Icelandic Met Office

ANNUAL REPORT 2014

INDEX

Icelandic Met
Office

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Cover photo: Gro Birkefeldt Møller Pedersen

One of the main goals of the merger of the Hydrological Service, HS, and the Icelandic Meteorological Office, IMO, was to improve the capabilities regarding monitoring, warnings and emergency response due to natural hazards. Prior to the merger, IMO already had geo hazards under its mandate. The central strategy of the merger was integration, integration for the benefits of end-users and society as a whole. The strategy was applied to various tasks within the new institution: In IT services, operation of measurement networks, hydrological-, meteorological-, climate- and earth research. The strategy was also used in all monitoring and 24/7 surveillance of natural hazards including forecasting and warnings. The events of the past year demonstrate the success of the strategy. IMO now provides more comprehensive services at lower cost; and regarding trust and goodwill of the Icelandic public, IMO rates at the top.

The events in Bárðarbunga and Holuhraun have clearly demonstrated the value of an integrated approach to natural hazards. There was a potential for hazards due to volcanic ash, due to melting of ice with consequential jökulhlaups and impacts on infrastructure and population. Less worry was concerning lava flow, but the emission of volcanic gasses was far in excess of expectation and caused the greatest impacts on the public. Integration and co-operation in the monitoring and surveillance of earth, water and air showed its strength and was in particular very helpful in the provision of gas-distribution forecasts for the public. All divisions of IMO contributed to the effort which was carried out in close co-operation with the University of Iceland and the Civil Protection in Iceland, with great backing from our ministry and the government.

It is not enough to strengthen monitoring and surveillance of natural hazards. It is also essential to carry out systematic assessment of the risks to society. Such a risk assessment does not only govern the response of the Civil Protection in Iceland, but also governs land use and mitigation strategies and measures. Furthermore, it dictates the level of monitoring and surveillance as well as the level of measures. Last year IMO was commissioned to continue with its risk assessment of volcanic activity, but also to start risk assessments due to storm surges. IMO has now for almost 30 years carried out systematic risk assessment on avalanches, in particular snow avalanches, so there is expertise for carrying out such an integrated approach to the risk assessments of natural hazards.

International co-operation is fundamental for successful delivery of our services. Iceland is a founding member of WMO and also full member of the European Meteorological Infrastructure. There is also a long standing formal co-operation between the Nordic Met Services that is continuously increasing. The focus is now very much on services for aviation, numerical weather prediction and high power computing. As a part of this development, IMO and the Danish Meteorological Institute, DMI, have signed a co-operation agreement on research and the operation of the next supercomputer of DMI in IMO´s premises. The partners are going to work together on climate studies, Arctic studies, development and operation of the Harmonie model and other topics of mutual interest. The benefit to IMO is substantial since DMI is a very strong Met Institute with a strong research- and operational culture from which we have benefitted for a number of years. A joint forecasting area over Iceland and large part of Greenland will be one of the products of the co-operation and will improve our forecasting and warning services. The computer will be installed in our facilities which are up to the best standards for quality and security. This co-operation has been based on the interest and strong support of both the Danish and the Icelandic governments and for this we are grateful. In this partnership we are not only taking progressive steps for the two institutes, but also for the Nordic Met community and maybe also internationally, because such a partnership is quite unique and will provide experiences that will be of value for others.

The strategy of integration demands the co-operation of staff as well as efficient communication and trust. Two of the values of IMO are therefore co-operation and reliability.

This does not only apply to the internal communication but also to our partners outside of the institute, both at the national level as well as internationally. All this developed progressively during several large scale events in Iceland, starting with the eruption of Eyjafjallajökull in 2010. Consequently the trust that society and the public have in our capabilities and activities has increased. I would like thank all the staff of IMO, who worked together with endurance and integrity to lay the foundation for such trust.

