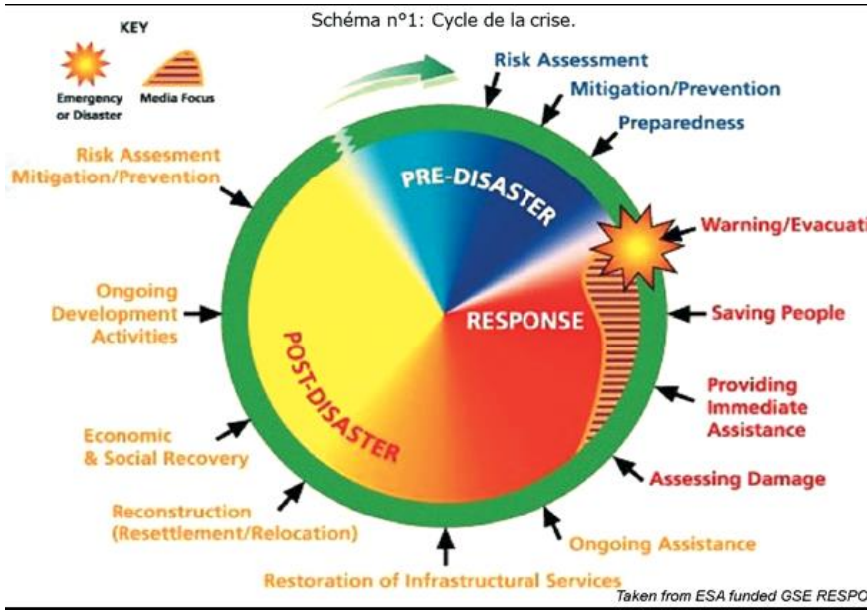
"From Volcanic Hazard to Risk Assessment"
Workshop in Geneva, June 27 -28, 2018

FROM RISK ASSESSMENT TO MITIGATION MEASURES IN VOLCANIC AREAS

GUÐRÚN JÓHANNESDÓTTIR

Aim of the Civil Protection Act 82/2008

- Civil Protection aim is to minimize or eliminate risk to people, property, environment and society with mitigation activities
- In this context the legislation promotes risk assessment and resilience – with the focus is risk reduction/preparedness
- All hazards approach – from **natural catastrophes human actions, pandemics, military action or other**
- Provide **emergency relief** and **assistance** due to any injury or damage that may occur or has occurred.

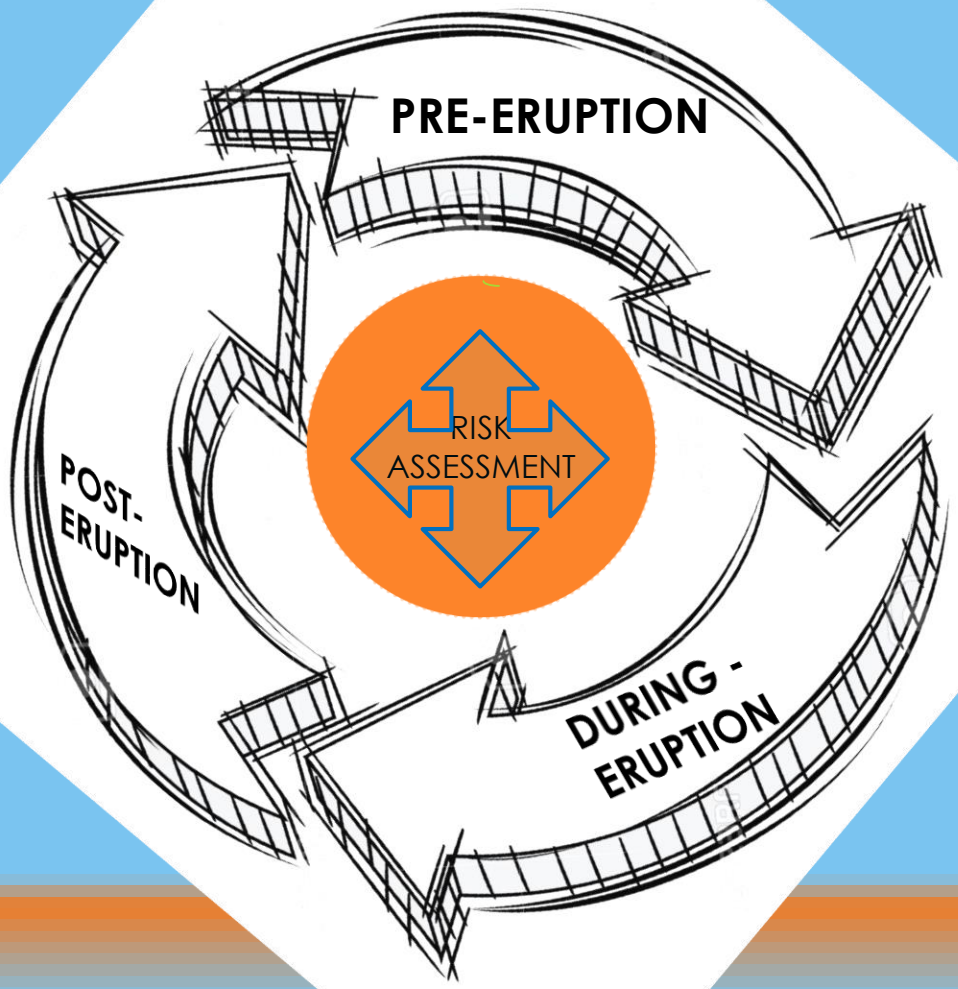


Why risk assessment in emergency management?

