Atlantic Conference on Eyjafjallajökull and Aviation
15-16 September 2010, Keflavik Airport, Iceland

Posters Presented at the Conference with and without Abstracts

Chairman of Poster Session:
Dr. Freysteinn Sigmundsson,
Nordic Volcanological Centre, Institute of Earth Sciences, University of Iceland.

The Keilir Aviation Academy Conference

This conference on **Eyjafjallajökull and Aviation** was organised by **the Keilir Aviation Academy**, Keflavik, Iceland (http://en.keilir.net/keilir/conferences/eyjafjallajokull) on September 15-16, 2010 in cooperation with the President of Iceland, The Icelandic Ministry of Transport, the Civil Aviation Administration, ISAVIA, the Meteorological Office, Institute of Earth Sciences, Icelandair, ICAO, IATA, ATA, AEA, IFALPA, EUROCONTROL CANSO and the Embassies of the US and Russia in Iceland.

The aim of the Conference was to address the impact of the volcanic eruption of Eyjafjallajökull in April –May 2010 on air transport as well as identifying what could be done to reduce such impact during future volcano eruptions in Iceland and world-wide. For this reason the conference was called to address the many facets of this multi-disciplinary subject that has been identified as the worst disruption by far of European and global air transport since the Second World War. Some 300 participants from all over the world attended the Conference. Participation from outside of Europe, in particular the United States and Russia, was emphasized in order to take advantage of the vast experience that has been gained in these countries in handling situations like the one that was faced by Europe in the spring of 2010.

A Poster Session was also organized at the Conference with some 20 different posters which are presented in this paper with abstracts.

Posters presented at the Conference on Eyjafjallajökull and Aviation
15-16 September 2010, Keflavik Airport, Iceland

Chairman of Poster Session: *Dr. Freysteinn Sigmundsson, Nordic Volcanological Centre, Institute of Earth Sciences, University of Iceland.*

A new motor that allow aircrafts to fly through volcanic ashes reducing pollutant emissions and fuel consumption.
Christian Hertzer, Chief Technical Officer, Aero Engineering, Spain

Geophysical Observations Supporting Research of Magmatic Processes at Icelandic Volcanoes
Kristín Vogfjörð, Sigurlaug Hjaltadóttir, Matthew J. Roberts

Eyjafjallajökull2010 - The activity of the eruption plume during the first 2 weeks
Árni Sigurðsson, Bolli Pálmason, Esther Hlíðar Jensen, Gudrun Nina Petersen, Halldór Björnsson, Hróbjartur, Þorsteinsson, and Þórður Arason

Eyjafjallajökull 2010: Monitoring the eruption site and changes in vent activity by over flights.
Björn Oddsson, Magnús Tumi Guðmundsson, Þórdís Högnadóttir, Eyjólfur Magnússon, Friðrik Höskuldsson

Aircraft based optical in-situ measurements of the distribution of the Eyjafjallajökull´s volcanic ash particles over north-western Germany with a light sport aircraft and an optical particle counter
WEBER, Konradin, POHL, Tobias, VOGEL, Andreas, FISCHER, Christian, VAN HAREN, Günther,

Thermal stability of Volcanic ash versus turbine ingestion test sands: an experimental investigation
Kueppers, U; Cimarelli, C; Hess, KU; Dingwell, DB; Rickerby, DS; Madden, P.

Short-term seismic precursors to Icelandic eruptions
Páll Einarsson

Infrasonic observations of recent eruptions at Eyjafjallajökull and Sarychev Peak: Robin Matoza (1), Julien Vergoz (1), Pierrick Mialle (2), Alexis Le Pichon (1) and Nicolas Brachet (1)

CTBTO Infrasound Event Analysis: Global detection of volcanic activity:
Pierrick Mialle, Nicolas Brachet, David Brown, Paulina Bittner, Andreas Becker, Monika Krysta, John Coyne, and Georgios Haralabus

International Science and Technology Center; Russia
Waclaw Gudowski and Konstantin Latynin

Near-field tephra dispersal monitoring by satellites
Ingibjorg Jonsdottir[1], Gudrun Larsen[1], Thor Thordarson[2], Armann Hoskuldsson[1], Fridrik Hoskuldsson[3], Ashley Gerard Davies[4]

The 20 March to 12 April basaltic Fimmvorduhals flank eruption at Eyjafjallajökull volcano, Iceland: Course of events
Armann Hoskuldsson[1], Thor Thordarson[2], Eyjolfur Magnusson[1], Magnus T. Guðmundsson[1], Freysteinn Sigmundsson[1], Olgeir Sigmarsson[1]

The 20 March – 12 April 2010 Fimmvorduhals eruption, Eyjafjöll volcano, Iceland: Volatile contents and magma degassing
Chris Hayward[1], Severine Moune[2], Margaret Hartley[1], Thor Thordarson[1], Olgeir Sigmarsson[2], Armann Hoskuldsson[3], Magnus Gudmundsson[3], Freysteinn Sigmundsson[3]

The 14 April – 22 May 2010 summit eruption at Eyjafjöll volcano, Iceland: Volatile contents and magma degassing
Thor Thordarson[1], Chris Hayward[1], Margaret Hartley[1], Olgeir Sigmarsson[2], Armann Hoskuldsson[2], Magnus Gudmundsson[2], Freysteinn Sigmundsson[2]

Why do models predict such large ash clouds?
An investigation using data from the Eyjafjallajőkull eruption, Iceland,
Larry G. Mastin, Hans Schwaiger, Roger Denlinger,

Eyjafjallajökull: lessons beyond the ash cloud
Domingo Gimeno[1] and Jose-Luis Fernandez-Turiel

TerraSAR-X satellite images of Eyjafjallajökull and Katla volcanoes
Ulrich Munzer and Ágúst Guðmundsson

E-Posters on Television Displays:

Ash distribution from Eyjafjallajökull eruption 2010

Ármann Höskuldsson, Gudrún Larsen, Magnús T. Gudmundsson, Þórdís Högnadóttir, Björn Oddsson, Eyjólfur Magnússon, Olgeir Sigmarsson, Níels Óskarsson, Freysteinn Sigmundsson, Páll Einarsson, Sigrún Hreinsdóttir, Rikke Pedersen, Ingibjörg Jónsdóttir, Thor Thordarson, Chris Hayward, Margaret Hartley, Rhian Meara.