Árni Snorrason
Director General

Bárðarbunga

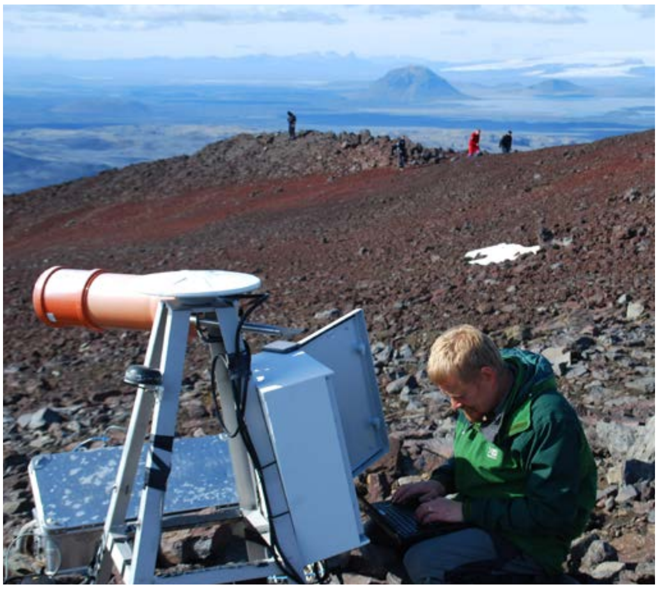
Monitoring Bárðarbunga

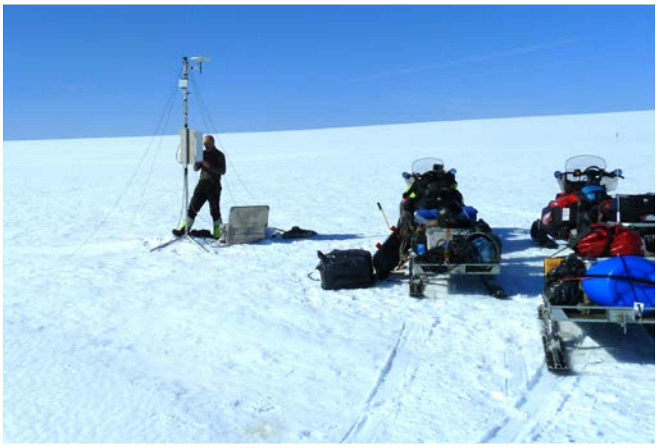
Rifting events, as in Bárðarbunga 2014-2015, are rather rare and can be part of a rifting episode that lasts months, years or even decades. One example of a rifting episode on land is Iceland's Krafla fires in 1975-1984. Whether the Bárðarbunga event is the beginning of a prolonged episode or not, is yet to transpire. But at least the extensive monitoring of this rifting event makes it quite unique.

An intense earthquake swarm began in the Bárðarbunga caldera on 16 August 2014. During the next two weeks, a magma intrusion formed a 49 km long dyke in the upper crust. It migrated from the caldera to Holuhraun, where a fissure eruption commenced at the end of August. This eruption is the largest in Iceland in over 200 years. The progression of the rifting occurred in sequences of variable rates and was off and on accompanied by low-frequency tremor. This tremor was presumed of volcanic origin, particularly after the appearance of four cauldrons above the dyke. Shortly after the earthquake swarm began, the Bárðarbunga caldera began to subside, totalling over 60 m. The rate of subsidence decreased slowly and terminated at around the same time as the eruption, on 27 February 2015.

In the case of a volcanic eruption beneath ice, the need for inter-disciplinary action and teamwork is crucial for efficient monitoring. Since the beginning of digital monitoring in the early nineties, there have been six volcanic eruptions beneath glaciers in Iceland. Monitoring capability, data interpretation and communication have advanced with these events. In addition, before the unrest, a variety of new instruments were installed around the Vatnajökull ice cap by collaborators in the research project Futurevolc.

Scientists followed the course of events closely.
Photo: Sigurlaug Gunnlaugsdóttir.





Pálmi Erlendsson, Bergur H. Bergsson and others installing GPS and communication equipment. *Photos: Þorgils Ingvarsson and Benedikt G. Ófeigsson.*

During the period of unrest, the Department of Civil Protection and Emergency Management met regularly with scientists to discuss the situation and obtain the most recent information on the ongoing events: the eruption status, possible hazards and likely scenarios. Earthquake and cGPS data processing enabled real-time monitoring of the rifting. At the start of the dyke intrusion, new updated models of the dyke volume were presented at these meetings near daily. The rapid growth of the dyke called for a quick response; additional seismic and GPS stations needed to be installed for enhanced monitoring of the intrusion. After careful consideration, a GPS instrument and accelerometer were installed in the centre of the Bárðarbunga caldera to closely monitor the subsidence. Additionally, seismographs specially designed for use on glaciers were installed. During regular monitoring flights, changes in the glacial surface were recorded and important data on the deformation of the caldera acquired.

The real-time monitoring and interpretation of geophysical data were made accessible to the public via the internet. Both automatic and manually checked earthquake locations were displayed on maps, updated every five minutes. Also, cGPS time series were mapped showing deformation in the area.