- The process of identifying potential hazards and analyze what could happen if hazard occurs, **is an essential first step** in emergency management
- The interdependency of hazards and risk – cascading risk, acceptable risk
- Addresses uncertainty - when allocating scarce resources for risk treatment and emergency prevention and preparedness measures
- Based on best available information – for policy – and decision making
- Qualitative and quantitative methods - scalability
- Take into account human and cultural factors – interaction between a hazard and a vulnerable population that can disrupt lives, economic- environmental, social and political stability.
- It is not a one time event – flexible and current, socially constructed- acceptable risk
- To inform the public and authorities about the risk

Data for volcanic risk assessments in Iceland

- Risk profiling and assessment in Civil Protection Districts
- Scientific projects
  - EU –FUTUREVOLC – monitoring and evaluation of volcanic hazard - risk communication
  - NORDRESS – resilience – studies on ash and gas in vulnerable areas during Holuhraun/Bárdarbunga eruption http://nordress.hi.is
  - Catalogue project http://icelandicvolcanoes.is
- Simulations and modelling the hazard
- Scientific Advisory Board of the Civil Protection
- Guided by Hyogo and Sendai – UNISDR
  - Understanding risk – Focusing on reducing disaster loss, risk and vulnerability
  - Risk informed development and governance – knowledge, policy guidance and decision making tools
  - Incentives for risk reduction – building codes, insurance, beliefs and tradition
  - Shared responsibility - invest in disaster preparedness – Build Back Better


PRE-ERUPTION
RISK
ASSESSMENT
POST-
ERUPTION
DURING -
ERUPTION

Why Risk Assessment for Civil Protection

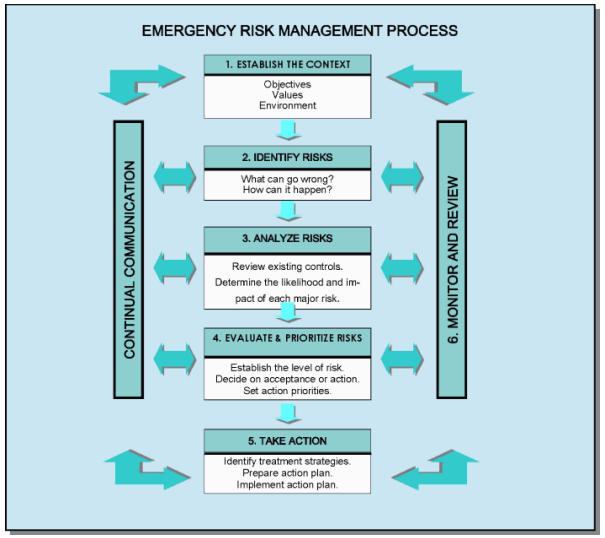
The law on Civil Protection stipulates risk reduction and resilience

- Cooperative approach
  - Local authorities, stakeholders, National agencies scientists – the same method in all districts
- **Risk profiling and assessment-** the likelihood and consequences were quantified to the greatest possible extent.
- **Product:** Risk matrix and scenarios prioritizing actions for mitigation measures

Mjög miklar líkur 5	5	10	15	20	25
Líklegt 4	4	8	12	16	20
Nokkuð líklegt 3	3	6	9	12	15
Frekar ólíklegt 2	2	4	6	8	10
Mjög ósennilegt 1	1	2	3	4	5
	Óverulegar 1	Minniháttar 2	Nokkrar 3	Miklar 4	Skelfilegar 5

Lítil áhætta venjubundið eftirlit | Möguleg áhætta skoða nánar - sviðsetja | Mikil áhætta úrlausnir skoðaðar | Gífurleg áhætta aðgerðir strax

ISO 31000 Risk Management Principle and Guidelines



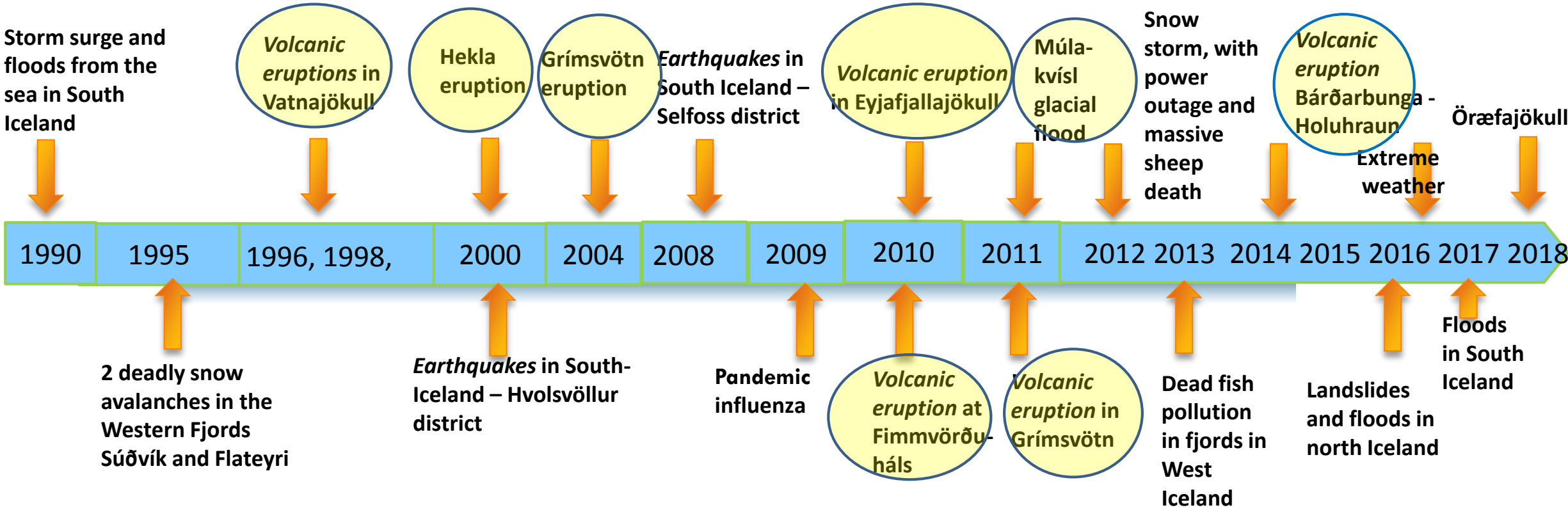
Tafla 9 Sviðsmynd vegna jökulhlaupa

	Jökulhlaup
Atburður	Stórt jökulhlaup vegna eldgosa/eldvirkni undir jökli.
Líkur	Undir mörgum jöklum er eldvirkni og eru jökulhlaup allt frá því að vera árviss í það að vera á nokkurra alda fresti.
Dæmi um fyrri atvik	Jökulhlaup frá Eyjafjallajökli árið 20 Skaftárhlaup hafa verið árviss, Grín Kötluhlaup 1918.
Afleiðingar	Allt frá litlum sem engum aflei samgöngumannvirkjum og eignum.
Dæmi um mótvægisaðgerðir og úrræði	Hönnunarforsendur Vegagerðarinn hættunnar. Varnargarðar við ár þ rannsóknir, fræðsla og upplýsingagj
Ábyrgð á vöktun	Veðurstofa Íslands
Dæmi um aðra sem vakta	Jarðvísindastofnun
Ábyrgð á viðbragði	Samhæfingar- og stjórnstöð, aðger þörfum
Endurreisn	Sveitarfélög og stofnanir í umdæm stofnanir þess eftir almannavarnaás
Endurmat	Ábyrgðaraðilar vöktunar, viðbúnaðar og viðbragða, rannsóknarnefnd almannavarna í stórum atburði.

