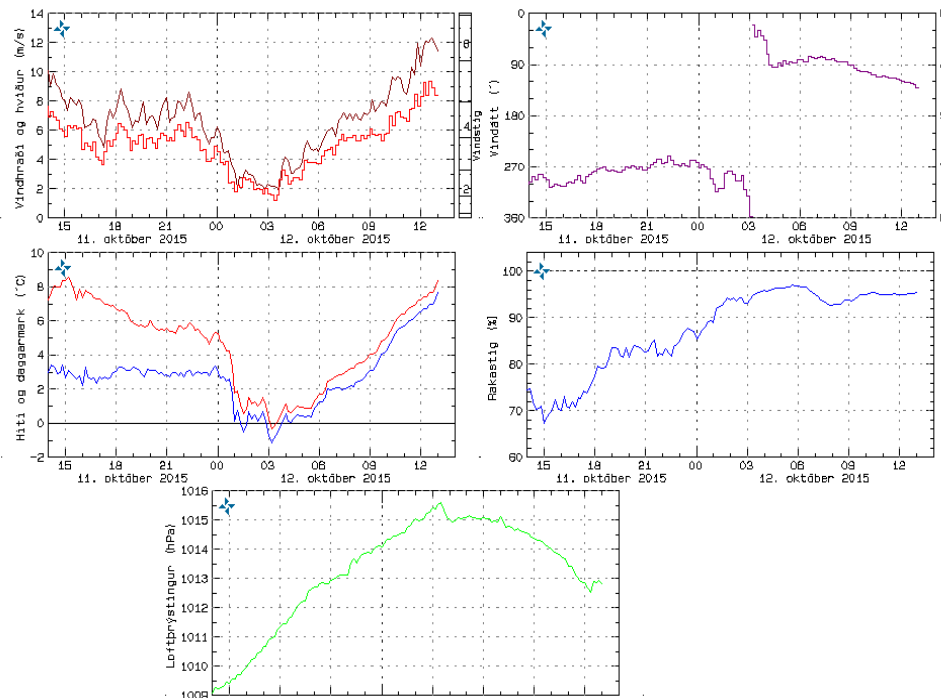
2015-M10-12 -M +M Í dag

01 02 03 04 05 06 07 08 09 10 11 12

Í gær Í dag Síðustu 4 klst



Veður síðasta sólarhring: Eyrarbakki



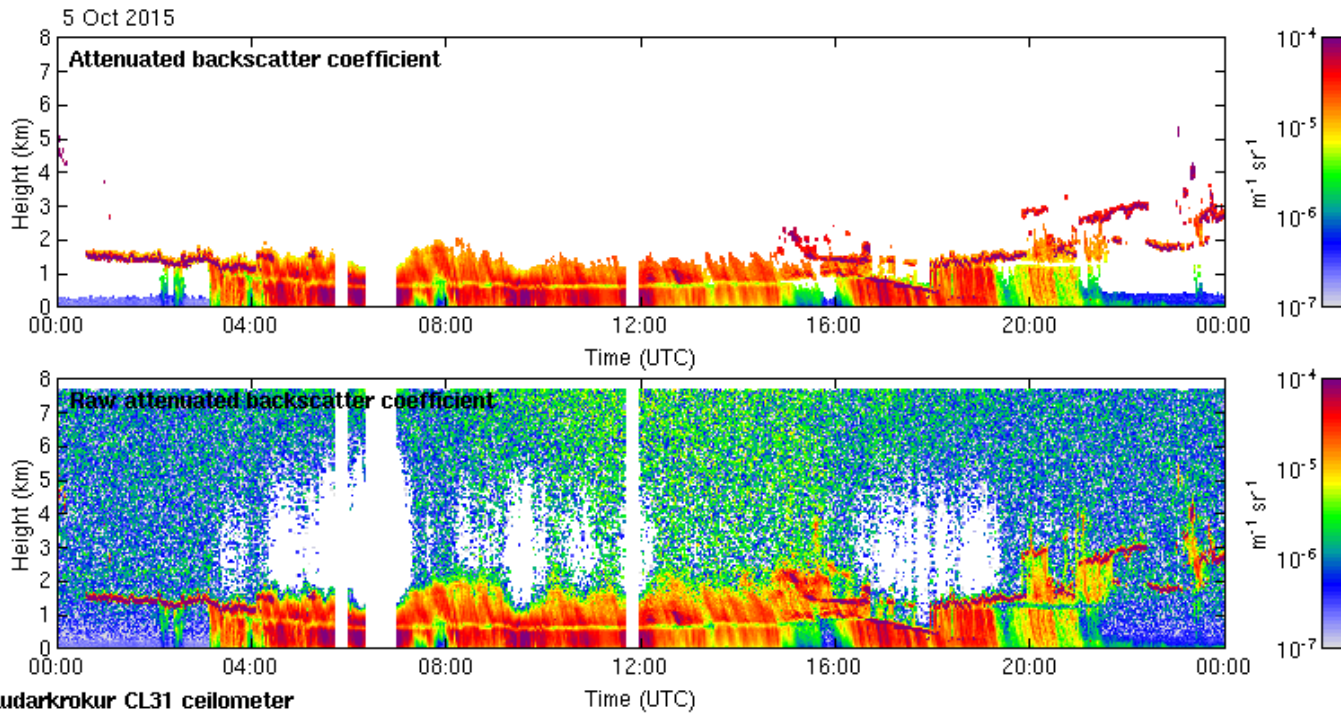
Sauðárkrókur

Mælingar með agnasjár og skýjahæðamælum

2015-M10-07 -M +M Í dag

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15