Putting the Volcanic Ash Hazard in Perspective

Tom Fahey, Mgr. Meteorology and Radio, Delta Airlines

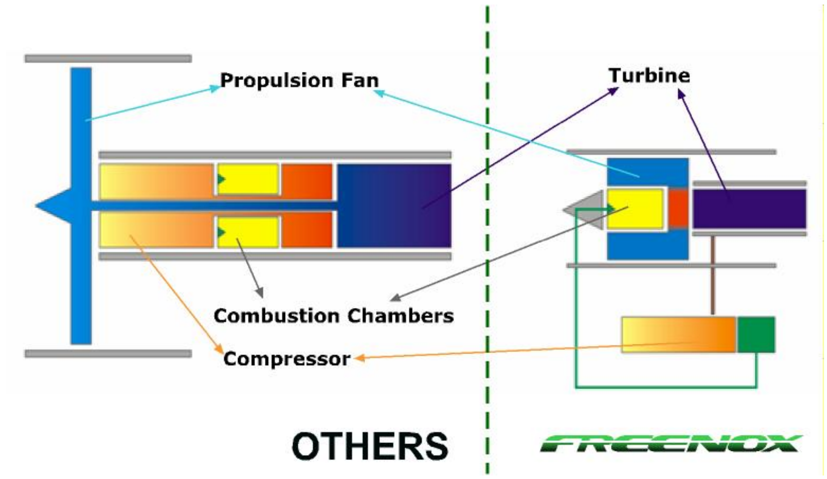
Listening to Ambrym volcano (Vanuatu), by a triangular acoustic network: a precursory to a Strombolian episode

S. Vergniolle, C. Zielinski, P. Bani, A. Le Pichon, M. Lardy, D. Ponceau, F. Gallois, P. Herry, S. Todman, E. Garaebiti

A new motor that allow aircrafts to fly through volcanic ashes reducing pollutant emissions and fuel consumption.

Christian Hertzer, Chief Technical Officer, Aero Engineering, Spain.

The Spanish firm has developed a new last generation of aero engine which gives important solution to current aeronautics problems including the ability of flying through volcano ashes.



This is possible thanks to new combustion chamber architecture which is completely close. Mixture of compressed air and fuel is done outside of the combustion chamber and sprayed afterwards directly inside. The Chief Technical Officer of Aero Engineering, Christian Hertzer, explains that in conventional motors air gets inside the engine producing that any foreign object can impact causing a serious damage and stopping the engine.

Christian Points out: "*This engine is completely immune to any foreign element. The worst scenario might cause some minority damages in the blades but it will never stop the motor while flying and it would not ever be necessary an emergency landing action giving enough time to the pilot to go around the ashes cloud avoiding major damage in the fuselage*".

FREENOX also has a minimum environmental impact as it can reduce fuel consumption up to 50%. The ERSystem ® (Endothermic Reaction System) which mixes O3 with fuel is one of the key modules that makes possible this great reduction.

This new motor also reduces acoustic emissions up to 50% besides a dramatically reduction of NOx up to 80% (Nitrous oxide which generates great number of pollutants when they are expelled to atmosphere).

Due to the new cone-shaped design of combustion chamber and a new temperature control system, the temperature inside the chamber is decreased reducing the NOx produced.

These improvements are in line with the environmental requirements that will come into effect by 2020.

After 10 years of development, Aero Engineering is currently manufacturing a funtional demonstrator of the core of this engine with the participation of several Spanish companies.

More information at www.aeengines.com

See also in the PDF of a PPT in the list of presentations.

Eyjafjallajökull 2010: Monitoring the eruption site and changes in vent activity by over flights.

Björn Oddsson[1], Magnús Tumi Guðmundsson[1], Eyjólfur Magnússon[1], Þórdís Högnadóttir[1] and Friðrik Höskuldsson[2].

1 Institute of Earth Sciences, University of Iceland (bjornod@hi.is)
2 Icelandic Coast Guard

The vent area of the eruption in Eyjafjallajökull was monitored by overflights as often as possible during the main activity and with less frequent flights in the first weeks after the eruption declined. Three types of aircrafts were used; TF-SIF(Dash 8 Q300 airplane) and TF-GNÁ (Aerospatiale Super Puma AS-332L1 helicopter) operated by the Icelandic coast guard and a small propeller driven Cessna 207 from Eagle Air, a private air service. The purpose for these overflights was to monitor any changes in volcanic activity and estimate possible hazards caused by the volcano (jökulhlaups, plume fallouts, possible pyroclastic flows, etc.). Changes in definitions of a no-fly zone during the eruption made flight monitoring more complicated as the eruption progressed; as it restricted the use of turbo-engined planes and helicopters.

TF-SIF is equipped with Synthetic Aperture Radar- radar (SAR), infrared/TV daylight camera and large windows for visual inspection and photography. It is most useful when visibility is low, since cloud and eruption plume are transparent to the SAR radar. The SAR images allow the monitoring of changes in the ice cauldrons, progress of a lava field and build up of crater cones within the Ice cauldrons. During the morning of April the 14 when the eruption started, this was the only way to locate the vents and monitor the evolution of ice cauldrons forming within the caldera. The aircraft cannot enter the no-fly zone, but the radar images are acquired at 18-20,000 feet along flight lines 15-20 km away from the target, making monitoring from outside the no-fly zone possible.

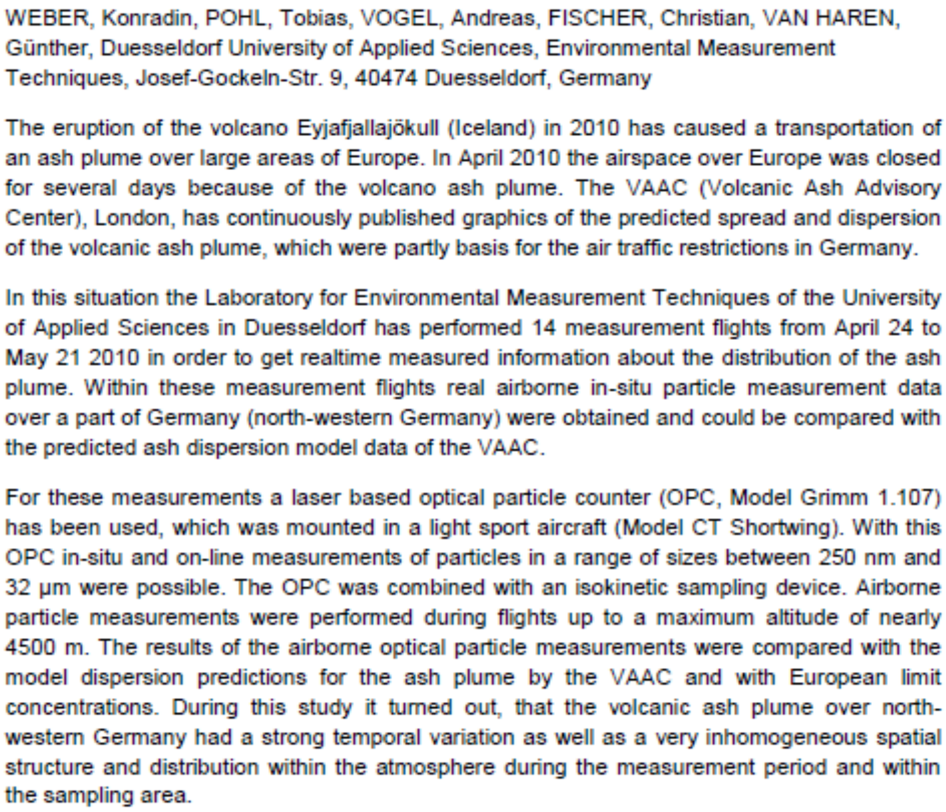
TF-GNÁ was used when visibility was good, and it was possible to fly close to the eruption site. It has an infrared camera on board (no absolute scale). Having the possibility of opening a large side door and hovering gave chances to focus on one target at a time, e.g. when using the hand--held infrared camera. The helicopter cannot enter the no-fly zone, but during the effusive phase in late April, it was possible to approach the eruption site and inspect the outlet glacier to learn more about the floodwater path and the progression of the lava. After the increase in explosive activity in early May, the helicopter was not used for monitoring due to the no-fly zone.