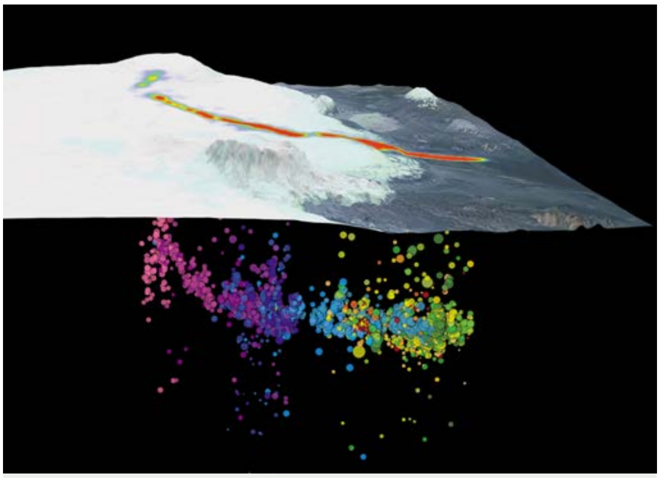
The magma intrusion from Bárðarbunga to the eruption site at Holuhraun and related tremor pulses

Increased earthquake activity has been observed in the Bárðarbunga volcano since 2005. Relative relocations (high-resolution locations) of earthquakes show that they are mainly restricted to an area north of the Bárðarbunga caldera and within the fissure system that extends north to Kistufell.

An abrupt increase in earthquake activity at the northern rim of the Bárðarbunga caldera and within the fissure system to the north was recorded in the early hours of 16 August 2014. The activity migrated from the caldera towards the southeast; then took a sharp turn to the northeast, reflecting a 49 km long horizontal magma intrusion. A short-lived eruption occurred on 29 August. Two days later on 31 August, another more powerful eruption began farther to the north which lasted until 27 February 2015.

There were periods when the magma stopped migrating, when tremor pulses lasting several hours were observed at seismic stations in the area. The character of the tremor was very similar to that of tremor recorded at IMO during previous eruptions when magma interacted with ice. A few days after these pulses, cauldrons were observed in the ice above the dyke, verifying the hypothesis of small eruptions under the glacier. At the same time, GPS data showed expansion of the dyke.

The magma intrusion was a significant rifting event located in Iceland's northern volcanic zone. Horizontal displacements were recorded at GPS stations, the largest up to 1.3 m at stations at about 15 km from the dyke, on either side of it. Rifting directly above the dyke was therefore probably a few meters.

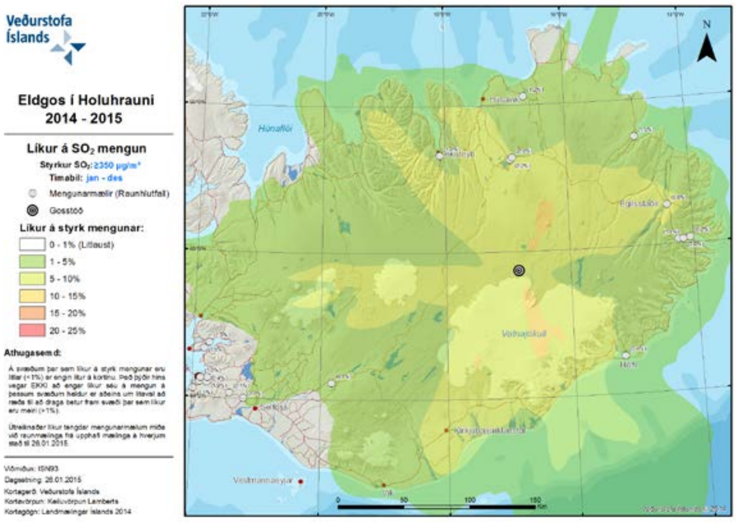


An interactive 3D model of the earthquakes during the magma intrusion. The different colours represent the activity in time from 16 August to 12 September.

During the magma intrusion, intense earthquake activity related to subsidence of the Bárðarbunga caldera was located at the caldera rim. Over 70 earthquakes above magnitude 5 occurred in the first four months after the onset of the rifting event. They were shallow, low-frequency and had unusual focal mechanisms. At the end of 2014, this activity had decreased significantly and since the end of February 2015 only small earthquakes have been recorded in the area.

Photo: Elín Björk Jónasdóttir.

