European volcanological supersite in Iceland: a monitoring system and network for the future

Report

D3.3 - Mapping best practice in the dissemination of scientific data and information from the scientific community to stakeholders

Work Package:	*Communications and supporting risk management*
Work Package number:	*3*
Deliverable:	*Mapping best practice in the dissemination of scientific data and information from the scientific community to stakeholders*
Deliverable number:	*3.3*
Type of Activity:	*RTD*
Responsible activity leader:	*Susan C. Loughlin*
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Type of Deliverable:	*Report* [X] *Prototype* [ ]	*Demonstrator* [ ] *Other* [ ]
Dissemination level:	*Public* [X] *Prog. Participants (FP7)* [ ]	*Restricted Designated Group* [ ] *Confidential (consortium)* [ ]

Seventh Framework Programme
EC project number: 308377

Abstract

The FUTUREVOLC project has enabled the institutional members to a) develop communication methods and strategies that will support the risk management process in Iceland and in Europe, b) enhance collaboration and communication techniques between research and operational partners within the FUTUREVOLC project, and c) enhance communication strategies about volcanic unrest, eruptions, hazards and risk within and beyond Iceland.

Specific activities have benefited from the FUTUREVOLC project including development of a daily collaborative 'Factsheet' for distribution by NCIP during eruptions, gas forecasts distributed by IMO, application of the Aviation Colour Code alert scheme and use of that scheme in weekly status reports and communications/collaboration of both scientists and civil protection with JRCC.

Through the use of questionnaires and surveys we have investigated the effectiveness of the new methods as they have been put into practice during the Bárðarbunga/Holuhraun eruption. Analysis of the results of these investigations demonstrates that the FUTUREVOLC project has made a significant contribution to communications in support of risk management. The outputs have been considered useful and informative by the great majority of users in Iceland and beyond.

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Introduction

This is the third report for the ‘Supporting risk management and communication’ work package in the FUTUREVOLC project. FUTUREVOLC is a research project and the role of this work package is to directly support the roles of operational partners including the Icelandic Met Office (IMO), the National Commissioner of Icelandic Police (NCIP) and the UK Met Office (UKMO), all of whom are also research partners in work package 3. The FUTUREVOLC project provides the research space and time to develop methodologies, generate evidence and invest in the collaboration needed to ensure that operational activities benefit in a timely manner from aligned research.

Through the course of the project, the institutional members of this work package have a) developed methods and strategies that will support the risk management process in Iceland and in Europe, b) enhanced collaboration and communication techniques between research and operational partners within the FUTUREVOLC project, and c) enhanced communication strategies about volcanic unrest, eruptions, hazards and risk within and beyond Iceland.

The project has been fortunate in that there was a significant period of volcanic unrest and subsequent eruption from August 2014 to February 2015 which enabled new methods and approaches to be developed and tested during a real emergency rather than just ‘in theory’. All of the primary objectives have therefore been met and we have also secured evidence that the FUTUREVOLC project has effectively supported risk management and communication in practice. In this report we consider ‘best practice’ to be a tried and tested technique or methodology based on research and experience that produces excellent outputs and outcomes.

Chapter 2 starts by outlining the broad range of activities that have been implemented and supported by the project relating to ‘supporting risk management and communication’ and that, in the context of Iceland and its volcanoes, we consider to be ‘best practice’. In Chapter 3 we present the results of a short questionnaire circulated among the research members of the FUTUREVOLC consortium and designed to capture information about how the project has changed their approach to communication of their research. In Chapter 4 we present a timeline analysis designed to demonstrate the improvements that the operational partners of the FUTUREVOLC project have made to their communication methods through the course of the project. Chapter 5 focuses on the newly designed ‘Factsheet’ that is now issued by the Scientific Advisory Board in Iceland during unrest and eruptions. A questionnaire exploring the effectiveness of the report during the Barðarbunga/Holuhraun eruption provides evidence that the new format is useful and used by stakeholders. Chapter 6 goes on to describe the implementation of reporting measures between Iceland and the ERCC. In Chapter 7 we review the features of communication implemented and supported during the FUTUREVOLC project that we consider to be ‘best practice’ and summarise the evidence for that and whether we are achieving our work package 3 objectives:

O3.1 Establish a framework for effective coordination and communication across Europe before, during and after volcanic unrest/eruption.
O3.2 Develop the state-of-the-art in crisis communication between scientists and civil protection agencies during volcanic crises includingcross-border affected countries, establish best practice.
O3.3. Provide the necessary platform and tools to facilitate on-going hazard and risk evaluation during volcanic unrest/eruption.
O3.4 Establish lessons learned from past eruptions and analyse the risk management process on an on-going basis.

1. Best practice in the dissemination of scientific data and information from the scientific community to stakeholders

Here we describe innovative activities that have been facilitated and supported by research in the FUTUREVOLC project and can be described as 'best practice'. In this report we define 'best practice' as follows:
'A best practice is a methodology that, through *research and experience*, has proven to lead to reliable, useful results.' Best practice should use all the relevant knowledge, technology and experience that is available to ensure success. Importantly 'best practice' as used in this report is not the same as '*the best* practice', we assume that best practice can continue to evolve and improve as new knowledge, experience and methods are acquired and developed.

The following activities and products could certainly be described as 'best practice' based on the contributions of FUTUREVOLC research, technology and eruption experience in their development. The feedback of users and FUTUREVOLC members (see chapters 3-6 for further detail and results) also implies that these tried and tested methodologies are producing useful, useable and valuable outputs.

2.1 Joint reporting and the new daily 'Factsheet'

The IMO and University of Iceland issued joint daily status reports as the unrest at Barðarbunga developed in August 2014. This integration of 'operations and research' demonstrates from the outset that the very best scientific advice, expertise and technology at the disposal of these institutions, is being used to update authorities and the public. These two institutions enjoy closer collaboration as a result of the FUTUREVOLC project (see Chapter 5).

The reports contain a range of information including: a) observations of the visible plume (acknowledging that there can be plumes and dispersal of ash before a magmatic eruption has occurred), b) evidence of subglacial meltwater, c) eruption site observations, d) monitoring results and, importantly, e) an overall assessment (interpretation) and forward look.

As the situation escalated in 2014, daily meetings of the Scientific Advisory Board (SAB) for volcanic eruptions in Iceland began on 25th August 2014. The SAB is a group of experts derived from multiple institutions and able to provide advice to the National Crisis Coordination Center (NCCC) during emergencies. From 25th August 2014, the SAB comprising staff members from University of Iceland, Icelandic Met Office and NCIP (and other institutions) met daily and produced an expanded daily report (a 'Factsheet') issued by NCIP. The design and content of the report is based partly on the results of FUTUREVOLC research (see Heiðarsson et al. 2014 (D3.1 – 'lessons learnt') and Heiðarsson et al. 2015, D3.2) and partly on the ongoing informal and formal feedback of users and effective collaboration between the key institutions. For example, these new format reports now also contain possible scenarios for future development of the situation. The inclusion of these short term scenarios that are considered most likely by the SAB is quite novel and responds to an expressed need from users (D3.1). This adds considerable expert value to the report whereas many volcano monitoring institutions worldwide simply report monitoring data and results with minimal interpretation. The reports were distributed widely across Europe and beyond.

2.2 Gas hazards and forecasts

Gas emissions and hazards are often overlooked when people consider planning for volcanic eruptions. This may be because gas hazards leave little long-term evidence of their former presence unlike, for example, lava flows or lahars. Gas emissions can vary significantly in magnitude and emission rate and such parameters are very difficult to anticipate or even measure during an eruption. Gases can lead to very significant impacts and at the highest concentrations can cause fatalities of people, livestock and wildlife. Even low concentrations can cause respiratory difficulty for sensitive individuals (Weinstein et al. 2013). Gases (in particular sulphur dioxide) may be oxidized in the atmosphere to aerosols (particulates) causing air pollution (sometimes referred to as 'vog' in Hawaii). Gases and aerosols may also react with water molecules in the atmosphere to produce 'acid rain'. One of the most infamous eruptions that generated severe impacts in Iceland as a result of gas and ash emissions was the Laki eruption in Iceland in 1783-84 (Thordarson and Self, 1993). This eruption also caused far-field impacts in Europe and beyond (Thordarson and Self, 2003), see D3.3. Mitigation measures can be taken against gases, aerosols and acid rain, for example, advice can be issued to stay inside, wear a mask and sensitive individuals can be advised to carry an inhaler. Hosing down of exposed surfaces (e.g. vehicles) can reduce the likelihood of corrosion. Therefore anticipation, forecasting and early warning is worthwhile.

Gas emissions (mainly sulphur dioxide) and the cascading hazards described above became the dominant problem for Iceland during the Barðarbunga/Holuhraun eruption. IMO (working with the Scientific Advisory Board) responded by developing innovative new methods to plot very simply a short-term forecast (hours) of the dispersal of gases from the eruption site (see Heiðarsson et al. 2015, D3.2). This forecast, combined with effective communication through multiple sources some of which were established as a result of the FUTUREVOLC project (e.g. social media), enabled short term planning and evasive action by authorities and communities. In addition, the Scientific Advisory Board produced information and guidelines about the health impacts of gases (http://www.ivhhn.org) based on WMO and international guidelines but tailored for local communities. Recommended actions for mitigating the impacts of gas were communicated by NCIP with the support of the Icelandic Environment Agency and international experts.

For longer term planning and hazard assessment, BGS and UKMO led work during the course of the FUTUREVOLC to develop an eruption scenario based on the Laki 1783-4 eruption (large magnitude fissure eruption) and its far-field impacts (mainland Europe).

The FUTUREVOLC project has therefore enabled the consideration of gas as a hazard to be developed on many fronts (monitoring, forecasting, early warning, source parameterization, dispersal modeling, hazards assessments in the near and far-field and impacts).

2.3 Alert levels and scientific decision making

During the course of the FUTUREVOLC project, IMO has introduced the use of alert levels for volcanoes, in particular the Aviation Colour Code (ACC). Changes to alert levels are now automatically communicated by email, text, website and social media using text, tables and maps based on lessons learned in 2010 and 2011 (Deliverable D3.1).
The scientific decision-making required to make these changes is different for each volcano and situation so IMO have also introduced decision-making protocols and thresholds to ensure that the process is as rigorous as possible. The thresholds are based primarily on past eruptions of a particular volcano and knowledge of the patterns and changes in monitoring data and observations before eruptions/hazardous events. Awareness of events at other volcanoes in Iceland and worldwide is also taken into account, particularly in accounting for uncertainty. As knowledge and experience is gathered and documented (e.g. in the Icelandic catalogue) these protocols and thresholds can be modified

2.4 Event trees and expert elicitation

IMO has further progressed the goal of better characterising volcanic threat by developing 'event trees' for Katla and Barðarbunga volcanoes with further plans for Hekla, Grimsvötn and Reykjanes volcanoes. Event trees are some of the basic tools needed to support the quantitative assessment of short and longer term hazards and are thus an essential factor in attempting to quantify risks at volcanoes (e.g. Newhall and Hoblitt, 2002; Sparks and Aspinall, 2004). Event trees enable scientists and authorities to explore possible future eruptive scenarios and their likelihood – most importantly, volcanoes are highly dynamic (non-linear) so these likelihoods will change on different time scales. Having the ability to elicit opinions from scientific experts for the long term and in close to real-time is a very useful tool to support both scientific decision making and the decision making of authorities and communities. The work on event trees has been funded by ICAO and the Iceland government but is highly complementary to the objectives of FUTUREVOLC. It also complements the procedures at NCIP for dealing with natural hazards risks.

The branches of event trees need to be populated with probabilities and these values are usually acquired (along with attendant uncertainties) through expert elicitation. An expert working group has been nominated and 'calibrated' to use the 'Cooke Method' of elicitation (e.g. Aspinall et al. 2013). The expert group are also members of the Scientific Advisory Board for the Icelandic Civil Protection. They are thus developing standardised language and approaches to deal with unrest, eruption and uncertainty on a variety of time scales. The scenarios considered in near real-time are also communicated in the daily Factsheet during eruptions (see 2.1).

2.4 Communication methods

Following the eruption of Eyjafjalljökull in 2010, the IMO was applauded for its policy to make automatically processed monitoring data (especially seismic data) available online on its website in near real-time (see Deliverable D3.1). This willingness to embrace open access and transparency has been built upon during the FUTUREVOLC project and the communication of NCIP, IMO and the University of Iceland are now also highly complementary. Developments have included an enhanced use of email alerts, and SMS texts by IMO, coordinated use of Facebook and Twitter by NCIP and the near real-time reporting of research activities and results by the University of Iceland (for the primary purpose of supporting effective risk management).

This extraordinary near real-time availability of information during volcanic unrest and eruption has transformed the ability of stakeholders including regulators, governments and scientists to respond across Europe. It is also used by individuals and communities in Iceland to make risk-based decisions and individuals further afield are using the information to support their decisions concerning travel. The evidence for the transformative effect of this communication is presented in Chapters 3-5 and will be developed further in Deliverable D3.4.

There are potential risks in embracing such an open approach but these have been acknowledged and are dealt with as they arise. For example, scientific opinion can change quickly during a dynamic and rapidly evolving crisis situation, for example, on 23rd August 2014 it was unclear whether a subglacial eruption had started or not http://en.vedur.is/earthquakes-and-volcanism/articles/nr/2970). A report was issued in the morning stating that a subglacial eruption may have begun (based on monitoring data) but by the afternoon additional evidence acquired suggested that no subglacial eruption had begun. It might be assumed that a situation like this might be damaging to institutional reputations, in fact, evidence suggests that in this case the very honest and transparent approach enhanced the reputation of scientists. Another potential risk is that monitoring data made available in near real-time is published by third parties. Unfortunately independent researchers can misunderstand the reasoning behind making preliminary data available and assume that it is an invitation to use the data without consultation. Permission should of course always be sought before using the data of others in research.