The Cessna 207 was the most used aircraft for monitoring the changes in the volcanic activity. It was allowed to enter the no-flight zone and it was possible to come quite close to the eruption site.

The data collected were videos, photographs, infrared images, radar images and observations by visual inspections.

Aircraft based optical in-situ measurements of the distribution of the Eyjafjallajökull´s volcanic ash particles over north-western Germany with a light sport aircraft and an optical particle counter

WEBER, Konradin, POHL, Tobias, VOGEL, Andreas, FISCHER, Christian, VAN HAREN, Günther,



WEBER, Konradin, POHL, Tobias, VOGEL, Andreas, FISCHER, Christian, VAN HAREN, Günther, Duesseldorf University of Applied Sciences, Environmental Measurement Techniques, Josef-Gockeln-Str. 9, 40474 Duesseldorf, Germany

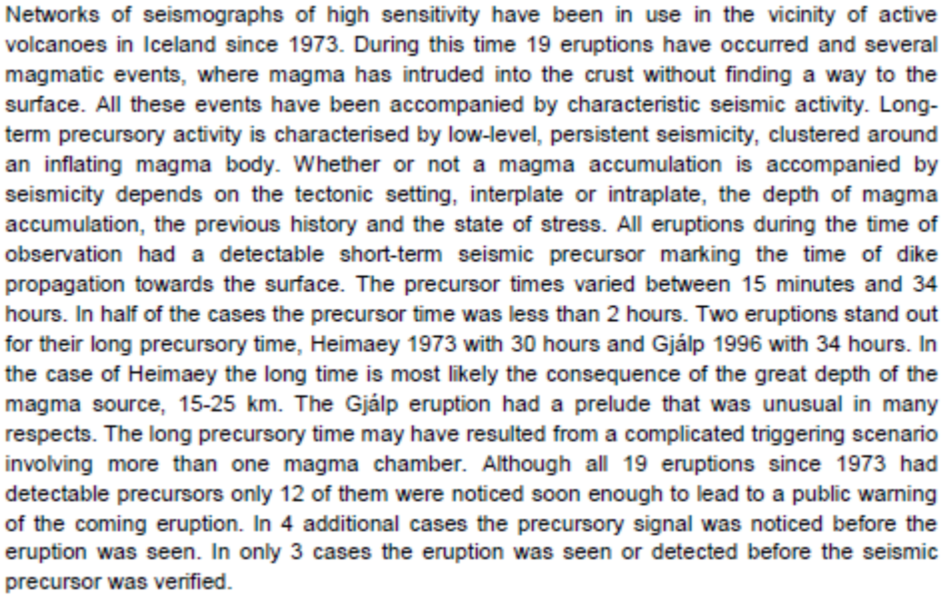
The eruption of the volcano Eyjafjallajökull (Iceland) in 2010 has caused a transportation of an ash plume over large areas of Europe. In April 2010 the airspace over Europe was closed for several days because of the volcano ash plume. The VAAC (Volcanic Ash Advisory Center), London, has continuously published graphics of the predicted spread and dispersion of the volcanic ash plume, which were partly basis for the air traffic restrictions in Germany.

In this situation the Laboratory for Environmental Measurement Techniques of the University of Applied Sciences in Duesseldorf has performed 14 measurement flights from April 24 to May 21 2010 in order to get realtime measured information about the distribution of the ash plume. Within these measurement flights real airborne in-situ particle measurement data over a part of Germany (north-western Germany) were obtained and could be compared with the predicted ash dispersion model data of the VAAC.

For these measurements a laser based optical particle counter (OPC, Model Grimm 1.107) has been used, which was mounted in a light sport aircraft (Model CT Shortwing). With this OPC in-situ and on-line measurements of particles in a range of sizes between 250 nm and 32 µm were possible. The OPC was combined with an isokinetic sampling device. Airborne particle measurements were performed during flights up to a maximum altitude of nearly 4500 m. The results of the airborne optical particle measurements were compared with the model dispersion predictions for the ash plume by the VAAC and with European limit concentrations. During this study it turned out, that the volcanic ash plume over north-western Germany had a strong temporal variation as well as a very inhomogeneous spatial structure and distribution within the atmosphere during the measurement period and within the sampling area.

Short-term seismic precursors to Icelandic eruptions

Páll Einarsson, University of Icealnd



Networks of seismographs of high sensitivity have been in use in the vicinity of active volcanoes in Iceland since 1973. During this time 19 eruptions have occurred and several magmatic events, where magma has intruded into the crust without finding a way to the surface. All these events have been accompanied by characteristic seismic activity. Long-term precursory activity is characterised by low-level, persistent seismicity, clustered around an inflating magma body. Whether or not a magma accumulation is accompanied by seismicity depends on the tectonic setting, interplate or intraplate, the depth of magma accumulation, the previous history and the state of stress. All eruptions during the time of observation had a detectable short-term seismic precursor marking the time of dike propagation towards the surface. The precursor times varied between 15 minutes and 34 hours. In half of the cases the precursor time was less than 2 hours. Two eruptions stand out for their long precursory time, Heimaey 1973 with 30 hours and Gjálp 1996 with 34 hours. In the case of Heimaey the long time is most likely the consequence of the great depth of the magma source, 15-25 km. The Gjálp eruption had a prelude that was unusual in many respects. The long precursory time may have resulted from a complicated triggering scenario involving more than one magma chamber. Although all 19 eruptions since 1973 had detectable precursors only 12 of them were noticed soon enough to lead to a public warning of the coming eruption. In 4 additional cases the precursory signal was noticed before the eruption was seen. In only 3 cases the eruption was seen or detected before the seismic precursor was verified.