Bárðarbunga



The map shows the likelihood at a specific location, that the hourly ground concentration of SO^2 will exceed a threshold of 2600 µg/m^3 during summer season. The colour scale shows different values (likelihood smaller than 1% has no colour associated).

Monitoring gas emission and environmental impact

The aerial monitoring of the eruption at Holuhraun has been set up by using various remote sensing and in-situ instruments: cameras, satellites and radars have been useful real-time monitoring tools to follow the evolution of the ongoing eruption; DOAS, MultiGAS and FTIR have been used for estimating the SO^2 flux and the plume composition; precipitation sampling and pH measurement have been maintained for monitoring the environmental impact due to the abundant gas release. Some of the operated instrumentations (i.e. Infra-Red camera, DOAS, MultiGAS) have been available thanks to the European project Futurevolc.

The eruption plume has been, in certain atmospheric conditions, visible on the C-band operational radar located in the East of Iceland. An X-band mobile radar was moved within about 25 km of the eruption site, providing higher resolution radar imagery, and it was removed before the onset of harsh winter conditions.

Three scanning Differential Optical Absorption Spectrometers (DOASes) capable of streaming data in almost real-time have been installed less than 15 km from the fissure. Two of them have provided the longest data time series. Traverses with a car-mounted DOAS have been made along the ring road, down-wind from the eruption, when conditions were favourable. These data was examined so that the uncertainty in the results from the scanning instruments could be constrained and the scanning DOAS measurements scaled appropriately. Preliminary SO^2 emission rates in the first months of the eruption have been estimated, in average, 900 kg/s. Plume composition measurements were made by FTIR, MultiGAS and DOAS during multiple campaigns early in the eruption.

Baldur Bergsson, Árni Snorrason and Amy Donovan measuring gas at Holuhraun. *Photo: Hermann Arngrímsson.*

IMO is collecting precipitation samples at ~20 meteorological observation sites. IMO performs the estimation of pH and amount of sulphates and other pollutants (HF, HCl) to identify potential areas affected by acid rain. These samples are then analysed in cooperation with the University of Iceland. The lowest values in pH have been detected in the south of Iceland with the lowest value at Borgir (pH3.18). The highest concentration of SO^4 and F content has been measured at Litla-Hlíð in Skagafjörður and Hjarðarland in Bláskógabyggð.

Numerical modelling of gas dispersal

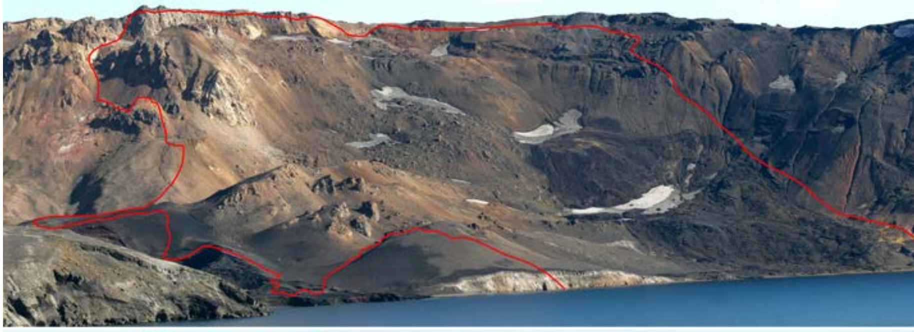
Forecasting of the volcanic gas dispersion has developed rapidly since the onset of the eruption. The CALPUFF dispersion model was set up in early September to produce hourly forecast of SO^2 concentration at the ground. The meteorologists on duty produced gas dispersion forecasts twice a day and issued both a text forecast as well as a forecast map indicating where levels of ground concentration of SO^2 might have exceeded health limits.

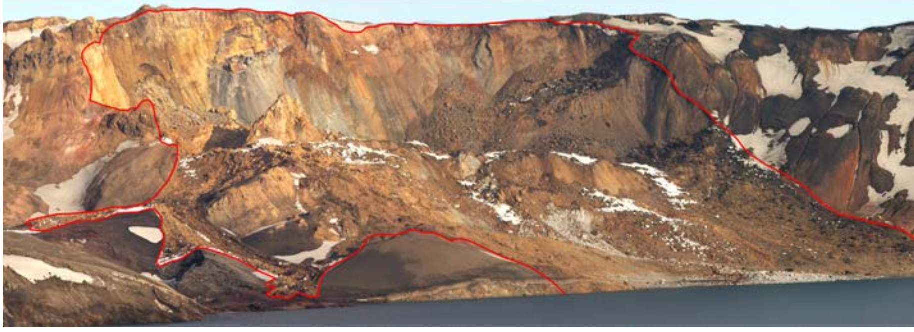
The CALPUFF model has also been used to produce probabilistic hazard maps for SO^2 concentration at ground. The maps have been produced using a wind statistics based on 10 years. The final products have been adopted by the Civil Protection for the definition of the restricted area around the eruption site.