2.5 Emergency Response Coordination Centre (ERCC)

NCIP is also working more formally with the Emergency Response Coordination Centre (ERCC) in Brussels, enabling scientific advice derived from the SAB to be delivered to civil protection agencies across Europe. The lessons learned from Eyjafjallajökull, Grímsvötn and now Bárðarbunga have been acted upon to improve communication, cooperation, collaboration between volcanologists and civil protection officials in Iceland and their counterparts in Europe; and ultimately to reduce volcano risk in Europe and enhance preparedness for such events.

a) NCIP attended the 4th Civil Protection Forum in 2013 where the first questionnaire (D3.1) was distributed. They attended the 5th Civil Protection Forum in 2015 with IMO and updated participants on FUTUREVOLC and progress and distributed a second questionnaire to assess the effectiveness of the improved communication methods adopted during the Bárðarbunga unrest and eruption (see the results in Chapter 5).
b) This questionnaire included a series of questions specifically about the use of social media.
c) A year long project has been completed in the UK (funded by the UK government and coordinated by the UK Civil Contingencies Secretariat of the Cabinet Office) in which the Laki 1783-84 eruption scenario has been modelled to investigate likely peak concentrations of SO_2 and aerosol that could affect the UK. This work demonstrated that levels of SO_2 in the UK during such a scenario could reach hazardous levels under certain meteorological conditions. Key researchers included UK Met Office and BGS staff also participating in FUTUREVOLC WP3 – this enabled coordination between the projects. The results, which actually cover all of Europe (with FUTUREVOLC in mind), are now available in full on the website of the UK Met Office http://www.metoffice.gov.uk/research/news/2016/effusive-eruption-hazards
d) The UK CCS carried out a series of meetings with civil protection in other European nations (e.g. Iceland, Norway) to share the outcomes of the study and to encourage coordinated planning for such scenarios. A key point is that gas emissions are a significant hazard in Iceland requiring enhanced focus but the potential hazards from gas, aerosol and acid rain also extend across Europe and during large magnitude eruptions may have subsequent hemispheric or global impacts. Again, hazards arising from gas emissions are often overlooked as the common focus is on volcanic ash.
e) The UK CCS hosted the First Scientific Seminar of the Knowledge Centre for Disaster Risk Management (KCDRM): Science for Policy and Operations in London and this was an opportunity for scientists and civil protection to discuss the outcomes of the FUTUREVOLC project and joint activities for the future. NCIP and IMO contributed directly to the opening seminar given by JRCC.

2.6 Summary

There has been significant innovation and progress during the FUTUREVOLC project and the evidence presented in the following chapters demonstrates that project has facilitated and enabled much of this progress. It might be asked whether some of this progress and innovation might have happened anyway following the events of 2010 but we also present evidence that without the research time and collaboration space provided by the FUTUREVOLC project, such progress might have been considerably more challenging and not as timely.

2. Scientific Advisory Board Factsheet Survey

3.1 Introduction

During the volcanic unrest and eruption at Bárðarbunga/Holuhraun (August 2014 – February 2015) the Scientific Advisory Board of the Icelandic Civil Protection (NCIP) had around 100 meetings to discuss unfolding events and issue reports and advice. Notes from these meetings where first distributed through the IMO web site and special IMO email lists (volcanic-info established in 2010) that had been previously prepared for disseminating volcanic information. Status reports were also sent out by the NCIP to a number of mailing lists and were posted on the NCIP web site.

As the event progressed, information was standardized into the Scientific Advisory Board Factsheet, which was ultimately sent in English to 377 email addresses and in Icelandic to 397 email addresses, including the volcanic-info mailing list operated by the IMO. The daily factsheet contents were the result of a combination of research (lessons learned), knowledge of user needs and experience from IMO, University of Iceland and NCIP.

In the first week of May 2015 an online survey was sent through the same mailing lists, both in English and Icelandic, to research and explore the distribution, impact of and acceptance of the factsheet. The survey was only sent out once without any reminders. We received 120 responses to the English survey and 109 to the Icelandic one.

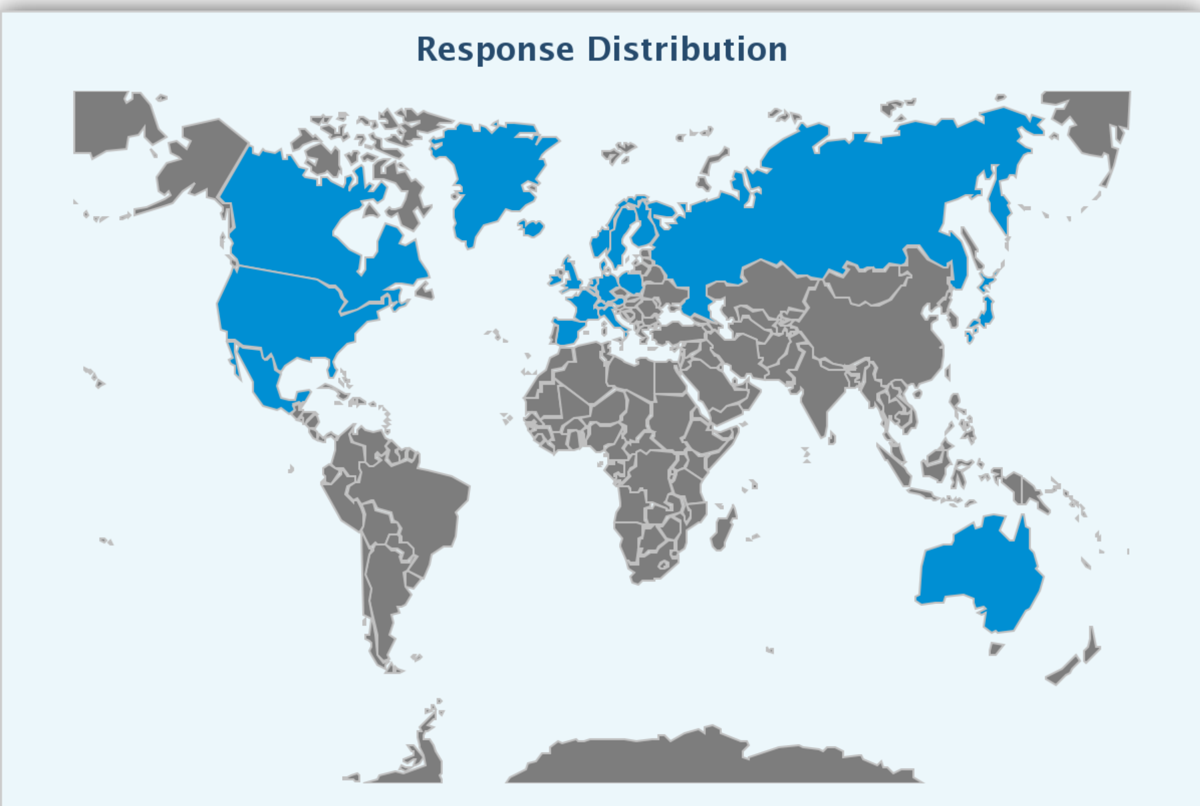

__Figure 1__: Country of origin of participants in the English language survey.

Responders to the survey are mainly from countries in the northern hemisphere with the addition of Australia (**Error! Reference source not found.** 1). The largest group of responders came from the UK, then Iceland, Germany, Norway, Sweden, Japan, Italy, Belgium, the United States, the Netherlands, France, Denmark and Canada, in this order.

3.2 Results of the survey

Here we present a summary of the main findings, mostly focused on the results of the English survey which represents the European and international responders but it is worth stressing that the findings of the Icelandic survey are in agreement with the English one. A version of the survey was also distributed through Twitter on #Bardarbunga and #Holuhraun but we only received 25 complete responses through this medium, that survey will thus not be discussed further here but results were also similar.

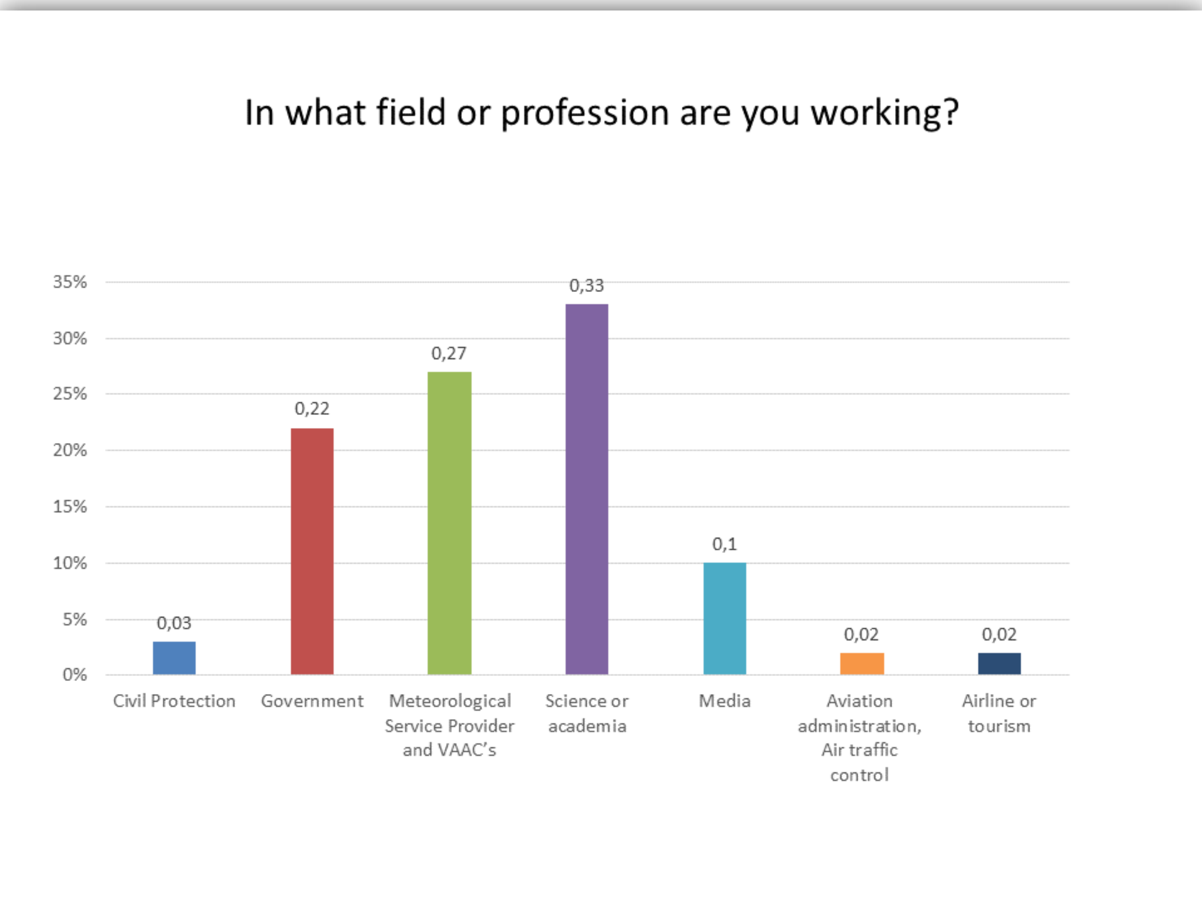

***Figure 2**: Profession of survey participants.*

The profession of the responders can be seen in Fig. 2. Most responders (33%) come from science and academia, 27% from the meteorological sector, 22% work in government, 10% in media and 3% in civil protection. The aviation and tourism sectors only make up 4% of the responders, which may be explained by the insignificant affect the event had on this sector compared to the 2010 and 2011 eruptions. This division between the sectors is quite different in the Icelandic version of the survey where the civil protection (including police and search and rescue) is 28%, government 25%, and science and the meteorological sectors combined are 30%. This is of course explained by the fact that the event took place in Iceland.

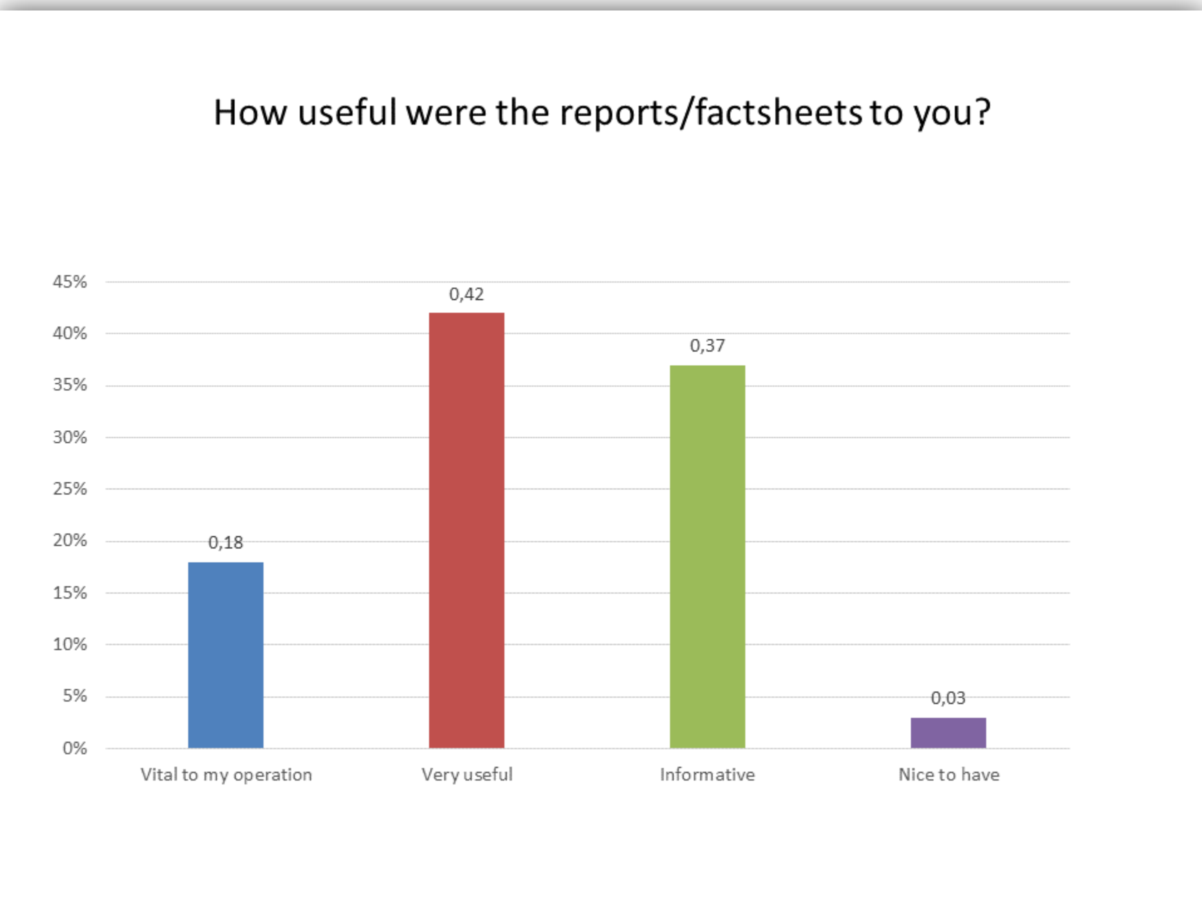

Figure 3*: Survey results showing evidence that the factsheets were considered very useful and informative.*

We asked if the factsheets were useful to the responders and both in the Icelandic and the English survey we got 100% yes. In the follow up question we asked how useful the factsheet were as can be seen in Fig. 3. 18% said the factsheets were vital to their operation, 42% said it was very useful and 37% described it as informative. Only 3% considered the Factsheet simply 'nice to have'. From these responses one can conclude that the factsheet is appreciated, useful and useable.