Tafla 8 Sérstaklega metin áhætta vegna eldgosa og áhrifa frá þeim í umdæmunum

Lítil áhætta - venjubundið eftirlit	Möguleg áhætta - skoða nánar -sviðsetja	Mikil áhætta - úrlausnir skoðaðar	Gífurleg áhætta - aðgerðir strax
Eyjafjörður og Fjallabyggð	Akranes	Eskifjörður og Hornafjörður	Suðurnes
Vestfirðir	Skagafjörður	Árnessýsla	Húsavíkurumdæmi
	Snæfellsnesumdæmi	Rangárvallasýsla og V-Skaftafellssýsla	Vestmannaeyjar
	Borgarfjörður og Dalir		Höfuðborgarsvæðið
	Seyðisfjarðarumdæmi		

What can we expect?



Different challenges in different eruptions– since 1973

from Heimaey to Holuhraun – what can we expect?

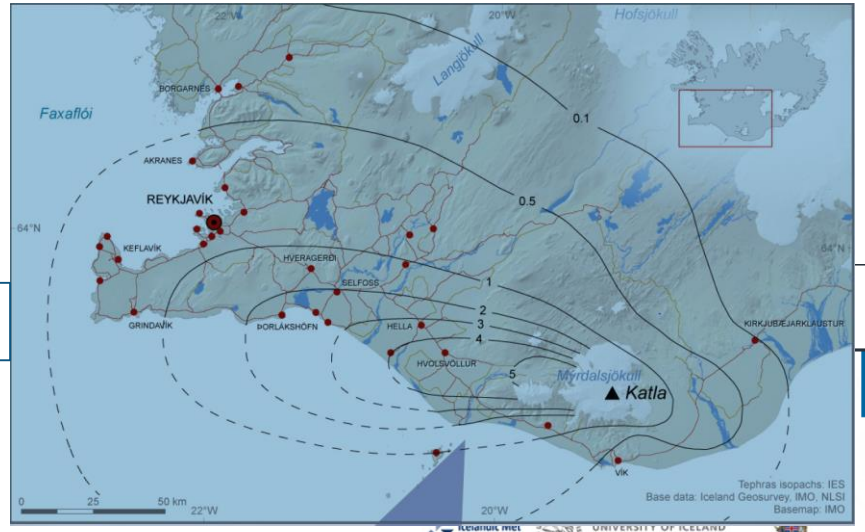
- The Vestmannaeyjar eruption in 1973 at Heimaey– *lavaflow, ash and gas/social challenges/ evacuation*
- The Krafla eruption 1975 -84 – *infrastructure – power plant development jeopardized /economic challenges*
- Gjálp in Vatnajökull – 1996 flash floods /jökulhlaup– with damage to the environments, roads, powerlines and bridges
- The Fimmvörðuháls eruption in 2010 – *large scale crowd control/tourist eruption*
- The Eyjafjallajökull eruption in 2010 – *ash distribution and aviation disruptions* world wide
- The Grímsvötn eruption in 2011 – *ash distribution* mostly at a local level, aviation disruptions
- The Bárðarbunga seismic activity and the eruption in Holuhraun 2014 – *toxic gas/potential flooding*