Rockslide in Askja

In the evening of 21 July 2014 a large rockslide occurred in Askja, which descended into the caldera lake (Lake Öskjuvatn). The slide was released from the southeastern caldera wall, triggering a tsunami in the lake that washed up on the lakeshores all around the lake, reaching up to 20–30 m elevation above the water level. The wave travelled farthest around 400 m (horizontally) into the flatland SE of the crater Víti. Fortunately, the rockslide occurred late at night and no one was at the lake. A few hours earlier, travellers who were on the shore might not have been able to escape.

The rockslide appeared as shallow tremor on IMO seismographs near Askja and the data show that the slide was released at around 23:24. The slide created seismic waves that travelled around most of Iceland in roughly one minute. The waves were picked up by most of the IMO seismic network; signals were clearest at the nearest stations, but only the lowest frequencies were picked up at seismometers farthest away.





[1] The rockslide area four hours before the slide occurred. The outline of the slide is indicated in the picture. Photo: Ármann Höskuldsson 21.7.2014. Drawing: Jón Kristinn Helgason.

[2] A photo taken three days after the rockslide. The outline of the slide is indicated in the picture. Photo and drawing: Jón Kristinn Helgason, 24.7.2014.

There were no eyewitnesses to the slide, but members of a search-and rescue team saw a white plume rise up above Askja at 23:27. The steam plume was created when the slide exposed shallow geothermal areas in the release area. In addition, a dust cloud created by the rockslide may have contributed to the plume.

The release area of the rockslide is approximately 800 m wide and 350 m above the lake surface. It may have been a "rotational slide movement", which means that the failure surface of the slide is concave. The volume of the slide is roughly estimated 30–50 million m^3, however, the estimation may change when further measurements and analyses have been carried out, especially on the part that is in the lake and regarding the depth of the sliding surface. If the bottom of the slide reaches below the lake bottom, the total volume of material that moved may be a lot more.

The water level of Lake Öskjuvatn rose 1–2 m after the rockslide. The rise of the water level will be measured precisely because it gives information on the volume of the slide. Bubbles and muddy plumes were noticed in Víti after the slide, most likely due to subsurface inflow of water after the water level rose in Öskjuvatn.

Askja consists of 3–4 calderas. The youngest one hosts Lake Öskjuvatn and was formed over a period of 30 years after an eruption in 1875. Before that, Öskjuvatn did not exist and, therefore, the rims of the caldera are geologically a very young area. Such slopes are more unstable than slopes in older landscape. It is clear from geological evidence that rockslides similar to the one that fell in July 2014 have been released before from the rims of Askja, although people have not noticed them.

Further rockslides in Askja should be expected within the next years or decades. Consequently, travel near the lake is associated with a certain risk. A person by the lake that notices a landslide should move immediately up the hill and away from the lake. It takes a tsunami wave about 1–2 minutes to travel across the lake and sound takes about 10 sec to cover that distance. A large rockslide is needed to cause a tsunami of a similar size as the one in July 2014, smaller slides may cause smaller waves and a small slide would hardly cause any wave, even though the noise may be considerable.

Photographs from the rockslide area over time indicate that considerable movement had started before the slide was released. Slow movement in the bedrock seems to have accelerated in the summer of 2014. There was deep snow in the mountains and fairly warm weather before the slide occurred. Percolating water from the melting snow may have increased the rate of movement. Seismic data indicate that a sudden movement occurred around 40 minutes before the slide, but at 23:24 the failure point was reached and the rockslide was released.