Infrasonic observations of recent eruptions at Eyjafjallajökull and Sarychev Peak:

Robin Matoza (1), Julien Vergoz (1), Pierrick Mialle (2), Alexis Le Pichon (1) and Nicolas Brachet (1)

(1) CEA/DAM/DIF, F-91297 Arpajon Cedex, France
(2) CTBTO/PTS, International Data Centre, Vienna, Austria

Volcanic eruptions represent a significant source of low-frequency acoustic energy radiated directly into the atmosphere. During explosive volcanic eruptions, release of overpressure and rapid and sustained injection of mass into the atmosphere are the primary sources of infrasound waves (0.01-20 Hz). Infrasound can propagate over large distances in the atmosphere due to low attenuation. For volcanic activity in remote regions of the globe, infrasound observations may be the only ground-based method available to aid interpretation of satellite data and constrain ash dispersal models.

The International Monitoring System (IMS) infrasound network of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) permits detection of volcanic activity throughout the globe. Over the past 10 years, the International Data Centre (IDC) in Vienna, Austria, has collected a significant number of infrasound recordings related to volcanic activity worldwide. Among them are the April-May 2010 eruption of Eyjafjallajökull, Iceland and the larger June 2009 eruption of Sarychev Peak (SP), Kuril Islands. We present analyses of these two eruptions as case studies on long-range infrasound observations of volcanism producing significant ash clouds. The Eyjafjallajökull eruption was recorded at 14 infrasound arrays across Europe (national facilities and IMS stations) to a range of >3,500 km. Such long-range propagation is remarkable considering the relatively modest level of explosive activity. The timing of this signal generally corresponds to the reported times of the summit eruption. The SP eruption was recorded at six IMS infrasound arrays and several infrasound arrays in South Korea (KIGAM), ~640-6,400 km from the volcano. Signals at the three closest recording stations IS44 (Kamchatka, Russian Federation, 643 km), IS45 (Ussuriysk, Russian Federation, 1,690 km), and IS30 (Isumi, Japan, 1.774 km) represent a detailed, continuous record of the explosion chronology that has higher temporal resolution than an eruption chronology based on satellite data. Source locations determined by cross-bearings of backazimuths measured at the infrasound arrays have a mean centroid 15 km from the true location of SP. The Kuril Islands region has particularly sparse seismic network coverage. This study therefore highlights the significant potential of the IMS infrasound network for aiding monitoring efforts in remote volcanic regions of the planet.

CTBTO Infrasound Event Analysis: Global detection of volcanic activity.

Pierrick Mialle, Nicolas Brachet, David Brown, Paulina Bittner, Andreas Becker, Monika Krysta, John Coyne, and Georgios Haralabus

CTBTO/PTS, International Data Centre, Vienna, Austria

The Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is tasked with monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT) which bans nuclear weapon explosions underground, in the oceans, and in the atmosphere. The verification regime includes a globally distributed network of seismic, hydroacoustic, infrasound and radionuclide stations which collect and transmit data to the International Data Centre (IDC) in Vienna, Austria shortly after the data are recorded at each station. The infrasound network of the International Monitoring System (IMS) comprises 60 infrasound array stations, of which 42 already are already certified. This constitutes the first global infrasound network ever built with such a large and uniform distribution of stations.

Each infrasound array is processed separately for signal detection using a progressive multi-channel correlation method (DFX-PMCC). For each detection, signal features – onset time, amplitude, frequency, duration, azimuth, phase velocity, F-statistics – are measured and used to identify a detection as infrasonic, seismic, or noise. Infrasonic signals along with seismic and hydroacoustic signals are subsequently associated from contributing stations to locate events. The IDC produces a daily Reviewed Event Bulletin (REB) which includes observations from all waveform technologies.

Significant infrasound events have been collected into IDC infrasound reference events database (IRED) during the last ten years originating from natural (e.g. 68 volcanic eruptions) or man-made (e.g. 132 atmospheric or surface explosions) sources. This database reflects the global detection capability of the network, illustrates the spatial and temporal variability of the observed phenomena, and illustrates the diversity of infragenic sources. Active volcanoes, such as Eyjafjallajökull, are sources of interest allowing the IDC to test its capabilities by providing ground truth for both infrasound technology and atmospheric dispersion modeling.

Over the past 3 years, the CTBTO has collaborated with various institutes on volcanic activity projects. These include Chile, regarding the Villarica and Llaima volcanoes, Japan, on the Sakura-Jima volcano, and Volcanic Ashe Advisory Centers (VAAC) from Toulouse and Darwin on various suspected volcanic activities. Results from these projects are presented.

Near-field tephra dispersal monitoring by satellites

Ingibjorg Jonsdottir[1], Gudrun Larsen[1], Thor Thordarson[2], Armann Hoskuldsson[1], Fridrik Hoskuldsson[3], Ashley Gerard Davies[4]

1 Institute of Earth Sciences, University of Iceland, Reykjavik, Iceland
2 School of Geosciences, University of Edinburgh, Edinburgh, UK
3 Icelandic Coast Guard, Reykjavik, Iceland
4 Jet Propulsion Laboratory-California Institute of Technology, Pasadena, CA, United States

Various satellite images were used to monitor the eruption plume from Eyjafjallajökull central volcano in real time from April 14 and throughout the eruption, which stopped, at least temporarily, on May 22. The main object was to study the dispersion of the ash; it's extent and direction, for scientific purposes as well as for public safety. The work included a detailed examination of the characteristics of the plume; it's content, height and density. Some effort was made to distinguish the plume from dust storms of remobilized ash that prevailed during part of the period.

MODIS and MERIS images, with a number of channels and geometric resolution in the optical channel of 250m and 1km in thermal bands, along with NOAA images with 1km resolution, provided over 15 observations from space daily, although not with equal intervals. ASTER, EO-1 and ENVISAT ASAR images were used when available for comparison and additional information.

A number of analyses were performed on the data, to enhance the images, classify the plume into different severity categories and to estimate the amount of ash in the atmosphere. Other methods included calculations of plume height and data merging in Geographical Information Systems.

Other independent sources of information were used for comparison of the satellite data, such as observations of the eruptions plume from the Icelandic Coast Guard reconnaissance flights, surveying from the ground, web cameras and measurements of the ash distribution, qualities and thickness on the ground.

The results are daily maps of the eruption plume, indicating the extent and severity of the plume at all orbit times. Satellite images, though not a continuous observation method, did record significant changes in the eruption behavior.

In conjunction with in situ investigations, the remote-sensing dataset from the Spring 2010 eruption is a valuable resource which is being used to refine image interpretation techniques and to improve the use of future satellite data of volcanic activity to assess volcanic risk and hazard.