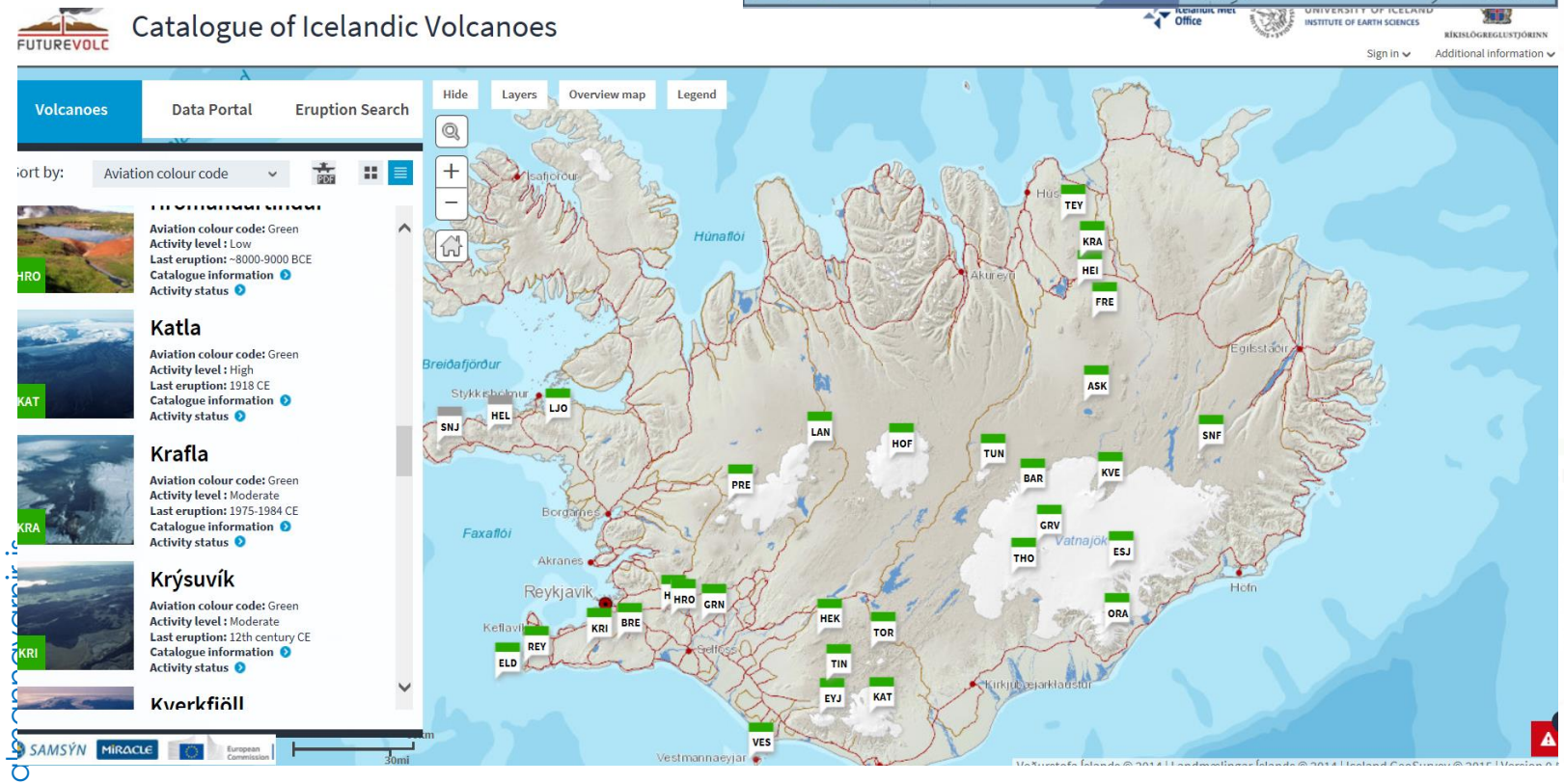



Collaboration and cooperation

- By law the Icelandic Met Office deals with monitoring the hazards and gives out warnings and the Icelandic Civil Protection deals with risk and mitigation measures except for snow avalanches.
- These and more institutions are involved in projects that are funded by The National Avalanche and Landslide Fund, with contribution from FutureVolc, ICAO, IRCA, National Power Company and more
- GOSVA - Integrated risk assessment of volcanoes in Iceland:
  - Icelandic volcanoes – catalogue – basic information on volcanoes in Iceland
  - **Risk assessment** of floods triggered by volcanic eruptions, volcanogenic floods (2016)
  - Pilot Project on disaster **risk assessment** to critical infrastructure in communities very close to volcanoes – two Civil Protection areas Suðurnes and Vestmannaeyjar (well under way)
  - Vulnerability of ecosystems near Hekla to ash
  - **Hazard assessment** of Skaftárhlaup
  - Initial risk assessment of explosive eruptions in Iceland (just started)

http://icelandicvolcanos.is/





ABOUT | VOLCANO INFORMATION

Detailed Description

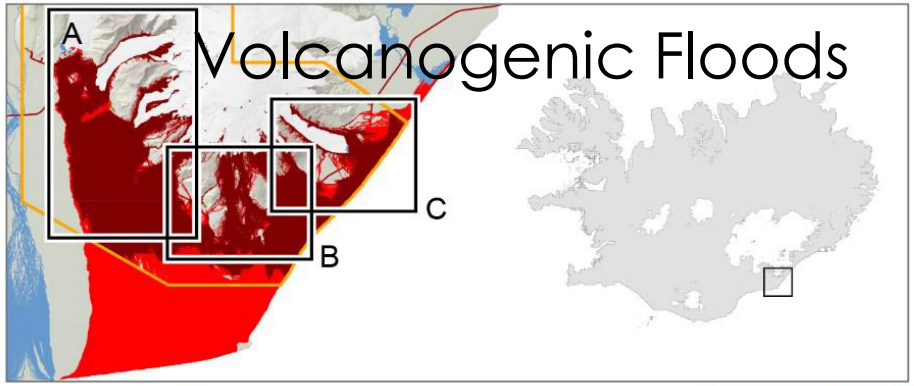
1. Geological setting and tectonic context
2. Morphology and topography
3. Plumbing system and subsurface structure
4. Eruption history and pattern
5. Characteristics during non-eruptive periods
6. Precursory signals
7. Erupted material & Grain size distribution
8. Volcanic hazards
9. Activity status and monitoring
10. Possible eruption scenarios – based on last 1100 years

Small eruption (tephra fallout <0.1 km³, recurrence time ~100 years)

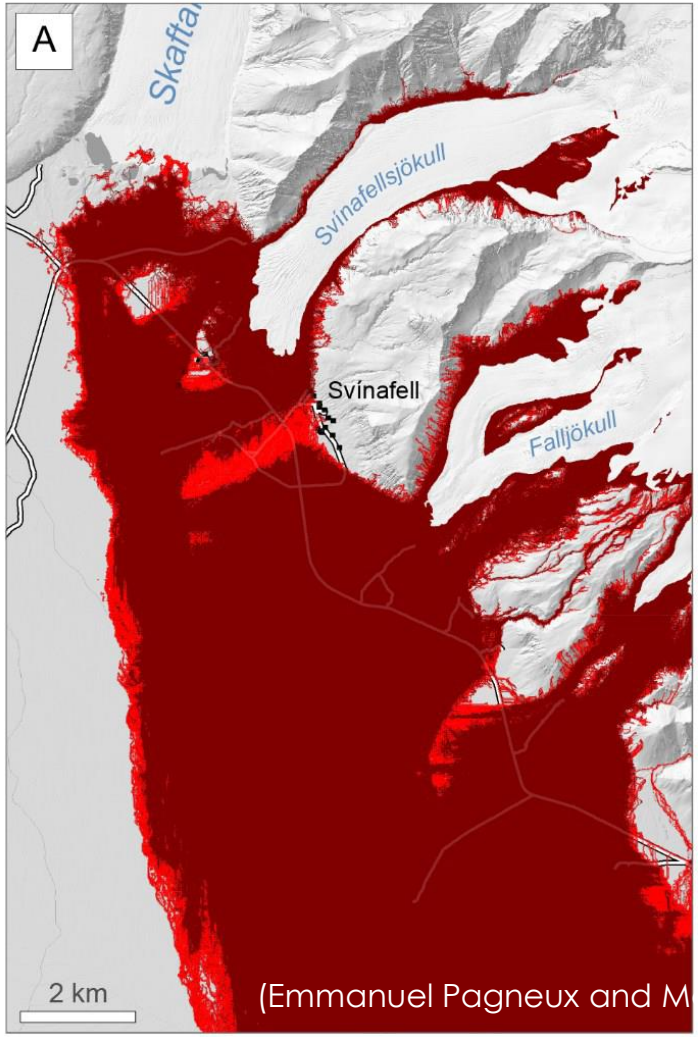
Small eruptions occur in the ice-filled caldera. They are likely to last for 2-3 weeks and are the most common eruption types in the Katla system (9 out of 20 historical eruptions). Instrumental warning period is unknown, but likely to be 4-24 hours before eruption breaks through the ice and an eruption column developes.

