Improved source parameter estimation and volcanic cloud characterisation through data integration: plans for the future at the Icelandic Meteorological Office

Talfan Barnie (Veðurstofa Íslands, talfan@vedur.is)
Sara Barsotti (Veðurstofa Íslands, sara@vedur.is)
Eysteinn Már Sigurðsson (Veðurstofa Íslands, eysteinn@vedur.is)
Michelle M. Parks (Veðurstofa Íslands, michelle@vedur.is)
Melissa A. Pfeffer (Veðurstofa Íslands, melissa@vedur.is)
Þórður Arason (Veðurstofa Íslands, arason@vedur.is)
Sibylle von Löwis (Veðurstofa Íslands, sibylle@vedur.is)
Ingvar Kristinsson (Veðurstofa Íslands, ingvar@vedur.is)

Overview

Volcanic ash clouds pose a threat to aviation and can cause great economic disruption. In northern Europe, it has been estimated that there is a twenty percent chance of an ash event during a given decade, and that during the last thousand years, the majority of these ash events of known provenance were sourced from Icelandic volcanoes (Watson et al. 2017). As the State Volcano Observatory, the Icelandic Meteorological Office (IMO) is tasked with monitoring these volcanoes and disseminating information about eruptions to Volcanic Ash Advisory Centres (VAACs). In recent years, the international bodies that coordinate these activities have stressed a number of key capabilities required for effective volcano monitoring, including, (1) accurate estimates of eruption source parameters for ash dispersion modelling (VASAG 2015), (2) data integration for better characterisation of volcanic clouds (WMO 2015) and (3) timely dissemination of volcanic information (ICAO 2016). To meet these aims, the project "Processing and integrating remote sensing data to improve volcanic ash dispersion models" has been funded by ICAO to build an operational framework at IMO for automatic estimation of source parameters, monitoring of volcanic clouds and retrieval of volcanic cloud properties. This project will integrate data from Radar, LiDAR, ceilometers, satellites, direct ash samples and ash size detectors, optical particle counters, sun photometers, UV spectrometers, and visible web cameras to provide rapid estimates of eruption source parameters and volcanic cloud properties. This information will then be disseminated to IMO weather forecasters and natural hazard specialists, other collaborators working on monitoring the eruption, and external end users such as Isavia, the national airport and air navigation service provider of Iceland, and the VAACs. In this poster we present an overview of some of the key assets that will be utilized in this endeavour.