The responders were asked if they disseminated the factsheet further and results can be seen in Fig. 4. 62% of the responders did disseminate the factsheet further while 38% did not. 35% shared the factsheet with coworkers, and 16% with other institutions and organizations. 11% selected the 'other' option and when asked to clarify the answer most of them said they disseminated the factsheet on web sites, media, and social media or used it as source material for their own reports.

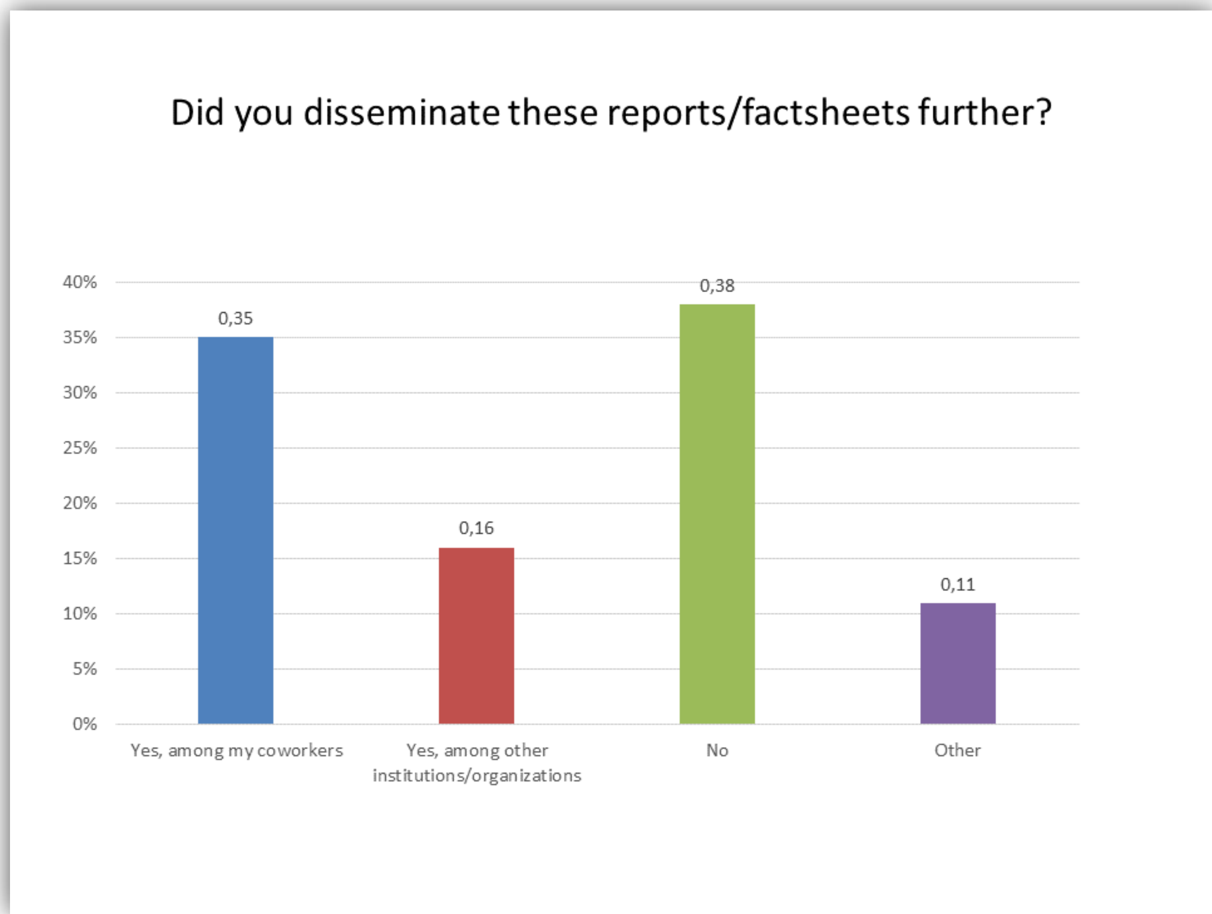

***Figure 4**: Survey results showing evidence of substantial onward dissemination of the factsheet.*

We also asked specifically if the responders used the factsheet as source material for their own publications and reports. More than one third (38%) of the responders said they did and 62% that they didn't. When asked further about the nature of these publications 37% said it was for government (53 responders), 35% used it for internal reports, 13% used it in the media, 4% for research and 11% for other kind of publication.

According to the survey, 62% of the English speaking recipients distributed the factsheet further among coworkers and other institutions. The same number from the Icelandic survey was 41%. A breakdown of the distribution can be seen in **Error! Reference source not found.** 5 which shows that 77% sent the factsheet to between 1 and 10 individuals or institutions, 7% sent the factsheet to between 11 and 20, 3% sent it to between 21 and 50, 5% to between 50 and 100 and 8% sent it to more than 100. By calculation the total number of recipients of both the English and Icelandic factsheet is therefore at least *over 8000*, or more than ten times the original circulation.

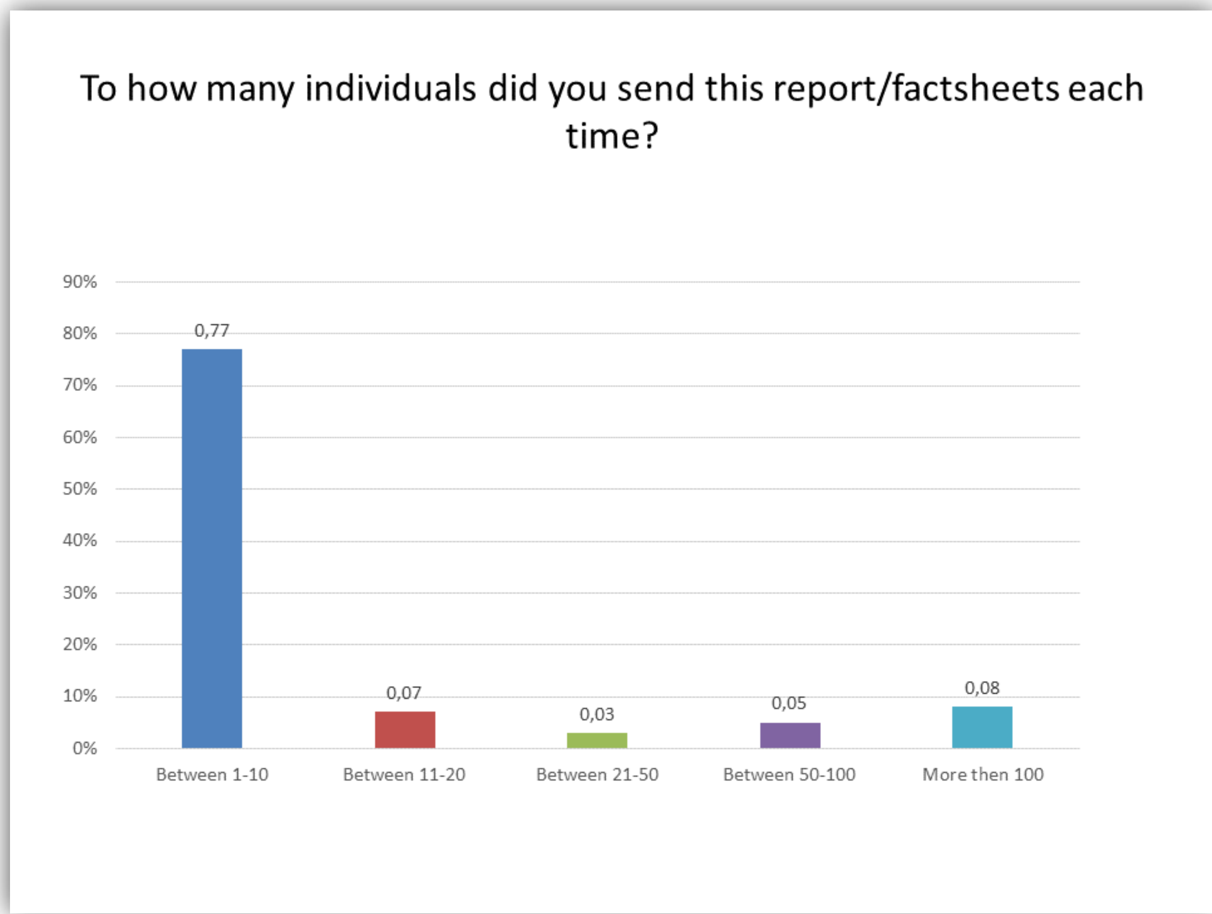

Figure 5*: Survey results showing evidence of onward dissemination to multiple stakeholders.*

In this calculation, we did not take into account dissemination via social media such as Twitter and Facebook, traditional media and secondary reports that were based on the factsheet. This increases the distribution further.

The Bárðarbunga/Holuhraun eruption was also quite well covered, or reported, on Twitter as was described in FUTUREVOLC report D3.3 (Heiðarsson, Loughlin, Witham, & Barsotti, 2015). The hashtags (#) Bardarbunga and Holuhraun were both widely used and are in fact still active.

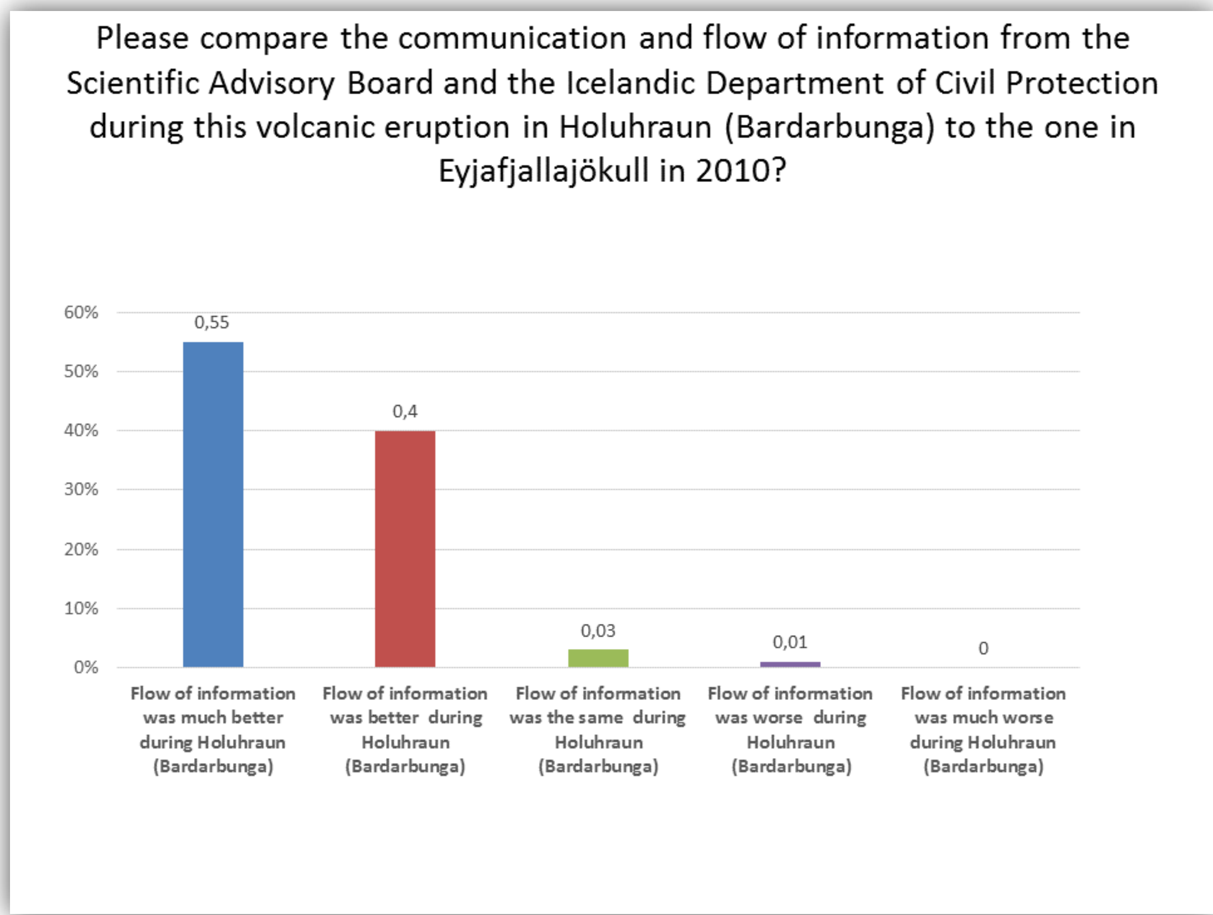

***Figure 6**: Comparing flow of information during the volcanic eruptions at Bárðarbunga (2014-15) and Eyjafjallajökull (2010.*

In the next part of the survey we aimed to investigate whether there had been a perceived improvement in the flow of information as compared to the Eyjafjallajökull and Grimsvötn eruptions in 2010 and 2011. We first asked the responders if they had worked in their field during the Eyjafjallajökull eruption in 2010 to which 58% confirmed. Then we asked that group to compare the communication and flow of information in the Bárðarbunga event to the flow of information during the Eyjafjallajökull eruption in 2010. The results can be seen in Fig. 6., 95% of the responders thought flow of information was either much better or better during the Bárðarbunga event then in the Eyjafjallajökull event. A small proportion, 3%, thought flow of information was the same and only 1% thought the flow of information was worse during the Bárðarbunga event than in Eyjafjallajökull.