2015-M10-05 2015-M10-06 2015-M10-07



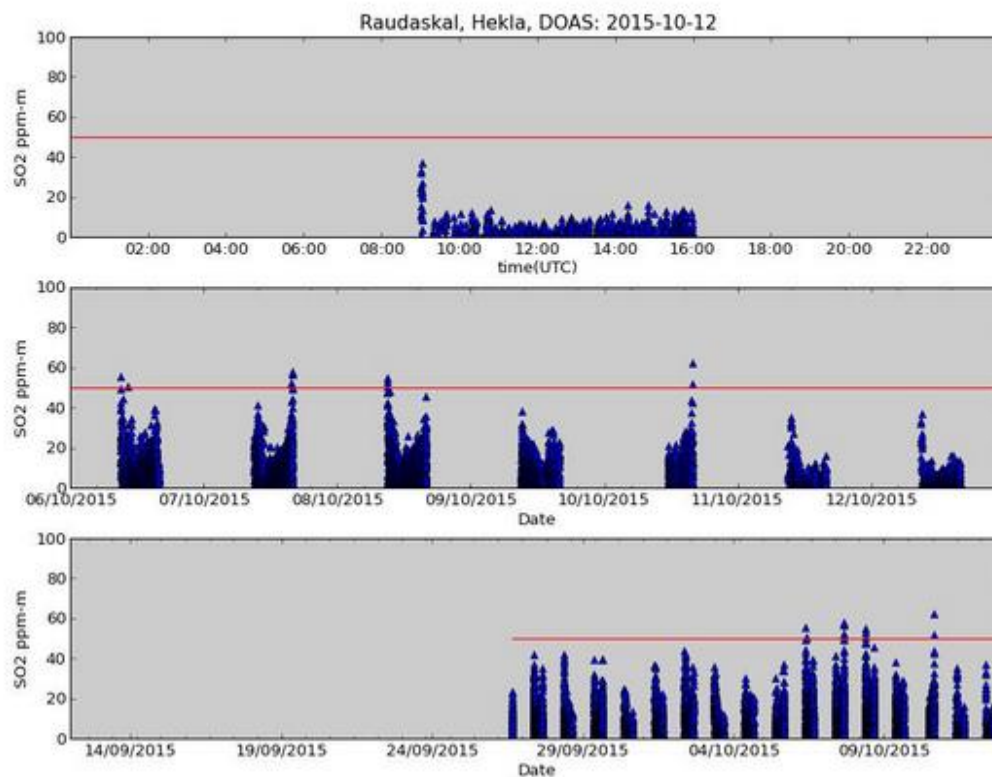
Mobile sounding station from 2013

- ▶ Standard sonde (Lat, long, height, P, T, T_d , Wind)
- ▶ Tested regularly, last time 7. October 2015
- ▶ Collaboration with the University in Reading England
 - ▲ Testing different sensors e.g. radioactivity