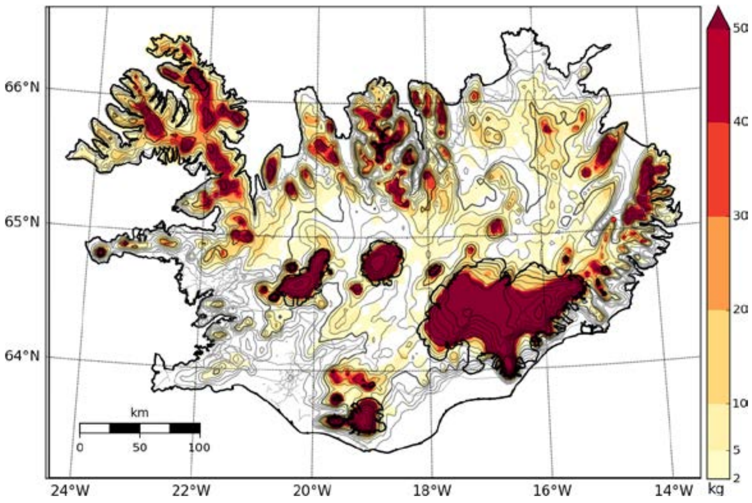
- Width of fracture line: 800 m
- Vertical drop: 350 m
- Run-out length beyond the lake shore: ~1000 m
- Volume: ~30–50 million m^3
- Estimated duration of the slide: 20 seconds according to seismographs
- Travel time of tsunami across the lake: 1–2 minutes

Projects

ICEWIND - Icing

During the years 2010-2015, the Icelandic Meteorological Office took part in a research project aimed at wind energy in cold climates (i.e., ICEWIND - Improved Forecast of Wind, Waves and Icing), which was funded by the Nordic Top-level Research Initiative Norden.

An important part of the project were resource assessments, to which aim a wind atlas was prepared for the land area of Iceland, as well as for the near coastal ocean. A major complicating factor for effective wind energy production in cold climates is icing on wind turbines and power lines and distribution systems. Therefore, methods were developed and improved, to estimate the local occurrence and spatial distribution of icing over the Icelandic land area, together with tools to provide icing forecasts based on numerical weather simulations.



Icing map. An example of the simulation of in-air icing loads.

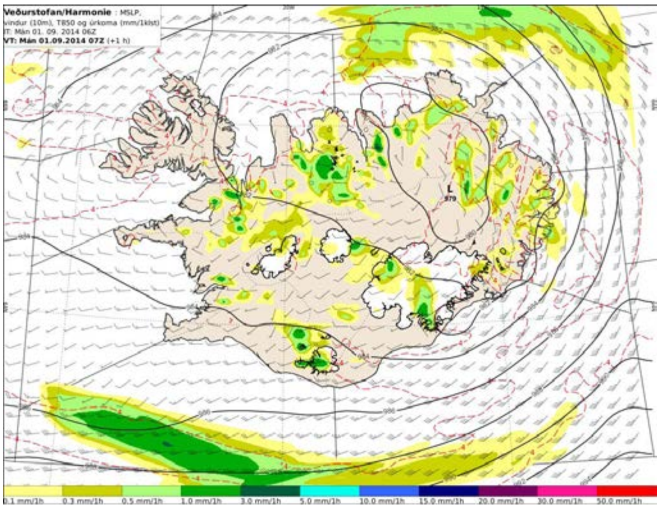
Harmonie – customized numerical weather forecasts

The Icelandic Meteorological Office (IMO) has taken part in the development of operational numerical weather forecasts since the early 1990s, starting with the collaboration in HIRLAM (High-Resolution Limited Area Modelling). Beginning in the middle of the last decade, a new project was begun, to combine the best features of HIRLAM and the French Arpege model. The result is Harmonie, which has become the basis for weather forecasts in many European countries.

IMO began testing Harmonie in the autumn of 2011, and has continuously run the model since 2012. Since the middle of 2014, it has been the main operational forecasting model. However, for comparison, HIRLAM is still being used.

At the boundaries, Harmonie uses the coarse-resolution operational forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF). Additionally, station data are used to ensure that model simulations remain close to the measured state of the near-surface atmosphere.

Starting this year, an improved surface cover description will be implemented in the model. In addition, the model domain will be increased. Both changes should result in improved weather forecasts.



Weather forecast at the start of the volcanic eruption in the Holuhraun lava field (1 September 2014). In addition to standard weather parameters (such as precipitation, temperature, and wind), Harmonie also simulates snow accumulation, runoff, evaporation, and more.

2014

Photo: Vilhjálmur S. Þorvaldsson.

The weather in Iceland 2014

The year 2014 was warm for most of the year, precipitation was abundant and the sunshine duration during most of the summer was considerably below average.