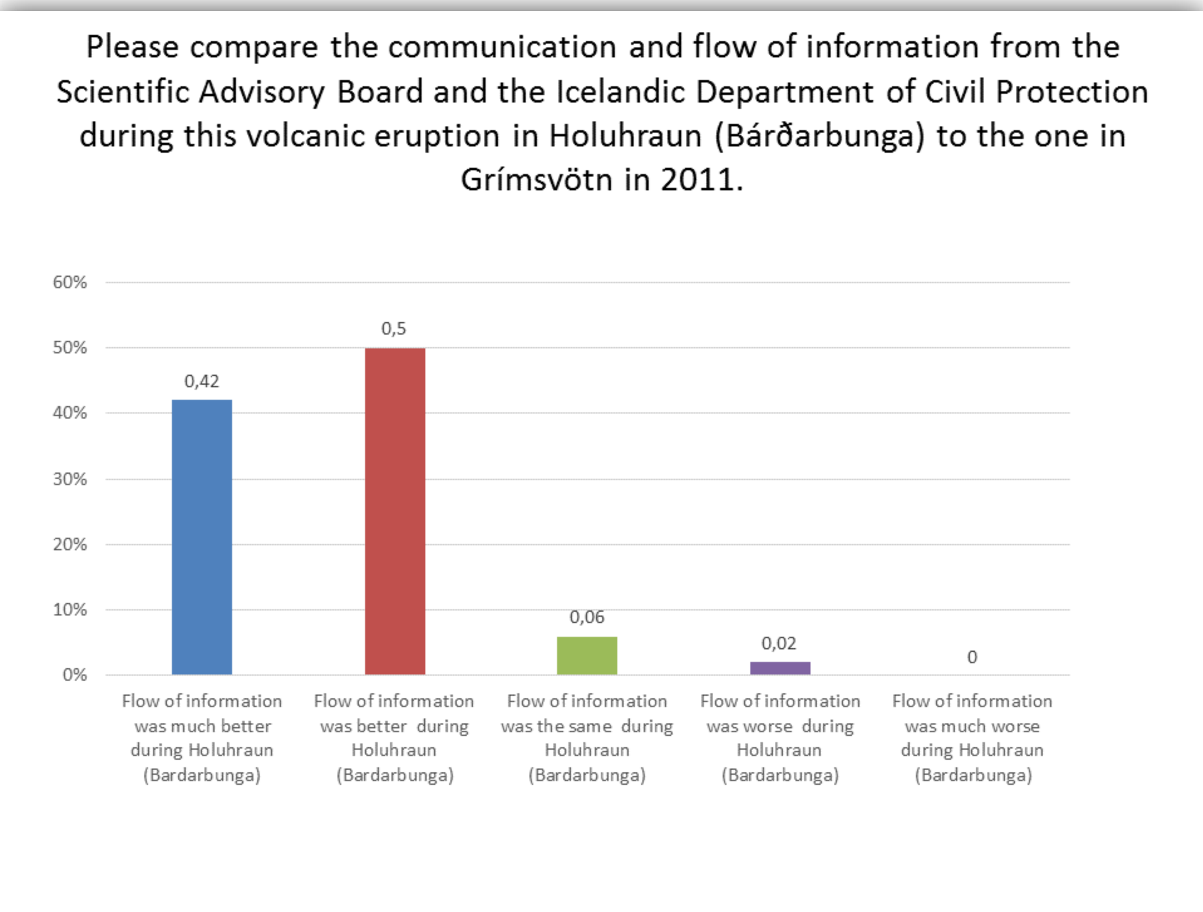

***Figure 7**: Comparing flow of information during the volcanic eruptions at Bárðarbunga (2014-15) and Grímsvötn (2011).*

We also asked our responders to compare communication and the flow of information during the volcanic eruptions at Bárðarbunga (2014-15) and Grímsvötn in 2011. A significant 53% of the responders to the English survey worked in the same field during the Grímsvötn eruption in 2011 and that group was asked to compare the two events. The findings are in harmony with the comparison between Bárðarbunga and Eyjafjallajökull (Fig. 7), although one can detect an improvement from Eyjafjallajökull to Grímsvötn. Still, 92% of the responders thought the flow of information was either much better or better during the Bárðarbunga volcanic eruption than during the volcanic eruption in Grímsvötn in 2011. 6% thought the flow of information was the same and 2% thought the flow of information was worse during the Bárðarbunga eruption than during the eruption in Grímsvötn.

The main findings of the survey are very positive and responses to both open and closed questions suggest that the factsheet was highly appreciated, widely used, distributed further, and was generally seen as great progress in volcanic risk communication compared to during the Eyjafjallajökull and Grímsvötn eruptions.

3. Communication of FUTUREVOLC research partners

4.1 Introduction

In order to ensure that the very best scientific advice is passed on to decision-makers, especially civil protection, in the most timely manner, the ideal is perhaps not just to consult the scientists in one institution but to also draw on the knowledge, experience and expertise of a wider research community. The FUTUREVOLC project has aimed to put this theory into practice by engaging 23 research partners in 10 countries with diverse skills and providing formal and informal methods by which they can communicate with operational partners (IMO and NCIP) in real-time if necessary. The project was at the outset designed to build a collaboration of relevant researchers in Europe who appeared to have the most to offer scientists and risk managers in Iceland (based at least partly on collaborative experiences and learning during the Eyjafjallajökull and Grímsvötn eruptions). In most cases there had been pre-existing relationships between the European researchers and Icelandic scientists and institutions. In order to build a cohesive consortium, engender trust and a willingness to collaborate and cooperate in real-time, strong project management, data management and excellent project communications were required. These aspects are discussed in other work package deliverables. The diverse collaborative research outputs achieved by FUTUREVOLC are also presented elsewhere. Here, we focus on whether decision-makers, and civil protection in particular, have benefitted from the collaborative research and science outputs developed in FUTUREVOLC. The hope was that development of such a large network should, by definition, greatly expand the horizons, opportunities and experience of all members of the consortium but should in particular enhance the flow of useful and useable science to decision-makers through enhanced collaboration and understanding of needs.

In this chapter we investigate what has been communicated and how it has been communicated. We investigate whether or not the FUTUREVOLC project has enhanced the ability of research scientists to share their knowledge effectively and ensure useful outputs reach operational partners. Knowledge might include monitoring data, observations, analysis, interpretation or opinion. We investigate how such information is communicated and whether scientists have a good understanding of what is needed in order to achieve optimal support for risk management (e.g. as performed by civil protection). The investigation uses a survey to seek examples of good practice and recommendations for improvement.

4.2 Survey on communication of FUTUREVOLC researchers

The survey was designed for all FUTUREVOLC research partners to study changes in communication methodologies and perceptions of changes in communication during the lifetime of the research project (Appendix 2). In particular, we aimed to capture the differences that the FUTUREVOLC project has made to communication and the time frame over which such changes may have occurred. The survey complements a timeline analysis presented in Chapter 6. The survey was designed to ensure maximum uptake and included ten subject questions plus two background questions. After a design period involving discussions by members of Work Package 3, the questionnaire was sent out on 1st September 2015 to 23 research partner organisations. Ultimately, 19 of the 23 partners replied.

4.2.1 Survey results

Of the 19 FUTUREVOLC partners who responded, 17 had some prior history of doing research in Iceland before the FUTUREVOLC project and had already established some cooperation with either IMO or UI. However, only 9 of these partners had responded in near-real-time to a volcanic eruption in Iceland prior to the project. In all cases except one, this response was during the Eyjafjallajökull (2010) and/or Grímsvötn (2011) eruptions (in other words at least 10 FUTUREVOLC research partners had no previous experience of responding in real-time to eruptions in Iceland). The University of Iceland is the exception in the survey as it has responded in near-real-time to every eruption in Iceland since 1947 although it has no mandate to do so. The cooperation between IMO and the UK Met Office began with the establishment of the VAACs in the mid-1990s.

The 17 partners with previous research experience in Iceland were then asked if FUTUREVOLC had led to a change in the communication methods used with collaborating research partners in Iceland (frequency, timeliness, value, quality, usefulness, usability). Two out of three said yes and one third no. Communications were described as more frequent and more direct, as well as being more personal and interactive than before the project.

When those who had no prior experience of doing research in Iceland were asked if FUTUREVOLC has changed the way their research is communicated, they reported that through FUTUREVOLC they have established new contacts in Iceland and are now sharing data and results regularly with Icelandic scientists and institutions.

We asked if research partners have communicated collaborative research outcomes with external (to FUTUREVOLC) scientists or non-scientists during the course of the project. Only one of the participants did not respond positively to this question (some of this is documented in detail by WP9). Almost all FUTUREVOLC partners are sharing and communicating research with a wide variety of external institutions and stakeholders such as the media, the aviation sector, the general public, academia, civil protection and government. The methods of communication are also diverse, such as in printed and broadcasted media, through social media and video, in academic journals and conferences and during either open or closed meetings with stakeholders.

We asked our partners to give a short description of tools or methods (e.g. visualisation, modelling tools, and social media) that have enhanced their communication of science during FUTUREVOLC. Eight partners gave some examples of communication tools which can be divided, based on their purpose into three types: a) project communication (e.g. Basecamp project management platform), b) risk management and early warning communication (e.g. the NCIP SAB Factsheet, the

FUTUREVOLC SMS Alert System that was developed in the spring of 2014 and tested during the FUTUREVOLC Exercise, and later used during the Bárðarbunga eruption), and c) research communication/visualisation tools (e.g. PlumeRiseQH, Python Packages, GMT and Spacefem3D). We got 9 negative answers to this question, meaning that the partners had not developed any *new* communication tools during the project.

We also asked our partners to describe uncertainties in their line of research and how these uncertainties have been communicated. All partners reported on uncertainties in their research and gave a number of examples. The question about how to communicate these uncertainties produced the most diverse responses, with some responders considering uncertainty as mainly a research issue. The project researchers are certainly embracing uncertainty and a number of papers have been published on the topic (e.g. Woodhouse et al. 2015). For those researchers called upon to communicate uncertainty in near real-time, methods to reduce uncertainty were described (e.g. for monitoring data), others described the use of a range of values to represent uncertainty (with 5 % and 95% confidence given), error-bars, probability maps of errors and finally disclaimers.

In the next question we asked our partners to give examples of good practice in communication between scientists or between scientists and other groups such as decision makers, government and authority, *during the FUTUREVOLC project*. In general, communication is considered by participants to have been good during FUTUREVOLC. Examples of good practice, each listed by several responders include: the Bárðarbunga Factsheet; the AGU and EGU FUTUREVOLC meetings with coordinated sessions; the SMS Alert System; the IMO Aviation Colour Code map and weekly reports; data sharing through the FUTUREVOLC hub; cooperation between IMO and NCIP; the IMO live seismic plot on Bárðarbunga; the MILA web-cams (available on the IMO website), and the IMO gas forecasts.

Next we asked our partners if they had been involved in any other projects or initiatives that deal with early warning systems, monitoring eruptions, observation and analysis of volcanic products, hazards or risk. Ten partners answered positively showing that through FUTUREVOLC there are connections with many relevant projects across Europe. The projects mentioned were: NOVAC; NEMOH; Grandi Rischi; MED-SUV; IsViews; STREVA; RACER; NORDRESSS; VETOOLS; NEPHRA – Nordic and North European Crisis Communication; CREDIBLE; APhoRISM; VANAHEIM; AVOID, ARISTOTLE, International Forward Look, Global Volcano Model, Ascension Island project and 'Looking into continents from space', there are also a number of funding platforms from which some of these projects arose e.g. PURE, Increasing Resilience to Natural Hazards.

Next we asked our partners to compare communication today with before the Eyjafjallajökull eruption in 2010 a) between scientists and b) between scientists and decision makers, government and authorities. According to our FUTUREVOLC partners, communication between scientists has somewhat improved during the project and also communication between scientists and civil protection and decision makers. Several suggested that on this time frame, the great factor may though have been the

Eyjafjallajökull eruption rather than the FUTUREVOLC project. The FUTUREVOLC project has provided a vehicle with which learning acquired during the Eyjafjallajökull eruption can be applied collaboratively to benefit Europe as a whole. The NCIP believe that they have much better connections with scientists in Europe as a result of the FUTUREVOLC project.

Finally we asked our partners how communication (between and from researchers) could be improved further based on learning from the Bárðarbunga eruption. Here are some of the suggestions:

1) by using special web pages (not social media);
2) by using closed Twitter accounts or feed;
3) strengthening communication between scientists and decision makers during 'peace times' to create trust and knowledge;
4) developing the FUTUREVOLC SMS system further;
5) by using the blog better;
6) improving access for foreign scientists and new scientific knowledge to the decision making process during volcanic events;
7) securing the continuation of the FUTUREVOLC consortium, and a dialogue between partners after FUTUREVOLC ends;
8) secure data sharing during eruption.

4.2.2 Analysis

As a result of this survey we can confidently say that of the 17 partners who had experience of carrying out research in Iceland before the FUTUREVOLC project, more than 10 have modified the way they communicate research as a result of the FUTUREVOLC project.

4. ERCC Implementation

The main component of research in work package 3 has been carried out at NCIP (civil protection) and they have led the engagement with civil protection at a European scale. FUTUREVOLC related products and information have been integrated into the European Union Civil Protection Mechanism throughout the project and this is still ongoing. Representatives of NCIP participated in the 4th European Civil Protection Forum early in the project where they distributed questionnaires and engaged the community in establishing lessons learned after the Eyjafjallajökull and Grimsvötn eruptions. In recognition of the importance of integrating science and research outputs into effective civil protection activities, IMO joined NCIP in participation at the 5th European Civil Protection Forum. There were 900 other participants from government, civil protection authorities, first emergency responders, international organisations, European Institutions and stakeholders. A FUTUREVOLC booth was set up in the exhibition area where the project was presented, flyers handed out and questions answered. The booth was well-received and visited by other participants and guests as well as by Director Generals, Christos Stylianides and Claus Sorensen (EC-ECHO, 2015).

Following the forum NCIP and IMO met with representatives of ERCC at the ERCC headquarters in Brussels, on 8th May 2015, to discuss the FUTUREVOLC project and implementation of its products into the European Civil Protection Mechanism 24/7 emergency response coordination operation.
Present at the meeting were:

NCIP:
Víðir Reynisson, Department manager
Guðrún Jóhannesdóttir, Project manager
Einar Pétur Heiðarsson, PhD student
Andri Júlíusson, Icelandic Embassy in Brussels

ERCC:
Olympia Imperiali, ERCC Analytical Group Leader
Ian Clark, Head of Unit, Policy and Implementation Frameworks, EC-ECHO
Christina Brailescu, Policy Officer EC-ECHO
Andrew Bower, Policy Officer EC-ECHO
Marcia Kammitsi, Intern.

Joint Research Centre (JRC), via teleconference:
Tom De-Grove
Alessandro Annunziato
Ioannis Andredakis

NCIP presented the FUTUREVOLC D3.1 report and left a printed version for the ERCC staff. The report focuses on sectoral response to the Eyjafjallajökull eruption with special focus on lessons learned and possible improvements in communication between volcanic monitoring institutions and civil protection in Iceland, on the one hand and ERCC and other key stakeholder sectors in Europe. Other FUTUREVOLC Milestones, relating to ERCC, were also introduced and discussed.

NCIP also presented the Icelandic Volcano Catalogue (www.FUTUREVOLC.vedur.is), which will be a great tool for operators in ERCC during volcanic eruptions in Iceland and especially during the time leading up to an eruption when uncertainty is high and there is a great demand for information. ERCC representatives expressed great interest in the catalogue and asked for hands-on instruction in operating the catalogue for when it is fully operational.