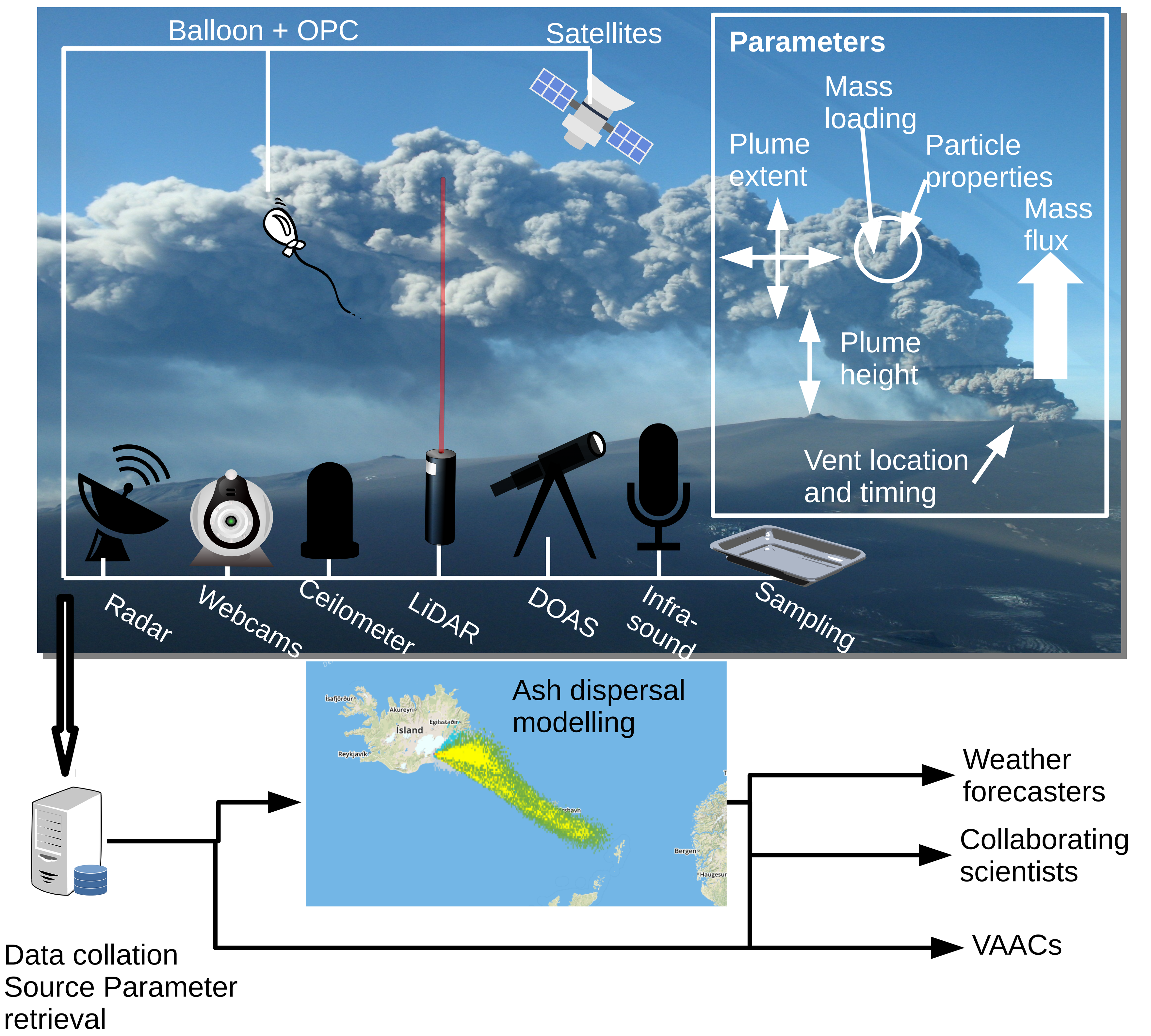


Figure 1: Overview of the proposed operational framework showing (i) the eruption source and cloud parameters to be retrieved, (ii) the monitoring data streams to be integrated (ii) the dissemination of the retrieved parameters. Photograph is from the 2010 Eyjafjallajökull eruption and was taken on May 11th. 10:25. Image credit: Sigurlaug Hjaltadóttir. Copyright: Veðurstofa Íslands.