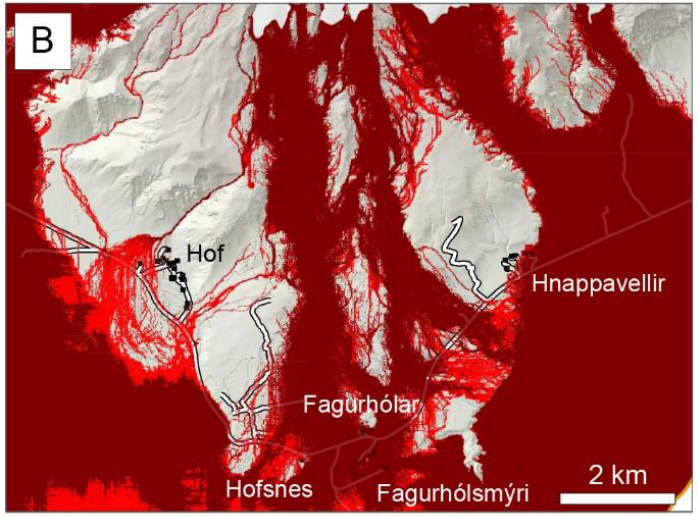
The height of the eruption column unlikely to exceed 11 km. Tephra fallout volume is <0.1 km³. The eruption is purely explosive and there are no lava flows. Peak plume height and tephra fallout will not necessarily occur at the beginning of the eruption and activity is expected to be intermittent. Intense tephra fall is unlikely except in the immediate vicinity of the volcanic fissure. Total maximum fallout thickness 25-30 km from volcano unlikely to exceed 5 cm. Likelihood of tephra being transported to Europe

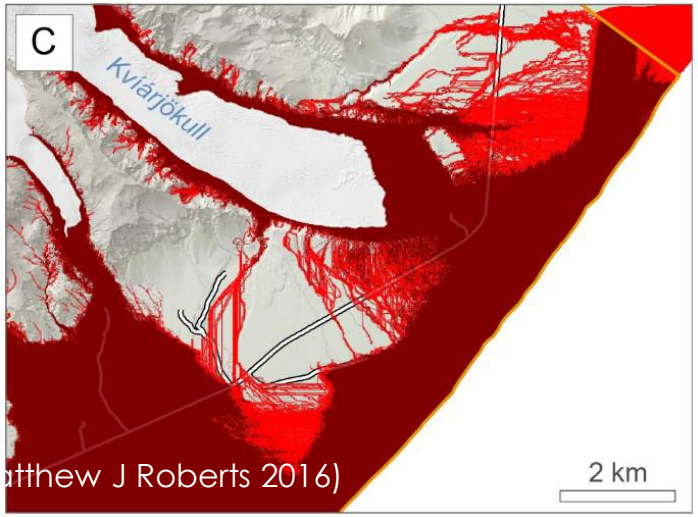
Volcanogenic Floods



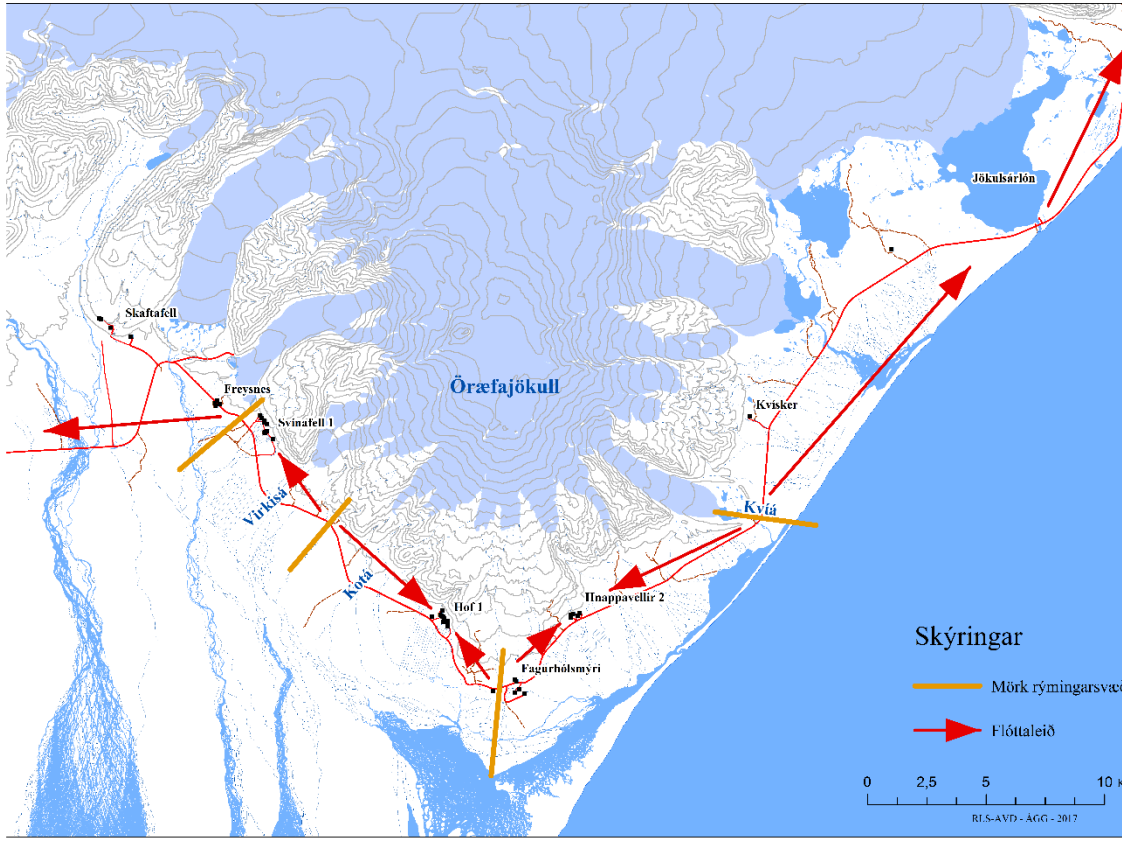
Hazard rate	km²	%	
Undetermined	0	0	Gre
Low	0	0	Yell
Moderate	0	0	Ora
High	164	47	Red
Extreme	183	53	Bro







(Emmanuel Pagneux and Matthew J Roberts 2016)