The temperature was unusually high. At the northern coast and in most of the eastern part of the country it was the warmest year ever recorded, e.g. at Grímsey (northern coast, measurements extending back to 1874) and at Teigarhorn (eastern coast, measurements starting in 1873). In other parts of the country, the year was generally the second or third warmest in the record. Relatively it was coldest in the Vestfirðir peninsula (West fjords) where it was the fifth warmest in the measurement series.

In spite of the high temperatures the weather was changeable and often dull. The first months of the year were especially wet in the north and east and the weather was difficult. In the west it was very dry at the same time, with favourable weather conditions. The summer was warm and considered fine in the north and east but in the south it was wet and dull. The autumn was fine, November extraordinarily warm, but the year ended with an unruly and rather cold December.

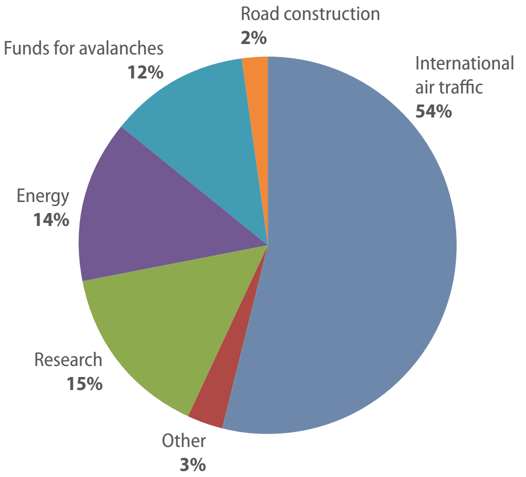
IMO field hydrologists participated in a 5 days long ADCP workshop (acoustic Doppler current profiler) at Sveriges Meteorologiska och Hydrologiska Institut (SMHI) in Sweden.The main focus was on ADCP river discharge measurements, site selection and post processing, but also covered salt dilution method for discharge measurements and technical solutions in the hydrometry network. Photo: Stina Nyman.

Participants at the annual meeting of the Futurevolc project, held 23–27 September 2014. Photo: Ingveldur Björg Jónsdóttir.

Statement of accounts for the year 2014

Income	**2014**	**2013**
Grants and donations	835.932.732	811.069.889
Public service	231.583.895	322.712.878
Other income	55.444.288	61.465.854
	1.122.960.915	1.195.248.621
Fees		
Wages and related expenses	1.269.515.241	1.166.624.658
Office and management fees	65.501.698	74.483.129
Conference, travel and training expenses	79.877.271	86.221.201
Contracted service	137.213.046	131.913.414
Operation of equipment	63.413.485	64.352.602
Other operational expenses	124.480.188	126.977.887
Housing expenses	113.887.230	116.458.659
Vehicle expenses	22.408.135	15.539.739
Transference between institutions	12.961.702	12.888.091
	1.889.257.996	1.795.459.380
Depreciation and purchase of assets	110.923.759	116.603.120
	2.000.181.755	1.912.062.500
(Deficit) Surplus for financial income	(877.220.840)	(716.813.879)
Financial income	(16.501.116)	(25.482.569)
(Deficit) Surplus for state contribution	(893.721.956)	(742.296.448)
State contribution	863.821.000	720.300.000
(Deficit) Surplus of the year	(29.900.956)	(21.996.448)
Principal amount at the beginning of the year	46.547.420	68.543.868
Operating results for the year	-29.900.956	-21.996.448
Principal amount at the end of the year	16.646.464	46.547.420

Division of income



IMO in figures

- Over **600** stations in operation
- **5** offices, including the headquarters in Reykjavik
- **136** staff and **91** additional surveillants
- Employment cost is **63%** of total cost
- **65%** of staff are male
- **41%** of administrators are female
- **43%** of IMO income are grants
- **64%** of non-governmental income is due to international projects

Education in percentage of the total number of staff

	Primary education	University degree	Ph.D.; doctorate
Male	21%	42%	16%
Female	20%	44%	18%

Staff publications

Peer-reviewed articles

Eibl, E. P. S., C. J. Bean, Kristín Vogfjörð & A. Braiden (2014). Persistent shallow background microseismicity on Hekla volcano, Iceland: A potential monitoring tool. Journal of Volcanology and Geothermal Research 289, s. 224-237. DOI: 10.1016/j.jvolgeores.2014.11.004.