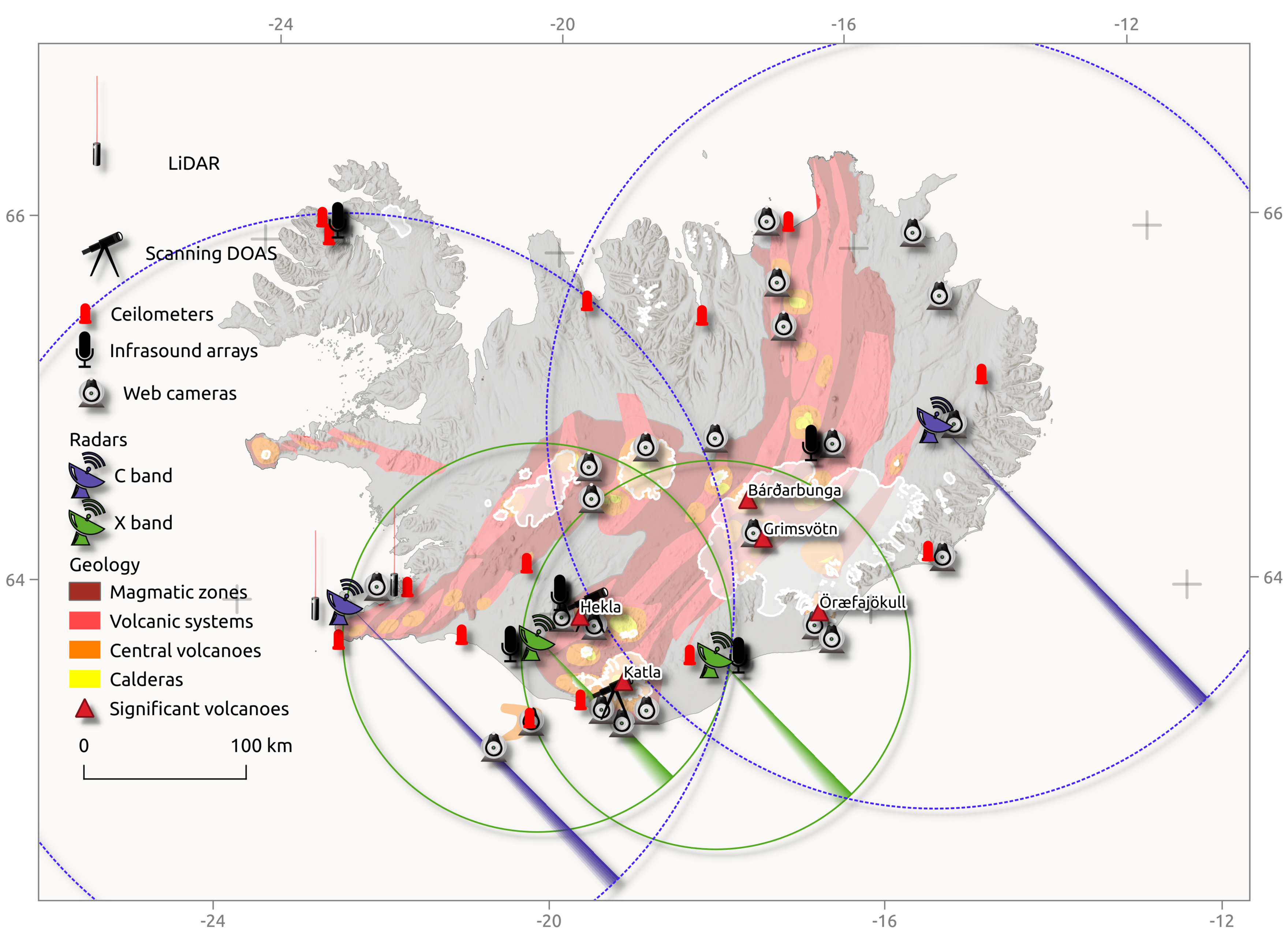


Figure 2. Map of Iceland showing major volcanic features and main IMO assets to be utilized in this project.

LiDAR

IMO operates two Leosphere WINDCUBE 200S Doppler scanning LiDARS with de-polarization channel, one permanently installed at Keflavik aiport, one mounted in a trailer for portability.