The 20 March to 12 April basaltic Fimmvorduhals flank eruption at Eyjafjallajökull volcano, Iceland: Course of events

Armann Hoskuldsson[1], Thor Thordarson[2], Eyjolfur Magnusson[1], Magnus T. Guðmundsson[1], Freysteinn Sigmundsson[1], Olgeir Sigmarsson[1]

1 Institute of Earth Sciences, University of Iceland, Reykjavik, Iceland
2 School of Geosciences, University of Edinburgh, Edinburgh, UK

At 11:30 PM on March 20, reports were received of an eruption in the region of the Fimmvorduhals pass between the glaciers of Eyjafjallajokull and Myrdalsjokull. A surveillance flight at daybreak on 21 March showed that a basaltic eruption was underway on a radial fissure on the east flank of the Eyjafjallajökull volcano, featuring a 300 m-long curtain of lava fountains feeding small lava streams. The onset of the eruption was unusually calm. Seismicity did not intensify immediately prior to the eruption despite the fact that in the week leading to the eruption, an earthquake swarm migrated towards the surface from depth of >14 km indicating rise of magma from depth. Only very weak seismic tremor was detected around 10:30 PM on the 20th, gently increasing through the night.

At the beginning the eruption featured as many as 15 lava fountains with maximum height of 150 m. On March 24 only four vents where active with fountains reaching to heights of 100 m. On March 31 and April 1 the activity was characterized by relatively weak fountaining through a forcefully stirring pool of lava. The vents were surrounded by 60-80 m high ramparts and the level of lava stood at approximately 40 m. This high stand led to opening of a new fissure trending northwest from the central segment of the original fissure. As activity on the new fissure intensified, the discharge from the original fissure declined and stopped on April 7.

The intensity of the lava fountains varied significantly on the time scale of hours and was strongly influenced the level of the lava pond in the vents, producing narrow, gas-charged, piston-like fountains during periods of low lava levels, but spray-like fountains when the lava level was high and dampened the rate of atmospheric venting of volatiles.

The eruption produced a fountain-fed lava flow field with an area of about 1.3 km^2. Initially (20-25 March), the lava advanced towards northeast, but on March 26 the lava began advancing to the west and northwest, especially after April 1 when the activity became concentrated on the new fissure. The flow field morphology is dominantly a'a, but domains of pahoehoe and slabby pahoehoe are present, particularly in the western sector of the flow field. The advance of the lava from the vents was episodic; when the lava stood high the lava surged out of the vents, but at low stand there was a lull in the advance. The lava discharged from the vents through open channels as well as internal pathways. The open channels were the most visible part of the transport system, feeding lava to active a'a flow fronts and producing spectacular lava falls when cascading into deep gullies just north of the vents. The role of internal pathways was much less noticeable, yet an important contribution to the overall growth of the flow field as it fed significant surface breakouts emerging on the surface of what otherwise looked like stagnant lava. When activity stopped on April 12 the fissure had issued about 0.025 km^3 of magma, giving a mean discharge of 13 m^3/s.

The 20 March – 12 April 2010 Fimmvorduhals eruption, Eyjafjöll volcano, Iceland: Volatile contents and magma degassing

Chris Hayward[1], Severine Moune[2], Margaret Hartley[1], Thor Thordarson[1], Olgeir Sigmarsson[2], Armann Hoskuldsson[3], Magnus Gudmundsson[3], Freysteinn Sigmundsson[3].

1 School of Geosciences, University of Edinburgh, Edinburgh, UK
2 LMV, CNRS, Clermont Ferrand, France
3 IES, University of Iceland, Reykjavik, Iceland

The 2010 March to April mildly alkalic basaltic fissure eruption on the east flank (Fimmvorduhals) of the Eyjafjoll volcano, Iceland, was a precursor to the main summit eruption that followed on April 14. It most likely represents the mafic magma that triggered the summit eruption by intrusion into and mixing with a silicic magma body residing at shallow levels within the volcano. The Fimmvorduhals eruption took place on a 300 m-long radial fissure, featuring up to 150 m-high lava fountains that produced an a'a lava flow field with a mean thickness of 20m, area of 1.3 km^2 and a volume of 0.025 km^3. The average magma discharge for the eruption is 13 m3/s.

Here we present results on major element composition and initial and residual volatile (S, Cl, F, H_2O, CO_2) concentrations in the Fimmvorduhals magma as determined by analysis of 87 melt inclusions (MI) and 177 analysis of glass groundmass obtained from a suite of 9 samples representing the first 14 days of the eruption. The groundmass glass (TiO_2 = 4.91±0.2 wt%; FeO = 14.52±0.46 wt%) and the MIs (TiO_2 = 4.91±0.2 wt%; FeO =13.12±1.77 wt%) have very similar FeTi basalt composition, although the MIs (MgO = 5.39±0.90 wt%) are slightly less evolved than the groundmass glass (MgO = 4.7±0.20 wt%). The data defines distinct trends on bivariate plots consistent with evolution by fractional crystallization. Volatile measurements in the MIs gave the following results: 0.148±0.041 (range 0.016–0.254) wt% S, 0.071±0.031 (range 0.022–0.240) wt% Cl and 0.095±0.042 (range 0.032–0.299) wt% F, 0.54±0.25 (range 0.20–0.88) wt% H_2O, 0.19±0.09 (range 0.04–0.32) wt% CO_2. MIs with the highest volatile concentrations are situated in the core of the pheneocrysts, those with lower and more variable volatile contents are typically located near their edges. We interpret this to indicate progressive entrapment of MIs into phenocrysts, first in the magma holding chamber and then during magma ascents, where additional growth is facilitated by the low magma discharge. Thus, only MIs from the core contain information on the initial volatile concentration of the magma at depth, the remainder records magma parcels degassed to variably degree during ascent and prior to entrapment. Consequently, the pre-eruption concentrations of dissolved volatiles in the Fimmvorduhals magma at depth are indicated by the highest values, giving the following estimate for the initial volatile values: 0.224±0.021 wt% S, 0.074±0.018 wt% Cl and 0.112±0.041 wt% F, 0.87±0.01 wt% H_2O, 0.294±0.02 wt% CO_2. This gives a total pre-eruption volatile content of 1.5±0.15 wt% for the Fimmvorduhals magma. The corresponding groundmass (residual) values are 0.047±0.012 wt% S, 0.068±0.008 wt% Cl and 0.118±0.018 wt% F, 0.07±0.02 wt% H_2O, 0.012±0.05 wt% CO_2. These data indicate that about 80% of the volatiles escaped into the atmosphere upon venting. The total mass of sulphur released into the atmosphere by the Fimmvorduhals eruption is therefore about 3 megatons.