During the meeting it was agreed to strengthen the cooperation between the ERCC and the NCIP on volcanic-related issues such as reporting and registration of data in the EU Common Emergency Communication and Information System (CESIS). The close cooperation between IMO and the London Volcanic Ash Advisory Centre (VAAC) run by the UK MET was acknowledged. Closer cooperation between IMO and JRC was also agreed in recognition of the essential role that volcano monitoring institutions play in establishing source parameters for atmospheric dispersal modelling (models run by VAACs),

It was also decided to add ERCC to the Weekly Volcano Status Report mailing list, produced and distributed by the IMO. The weekly (Appendix 1), is prepared and sent out every Wednesday morning containing a list of every volcanic system in Iceland with GPS position, Smithsonian #, the current Volcano Aviation Colour Code, and short status description. The report also includes a section called Additional notes, where duty officers can write a longer text on the general observations over the last seven days and put it into context with background information of a specific Icelandic volcanic system. The report contains general contact information and a link to an Aviation Colour Code map of Iceland, posted publicly on the IMO website (http://en.vedur.is/earthquakes-and-volcanism/volcanic-eruptions/). The Weekly Volcano Status Report is not yet in very wide circulation at European or global scales.. The document has the potential to become a widespread reference and monitoring document for a range of stakeholder's and sectors who require accurate flow of information about the status of volcanoes in Iceland. Even small volcanic eruptions have potential to cause cascading global impacts across sectors.

At the meeting, representatives of JRC presented the First Scientific Seminar of the Knowledge Centre for Disaster Risk Management: Science for Policy and Operations and the NCIP representative was invited to take a part in a preparation meeting for the seminar, which was accepted. The first meeting of the KCDRM was held in London on November 24-25 2015 and hosted by the UK civil protection (Civil Contingencies Secretariat). A special Break-out group on Icelandic volcanic eruptions was held and FUTUREVOLC research and outcomes were presented and discussed. Outcomes from the seminar can be found at http://drmkc.jrc.ec.europa.eu/knowledge/Meetings/Meeting-2015.

Another outcome of the meeting is an ERCC proposed high level meeting / presentation of the FUTUREVOLC project in Brussels in spring 2016. This idea has been well perceived by FUTUREVOLC management team and preparation is underway.

5. The Timeline

In this chapter we briefly compare, using a timeline method (Sheridan et al., 2011), change, innovation and development in risk management support and communication, within and related to the key operational WP3 partner institutions. In other words we map the best practice onto a timeline to demonstrate that best practice has developed during and facilitated by the FUTUREVOLC project.

All WP3 partners (NCIP, IMO, UI, BGS and UK-MET) were asked to provide a timeline for their institution, listing major changes, innovation projects and development in communications from 2010 to the present (Appendix 3). The year 2010 was selected as a starting point because of the great impact of the Eyjafjallajökull eruption on the European region in terms of recognizing volcanic risk as a potential issue that can affect the region as a whole. The effect of the 2010 eruption does not need to be described in detail here since it has been documented extensively in numerous reports and articles over the years (e.g. Heiðarsson et al., 2014; Miller, 2011; Þorkellsson, 2012; Bolić & Sivčev, 2011) . Nevertheless, it is important that we attempt to identify what innovation and progress may have been made anyway as a result of the events of 2010 and what additional innovation and best practice FUTUREVOLC the project has introduced and facilitated.

Since 2010 we have experienced two more major volcanic eruptions in Iceland, the Grímsvötn eruption in 2011 and the Bárðarbunga/Holuhraun eruption in 2014-2015. The Grímsvötn eruption in 2011 was larger in magnitude than the Eyjafjallajökull eruption (by an order of magnitude) but had a much reduced impact partly because of the much shorter duration. An additional factor was that this more powerful eruption sent material into the stratosphere so aviation impacts, at least, were reduced. The Barðarbunga eruption was a fissure eruption which introduced many to the concept of volcanic gases (especially sulphur dioxide) as a hazard for the first time.

6.1 Civil Protection in Iceland (NCIP)

The FUTUREVOLC project has enabled the NCIP, through the dedicated time of a researcher (Heiðarsson), to fully articulate its needs to scientists from different disciplines, engage closely with scientists from Iceland and overseas in a research environment and act immediately upon the findings of FUTUREVOLC research. In addition, NCIP were the chief architects in the design of the work package so the researcher has enabled NCIP to achieve many of its objectives in terms of ensuring science better supports risk management and communication. The NCIP timeline (Fig. 8) demonstrates clearly that the FUTUREVOLC project is an element of the long term NCIP strategy which considers both national interests and also international frameworks such as the Hyogo Framework for Action (HFA) and now the Sendai Framework for Disaster Risk Reduction (SFDRR).

The FUTUREVOLC researcher at NCIP has been able to integrate research and practice particularly in terms of communication related to volcanic risk. For example, as a result of the FUTUREVOLC project, NCIP was able to integrate learning from D3.1 into communication practice during the Bardarbunga eruption (the Factsheet). The NCIP was also able to engage proactively with other civil protection agencies across Europe in order to engage them in research and to share the outcomes of the FUTUREVOLC research (4th and 5th Civil Protection fora). This aspect of best practice also included collaboration in these presentations with IMO. IMO and NCIP made joint representations to JRCC and also attended the First Scientific Seminar of the Knowledge Centre for Disaster Risk Management: Science for Policy and Operations together in London (hosted by UK civil protection, the Civil Contingencies Secretariat).

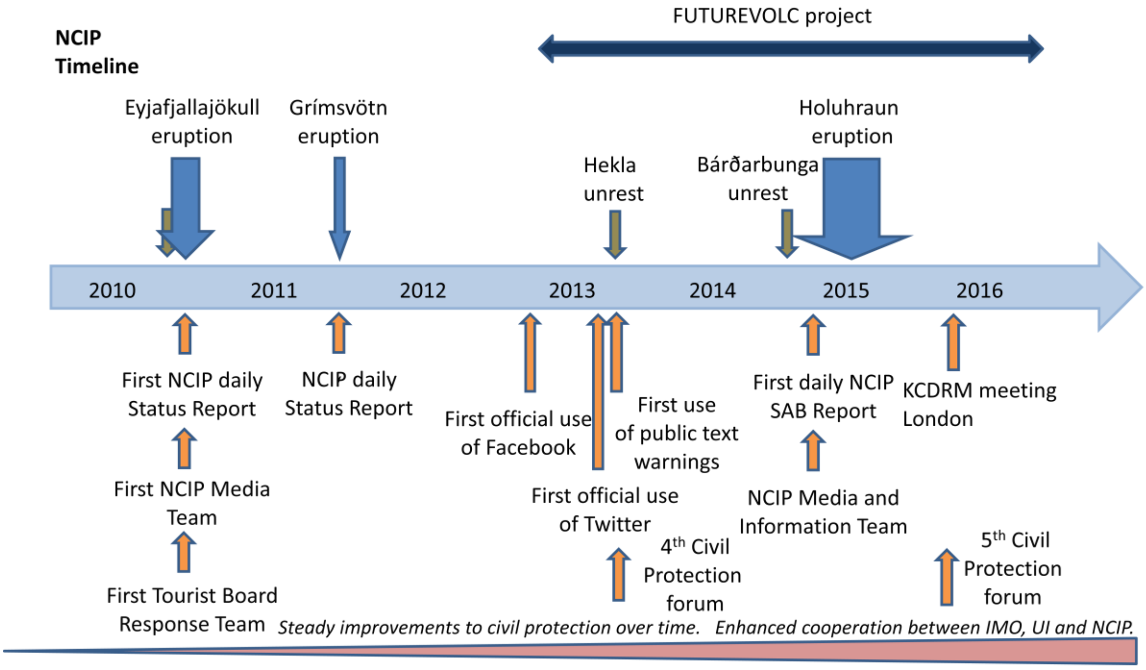

***Figure 8**: The NCIP timeline shows that the FUTUREVOLC project has enabled NCIP to achieve long-term objectives related to enhancing the use of science in volcanic risk management, it has also improved the collaboration between NCIP and the main scientific institutions in Iceland (as well as other operational institutions in Europe such as BGS and UK Met Office). NCIP has had a proactive presence at the Civil Protection forums (2013 and 2015) held during the project.*

6.2 Icelandic Met Office

As the main operational scientific institution in Iceland, IMO is the conduit through which all additional knowledge, information and data on volcanoes should flow in order to reach stakeholders such as civil protection. Like NCIP, IMO are key architects of the FUTUREVOLC proposal (and co-leaders) so the project has enabled them to address key strategic objectives in communication (Fig. 9).

The Icelandic Met Office had a very advanced attitude and approach to information in 2010 and made processed seismic data available online as well as reports, analysis and information on a daily basis. They also hosted the MILA webcams.

All this information *greatly* assisted the appropriate response of overseas institutions such as BGS and hence Cabinet Office (civil protection) in the UK. Collaboration between IMO and the University of Iceland during eruptions has always taken place but FUTUREVOLC has provided additional research time and space to develop this collaboration and mutual understanding. The IMO has always collaborated well with NCIP, and the national response to the Eyjafjallajokull eruption despite being challenging was effective (ranging from collaboration between services and agencies, handling of media, and joint reporting).

The FUTUREVOLC project has again provided the time and space for IMO to engage specifically with some of the science areas of key importance to early warning, source characterisation for ash dispersal modelling, remote sensing observations and integration of all data streams and subsequent interpretation. Research enables the evidence to be collected to support scientific decision-making. Both social and physical science has had such a role in FUTUREVOLC and IMO has engaged fully with the research and outcomes of both. They have enacted changes in communication practice in discussion with NCIP throughout the project and been innovative in response to gas hazards.

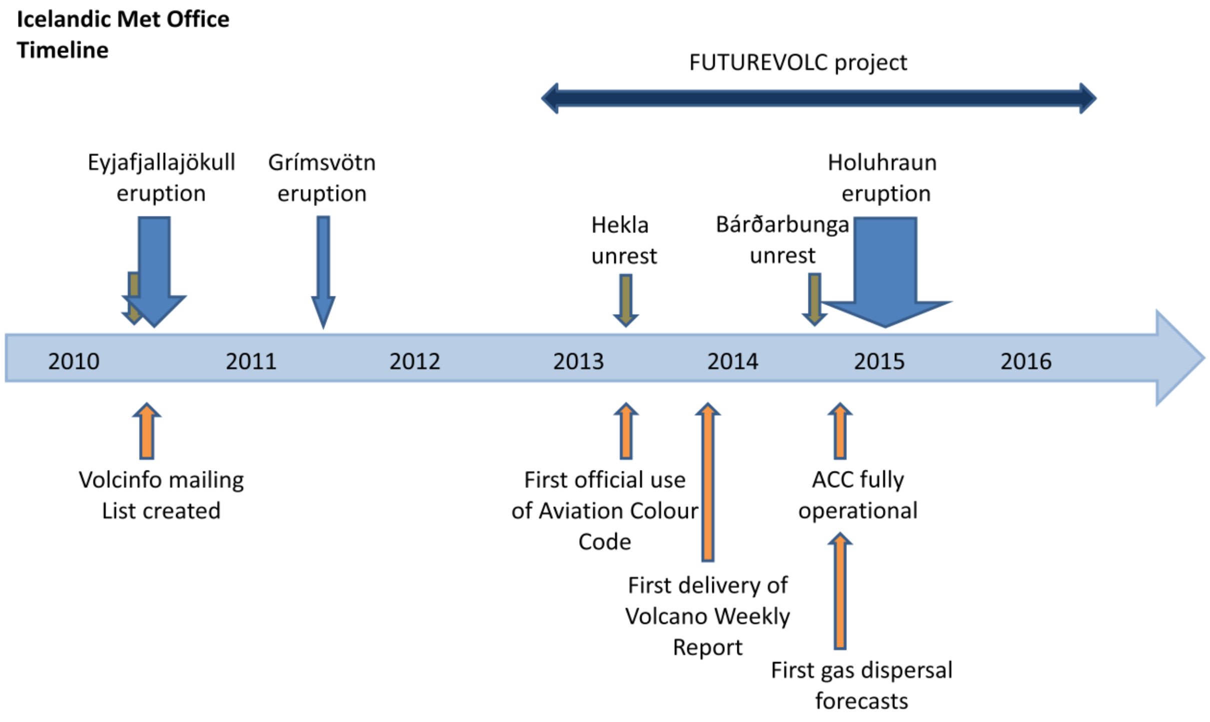

Figure 9*: The IMO timeline The IMO timeline demonstrates the successful introduction of new practices in communication that were strategic objectives facilitated by the FUTUREVOLC project.*

6.3 Academia

The University of Iceland is also a key architect of the FUTUREVOLC proposal (and co-leader) so the project has enabled them and others to address key strategic science objectives. The timeline (which contains only a fraction of the activities in the academic world during this period) suggests that one achievement of FUTUREVOLC is to help maintain the *pace* of scientific advance on topics around early warning, integration of space, air and ground monitoring, source parameters for dispersal modelling and technological advances (Fig. 10). The first peer-reviewed journal publications arising from the Eyjafjallajokull eruption began to be published in significant numbers in early 2012. The FUTUREVOLC project has enabled a sustained integrated research approach to the problems Iceland's volcanoes pose to society encompassing several disciplines from satellite remote sensing to geochemistry and petrology to social science. FUTUREVOLC has organised a number of special sessions at key scientific conferences (e.g. AGU, EGU and others) and the frequency and focus of these events have been described by many members of FUTUREVOLC as another aspect of 'best practice' in communication between scientists. Such a sustained, coordinated and collaborative trans-disciplinary approach to the issues around Iceland's volcanoes could not have been achieved without the FUTUREVOLC project.