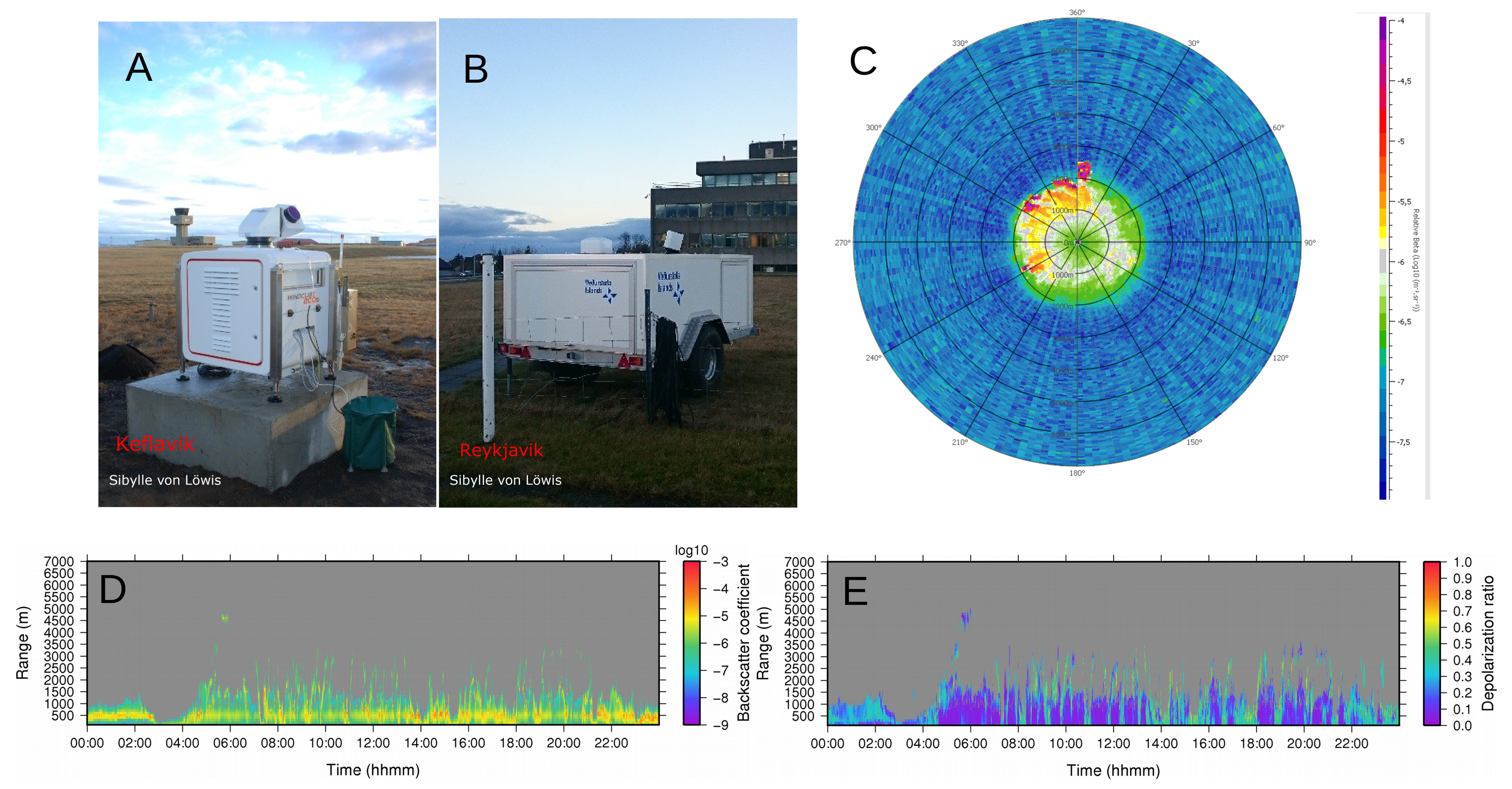
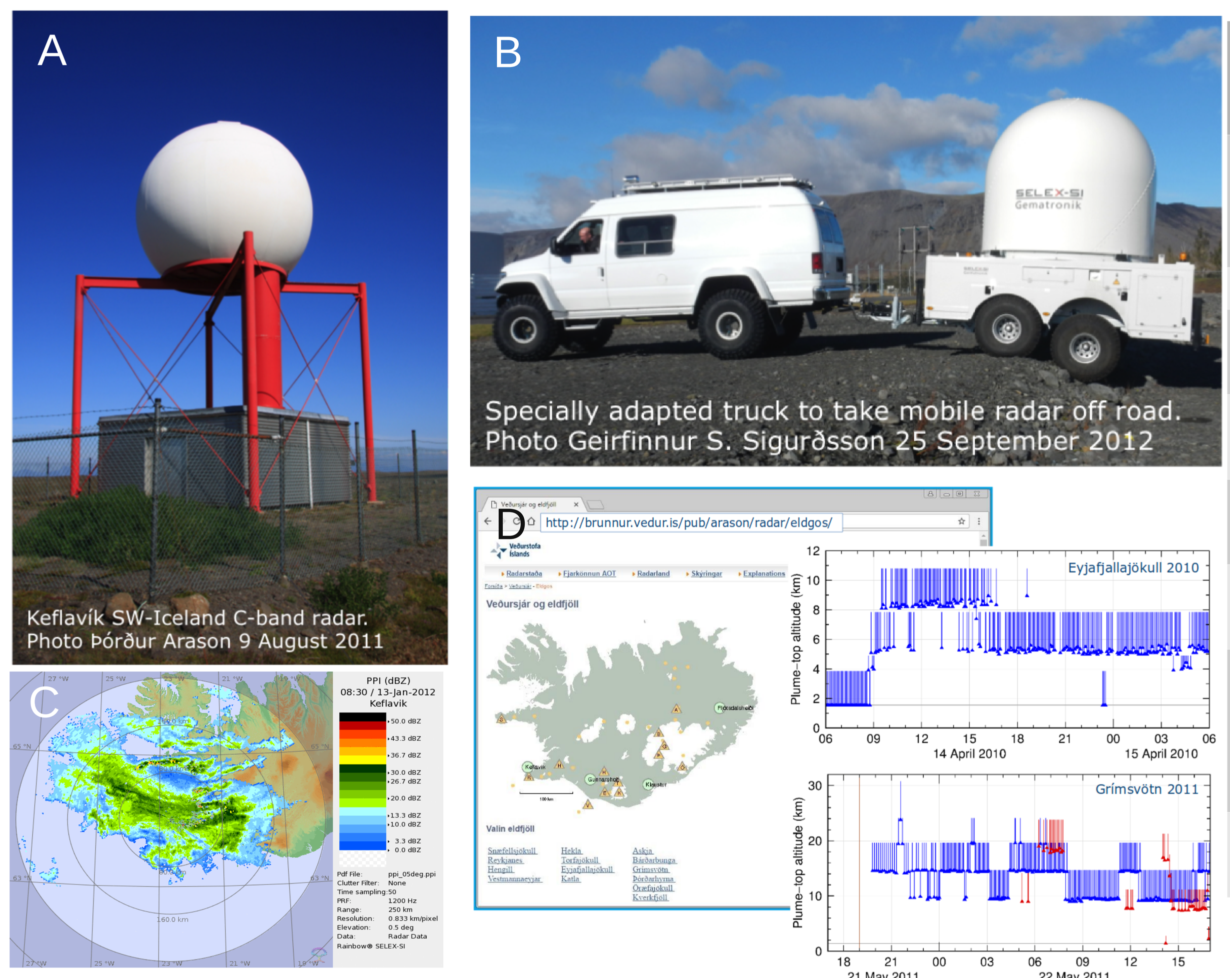