The 14 April – 22 May 2010 summit eruption at Eyjafjöll volcano, Iceland: Volatile contents and magma degassing

Thor Thordarson[1], Chris Hayward[1], Margaret Hartley[1], Olgeir Sigmarsson[2], Armann Hoskuldsson[2], Magnus Gudmundsson[2], Freysteinn Sigmundsson[2]

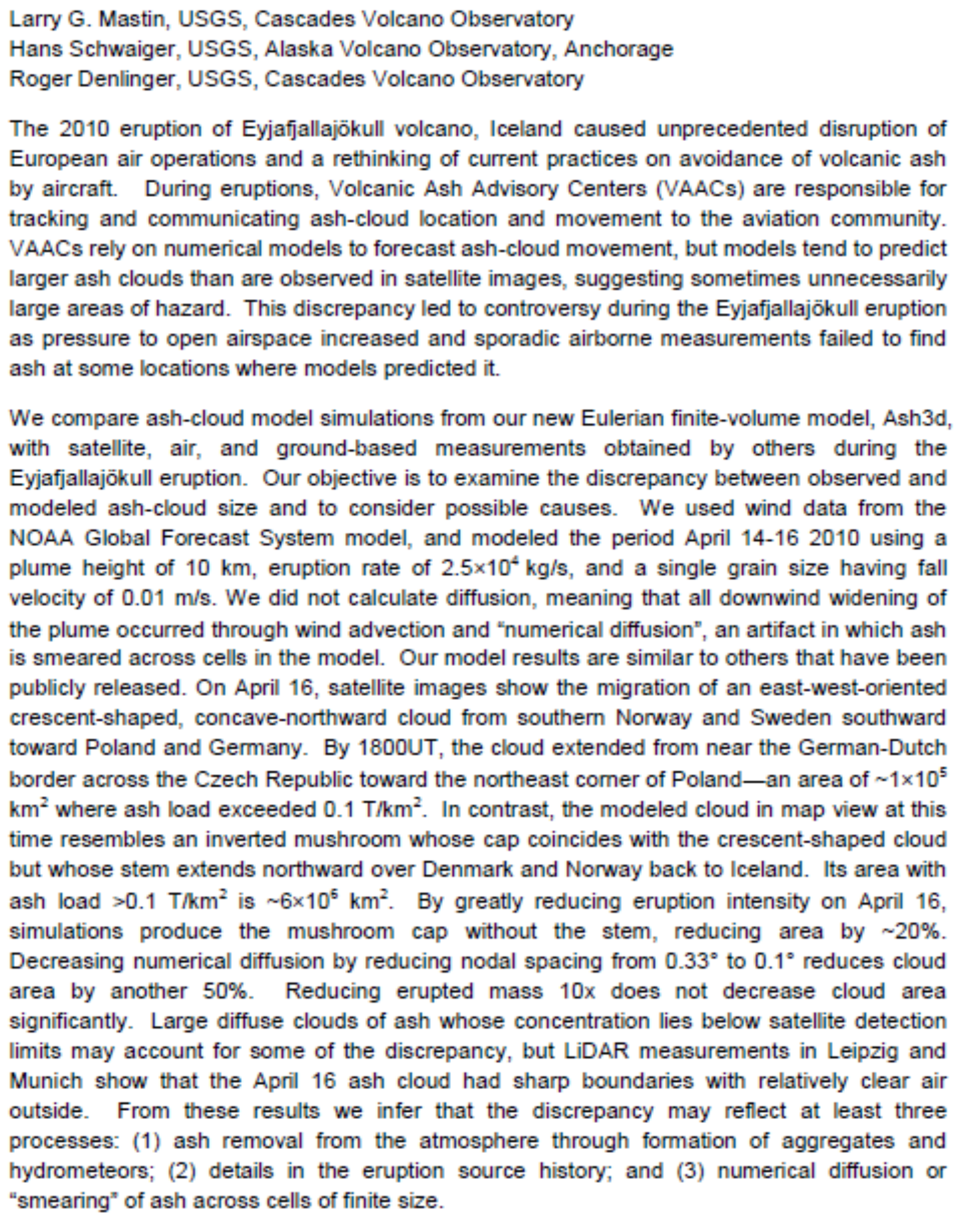
1 School of Geosciences, University of Edinburgh, Edinburgh, UK
2 Institute of Earth sciences, University of Iceland, Reykjavik, Iceland

The unexpected disruption to aviation over Europe during the 14 April-22 May 2010 explosive eruption at the Eyjafjöll volcano, Iceland, was primarily caused by the large proportions of fine ash generated by the event and consistent westerly airflow over |Iceland during the 39 days of activity. The 2010 summit eruption produced about 0.1 km^2 (DRE) of trachyandesite tephra containing between 10-20% of extremely fine ash (≤10 micrometers). Three main phases are identified in the eruption: a) an initial intraglacial phase lasting from 14-19 April, featuring semi-continuous phreatomagmatic and magmatic Vulcanian-type explosions; b) about 14 day-long (19 April-3 May) phase of weak magmatic explosions and lava emission; and c) a renewed moderately intense, intermittent Vulcanian-type explosions lasting another 21 days. In order to fully understand fragmentation processes that produce large amounts of fine ash, it is important to assess role of magmatic volatiles and degassing mechanism.

Here we present results on major element composition as well as initial and residual volatile (S, Cl, F, H_2O, CO_2) concentrations in the Eyjafjoll summit eruption as determined by analysis of 14 melt inclusions (MI), hosted by plagioclase, olivine and pyroxene pheneocrysts, and 78 analysis of glass groundmass obtained from a suite of 7 samples representing the initial phase (first 7 days) of eruption. The composition of the groundmass glass of the tephra (SiO_2 = 61.13±1.08 wt%) and the MIs (SiO_2 = 58.59±2.52 wt%) is trachyandesite. Volatile concentrations in the MIs are 0.063±0.024 wt% S, 0.269±0.026 wt% Cl and 0.168±0.0418 wt% F, 1.7 wt% H_2O and the CO_2 content ranges from 0.11 – 0.13 wt%. The corresponding groundmass (residual) values for the trachyandesite grondmass glasses are 0.031±0.006 wt% S, 0.277±0.019 wt% Cl and 0.171±0.019 wt% F, 0.58±0.17 wt% H_2O and 0.014±0.014 wt% CO_2. This data indicates that 50-60% of the sulfur and H_2O and about 90% of the CO_2 was realest upon venting. Cl and F do not appear to have been released in any significant amounts. This data indicates that the total mass of sulphur released into the atmosphere by the initial phase of the Eyjafjoll summit eruption was ≤0.1 megaton.

Why do models predict such large ash clouds?
An investigation using data from the Eyjafjallajőkull eruption, Iceland,

Larry G. Mastin, Hans Schwaiger, Roger Denlinger,



Larry G. Mastin, USGS, Cascades Volcano Observatory
Hans Schwaiger, USGS, Alaska Volcano Observatory, Anchorage
Roger Denlinger, USGS, Cascades Volcano Observatory

The 2010 eruption of Eyjafjallajökull volcano, Iceland caused unprecedented disruption of European air operations and a rethinking of current practices on avoidance of volcanic ash by aircraft. During eruptions, Volcanic Ash Advisory Centers (VAACs) are responsible for tracking and communicating ash-cloud location and movement to the aviation community. VAACs rely on numerical models to forecast ash-cloud movement, but models tend to predict larger ash clouds than are observed in satellite images, suggesting sometimes unnecessarily large areas of hazard. This discrepancy led to controversy during the Eyjafjallajökull eruption as pressure to open airspace increased and sporadic airborne measurements failed to find ash at some locations where models predicted it.