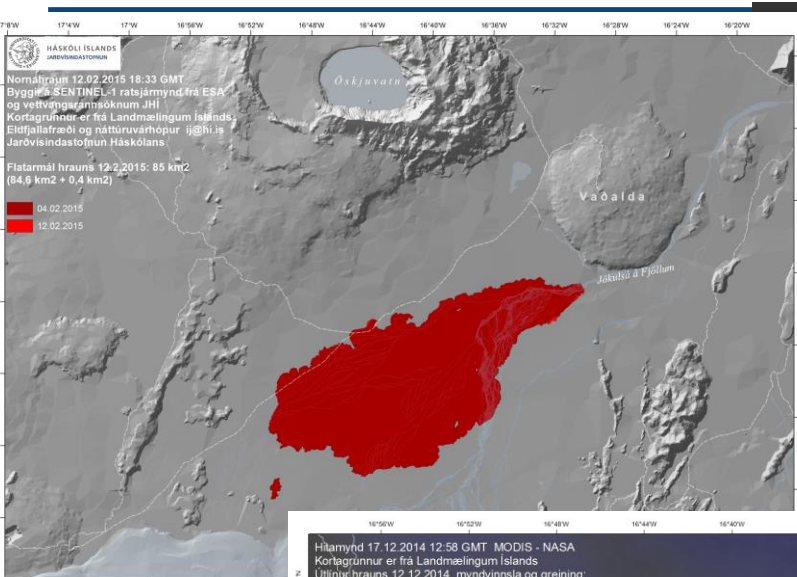


Gas measurements important

- ▶ In the last eruption in Iceland.
- ▶ To understand eruption precursors.
- ▶ The goal is to define thresholds which can be used as indicators for possible eruption.



Satellite information e.g. MODIS, LANDSAT, MIROVA, ...



