Development of the atmospheric volcanic monitoring system in Iceland

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Introduction

The eruption in Eyjafjallajökull in 2010 demonstrated how volcanic eruptions can become international and how widespread the dispersion can be, even from a rather small explosive eruption. IMO is responsible for the monitoring of natural hazards in Iceland. Currently the atmospheric volcanic monitoring system is being expanded, in order to cover the whole active volcanic zone, as well as to monitor volcanic plumes, volcanic gasses and near-field suspension and re-suspension of ash.

Fixed-location weather radars

- A C-band radar is located close to Keflavík International Airport, Figure 2(a). Its main purpose is weather monitoring but since operations started in 1991 it has shown itself to be an effective volcanic plume monitoring device. Its maximum monitoring range is 480 km but normally is set to scan 240 km.
- A second C-band radar is currently being installed in East-Iceland.

⇒ From summer 2012: A complete coverage of Iceland's active volcanic zone by fixed point radars.

Near-plume LIDAR observations

A Lidar, owned by NCAS, was installed in South-Iceland in May 2011 as a part of a project between IMO and NCAS. The aim of the project is to test the potential use of LIDARs in the near-field during explosive eruptions by monitoring re-suspension of ash (Figure 3). During the Grímsvötn eruption in May 2011 the LIDAR was moved to Keflavík Airport for monitoring suspended ash over the airport.

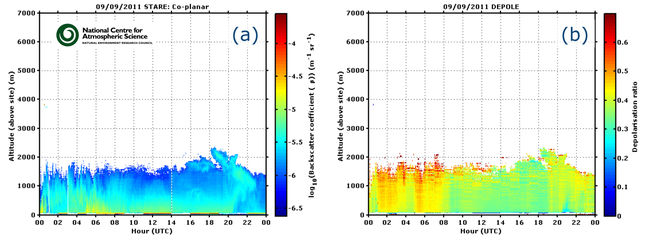

Figure 3. (a) The backscatter coefficient ($m^{-1}sr^{-1}$) and (b) the depolarisation ratio (right), as a function of the height above the LIDAR (m) and time on 9 September 2011, during an intense re-suspension episode in South-Iceland.

Volcanic gasses

Gas emissions provide important information about the volcano activity state. IMO has initiated work on including gas measurements in its monitoring systems and several spectrometers (visible, UV and IR), and other gas sensors have been acquired. Regular measurements are done at Grímsvötn and Krísuvík volcanoes, and Hekla will be continuously monitored from summer 2012.

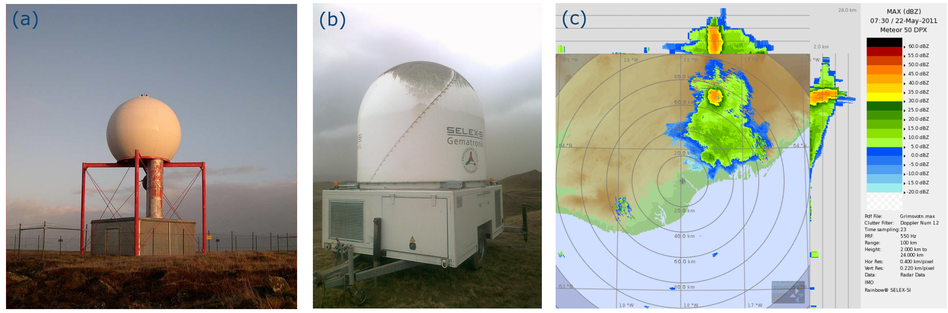

Figure 2. (a) The C-band radar near Keflavík airport, (b) the mobile radar operating in South-Iceland in May 2011 and (c) the maximum reflectivity (dBZ) measured by the mobile radar in the morning of 22 May. Photos: a) Jonas Haraldsson, b) Geirfinnur S. Sigurðsson.