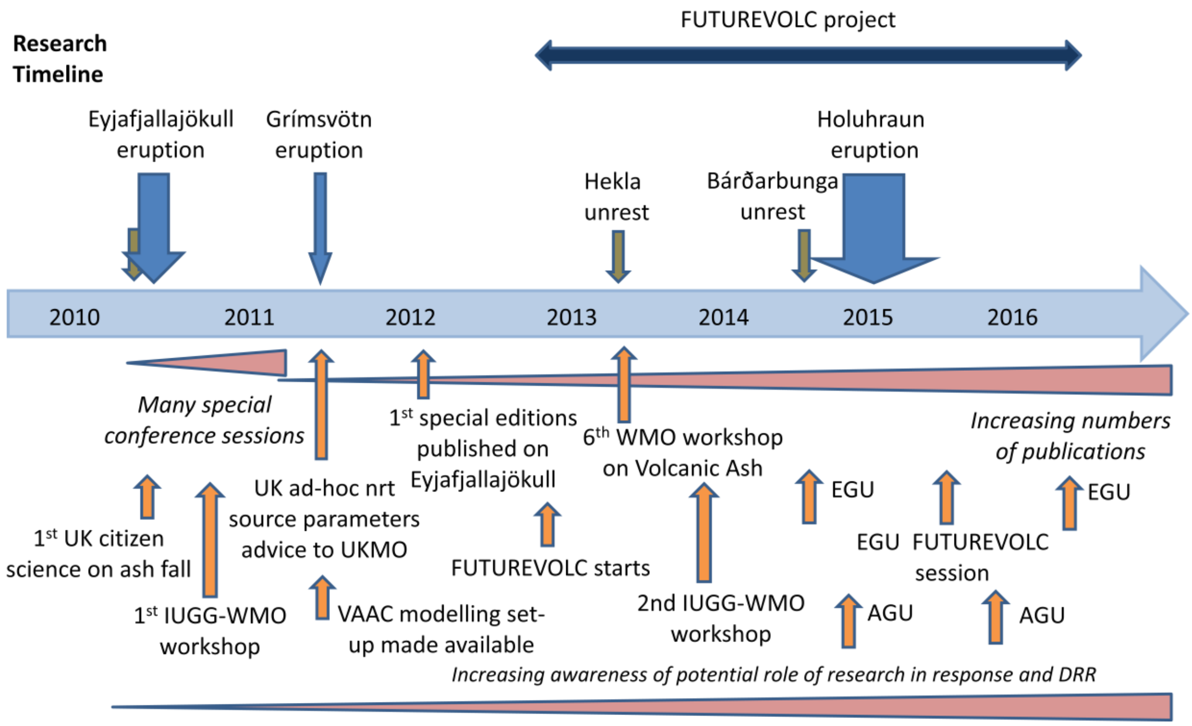

***Figure 10**: The research timeline shows that the pace of scientific advance has not slowed at all since the years immediately following 2010. Projects like FUTUREVOLC enabling coordinated international collaboration in support of international frameworks like GEO are supporting this progress.*

Outcomes from the FUTUREVOLC project have been shared in numerous events, meetings, workshops and conferences at national, regional and international levels. One important aspect is the increased awareness in the meteorological community across Europe of the role of earth science in managing volcanic risk. As more agencies, institutions and networks align with international frameworks such as SFDRR, or integration frameworks such as the GEO roadmap, projects like FUTUREVOLC have a major role to play in enabling nations to collaborate on an equal basis to address these challenges using the best available research and technology.

6.4 UK preparedness (BGS and UKMO)

The additional timelines compiled by BGS and the UK Met Office cover a range of topics from aviation and VAAC activities to UK planning (civil protection). It is the latter that is carried out collaboratively and FUTUREVOLC has had most influence upon (Fig. 11). In the UK there was no planning for the impacts of volcanic eruptions in 2010 but this was very quickly rectified and by the time of the Bárðarbunga/Holuhraun eruption in 2014, the UK was so comfortable with the planning in place for a 'Laki-type eruption' that no emergency meetings were called. The situation was handled in a low key manner by agencies with responsibilities for particular impacts.

The UK took the guidelines of the Hyogo Framework for Action very seriously and already had a risk planning system in place in 2010 so volcanic hazards and risk was immediately incorporated through a Scientific Advisory Group in Emergencies (SAGE) subgroup. The preliminary April-May 2010 entries for the chosen volcanic risk scenarios were updated and modified over a number of years, the last update in 2015 reduced the risk level of a 'Laki-type' scenario based on the results of a short research project into UK hazard conducted by UK Met Office, BGS (both active in FUTUREVOLC) and others.

The UK government has always been cognisant of the UK reliance on the scientific expertise in Iceland, particularly during eruptions and crises which have trans-border impacts or affect North Atlantic airspace. Icelandic scientists participated in the UK SAGE meetings of 2010. The UK government has actively supported the ongoing collaborations between UK and Icelandic scientists. This recognition is manifest in, for example, the UK-Iceland MoU signed in 2010 and maintained by 6 monthly meetings.

FUTUREVOLC is a key research project, recognised by many agencies in the UK beyond research, that enables necessary research collaboration to take place at a European scale. In order to facilitate and support collaboration and coordination between civil protection agencies, the UK civil protection has visited Iceland's NCIP to share the outcomes of UK research into the impacts of a 'Laki-type' eruption scenario (large magnitude fissure eruption). This work has directly supported the FUTUREVOLC project. The first meeting of the KCDRM was held in London on November 24-25 2015 and hosted by the UK civil protection (Civil Contingencies Secretariat). The

FUTUREVOLC project outcomes were discussed in presentations by JRCC and IMO, and in break-out discussions at this meeting.

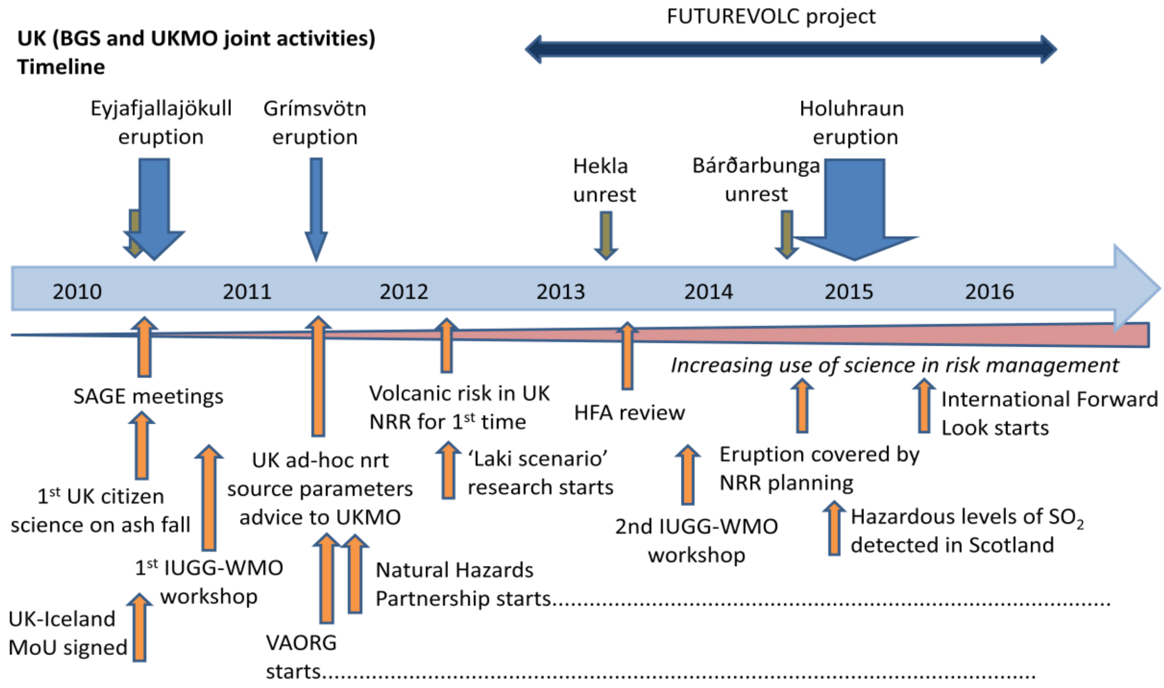

***Figure 11**: The UK timeline shows some of the joint BGS-UKMO activities in the UK which since the start of the FUTUREVOLC project have benefitted from project learning and outcomes, for further activities see Appendix 3.*

The roles of UK Met Office (VAAC) and BGS during volcanic unrest and eruption and their advisory positions are well-established, both advise CCS during any volcanic unrest and eruption. Both institutions have been able to draw on the activities and outcomes of the FUTUREVOLC project whenever necessary. Some aspects of FUTUREVOLC best practice such as the 'Factsheet' and gas dispersal forecasts have been shared by BGS with other collaborative partners worldwide (e.g. in Colombia, Ecuador and Ethiopia).

6. Summary

The FUTUREVOLC project has made considerable contributions in the development of communications to ensure scientific research plays a larger role in informing operational practice. Our research has provided the evidence both for what different sectors need (Heidarsson et al. 2014, D3.1) and also whether stakeholders believe what they have received more recently is an improvement (this study). We have been able to identify a number of examples of best practice that members of the consortium agree demonstrate a considerable advance as compared to 2010 and 2011.

The Barðarbunga/Holuhraun eruption enabled ideas and methods to be tested in a real evolving situation. Farther afield, the Barðarbunga eruption enabled the UK to test the basis of its planning for a similar but larger eruption (based on the Laki 1783-4 scenario). These shared experiences and connections with JRCC, ECHO and the new KCDRM through the FUTUREVOLC project have enhanced relationships of both scientists and civil protection agencies across Europe.

Could this have been achieved without FUTUREVOLC? The collaboration across Europe and across disciplines, particularly in the integration of data from space, air and ground, and the increased understanding of the role research can and should take in risk management and reduction would likely not have been achieved.

FUTUREVOLC best practice has also contributed to development of new initiatives and collaborations at European and international scales (e.g. ARISTOTLE, Global Volcano Model network).

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Appendix 1 – Weekly volcano status report

EBE-032-4

Veðurstofa Íslands

Volcano weekly status report

Date and time of report: *17.09.2014, 12:10 UTC*

Week of validity: *10.09.2014 - 17.09.2014*

Reported by: *Sara Barsotti and Bergthóra S. Thorbjarnardóttir*

Please contact the Icelandic Meteorological Office to discuss any of the content at +354 522 6315 (9am-5pm) or +354 522 6313 (5pm-9am)

Volcano name	Latitude	Longitude	Smithsonian #	Colour code (G, Y, O, R)	Status description *[date]*
Askja	65.0457°	-16.7130°	373060	G	*The colour code has been moved back to green on 11 September due to decreased seismic activity and confirmation that no changes in the geothermal system have been occurred in the last month.*
Bárðarbunga	64.6368°	-17.5148°	373030	O	*The Holuhraun eruption is still ongoing.*
Brennisteinsfjöll	63.9408°	-21.7922°	371040	G	-----
Eldey	63.7444°	-22.9674°	NA	G	-----
Esjufjöll	64.2875°	-16.5001°	374020	G	-----
Eyjafjallajökull	63.6261°	-19.6364°	372020	G	-----
Fremrinámur	65.4290°	-16.6590°	373070	G	-----
Grímsnes	64.0203°	-20.9406°	371060	G	-----
Grímsvötn	64.4166°	-17.3166°	373010	G	-----
Hekla	63.9917°	-19.6733°	372070	G	-----
Hengill	64.0784°	-21.2945°	371050	G	-----
Hofsjökull	64.7909°	-18.9031°	371090	G	-----
Hrómundartindur	64.0685°	-21.2092°	371051	G	-----
Katla	63.6352°	-19.0833°	372030	G	*Normal background activity*
Kerlingarfjöll	64.6375°	-19.2413°	NA	G	-----
Krafla	65.7142°	-16.8025°	373080	G	-----
Krýsuvík	63.8959°	-22.0991°	371030	G	-----
Kverkfjöll	64.6593°	-16.6931°	373050	G	-----
Ljósufjöll	64.9158°	-22.6664°	370030	G	-----
Lýsuskarð/ Helgrindur	64.8669°	-23.2487°	370020	*	-----
Oddnýjarhnjúkur	64.8592°	-19.7145°	371080	G	-----
Prestahnúkur	64.5864°	-20.6675°	371070	G	-----
Reykjanes	63.8647°	-22.5741°	371020	G	-----
Snæfell	64.7982°	-15.5588°	NA	G	-----
Snæfellsjökull	64.8012°	-23.8023°	370010	*	-----
Tindfjöll	63.7858°	-19.5678°	372040	G	-----
Torfajökull	63.9441°	-19.1500°	372050	G	-----
Tungnafellsjökull	64.7374°	-17.9075°	373040	G	*We still observe a few events at Tungnafellsjökull and SE of it, as we have since the beginning of the unrest in Bárðarbunga.*
Vestmannaeyjar	63.4332°	-20.2506°	372010	G	-----
Þeistareykir	65.8819°	-17.0319°	373090	G	-----
Þórðarhyrna	64.2724°	-17.5318°	373010	G	-----
Öræfajökull	63.9955°	-16.6433°	374010	G	-----

EBE-032-4

Veðurstofa Íslands

Volcano weekly status report

* Volcano appears quiet but is not monitored adequately. Absence of unrest confirmed. Shown as grey in the map.

Additional notes:

Factsheet Bardarbunga 17.09.2014

Measurements show that the lava field in Holuhraun continues to expand. There are no signs of decreasing lava production.

- The subsidence of the Bardarbunga caldera continues with the rate of about 50 cm over the last 24 hours.
- Seismic activity has been rather intensive over the last 24 hours. Yesterday 7 earthquakes larger then M3,0 were detected in Bardarbunga. The biggest were M5,4 and M4,8 last night. Smaller earthquakes were detected in Dyngjujokull glacier and in north part of the dyke.
- GPS monitoring show irregularity in in the crustal movements over the last few days. This sign could indicate that the magma movement under Bardarbunga is changing.
- No change has been detected in water measurement.

Air quality:

- A prediction from the Icelandic Met Office: Easterly winds with the polluted area to the west and southwest, marked by Langjokull glacier in the west and Tindfjoll in the south. Valid until noon tomorrow, Thursday.

- 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 ashfall.

EBE-032-4

Veðurstofa Íslands

Volcano weekly status report

Other scenarios cannot be excluded.

The report is issued every Wednesday at 11:30 UTC and sent to vwr@vedur.is

The updated Aviation Colour Code Map is available at

http://en.vedur.is/earthquakes-and-volcanism/volcanic-eruptions/

Appendix 2 Survey on communication for FUTUREVOLC participants

Dear FUTUREVOLC partners.
Work Package 3 of FUTUREVOLC is entitled 'Communications and supporting risk management' and we are now seeking to compile evidence that your scientific research (including monitoring data, observations, analysis, interpretation, opinion etc.) has indeed been effectively communicated to operational institutions in order that they can support risk management (e.g. as performed by civil protection, civil aviation, airlines etc.)
If you are a research scientist representing an operational institution, we also need to know how your research has been communicated and used.
Our aim is to assess how FUTUREVOLC partners have communicated their research, who partners have communicated with, what the communication process has involved, what tools or products have been developed that may assist communication, and how communication has changed over the duration of the project.
Please read this **short** questionnaire carefully; fill out the form as fully as possible and send one response pr. institution back to us, at einarp@rls.is **no later than September 10th.** This short survey will be used for Deliverable D3.3 and **all FUTUREVOLC partners are required to respond**. If you have any questions regarding this questionnaire, its goal, your role in this task or anything, please do contact us via email or phone (+354 570 2662).