We compare ash-cloud model simulations from our new Eulerian finite-volume model, Ash3d, with satellite, air, and ground-based measurements obtained by others during the Eyjafjallajökull eruption. Our objective is to examine the discrepancy between observed and modeled ash-cloud size and to consider possible causes. We used wind data from the NOAA Global Forecast System model, and modeled the period April 14-16 2010 using a plume height of 10 km, eruption rate of 2.5×10^4 kg/s, and a single grain size having fall velocity of 0.01 m/s. We did not calculate diffusion, meaning that all downwind widening of the plume occurred through wind advection and "numerical diffusion", an artifact in which ash is smeared across cells in the model. Our model results are similar to others that have been publicly released. On April 16, satellite images show the migration of an east-west-oriented crescent-shaped, concave-northward cloud from southern Norway and Sweden southward toward Poland and Germany. By 1800UT, the cloud extended from near the German-Dutch border across the Czech Republic toward the northeast corner of Poland—an area of $\sim1\times10^5$ km^2 where ash load exceeded 0.1 T/km^2. In contrast, the modeled cloud in map view at this time resembles an inverted mushroom whose cap coincides with the crescent-shaped cloud but whose stem extends northward over Denmark and Norway back to Iceland. Its area with ash load >0.1 T/km^2 is $\sim6\times10^5$ km^2. By greatly reducing eruption intensity on April 16, simulations produce the mushroom cap without the stem, reducing area by ~20%. Decreasing numerical diffusion by reducing nodal spacing from 0.33° to 0.1° reduces cloud area by another 50%. Reducing erupted mass 10x does not decrease cloud area significantly. Large diffuse clouds of ash whose concentration lies below satellite detection limits may account for some of the discrepancy, but LiDAR measurements in Leipzig and Munich show that the April 16 ash cloud had sharp boundaries with relatively clear air outside. From these results we infer that the discrepancy may reflect at least three processes: (1) ash removal from the atmosphere through formation of aggregates and hydrometeors; (2) details in the eruption source history; and (3) numerical diffusion or "smearing" of ash across cells of finite size.

Why do models predict such large ash clouds? An investigation using data from the Eyjafjallajökull eruption, Iceland

by Larry G. Mastin[1], Roger P. Denlinger[1], and Hans Schwaiger[2]

[1]U.S. Geological Survey, Cascades Volcano Observatory, 1300 SE Cardinal Court, Vancouver WA 98683 lgmastin@usgs.gov
[2]U.S. Geological Survey, Alaska Volcano Observatory, 4210 University Drive, Anchorage, AK 99508-4626

Introduction

The 2010 eruption of Eyjafjallajökull volcano, Iceland caused unprecedented disruption of European air operations and a rethinking of current practices on avoidance of volcanic ash by aircraft. During eruptions, Volcanic Ash Advisory Centers (VAACs) are responsible for tracking and communicating ash-cloud location and movement to the aviation community. VAACs rely on numerical models to forecast ash-cloud movement, but models tend to predict larger ash clouds than are observed in satellite images. This discrepancy led to controversy during the Eyjafjallajökull eruption as pressure to open airspace increased and sporadic airborne measurements failed to find ash at some locations where models predicted it.

The Study

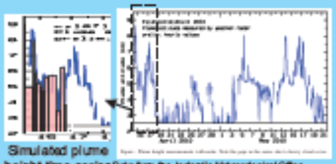
We compare ash-cloud model simulations from our new Eulerian finite-volume model, Ash3d, with satellite, air, and ground-based measurements obtained by others during the Eyjafjallajökull eruption. Our objective is to examine the discrepancy between observed and modeled ash-cloud size and to consider possible causes. We used wind data from the NOAA high-resolution (0.5 degree) Global Forecast System model, modeled the period April 14-16 2010.

For illustration, we ran two simulations with plume height set as follows:

1) Constant plume height at 8 km throughout the simulation. (a reasonable estimate for the first hours of the eruption, given sparse information).

2) Plume height that varied with time following radar measurements made by the Iceland Meteorological Office (see figure)

The mass eruption rate was adjusted with plume height to match empirical relations given in the figure



Simulated plume height time series

Data from the Icelandic Meteorological Office, International Volcanic Ash Task Force Report 14 03

Model input parameters

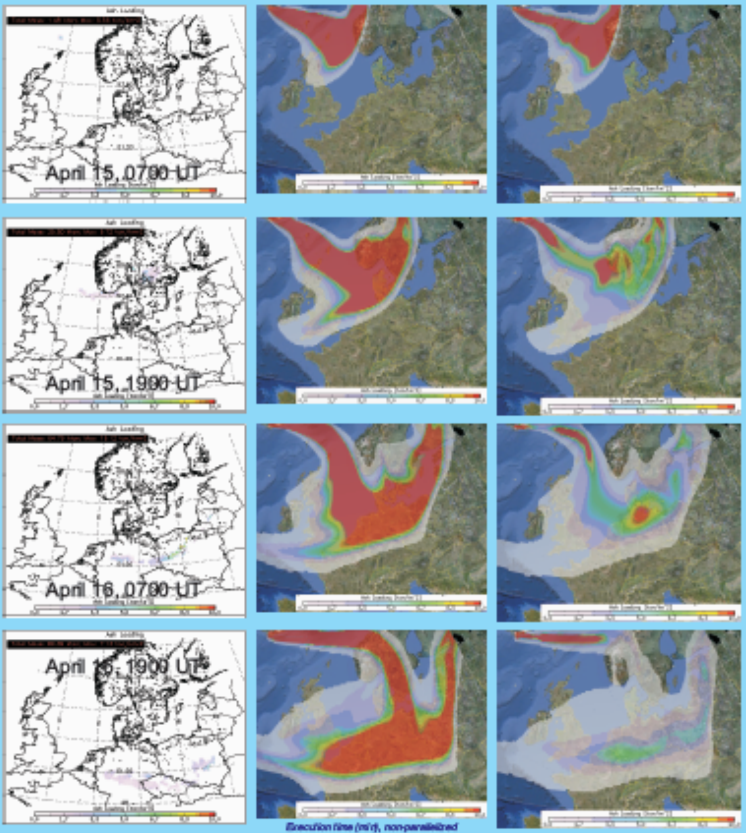
Parameter	Run 1	Run 2
Plume height	Constant, 8 km asl	Variable, following Radar measurements
Mass eruption rate	empirical best fit: 1×10^{6} kg/s	empirical best fit*
Grain size distribution	[illegible]	same as run 1
Duration	72 hours (100% of model run)	72 hours

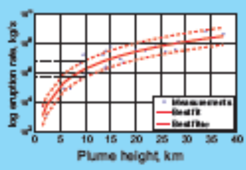
*see plot to right

Preliminary Satellite cloud load, tonnes/km²
Courtesy of Mike Pavolonis, NOAA

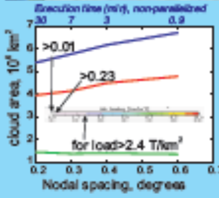
Model run using constant 8 km plume height

Model run using variable plume height





Mass eruption rate was estimated through an empirical relationship with plume height (Mastin et al., *JVGR 186*:10-21, 2009).