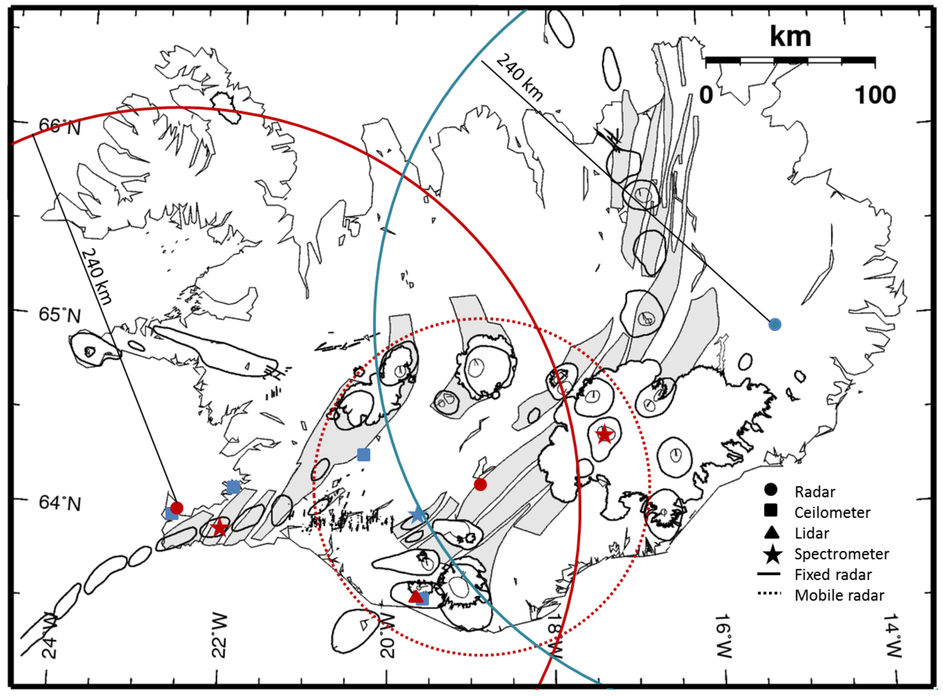

Figure 1. The current atmospheric volcanic monitoring system (red) and the planned development (blue).

Ceilometers

Ceilometers can give information about aerosols in the atmosphere, e.g. suspended and re-suspended ash. IMO is currently in the process of changing its system to record the full signal from the operational ceilometers, and providing real time visualization of the data.

State Volcano Observatory

IMO is a State Volcano Observatory in regards to ICAO.
IMO is thus responsible for
a) monitoring pre-eruption volcanic activity,
b) monitoring volcanic eruption including cessation thereof,
c) monitoring volcanic ash in the atmosphere,
d) informing associated VAAC and aviation authorities.

Mobile weather radars

- ICAO has agreed to finance two X-band, dual polarization, mobile radars, the first one arriving in May 2012.
- Until end of April a mobile radar is on loan from the Italian Civil Protection Agency, Figure 2(b).
- During the eruption of Grímsvötn in 2011 it was operating in South-Iceland, Figure 2(c).
- A mobile radar located at a favourable site can provide higher resolution data than a fixed-point radar.
- X-band radars operate on shorter wavelengths than C-band radars and can therefore detect smaller particles.

Monitoring of lightning activity

Lightning activity in volcanic plumes often gives indications on the intensity of the eruption. In Iceland, the ATDnet of the UK Met Office is used for lightning activity monitoring. During the Grímsvötn 2011 eruption the maximum 1-hour lightning rate was 2198 lightning strokes, Figure 4. In comparison, the maximum 1-hour lighting rate was 22 strokes during the Eyjafjallajökull eruption in 2010.

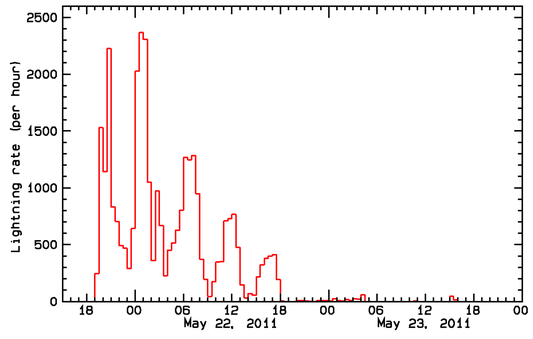

Figure 4. Lightning rate per hour during the first two days of the Grímsvötn 2011 eruption.

Other potential systems

The atmospheric state impacts the volcanic plume. Good information on the ambient atmosphere is therefore a vital part of a volcanic plume monitoring system. IMO has two upper-air stations, in southwest and east Iceland. A mobile radiosonde station that could launch sondes measuring the ambient atmospheric profile and even measure within the plume would be a valuable addition to the atmospheric volcanic monitoring system in Iceland.

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Abbreviations:
ATD network (Arrival Time Differences network), ICAO (International Civil Aviation Organization), IMO (Icelandic Meteorological Office), LIDAR (Light Detection And Ranging), NCAS (National Centre for Atmospheric Science, UK), VAAC (Volcanic Ash Advisory Centre)