No.	Issues/question:	Answers:
1)	Name of FUTUREVOLC partner:	
2)	Name of contact person and email:	
3)	Before the FUTUREVOLC project, can you please describe a) what research you and/or your institution did in Iceland, and b) what institutions in Iceland you shared your results with (how and when)?	
4)	Did you ever respond in near-real-time to Icelandic eruptions before the FUTUREVOLC project? Which ones (e.g. Eyjafjallajökull, Grimsvötn)? What exactly was your role, who did you communicate with, and what did you communicate?	
5)	Has FUTUREVOLC changed your communication methods with collaborating individuals and institutions in Iceland (e.g. frequency, timeliness, value, quality, usefulness, usability)?	
6)	If you did not previously do research in Iceland, has FUTUREVOLC changed the way you communicate your research in any way? If so, how?	
7)	During the course of the FUTUREVOLC project did you communicate to external scientists or non-scientists about your research	

No.	Issues/question:	Answers:
	and the situation in Iceland? If so who (e.g. aviation, government, regulators, conferences, media, public etc.)?	
8)	Please name and give a short description of any tools or methods (e.g. visualisation, modelling tools, and social media) that have enhanced your communication during the FUTUREVOLC project.	
9)	Please give a brief description of uncertainties in your line of research and how these have been communicated.	
10)	In your opinion, were there any examples of good practice in terms of communication (between scientists, or between scientists and decision-makers/government/authority) during the FUTUREVOLC project? Please describe.	
11)	During the course of FUTUREVOLC, have you been involved in any other projects or initiatives that deal with early warning systems, monitoring eruptions, observation and analysis of volcanic products, hazards or risk? If so, please can you list them?	
12)	What is your overall estimation of the current state of communication a) between scientists, and b) between scientists and decision makers/government/authority, compared to before the Eyjafjallajökull 2010 eruption?	
13)	In general (not just yourself and your institution) and based on your experience, how can communication be improved (e.g. lessons learned after Bárðarbunga)?	

Appendix 3 Timeline documentation

Timeline documentation
Activities that were supported by, facilitated by, or benefited from, the FUTUREVOLC project in bold

Date	Contributor	Text
		Aviation Industry
19 April 2010	UK-MET	EU-27 Transport Ministers meeting is convened to discuss airspace restrictions. The conference concluded that, while the initial reaction by the States was prudent and reduced risk to an absolute minimum, it was now time to move towards a harmonized European approach that permitted flights – but only where safety was not compromised.
20 April 2010	UK-MET	New procedures for air traffic and volcanic ash are introduced in Europe. "A limited "No-fly zone" will be established by the States concerned, based on forecasts from the VAAC. Aircraft Operators will be permitted to operate outside this zone. In their decision as to whether to fly, they will be supported by shared data including advice from the scientific community (meteo, volcanic ash proliferation etc.) – including safety assessments supported by tests under the oversight of the competent Safety Authorities."
20 April 2010	UK-MET	Introduction of supplementary concentration charts by the Met Office, representing a massive change in the communication of hazard to the aviation industry. Initially these display 2 contamination zones in black and red. • 18 May 2010: Late in the eruption these evolve to 3 contamination zones.
April 2010	UK-MET	Dissemination of VAAC data via Met Office website, including: • More information • Volcanic Ash Graphics and supplementary charts
	UK-MET	During and since Eyjafjallajökull in 2010 a vast range of teleconferences have been introduced to aid communication including • Introduction of telecon to EUROCONTROL during Eyjafjallajökull • Phone call from VAAC to UK CAA before NOTAMS are issued
May 2010	UK-MET	European Aviation Crisis Coordination Cell (EACCC) (which sits under EUROCONTROL) set up in response to Eyjafjallajökull with a coordination role for the European response to volcanic ash and other hazards (http://www.eurocontrol.int/articles/european-aviation-crisis-coordination-cell-eaccc)
Jul 2010	UK-MET	Jul 2010 – First meeting of the ICAO International Volcanic Ash Task Force (IVATF). This held 4 meetings before being disbanded in 2012 (July 2011, Feb 2012, June 2012). A large number of recommendations were produced which have influenced communications and procedures across the world. Meeting reports at: http://www.icao.int/safety/meteorology/ivatf/Lists/Meetings/AllItems.aspx
Dec 2010	UK-MET	ICAO EUR/NAT contingency plan revised to include volcanic ash contamination areas and reference to supplementary concentration charts

		• This plan sits under the European Air Navigation Planning Group (EANPG), which encompasses representatives of each of the 35 member and non-member states. • The Safety Risk Assessment process has been introduced gradually since Dec 2010 and: o Each country has its own process for airlines registered in that country o Each country within Europe can also set its own response as to whether it will close sovereign air space at certain contamination levels
March 2011	UK-MET	Revised colour scheme introduced for volcanic ash concentration charts (blue, grey, red) together with accompanying explanatory documentation.
March 2011	UK-MET	Quantitative volcanic ash satellite data introduced by EUMETSAT to support VAACs and member states National Met Services (http://navigator.eumetsat.int/discovery/Start/DirectSearch/DetailResult.do?f%28r0%29=EO:EUM:DAT:MSG:VOL).
April 2011	UK-MET	A major VOLCEX exercise was run by London VAAC including EUROCONTROL, airlines etc to test new procedures. The EUR/NAT VOLCEX process came out of Grímsvötn 2004, but was reinvigorated following Eyjafjallajökull, with exercises deliberately planned to test new functionality and encompass parts of the European response infrastructure that weren't impacted by Eyjafjallajökull.
April 2011	UK-MET	EUROCONTROL test their new EVITA software for visualising volcanic ash data and flight data. This supports the sharing of information between airlines, state regulators and air navigation service providers, in particular through functionality that allows airlines to identify precisely which of their flights may be impacted by ash.
July 2011	UK-MET	New data files for use in the EVITA software tool by EUROCONTROL for depicting the volcanic ash concentration contours are introduced by the London VAAC.
Post Grímsvötn 2011	UK-MET	The **CAA Volcanic Ash Advisory Group (VAAG)** industry group came out of Grímsvötn 2011. The objective of this group was to develop an improved collaborative decision making process involving all UK aviation stakeholders (including Defence) for future volcanic ash events. This group was instrumental in defining and introducing the following items: • Procedure to hold a daily 16:30 briefing between the London VAAC and the CAA and aviation industry during an eruption • Process for the VAAC to produce an annotated satellite image every 3 hours during an eruption
Mar 2013	UK-MET	The seventh meeting of the International Airways Volcano Watch Operations Group (IAVWOPSG) reviews a paper discussing (amongst others): • Definitions of visible and discernible ash, to clarify previous uncertainty around the use of "visual ash". This terminology is accepted.
Sep 2013	UK-MET	EUROCONTROL hosts meetings between France, Germany, Norway and UK to improve exchange of volcanic ash data including observations and dispersion model information within Europe • Process for exchange pre-, during- and post-crisis phases drawn up

		together with a roadmap for testing and implementation. • Aug 2014 - Satellite products made available to Met Service providers and airlines via MO website as a consequence.
Feb 2014	UK-MET	The eighth meeting of the International Airways Volcano Watch Operations Group (IAVWOPSG) reviews a paper discussing (amongst others): • The communication of confidence in VAAC forecasts
Mid 2014	UK-MET	Introduction of separate contingency plans for the ICAO NAT region and EUR region. This reduces the coordination and consistency between these two regions, and may lead to potential communication issues in future.
Sep 2014	UK-MET	Changes in procedures for pilot reporting of volcanic ash. These modifications are introduced following testing in exercises.
April 2015	UK-MET	The ICAO IAVWOPSG is superseded by the ICAO Met Panel. • This represents a potential challenge to the communications situation.
29 August 2015	UK-MET	The first operational Met Office annotated satellite image is published via the London VAAC public website to show that there was no ash from Bárðarbunga and demonstrate why no volcanic ash advisory product had been issued (http://www.metoffice.gov.uk/aviation/vaac/data/VolcanicAsh-Nephanalysis-1409283569issue.pdf).
		Iceland:
Pre-2010 to today	UK-MET	VOLCICE exercises between IMO and London VAAC to test communications and procedures. These occurred prior to Eyjafjallajökull and have continued regularly since.
May 2010	UK-MET	Met Office staff work at IMO during Eyjafjallajökull eruption. The Volcanic Ash status report is introduced, containing regularly updated information. This is essential to the VAAC for initiating model simulations.
May 2010	UK-MET	Memorandum of Understanding (MoU) signed between IMO, UKMO, BGS and NCAS to further collaboration and communication on volcanic issues.
Oct 2010	UK-MET	Met Office starts providing daily resuspended ash forecasts to IMO to help with their interpretation of these events and communication of risk to the Icelandic public.
January 2011	UK-MET	First MoU meeting between UKMO, IMO, BGS and NCAS to discuss common ground and explore joint projects.
Mid 2011	UK-MET	Weekly telephone call between IMO and London VAAC introduced to promote contact between staff and mutual understanding during “peace time”.
Oct 2011	UK-MET	Met Office provide training course on NAME model at IMO.
June 2013	UK-MET	**Introduction of IMO aviation colour codes.**
Sep 2013	UK-MET	IMO staff attend NAME training course at Met Office.
Nov 2013	UK-MET	**Weekly volcano status report introduced following discussion between IMO and London VAAC.**
May 2014	UK-MET	**Introduction of FUTUREVOLC SMS and email alert for researchers to notify of changes in volcanic activity (Note: this is not an operationally used product).**
Aug-Sep 2014	UK-MET	**Increased information on IMO website during Bárðarbunga crisis used by Met Office as a key resource and also as a single source of information to point stakeholders to.**

		International & VAACs
March 2010	UK-MET	Concept of Volcanic Ash Science Advisory Group (VASAG) introduced, to link science through to operations, as a result of the fifth International Workshop on Volcanic Ash.
April /May 2010	UK-MET	Introduction of daily teleconferences by London VAAC with European National Met Services. This practice is subsequently written into procedures.
August 2010	UK-MET	First meeting of WMO VASAG. During the existence of the IVATF, the VASAG submits key scientific papers to the task force to improve understanding of the state of the science amongst attendees and the industry.
Feb 2012	UK-MET	First official VAAC Best Practices Seminar held. Since 2010 VAAC managers meetings have increased in frequency leading to refined inter-VAAC communications and increased VAAC coordination.
Nov 2012	UK-MET	Inputs and Outputs (Ins and Outs) Dispersion Modelling Workshop. Final report: https://docs.google.com/file/d/0B50bTmQtOwH6dUFkcjZzaG9UYlk/edit?usp=sharing
Feb 2013	UK-MET	Introduction of European Lidarnet (by DWD) allowing visualisation and communication of data from across all of Europe (http://www.dwd.de/bvbw/appmanager/bvbw/dwdwwwDesktop?_nfpb=true&_pageLabel=_dwdwww_spezielle_nutzer_forschung_chemie&T14607849251144915981049gsbDocumentPath=Navigation%2FForschung%2Fchemie__der__atmos%2FGAW%2Fceilomap__de__node.html%3F__nnn%3Dtrue&_state=maximized&_windowLabel=T14607849251144915981049
Mid 2013	UK-MET	New back-up procedures between London VAAC and Toulouse VAAC implemented and tested.
Summer 2013	UK-MET	EU WEZARD project delivers report including gap analysis and recommendations for improving coordination and communications between aviation met service providers and the aviation industry for volcanic ash.
Jan 2014	UK-MET	Changes to the Smithsonian Database of Volcanoes of the World implemented in VAAC operations, leading to standardisation across all VAACs for volcano naming and numbering and consistency in communications between VAACs and volcano observatories.
Aug 2014	UK-MET	Significant revamp of Met Office VAAC website. Context and background information added about our volcanic ash response to aid communication with the public and stakeholders (http://www.metoffice.gov.uk/aviation/vaac/)
Aug 2014	UK-MET	Met Office website with satellite volcanic ash data for National Met Services goes live (password protected).
Oct 2014	UK-MET	Prototype website for sharing model output between the VAACs is tested.
Nov 2014	UK-MET	VAAC areas of responsibility changed. London VAAC now responsible for Scandinavia due to prevailing wind direction from Iceland. • IAVW handbook updated to reflect changes.
May 2015	UK-MET	**VAAC Best Practice workshop 2015** held in London incorporating a range of industry representatives to enhance communications. Final report at: https://drive.google.com/open?id=0B50bTmQtOwH6TEtJMG5aekpqYkE&authuser=0
		Met Office Internal
Apr 2010 onwards	UK-MET	Met Office internal communications guidance on volcanic ash to ensure staff are up-to-date with latest science and technologies and can brief stakeholders effectively has evolved out of Eyjafjallajökull. This is regularly updated.

Apr 2010	UK-MET	Improved satellite 3-channel ash detection product introduced during Eyjafjallajökull's first eruptive phase.
Aug 2010	UK-MET	Introduction of quantitative volcanic ash satellite data.
Sep 2010	UK-MET	MO "Volcanic Ash Coordination Program" (VACP) established. Regular meetings held until its transfer into the Natural Hazards Group in March 2014. • VACP internal reports in Dec 2010, 2012 and 2015 document changes to web and communications policies over time.
Late 2010 /Early 2011	UK-MET	Introduction of centralised data visualisation for the UK LCBR & Lidar network, enabling easy access for VAAC forecasters and MO science support staff to this data.
Mar 2011	UK-MET	Introduction of MO alert states for volcanic ash, with corresponding actions for informing Stakeholders. • These have since undergone subsequent changes to better reflect IMO alerts and be fit for purpose for different eruption types.
August 2011	UK-MET	Volcanic ash observations course introduced. This 2 day course was attended by all VAAC staff and key science staff. It has continued as a rolling 1-day refresher course. • Competency based assessment for VAAC forecasters introduced according to international guidelines.
Late 2013	UK-MET	Stakeholder mapping carried out to clarify key points of contact.
Mar 2014	UK-MET	**Met Office internal Volcanic Ash workshop to ensure all relevant Met Office staff and a few key stakeholders (CAA, DfT) are aware of new science, developments and linkages in the volcanic ash area.**
Aug 2014	UK-MET	**"Volcanic Information Process" formal document outlining how the cascade of information to external stakeholders from the UKMO should occur. This draws together processes that already existed in local operating procedures.**
		BGS
April 2010	BGS	Larry Mastin (USGS) sets up a listserv for ash-cloud modelers to share source parameters and modeling results
April 2010	BGS	Provides real-time 24/7 volcanological information to Cabinet Office, COBR, CAA and government departments in a number of emergency telecons and meetings.
April 2010	BGS	BGS develops future eruption scenarios for the ongoing situation and future eruption scenarios to support UK planning guidelines. These are developed further through SAGE and beyond, then ultimately two scenarios are added to the UK National Risk Register.
April 2010	BGS	BGS uses IMO website and engages directly with University of Iceland and IMO to check facts (existing contacts), provides information direct to UK government and media
April 2010	BGS	BGS contributes to Scientific Advisory Group for Emergencies (SAGE) meetings: BGS leads subgroup on Geology (monitoring, early warning, forecasts, Katla etc) and contributes to subgroup on Lake-type' eruptions and potential hazard to UK form sulphur dioxide emissions in Iceland.
April 2010	BGS	BGS advises Department of Environment, Farming and Rural Affairs Scientific Advisory Group in a series of meetings and telecons focusing on ash and fluoride and to coordinate sampling and analysis. BGS brings in IVHHN and others

