Radar volcano monitoring system in Iceland

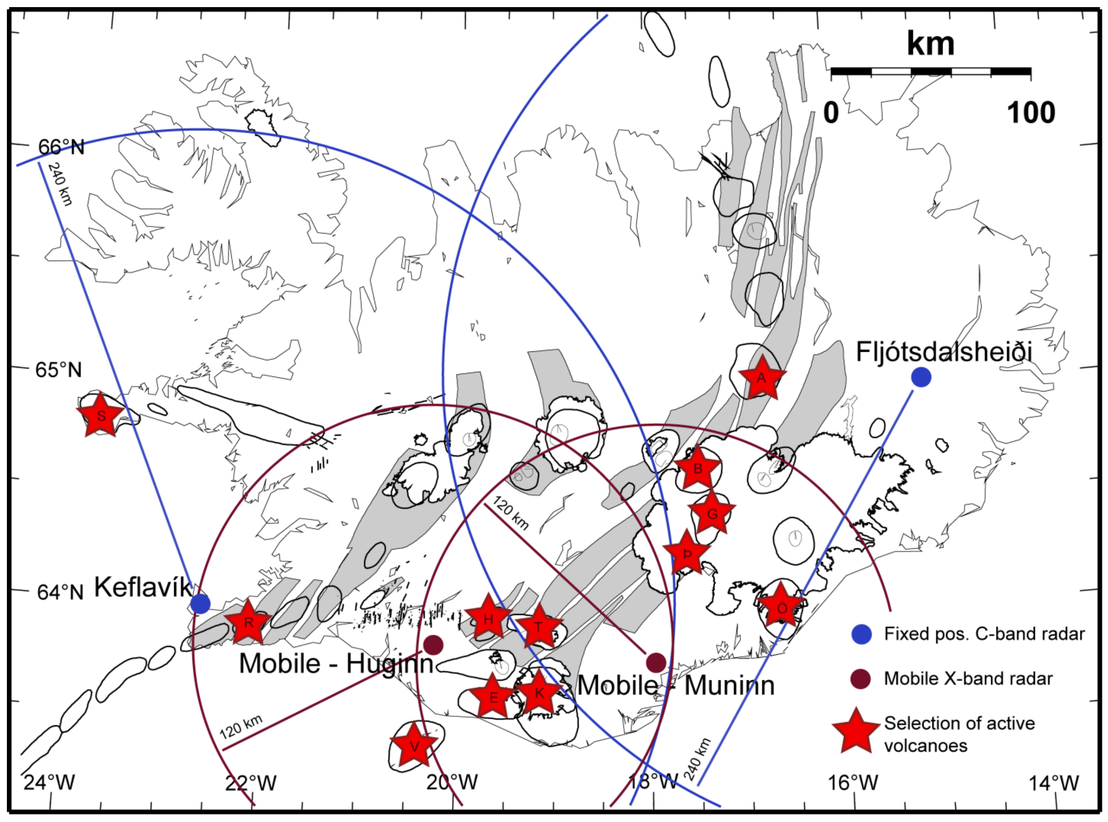
Hermann Arngrímsson (hermann@vedur.is), Þórður Arason and Baldur Bergsson

Icelandic Met Office

Weather radars are valuable instruments in monitoring explosive volcanic eruptions. Temporal variations in the plume and ash dispersal can be monitored and thus eruption strength estimates derived. Radar reflectivity of a volcanic plume is related to the composition, concentration and size-distribution of the complex mixture of ice, water and ash as well as type, shape and orientation of the ash grains.

After the Eyjafjallajökull volcanic eruption in 2010, the radar capabilities in Iceland were greatly increased in cooperation with the International Civil Aviation Organization (ICAO). The Icelandic Meteorological Office (Veðurstofa Íslands), a government institute, now owns and operates four radars that can be utilized for volcano monitoring. In addition to issuing weather forecasts and warnings of natural hazards, the institute is responsible for monitoring and conducting research on meteorology, hydrology, avalanches, glaciology, earthquakes, tectonics and volcanology.

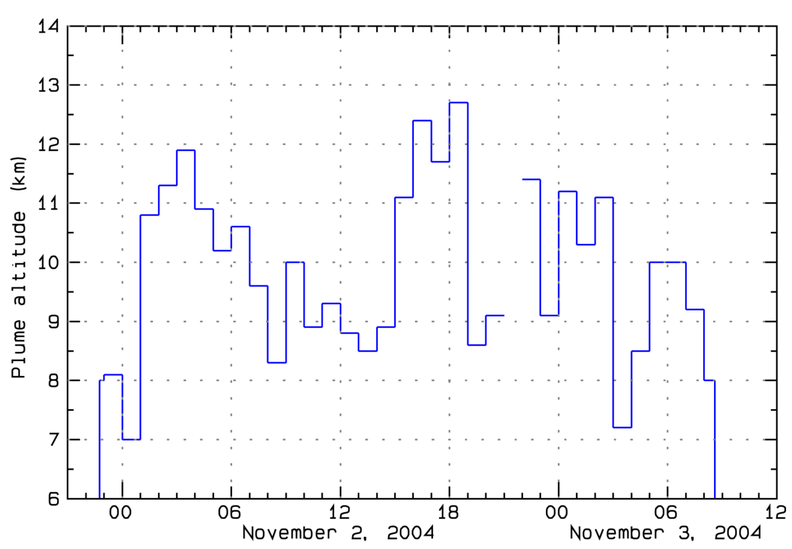
This poster presents detailed technical information on the four radars with examples of the information acquired during previous eruptions. This expanded network of radars is expected to give valuable information on future volcanic eruptions in Iceland.