Figure 3: The IMO Windcube 200s LiDARs. (a) Permanent installation at Keflavik airport, (b) mobile trailer mounted unit. Example data from Keflavik: (c) polar plot of an azimuthal scan (relative beta), (d) time plot of backscatter, (e) time plot of depolarization.

Radar

IMO operates four weather radars; two fixed position C band radars at Fljótdalsheiði in E. Icleand and Keflavík in S.W Iceland, and two mobile X band radars. With a routine operating range of 240 km, the C band radars cover most of the country, while the X band radars are currently placed to maximize the chance of catching the start of an eruption from one of the volcanoes of highest concern (see figure 2) however these can be moved into position during an eruption for optimal acquisitions given access constraints and orographic blocking. The radar data is currently operationally processed by the Volcanic Eruptive Source Parameter Assessment (VESPA) system (Arason et al. 2018), which automaticallly estimates plume height every hour from radar data, inverts these heights for source parameters using the 1D DAKOTA-PlumeMoM model and ECMWF atmospheric profiles, and then runs the Vol-CALPUFF and name dispersion models to predict the location of ash. Additionally, data from the radars have been used for estimating ash particle size category and concentration, amongst other source parameters, using the Volcanic Ash radar Retrieval (VARR) method (e.g. Marzano et al. 2013).