April 2010	BGS	BGS instigates UK-Iceland MoU (IMO, BGS, UKMO and NCAS) to enhance the free flow of information in support of response (SAGE). University of Iceland unable to join an institutional MoU because each researcher is free to make up their own mind about data access but very supportive of the principle.
April 2010	BGS	Citizen science used for collection of ash fall samples across the UK. Attempts made to coordinate sample collection with aviation sector, research planes etc. Ultimately airborne samples retained by collectors.
May 2010	BGS	BGS and UKMO address CAA aviation industry briefing in London (13th May)
May 2010	BGS	Three volcanic risk scenarios identified and in consideration to be added to UK National Risk Assessment (Subgroup activity for SAGE)
June 2010	BGS	BGS gives oral evidence to Commons Select Committee Inquiry into 'Scientific Advice and evidence in emergencies'
Nov 2010	BGS	1st IUGG-WMO Workshop on Ash Dispersal Forecast and Civil Aviation. Aim to bring modellers together and ensure sharing of expertise across disciplines and between research and operations. State of the science and consensual document are available here: http://www.unige.ch/sciences/terre/mineral/CERG/Workshop/results.html
May 2011	BGS	BGS advises Cabinet Office, COBR, DEFRA. Protocols now in place so delegated activities underway (e.g. Environment Agency on air pollution etc), no SAGE necessary
Feb 2012	BGS	Scenario planning discussions started in 2010 result in addition of volcanic risk to the UK National Risk Register for Civil Emergencies – 2012 update (https://www.gov.uk/government/publications/national-risk-register-for-civil-emergencies-2012-update)
Feb 2012	BGS	CO initiate funded project to provide quantitative characterisation of UK hazard from large fissure eruptions in Iceland (Laki scenario).
May 2012	BGS	BGS organises elicitation to characterise source parameters for modelling of sulphur dioxide dispersal during a 'Laki-type' fissure eruption. Report issued later in the year. http://www.bgs.ac.uk/research/volcanoes/LakiEruptionScenarioPlanning.html
Oct 2012	BGS	**FUTUREVOLC project starts**
May 2013	BGS	UK is first country to undergo peer review to assess progress towards implementing Hyogo Framework for Action goals (DRR). **BGS provides evidence to the review panel.**
May 2013	BGS	Citizen science used for collection of ash fall samples across the UK and now UKMO contributing rainfall and pollen samples. BGS now supporting Royal Society Fellowship PDRA John Stevenson who collaborates on the work.
Nov 2013	BGS	**2nd IUGG-WMO Workshop on Ash Dispersal Forecast and Civil Aviation**, co-organised by three members of FUTUREVOLC. Resulting documents addressing the state of the science and future developments available at: http://www.unige.ch/sciences/terre/mineral/CERG/Workshop2/results-2.html
Nov 2013	BGS	BGS and UKMO present update to Royal Aeronautical Society and the Institute of Mechanical Engineers including representatives from civil and military aviation.
Mar	UK-	**UK risk from large magnitude fissure eruption in Iceland reduced in the**

2015	MET BGS	**2015 edition of the UK National Risk Register for Civil Emergencies** (https://www.gov.uk/government/publications/national-risk-register-for-civil-emergencies-2015-edition).
		UK Government & Agencies
April /May 2010	UK-MET BGS	Teleconferences between UK Public Health representatives (HPA/PHE), the Met Office, BGS and other key experts held to understand the risks to the UK from a health perspective (both ash and gas/aerosol) during both eruptions. • Follow up work has led to UK Government guidance on the health hazards from volcanic ash and volcanic gases (HPE/IVHHN).
During and post April 2010	UK-MET BGS	Evolution of frameworks for provision of scientific and technical advice into UK Government: • Scientific Advisory Group for Emergencies (SAGE) meetings held during Eyjafjallajökull • SAGE sub-groups established to look at : 1. Aviation issues, 2. UK long-term preparedness and contingency planning, 3. Potential impacts in UK of sulphur dioxide. • Commons Select Committee Inquiry into 'Scientific Advice and evidence in emergencies' • A clear process for forming SAGE during volcanic eruptions has been established, together with core attendees
Apr 2011	UK-MET	Introduction of National Severe Weather Warning Service in the UK.
Jun 2011	UK-MET BGS	Volcanic Ash Observations Review Group (VAORG) established after Grímsvötn – this group now provides science guidance into DfT. • Report produced in July 2011 with recommendations.
Oct 2011	UK-MET BGS	Inception of the UK National Hazards Partnership.
Dec 2011	UK-MET	Met Office Civil Contingencies Aircraft (MOCCA) becomes operational (funded by UK Gov). • Data will feed directly into VAAC forecaster decision making.
Feb 2012	UK-MET BGS	Formal addition of volcanic risk to the UK National Risk Register for Civil Emergencies – 2012 update (https://www.gov.uk/government/publications/national-risk-register-for-civil-emergencies-2012-update)
Feb 2012	UK-MET BGS	UK Cabinet Office initiates funded project on the UK hazards from Icelandic fissure eruptions to update the NRR: numerous meetings and briefings with UK and European Stakeholders over the next 2 years.
Apr 2013	UK-MET BGS	Introduction of the National Hazard Partnership Daily Hazard Assessment, which is emailed to stakeholders in National and Local Government (and more recently emergency responders). This daily brief includes a range of hazards including volcanic eruptions in Iceland.
Mar 2015	UK-MET BGS	**UK risk from large magnitude fissure eruption in Iceland reduced in the 2015 edition of the UK National Risk Register for Civil Emergencies** (https://www.gov.uk/government/publications/national-risk-register-for-civil-emergencies-2015-edition).
Summer 2015	UK-MET BGS	**Scottish Government expand PM and SO2 monitoring network in Scotland in response to recent eruptions (and advice from BGS).**
		Academia
April	BGS	IMO and University of Iceland posting a great deal of information (including

2010		research data) about unrest and eruption on websites - facilitating UK response greatly.
Post April 2010	UK-MET BGS	Many special sessions at scientific conferences following Eyjafjallajökull, e.g. CoV6, EGU, AGU, AMS, IUGG, leading to greater awareness in science community as to what would help inform response and interdisciplinary discussions.
May 2010	BGS	Concerns expressed in Iceland about appropriation of information from websites and publication by UK scientists. Amount of available information is reduced.
Nov 2010	UK-MET BGS	1st IUGG-WMO Workshop on Ash Dispersal Forecast and Civil Aviation, with participants primarily from the modelling and satellite communities. The resulting state of the science and consensual document are available here: http://www.unige.ch/sciences/terre/mineral/CERG/Workshop/results.html
May 2011	UK-MET BGS	During the Grímsvötn eruption the Met Office established an ad-hoc science group formed of academics and BGS staff to help inform understanding of the eruption and decide on appropriate modelling source parameters.
May 2011	UK-MET	Details of the modelling source term and set-up being used by the London VAAC made available via email during the eruption.
May 2011	UK-MET BGS	Citizen science used for collection of ash samples over the UK. Work led by BGS and John Stevenson (see http://all-geo.org/volcan01010/2011/05/ash-sampling/)
Dec 2011	UK-MET	Documentation of the London VAAC modelling approach published on public website (Last update: Witham et al, 2012, http://www.metoffice.gov.uk/media/pdf/p/7/London_VAAC_Current_Modelling_SetUp_v01-1_05042012.pdf)
Jan 2012	UK-MET	Special editions of Atmospheric Chemistry and Physics, Journal of Geophysical Research and Atmospheric Environment are published, all dedicated to science developments during and related to Eyjafjallajökull.
Jan 2012	UK-MET	Academic paper by Webster et al published in the special edition of the Journal of Geophysical research explaining the operational procedures for predicting volcanic ash concentrations (http://onlinelibrary.wiley.com/doi/10.1029/2011JD016790/abstract).
Oct 2012	UK-MET	FUTUREVOLC project starts.
Mar 2013	UK-MET	Sixth International WMO Workshop on Volcanic Ash in Indonesia, involving all the VAACs, expert scientists and local specialists. This addressed best practice and regional challenges. Report available at: https://www.wmo.int/aemp/archive
Nov 2013	UK-MET BGS	**2nd IUGG-WMO Workshop on Ash Dispersal Forecast and Civil Aviation**, with attendees from across industry and science. Resulting documents addressing the state of the science and future developments available at: http://www.unige.ch/sciences/terre/mineral/CERG/Workshop2/results-2.html
Apr 2015	ALL	FUTUREVOLC special session at EGU Vienna
Apr 2015	ALL	Article in Nature by Matt Watson (University of Bristol) reviewing progress since 2010 and remaining gaps: http://www.nature.com/news/test-the-effects-of-ash-on-jet-engines-1.17273
		NCIP
2008	NCIP	Service centres for habitants of affected area were first opened after the M6.1 earthquake in Southern Iceland in 2008. The service centres are a ‘one stop

		shop' for the habitants who would normally have to go to number of different institutions and organizations to sort out their issues after such an event with such devastation and disruption to normal lives. Service centres were again opened in 2010 and 2011 during the volcanic eruptions with positive results. One of the learnings is that one cannot expect people to use the service provided if they have to drive more than 25km to get to the service centre. In the case of large affected areas it is necessary to open up more than one centres.
2010 Onwards	NCIP	Gradual improvements of the civil protection system over time. No major steps have been taken to transform the system, but instead the focus has been on constant gradual improvements.
2010 Onwards	NCIP	The cooperation with IMO and UI has gradually increased since 2010 and during FUTUREVOLC.
2010 Onwards	NCIP	The NCIP Status Report was first issued during the Eyjafjallajökull eruption in 2010 as a cooperation between IMO, UI and NCIP, as a response to the enormous demand for information about the development of the eruption. The Status Report saved a great deal of time and allowed these key institutions to speak in a one uniformed voice. The Status Report was issued again during the Grímsvötn eruption. During the Bárðarbunga eruption the NCIP Status Reports were again issued on a daily basis but after the first few weeks of the eruption the report was replaced with a daily report coming directly from the NCIP Scientific Advisory Board. The report was disseminated in English and Icelandic with email to key stakeholders. The English report was sent on 377 email addresses and the Icelandic one on 397 email addresses. The report was also published on the NCIP special web page for the Bárðarbunga eruption www.avd.is and a link to that page was published on Twitter under the hashtags #Bardarbunga and #Holuhraun. The report was also published on IMO web page www.vedur.is and on the Institute of Earth Sciences at the UI www.earthice.hi.is/bardarbunga_holuhraun.
2010	NCIP	Assessment missions were employed during the later stages of the Eyjafjallajökull eruption in 2010. A team of experts were sent to the affected area to assess the scope of the damage to private and public properties. The findings were then communicated to the appropriate government authority. During Grímsvötn eruption in 2011 the assessment mission was successfully employed right at the start of the event. Assessment missions are now employed early in the operations were they are needed. The eruption in Bárðarbunga did not call for an assessment mission due to the remote location of the eruption.
2010	NCIP	The Tourist Board Response Team was first employed during the Eyjafjallajökull eruption in 2010. That experience proved very successful and has been used on number of operations since. The Response Team is now activated at the onset off every major civil protection operation.
2010	NCIP	The Icelandic National Broadcasting Service (RUV) has a mandate by law to broadcast warnings and announcements from the Icelandic Civil Protection. RUV have a permanent studio stationed in the National Crisis Coordination Centre (NCCC) securing flow of information over radio during national crisis. This arrangement has not been changed in years but advances in broadcasting technology, and increased number of broadcasting services in Iceland, has enabled RUV to broadcast live from remote locations both over radio and TV.
2010	NCIP	The NCIP Media Team / Information Team was first formed during the

		Eyjafjallajökull eruption in 2010. Public relation specialists working for the government in different ministries and institutions, and in independent organizations, were called in to help the NCIP staff with the tremendous demand for information from the international mass media. Following the event the media team became a part of the NCCC crew and has been called upon in every major crisis operation handled by the NCIP (2011 and 2014). The original media team is now called Media and Information Team or only Information Team, following a review meeting of the team after the Bárðarbunga eruption. The role of the Information Team has also been defined in a newly released policy report by the Ministry of Interior entitled Civil Protection and National Security Strategy for 2015-2017.
2010	NCIP	NORDEN (The Nordic Countries Regional Partnership Platform including Denmark, Finland, Iceland, Norway, Sweden as well as Faroe Islands, Greenland and the Åland Islands) General Civil Protection Directors have increased their collaboration following the Eyjafjallajökull eruption. Volcanic eruptions in Iceland are now defined as risk factor for Norway and for the UK.
2010	NCIP	Closer collaboration between NCIP and the Iceland Catastrophe Insurance, which has been developing vulnerability data base for Iceland and other response tools.
2012	NCIP	The **NCIP used social media systematically in the Bárðarbunga eruption**. Facebook has been used by the department since 2012 and **Twitter since 2013**. As with other operational instruments the **NCIP has gradually increased its usage of social media. Facebook had been used to communicate warnings and other information to the general public during number of operations.**
2012	NCIP	Cell broadcasting was first employed by the NCIP in 2012. **Text messages with warnings or instructions, in English and Icelandic, are sent to all cell phones in a selected area. This operation is carried out in close collaboration with the Icelandic phone companies and the Icelandic 112.** Cell broadcasting been proven useful and very high proportion of the cell phones do get the message. Cell broadcasting is though not 100% reliable due to technical issues with individual cell phones and in the transmitting system. Cell broadcasting is considered a supplementary communication tool and is always used parallel to traditional means of communication.
2013	NCIP	**A PhD student was hired in 2013 as a part of FUTUREVOLC (WP3)**. • **Student (Einar Heiðarsson) integrates FUTUREVOLC WP3 research with NCIP practice.**
2013	NCIP	**NCIP attend the 4th Civil Protection Forum and distribute FUTUREVOLC questionnaires.**
2013	NCIP	**NCIP and IMO attend the 5th Civil Protection Forum and discuss communication protocols.**
		IMO
May 2010	IMO	Creation of Volcinfo mailing list.
May 2010	IMO	UK-Iceland MoU signed (IMO, BGS, UKMO & NCAS). • Subsequent meetings every 6 months
Mar 2013	IMO	**First official use of the Aviation Colour Code, because of unrest in Hekla.**
Nov 2013	IMO	The first delivery of **Volcano Weekly Report**.

Jan 2014	IMO	Monthly exercise in collaboration with ISAVIA and London VAAC. All the North Atlantic aviation community participated.
Sep 2014	IMO	The Volcinfo mailing list was updated.
Oct 2014	IMO	**The Aviation Colour Code map is put on-line and fully operational.**
Oct 2014	IMO	**Gas dispersal forecasts are published on the IMO web site following the Holuhraun eruption**.