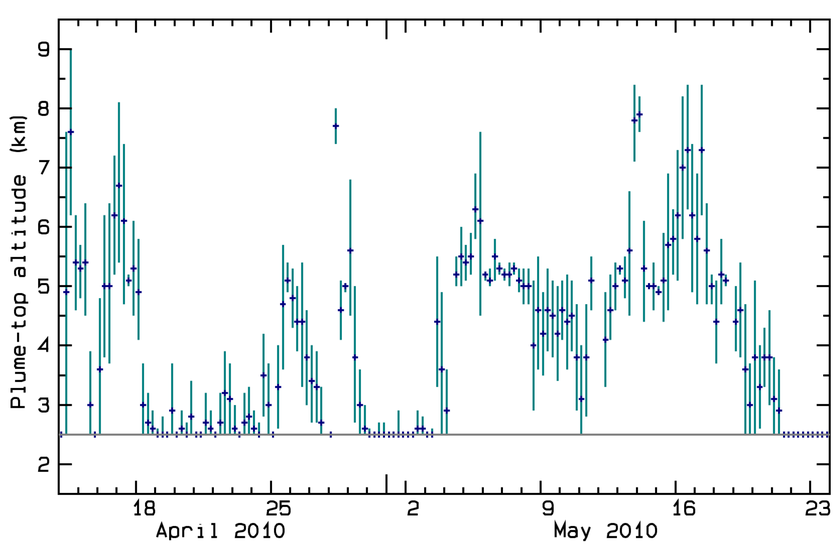
(a) The Keflavík C-band weather radar, (b) Huginn mobile X-band radar, (c) A sample radar reflectivity plot during the Grímsvötn 2011 eruption measured by a mobile radar on loan from the Italian Civil Protection Authorities (Selex Meteor 50DX). Photos Þórður Arason and Geirfinnur S. Sigurðsson.

Table 1 Recent explosive eruptions in Iceland

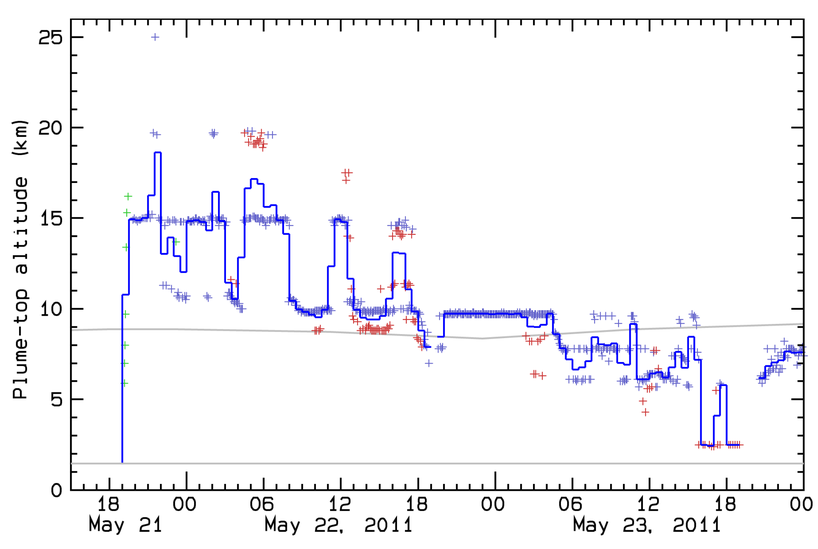
Volcano	Initiation	Duration	Explosive phase
Grímsvötn	21 May 2011	8 days	8 days
Eyjafjallajökull	14 April 2010	39 days	29 days
Grímsvötn	1 Nov 2004	6 days	6 days
Hekla	26 Feb 2000	12 days	~12 hours
Grímsvötn	18 Dec 1998	10 days	10 days
Gjálp	30 Sept 1996	13 days	13 days
Hekla	17 Jan 1991	53 days	~10 hours
Grímsvötn	28 May 1983	few days	very brief
Hekla	9 April 1981	8 days	few hours
Hekla	5 May 1970	61 days	~2 hours



Grímsvötn 2004: Plume-top altitude – 1 hour averages during the initial most powerful 39 hours, 1–3 Nov 2004.



Eyjafjallajökull 2010: Plume-top altitude – 6 hour averages and standard deviation during the 39 days of the eruption, 14 April – 23 May 2010.