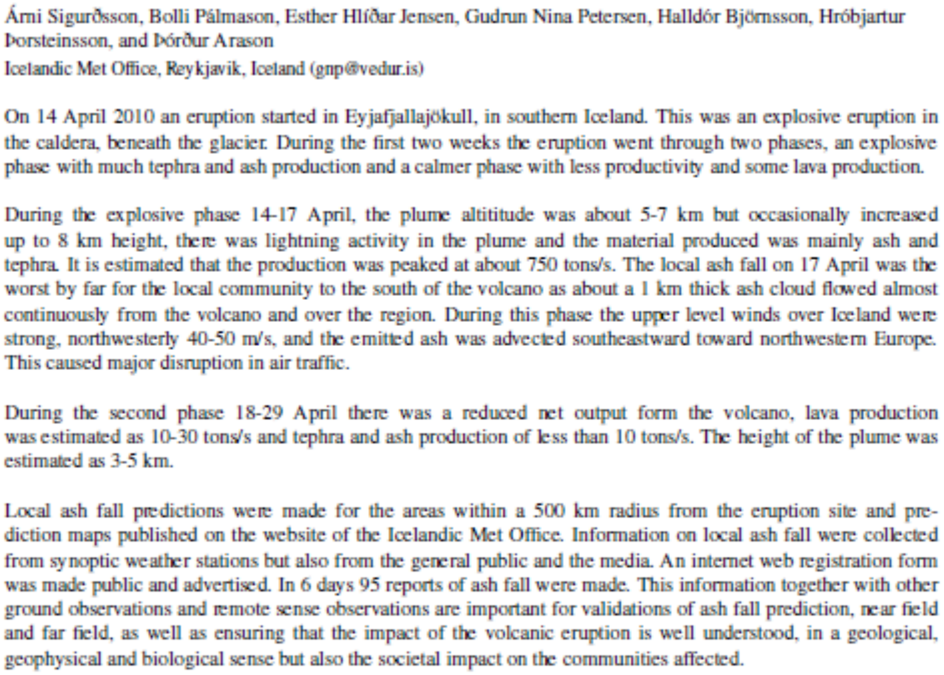


For Eulerian models like Ash3d, cloud area is also affected by model resolution, but primarily for the most dilute cells.

Inferences

- The size and concentration of modeled ash clouds depend significantly on details of the plume height and eruption rate history.
- For Eulerian models, numerical diffusion may also increase cloud size, though for ash-cloud concentrations great enough to be hazardous this is probably not a strong effect.

Eyjafjallajökull2010 - The activity of the eruption plume during the first 2 weeks



Árni Sigurðsson, Bolli Pálmason, Esther Hlíðar Jensen, Gudrun Nina Petersen, Halldór Björnsson, Hróbjartur Þorsteinsson, and Þórður Arason
Icelandic Met Office, Reykjavik, Iceland (gnp@vedur.is)

On 14 April 2010 an eruption started in Eyjafjallajökull, in southern Iceland. This was an explosive eruption in the caldera, beneath the glacier. During the first two weeks the eruption went through two phases, an explosive phase with much tephra and ash production and a calmer phase with less productivity and some lava production.

During the explosive phase 14-17 April, the plume altititude was about 5-7 km but occasionally increased up to 8 km height, there was lightning activity in the plume and the material produced was mainly ash and tephra. It is estimated that the production was peaked at about 750 tons/s. The local ash fall on 17 April was the worst by far for the local community to the south of the volcano as about a 1 km thick ash cloud flowed almost continuously from the volcano and over the region. During this phase the upper level winds over Iceland were strong, northwesterly 40-50 m/s, and the emitted ash was advected southeastward toward northwestern Europe. This caused major disruption in air traffic.

During the second phase 18-29 April there was a reduced net output form the volcano, lava production was estimated as 10-30 tons/s and tephra and ash production of less than 10 tons/s. The height of the plume was estimated as 3-5 km.

Local ash fall predictions were made for the areas within a 500 km radius from the eruption site and prediction maps published on the website of the Icelandic Met Office. Information on local ash fall were collected from synoptic weather stations but also from the general public and the media. An internet web registration form was made public and advertised. In 6 days 95 reports of ash fall were made. This information together with other ground observations and remote sense observations are important for validations of ash fall prediction, near field and far field, as well as ensuring that the impact of the volcanic eruption is well understood, in a geological, geophysical and biological sense but also the societal impact on the communities affected.

POSTER PRESENTATIONS WITHOUT ABSTRACTS

Geophysical Observations Supporting Research of Magmatic Processes at Icelandic Volcanoes

Kristín Vogfjörð, Sigurlaug Hjaltadóttir, Matthew J. Roberts

Thermal stability of Volcanic ash versus turbine ingestion test sands: an experimental investigation

Kueppers, U; Cimarelli, C; Hess, KU; Dingwell, DB; Rickerby, DS; Madden, P.

International Science and Technology Center; Russia

Waclaw Gudowski and Konstantin Latynin

Eyjafjallajökull: lessons beyond the ash cloud

Domingo Gimeno[1] and Jose-Luis Fernandez-Turiel

TerraSAR-X satellite images of Eyjafjallajökull and Katla volcanoes

Ulrich Munzer and Ágúst Guðmundsson

E-Posters on Television Displays:

Ash distribution from Eyjafjallajökull eruption 2010

Ármann Höskuldsson, Gudrún Larsen, Magnús T. Gudmundsson, Þórdís Högnadóttir, Björn Oddsson, Eyjólfur Magnússon, Olgeir Sigmarsson, Níels Óskarsson, Freysteinn Sigmundsson, Páll Einarsson, Sigrún Hreinsdóttir, Rikke Pedersen, Ingibjörg Jónsdóttir, Thor Thordarson, Chris Hayward, Margaret Hartley, Rhian Meara,

Putting the Volcanic Ash Hazard in Perspective

Tom Fahey, Mgr. Meteorology and Radio, Delta Airlines

- Separate on in Conference Session No. 4

Listening to Ambrym volcano (Vanuatu), by a triangular acoustic network: a precursory to a Strombolian episode

S. Vergniolle, C. Zielinski, P. Bani, A. Le Pichon, M. Lardy, D. Ponceau, F. Gallois, P. Herry, S. Todman, E. Garaebiti