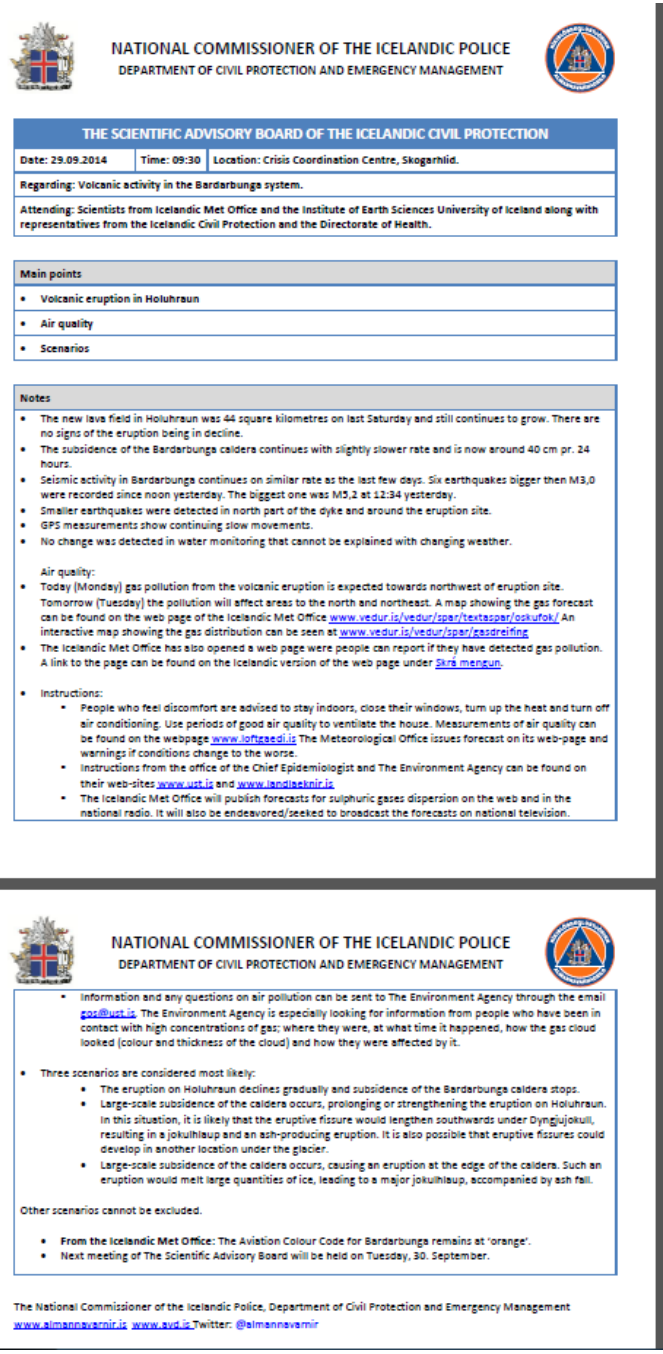
Hazard and risk maps – Hazard and risk assessment for volcanic eruption in Öræfajökull is the basis for an emergency evacuation plan.
Assessment of flood duration and/or pyroclastic flows to reach the highway (20 – 27 min) SMS messages will be sent to mobile phones in the area.
Two major eruptions in 1362 and 1727

Collaboration and coordination

- Scientific Advisory Board of the Civil Protection. During quiet time scientists and Civil Protection authorities meet 2 – 3 times a year to identify and analyze potential hazards.
- During volcanic eruptions the Civil Protection Scientific Advisory Board meets every day to assess the situation and publish the assessment.
- Short term and long term assessments – scientist from the IMO Environmental Agency, Earth Science Institute, the Medical Directorate of Health (epidemiology), the Occupational Safety and Health Agency and the Food and Veterinary Agency. Experts from other agencies or institutes are called to the task if their expertise is required.
- Regular Civil Protection information meetings with the public and scientists

Holuhraun eruption – Every day hazard assessments scenarios by the CP Scientific Advisory Board

- The eruption in Holuhraun continues until the subsidence of the Bardarbunga caldera stops.
  The eruption can still go on for many months.
- The volcanic fissure may lengthen southwards under Dyngjujokull, resulting in a jokulhlaup and an ash-producing eruption. It is also possible that eruptive fissures could develop in another location under the glacier
  If such an eruption would be prolonged it could eventually produce a lava flow.
- Volcanic eruption in the Bardarbunga caldera. Such an eruption would melt large quantities of ice,
  leading to a major jokulhlaup, accompanied by ash fall.
- Other scenarios cannot be excluded.



NATIONAL COMMISSIONER OF THE ICELANDIC POLICE
DEPARTMENT OF CIVIL PROTECTION AND EMERGENCY MANAGEMENT

THE SCIENTIFIC ADVISORY BOARD OF THE ICELANDIC CIVIL PROTECTION

Date: 29.09.2014	Time: 09:30	Location: Crisis Coordination Centre, Skogarhlid.

Regarding: Volcanic activity in the Bardarbunga system.

Attending: Scientists from Icelandic Met Office and the Institute of Earth Sciences University of Iceland along with representatives from the Icelandic Civil Protection and the Directorate of Health.

Main points

- Volcanic eruption in Holuhraun
- Air quality
- Scenarios

Notes

- The new lava field in Holuhraun was 44 square kilometres on last Saturday and still continues to grow. There are no signs of the eruption being in decline.
- The subsidence of the Bardarbunga caldera continues with slightly slower rate and is now around 40 cm pr. 24 hours.
- Seismic activity in Bardarbunga continues on similar rate as the last few days. Six earthquakes bigger then M3,0 were recorded since noon yesterday. The biggest one was M5,2 at 12:34 yesterday.
- Smaller earthquakes were detected in north part of the dyke and around the eruption site.
- GPS measurements show continuing slow movements.
- No change was detected in water monitoring that cannot be explained with changing weather.