Grímsvötn 2011: Plume-top altitude – 30 min averages and individual estimates during the initial and most powerful 57 hours, 21–23 May 2011.

Table 2 Keflavík radar, SW-Iceland

Location	64°01.54' N, 22°38.11' W (fixed position)
Type	Ericsson UBS 103 04 radar system
Operational since	January 1991; doppler since April 2010
Operating frequency	5.61 GHz, C-band
Wavelength	5.3 cm
Peak transmitted power	~250 kW
Maximum range	480 km
TX type	Magnetron
RX type	Analog
Polarization	Linear horizontal
Signal Processor	UFC 108 14/8
Data managing software	Rainbow®5
Reflector diameter	4.2 m
Height of antenna	47 m above sea level
Pulse duration	0.58±0.05 µs (doppler); 2.0±0.2 µs (refl.)
Pulse repetition frequency	900/1200 Hz (0.6 µs); 250±2 Hz (2 µs)
Half-power beam width	0.9°
Range resolution	1 km (doppler); 2 km (reflectivity) (typical)
Actual gain of antenna	44.9 dB
Minimum detectable signal	−114 dBm (0.6 µs); −109 dBm (2 µs)
Scanning speed	1 - 6 rpm; 2 rpm (typical)
Elevation angles reflectivity	0.5°, 0.9°, 1.3°, 2.4°, 3.5°, 4.5°, 6.0°, 8.0°, 10.0°, 12.0°, 15.0° & 20.0° (typical)
Elevation angles doppler	0.5°, 1.3°, 2.4°, 5.0°, 7.0°, 10.0°, 15.0°, 20.0° & 30.0° (typical)
Refl. threshold (echo top)	−20 dBZ (typical)

Table 3 Fljótsdalsheiði radar, E-Iceland

Location	65°01.68' N, 15°02.29' W (fixed pos.)
Type	EEC SWR-250C(F)
Operational since	May 2012
Operating frequency	5.52 GHz, C-band
Wavelength	5.4 cm
Peak transmitted power	~250 kW
Maximum range	480 km
TX type	Magnetron
RX type	Digital
Polarization	Linear horizontal
Signal Processor	IQ2
Data managing software	EDGE V5.5
Reflector diameter	4.25 m
Height of antenna	698 m above sea level
Pulse duration	0.5 µs & 2 µs
Pulse repetition frequency	250-934 Hz (0.8 µs); 250-300 Hz (2 µs)
Half-power beam width	1°
Range resolution	0.016-2.000 km; 0.25-0.50 km (typical)
Azimuthal resolution	0.2°-1.2°; 0.4° (typical)
Minimum gain of antenna	44 dB
Minimum detectable signal	−115 dBm (0.8 µs); −117 dBm (2 µs)
Angle position accuracy	< 0.1°
Scanning speed	1 - 6 rpm; 2 rpm (typical)
Elevation angles reflectivity	0.0°, 0.5°, 0.9°, 1.3°, 2.4°, 3.5°, 4.5°, 6.0°, 8.0°, 10.0°, 15.0° & 25.0° (typical)
Refl. threshold (echo top)	−20 dBZ (typical)

Table 4 Huginn & Muninn mobile radars

Location	mobile
Type	Selex Gematronik Meteor 50DX
Gross weight	3500 kg
Operational since	Hu: June 2012 / Mu: February 2013
Operating frequency	Hu: 9.375 GHz / Mu: 9.355 GHz, X-band
Wavelength	3.2 cm
Peak transmitted power	~75 kW
Maximum range	120 km
TX type	Magnetron
RX type	Digital
Polarization	Horizontal and vertical
Signal Processor	GDRX
Data managing software	Rainbow®5
Antenna type	XDP15, parabolic, prime focus reflector
Reflector diameter	1.88 m
Height of antenna	3 m above ground
Pulse duration	0.5 µs, 1 µs & 2 µs
Pulse repetition frequency	250 - 2000 Hz
Half-power beam width	1.25°
Minimum gain of antenna	42.4 dB
Minimum detectable signal	Hu: H&V: −117 dBm Mu: H/V: −117/−119 dBm
Range resolution	0.03 - 2.00 km; 0.1 km (typical)
Azimuthal resolution	1° (typical)
Angle position accuracy	< 0.1°
Scanning speed	1 - 6 rpm; 3 rpm (typical)
Elevation angles reflectivity	0.7°, 1.8°, 3.1°, 4.6°, 6.3°, 8.3°, 10.6°, 13.2°, 16.2°, 19.7°, 23.8°, 28.4°, 33.8° & 40.0° (typical)
Refl. threshold (echo top)	−20 dBZ (typical)

Veðurstofa Íslands – Icelandic Meteorological Office
Bústaðavegur 9, IS-108 Reykjavík, Iceland
Tel. +354 522 6000, www.vedur.is

Weather Radar Calibration & Monitoring Workshop (WXRCalMon) ,Offenbach, Germany, 18-20 October 2017