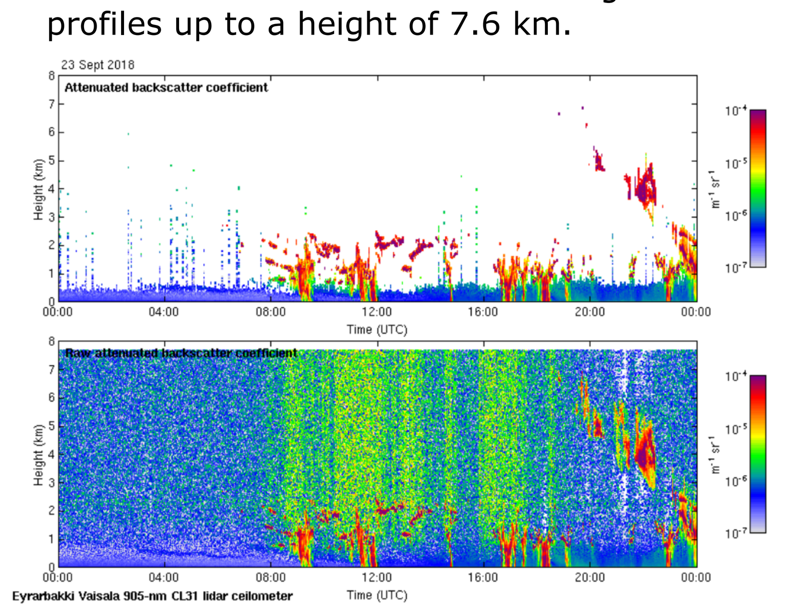


	Keflavík	Fljótsdal sheiði	Huginn & Muninn
Model	Ericsson UBS 103 04 radar system	EEC SWR-250C(F)	Selex Gematron ik Meteor 50DX
Mobility	Fixed	Fixed	Mobile
band	C (5.3 cm)	C (5.4 cm)	X (3.2 cm)
Range	240 km (480 max)	240 km (480 max)	120 km max
Doppler	Since April 2010	No	No
Polarisati on	Linear horizontal	Linear horizontal	Dual
Range resolution	1 km doppler 2km reflectivity (typical)	0.25-0.5 km (typical)	0.1 km (typical)
Azimuth resolution		0.4° (typical)	0.1 km (typical)

Figure 4: The IMO radars. (a) C band radar at Keflavik airport, (b) mobile X band radar. (c) example C band radar scan, (d) example plume height timeseries from two recent eruptions.

Ceilometers

IMO and ISAVIA run a network of Vaisala CL31 905 nm LiDAR ceilometers which give backscatter profiles up to a height of 7.6 km.



Satellites

IMO receieves the EUMETCAST basic sevice and has access to ESA Sentinel data through Scihub and the Norwegian science hub. Currently ash colour composites, brightness temperature difference and fog products are operationally produced. In the future IMO will perform ash retrievals in-house, to be validated using terrestrial remote sensing and direct sampling.

Sun photometer

IMO currently operates a portable CIMEL CE318 sun photometer on loan from Mathia Wiegner.

... everything else

Web cameras

Scanning UV spectrometers

Balloon borne Optical Particle Counters (OPCs)

Ashers (data to be provided by University of Iceland Earth Sciences Department)

Infrasound (existing eruption detection network)

Veðurstofa Íslands
Bústaðavegur 7–9 IS-108 Reykjavík
Sími/Tel: +354 522 6000 www.vedur.is

This project is funded by the International Civil Aviation Organization.
Figure 1 partly based on data from National Land Survey of Iceland (https://www.lmi.is/en/licence-for-national-land-survey-of-iceland-free-data/)

ICAO (2016). Volcanic ash contingency plan.
VASAG (2015). 6th meeting of VASAG – Final report.
WMO (2015). 7th international workshop on volcanic ash.
Watson, E. J., Swindles, G. T., Savov, I. P., Lawson, I. T., Connor, C. B., & Wilson, J. A. (2017). Estimating the frequency of volcanic ash clouds over northern Europe. Earth and Planetary Science Letters, 460, 41-49.
Arason. Þ, Barsotti, S. de' Michieli Vitturi, M., Jónsson, S. Gísladóttir, . (2018), The Vespa-system: Real-time estimation of eruption source parameters, Cities on Volcanoes - 10, Napólí, Ítalíu, 2.-7. september 2018.
Marzano, F. S., Lamantea, M., Montopoli, M., Herzog, M., Graf, H., & Cimini, D. (2013). Microwave remote sensing of the 2011 Plinian eruption of the Grímsvötn Icelandic volcano. Remote sensing of Environment, 129, 168-184.