Air quality:

- Today (Monday) gas pollution from the volcanic eruption is expected towards northwest of eruption site. Tomorrow (Tuesday) the pollution will affect areas to the north and northeast. A map showing the gas forecast can be found on the web page of the Icelandic Met Office www.vedur.is/vedur/spar/textaspar/oskufok/ An interactive map showing the gas distribution can be seen at www.vedur.is/vedur/spar/gasdreifing
- The Icelandic Met Office has also opened a web page were people can report if they have detected gas pollution. A link to the page can be found on the Icelandic version of the web page under Skrá mengun.
- Instructions:
  - People who feel discomfort are advised to stay indoors, close their windows, turn up the heat and turn off air conditioning. Use periods of good air quality to ventilate the house. Measurements of air quality can be found on the webpage www.loftgaedi.is The Meteorological Office issues forecast on its web-page and warnings if conditions change to the worse.
  - Instructions from the office of the Chief Epidemiologist and The Environment Agency can be found on their web-sites www.ust.is and www.landlaeknir.is
  - The Icelandic Met Office will publish forecasts for sulphuric gases dispersion on the web and in the national radio. It will also be endeavored/seeked to broadcast the forecasts on national television.

NATIONAL COMMISSIONER OF THE ICELANDIC POLICE
DEPARTMENT OF CIVIL PROTECTION AND EMERGENCY MANAGEMENT

- Information and any questions on air pollution can be sent to The Environment Agency through the email gas@ust.is. The Environment Agency is especially looking for information from people who have been in contact with high concentrations of gas; where they were, at what time it happened, how the gas cloud looked (colour and thickness of the cloud) and how they were affected by it.

- Three scenarios are considered most likely:
  - The eruption on Holuhraun declines gradually and subsidence of the Bardarbunga caldera stops.
  - Large-scale subsidence of the caldera occurs, prolonging or strengthening the eruption on Holuhraun. In this situation, it is likely that the eruptive fissure would lengthen southwards under Dyngjujokull, resulting in a jokulhlaup and an ash-producing eruption. It is also possible that eruptive fissures could develop in another location under the glacier.
  - Large-scale subsidence of the caldera occurs, causing an eruption at the edge of the caldera. Such an eruption would melt large quantities of ice, leading to a major jokulhlaup, accompanied by ash fall.

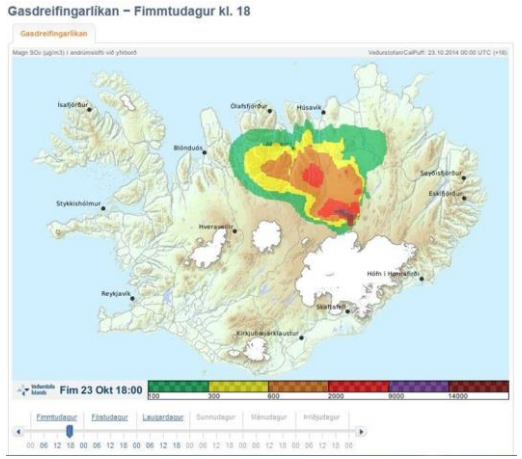
Other scenarios cannot be excluded.

- **From the Icelandic Met Office:** The Aviation Colour Code for Bardarbunga remains at 'orange'.
- Next meeting of The Scientific Advisory Board will be held on Tuesday, 30. September.

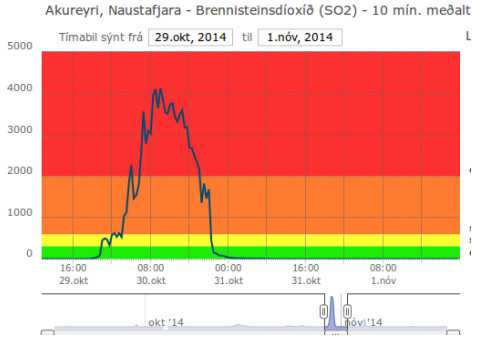
The National Commissioner of the Icelandic Police, Department of Civil Protection and Emergency Management
www.almannavarnir.is www.avd.is Twitter: @almannavarnir

The hazard assessment required risk assessment for each scenario
The Holuhraun/Bárðarbunga eruption

IMO gas dispersal forecasting tool -Monitoring data from the Environmental Agency (hazard assessment)



Modelled gas distribution
(Harmonie model from IMO)



Monitoring data from the Environmental Agency

- Models and simulation Jökulhlaup/glacial outburst floods
- Seismic, geodetic, hydrological and landscape monitoring

The Civil Protection performed risk assessments for each scenario for mitigation purpose in collaboration with stakeholders

- **SO2 Gas emission**
- **Cell broadcasting SMS**
  SO_2 concentration >1500 µg m^{-3}.
- Protective gears
- Goggles and masks
- Handheld gas meters

Concentration of SO_2		Air quality description	Recommended actions	
µg/m³	ppm		All children. Sensitive Groups *	Healthy individuals
		Good		
0-350	0-0.1	Poses little or no health risk.	Can experience mild respiratory symptoms.	No health effects expected.
		Moderate		
350- 600	0.1-0.2	May cause respiratory symptoms in individuals with underlying diseases.	Caution advised. Follow SO2 measurements closely. Avoid outdoor activities. Shut down air conditioning.	Health effects unlikely. Shut down air conditioning.
		Unhealthy for sensitive individuals		
600-2,600	0.2-0.7	Individuals with underlying diseases likely to experience respiratory symptoms. Health effects unlikely in healthy individuals.	Avoid outdoor activities. Shut down air conditioning.	Health effects not expected. Heavy outdoor activities not advised.
		Unhealthy		
2,600-9,000	0.7-3.0	Everyone may experience respiratory symptoms especially individuals with underlying diseases.	Remain indoors and close the windows. Shut down air conditioning.	Avoid outdoor activities. Remaining indoors advised. Close the windows and shut down air conditioning.
2,600	1.0	Working limits fro 15 minutes	All work forbidden except with use of gas masks.	All work forbidden except with use of gas masks.
		Very unhealthy		
9,000-14,000	3.0-5.0	Everyone may experience more severe respiratory symptoms.	Remain indoors and close the windows. Shut down air conditioning. Follow closely official advises.	Remain indoors and close the windows. Shut down air conditioning. Follow closely official advises.
		Hazardous		
>14,000	>5.0	Serious respiratory symptoms expected.	Remain indoors and close the windows. Shut down air conditioning. Follow closely official advises.	Remain indoors and close the windows. Shut down air conditioning. Follow closely official advises.