Iceland

Askja

Latitude	Longitude	Elevation
65.03	-16.75	1516 m

Latest images

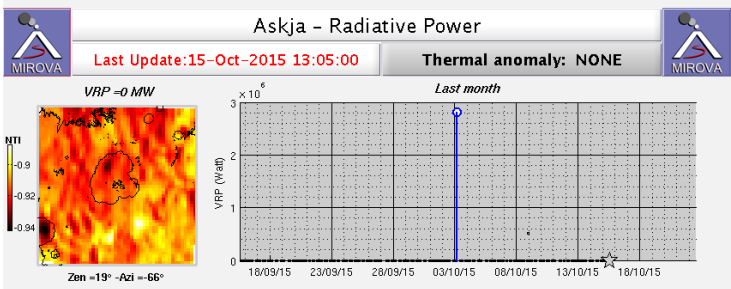
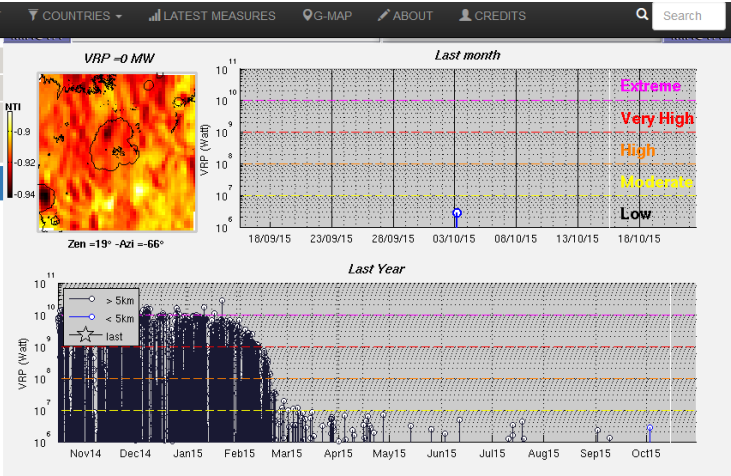
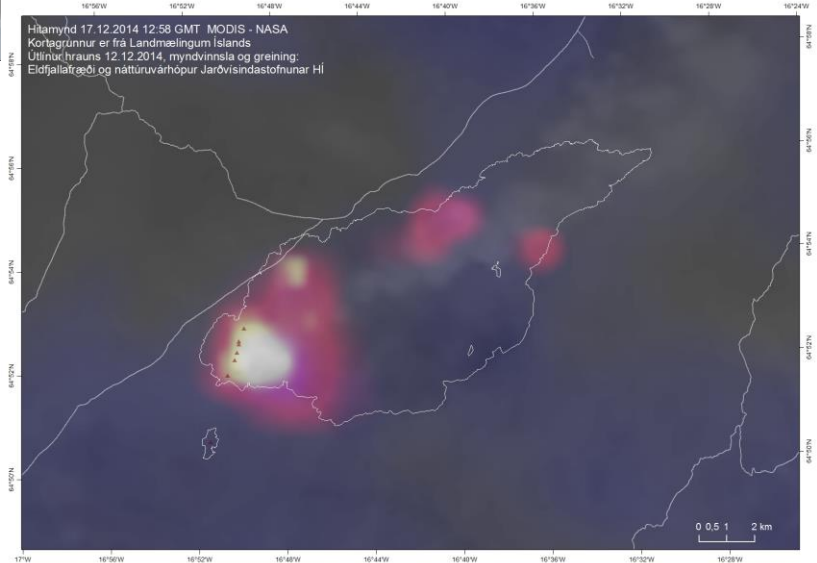
Log Rad Power

Rad Power

Distance from summit

Google earth

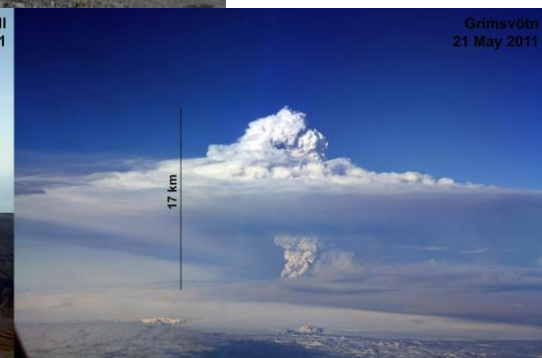
Global Volcanism Program



Conclusion

- ▶ The increased observations and development of retrieval algorithms that has taken place in the past years has improved our knowledge about volcanoes and their behaviour.
- ▶ This knowledge will improve IMO's capability to predict volcanic eruptions, information about volcanic ash → important input parameter in dispersion models

©Baldur Bergsson





Give us feedback

Sign in Additional information

Volcanoes Data Portal Eruption Search Hide Layers Overview map Legend

Sort by: Aviation Color Code

- Askja**
Aviation Colour Code: Green
Activity Level: Moderate
LastEruption: 1961 CE
Catalogue information
Activity status
- Brennisteinsfjöll**
Aviation Colour Code: Green
Activity Level: Moderate
LastEruption: Late 10th century CE
Catalogue information
Activity status
- Bárðarbunga**
Aviation Colour Code: Green
Activity Level: High
LastEruption: 2014 CE
Catalogue information
Activity status
- Eldey**
Aviation Colour Code: Green
Activity Level: Low
LastEruption: 1926 CE
Catalogue information
Activity status
- Esjufjöll**
Aviation Colour Code: Green
Activity Level: Low
LastEruption: 1927 CE
Catalogue information
Activity status
- Eyjafjallajökull**

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