Eydís Salome Eiríksdóttir, Árni Sigurðsson, Sigurður Reynir Gíslason & P. Torssander (2014). Chemical Composition of Precipitation and River Water in Southern Iceland: Effects of Eyjafjallajökull Volcanic Eruptions and Geothermal Power Plants. Procedia Earth and Planitary Science 10, 358-364.

Hálfdán Ágústsson & Haraldur Ólafsson (2014). Simulations of observed lee waves and rotor turbulence. Monthly Weather Review 142(2), 832–849; doi.org/10.1175/MWR-D-13-00212.1.

Hálfdán Ágústsson & Haraldur Ólafsson (2014). The Advection of Mesoscale Atmospheric Vortices over Reykjavik. Monthly Weather Review 142(10), 3549-3559.

Hálfdán Ágústsson, Haraldur Ólafsson, M. O. Jonassen, & Ólafur Rögnvaldsson (2014). The impact of assimilating data from a remotely piloted aircraft on simulations of weak-wind orographic flow. Tellus, Series A - Dynamic Meteorology and Oceanography 66, Article No: 25421; DOI: 10.3402/tellusa.v66.25421.

Jonassen, M. O., Hálfdán Ágústsson & Haraldur Ólafsson (2014). Impact of surface characteristics on flow over a mesoscale mountain. Quarterly Journal of the Royal Meteorological Society 140(684), 2330-2341; DOI: 10.1002/qj.2302.

Muri, H., Jón Egill Kristjánsson, T. Storelvmo & Melissa Anne Pfeffer (2014). The climatic effects of modifying cirrus clouds in a climate engineering framework. Journal of Geophysical Reserch - Atmospheres 119(7), 4174-4191; DOI: 10.1002/2013JD021063.

Nawri, Nikolai, Guðrún Nína Petersen, Halldór Björnsson, A. N. Hahmann, Kristján Jónasson, C. B. Hasager & N-E. Clausen (2014). The wind energy potential of Iceland. Renewable Energy 69, 290–299. Opið aðgengi / Open access.

Pfeffer, W. T., A. A. Arendt, A. Bliss, ... Oddur Sigurðsson ... [total of 57 authors] (2014). The Randolph Glacier Inventory: a globally complete inventory of glaciers. Journal of Glaciology 60(221), 537-552.

Sigrún Hreinsdóttir, Freysteinn Sigmundsson, Matthew J. Roberts, Halldór Björnsson, R. Grapenthin, Þórður Arason, Þóra Árnadóttir, Jósef Hólmjárn, Halldór Geirsson, R. A. Bennett, Magnús Tumi Guðmundsson, Björn Oddsson, Benedikt G. Ófeigsson, T. Villemin, Þorsteinn Jónsson, Erik Sturkell, Ármann Höskuldsson, Guðrún Larsen, Thor Thordarson & Bergrún Arna Óladóttir (2014). Volcanic plume height correlated with magma-pressure change at Grímsvötn Volcano, Iceland. Nature Geoscience 7(3), 214-218; doi:10.1038/ngeo2044.

Staines, K. E. H., J. L. Carrivick, F. S. Tweed, A. J. Evans, A. J. Russell, Tómas Jóhannesson & Matthew J. Roberts (2014). A multi-dimensional analysis of pro-glacial landscape change at Sólheimajökull, Southern Iceland. Earth Surface Processes and Landforms November 2014; DOI: 10.1002/esp.3662.

Marianne Thyrring, Director General, Danish Meteorological Institute (DMI) (left), and Hafdís Karlsdóttir, Deputy Director General of IMO, signed on 12 November 2014 a General Agreement on research and weather services. IMO accepted to host DMI's supercomputer, with access to operate it according to DMI's needs and requirements. DMI will deliver a model setup for Numerical Weather Prediction (NWP) covering Iceland, Icelandic waters and part of Greenland. Photo: Vigfús Gíslason.

Other research contributions

Birta Líf Kristinsdóttir (2014). Atmospheric conditions during two weather related aircraft incidents in Iceland and elements of the climatology of windstorms. 90 ECTS thesis submitted in partial fulfillment of a Magister Scientiarum degree in Physics. Advisors: Haraldur Ólafsson, Guðrún Nína Petersen. External examiner: Ólafur Rögnvaldsson. Reykjavík: Faculty of Physical Science, School of Engineering and Natural Sciences, University of Iceland, 107 s.

Crochet, Philippe (2014). Probabilistic daily streamflow forecasts based on the combined use of a hydrological model and an analogue method. Skýrsla Veðurstofu Íslands 2014-006, 68 s.

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