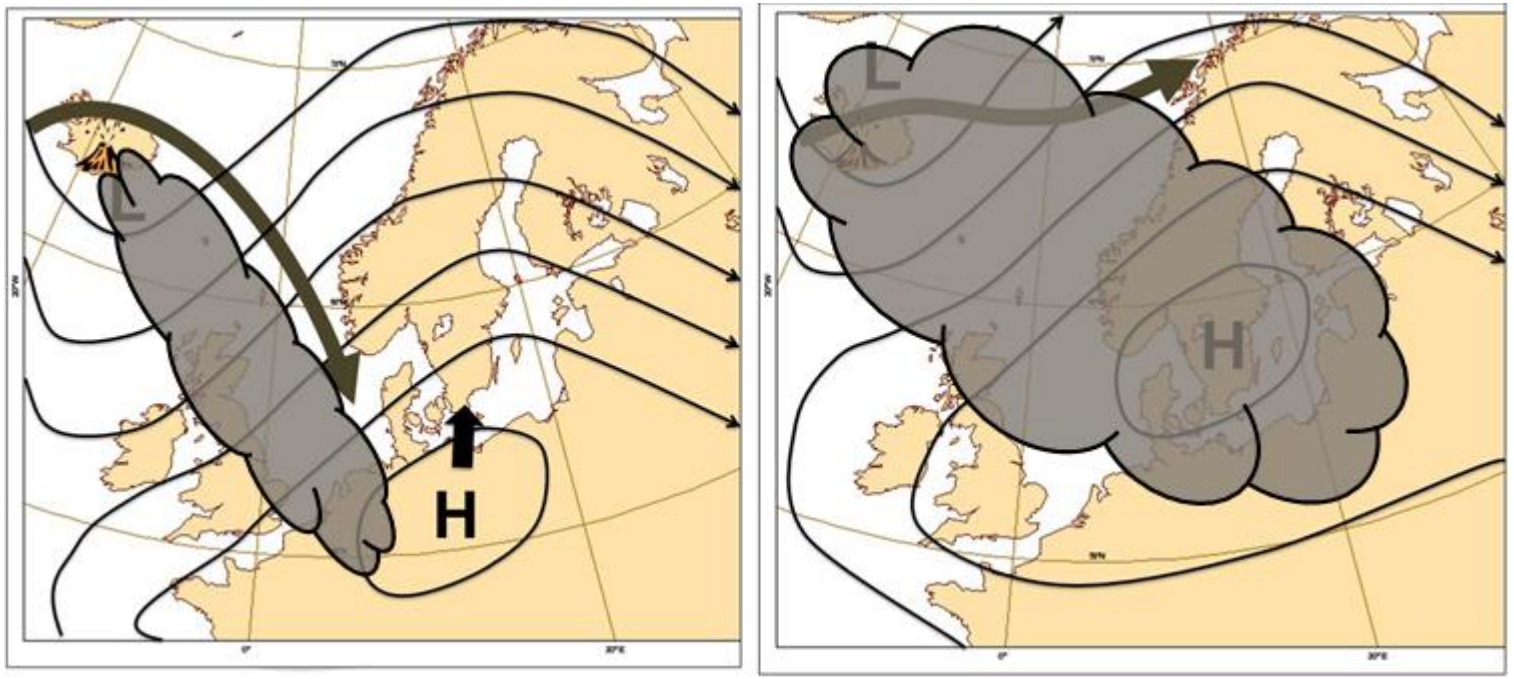
*Children and adults with pre-existing bronchial asthma, bronchitis, emphysema and/or heart diseases.

- **Risk Assessment: flooding from Vatnajökull with the potential breakdown of 40% of electricity in Iceland**
- **Response/evacuation plans for ash/tephra and jökulhlaup**
- **Civil Protection Alert phase and Access restrictions**
- **Sheep roundup in a vast area**
- **Information meetings with residents and governmental authorities**

Joint Nordic Risk assessment for volcanic dry fog

Effects on:

- Human life
- Health
- Economic values
- Infrastructure
- Environment
- Livelihood
- Vulnerability



Challenges for risk assessments

- Risk is all about uncertainty
- We need a systematic application of policies, procedures and practices
- As reliable information as possible for decision making, disaster planning, land use planning, and socio-economic activities that are influenced by volcanic activity
- Research of perception, experience, acceptance, interpretation of volcanic risk
- If the risk is not properly evaluated the risk assessment itself becomes the biggest risk

THANK YOU!

Hekla volcano
picture Oddur Sigurðsson

References

Emmanuel Pagneux and Matthew Roberts: Öræfi District and Markarfljót outwash Plain: Rating of Flood Hazard, chapter V (pp101-122) http://www.vedur.is/gogn/vefgogn/jokulhlaup/haettumat/oraefajokull_markarfljotsaurar/bok_en/chapter_V.pdf in Volcanogenic floods in Iceland – an assessment of hazards and risks in Öræfajökull and on the Markarfljót outwash plain Pagneux E., Gudmundsson, M.T., Karlsdóttir, S & Roberts, M.J (Eds) 2015), Reykjavik, IMO, IES-UI, NCIP-DCPEM http://www.vedur.is/skjalftar-og-eldgos/eldgos/oraefajokull/nylegar-rannsoknir/

https://www.almannavarnir.is/frettir/neydarrymingaraaetlun-fyrir-oraefajokul/ Evacuation plan for Öræfajökull, NCIP-DCPEM

Volcanic eruption in Iceland – volcanic dry fog affecting the Nordic countries. A joint Nordic risk and capability analysis (2015) A report from a joint workshop on volcanic eruption in Iceland. Cooperation between the Nordic countries. The report was presented at the Nordic Directors General meeting in Stavanger 27-28 May 2015

The Catalogue of Icelandic Volcanoes http://icelandicvolcanos.is/

National risk assessment in Iceland – executive summary https://www.almannavarnir.is/wp-content/uploads/2016/10/NATIONAL-RISK-ASSESSMENT-FOR-ICELAND_.pdf in English, DCPEM

Áhættuskoðun 2011 Risk assessment and risk profiles in Iceland. Gudrun Johannesdottir ed. In Icelandic, NCIP-DCPEM, Ríkislögreglustjóri https://www.almannavarnir.is/utgefid-efni/ahaettuskodun-almannavarna-helstu-nidurstodur-2011/?wpdmdl=21509

M. T. Gudmundsson, G. Larsen, Á. Höskuldsson and Á. G. Gylfason Volcanic hazard in Iceland in JÖKULL No. 58, 2008 https://www.almannavarnir.is/utgefid-efni/volcanic-hazards-in-iceland/?wpdmdl=21828

ISO-31000 Risk Management - Guidelines IES 31010 Risk assessment techniques. International Organization for Standardization (2009)