EUROVOLC

European Network of Observatories and Research Infrastructure for Volcanology

Deliverable Report

D7.1 Consultation document on EUROVOLC Civil Protection needs and inventory of hazard communication styles

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Contents

Summary

Task 7.1 aimed to capture lessons learned, good practice and strategies for effective communication between volcano observatories, volcano research institutions and civil protection. This was achieved through consultations on needs with civil protection authorities across Europe, interviews with senior volcano scientists (from volcano observatories and volcano research institutions) and members of civil protection, collation of case studies detailing experiences of crises, and frequent WP7 meetings. The COVID-19 pandemic prevented additional data collection through workshops and surveys, however a diverse range of experiences from across different countries and contexts has successfully been obtained. Consultations established the frameworks and relationships by which volcano monitoring institutions, research institutions and CP authorities operate in different countries across Europe. They were also used to identify civil protection needs from volcano scientists. These have been summarised and presented as a list that identifies their hazards, impact, risk and communication needs. The results of interviews are presented according to the themes that emerged, which cover scientist-civil protection interactions during peace-time and emergencies, communication of hazard and risk, communication of uncertainty, roles and responsibilities, and institutional/interpersonal relationships. Good practice recommendations from both the consultations and interviews are detailed. Overall the results have relevance for scientist-civil protection interactions across Europe and globally. Recommendations for the future are suggested that include: the continuation of knowledge and good practice sharing across Europe and European Territories, the development of an inter-disciplinary community for translating hazard into risk, recognition of the resource challenges faced by scientists and civil protection during emergencies, and the development and formalisation of a European network that can provide observatories with support in meeting civil protection needs during an emergency. In terms of legacy, the WP7 group has agreed to continue meeting on a monthly basis, initially to turn the report into a peer-reviewed output, then to focus on themes that have emerged through the course of data collection for the task.

Acknowledgements

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1. Introduction

Scientists in any country with active volcanoes can anticipate volcanic activity and hazards and contribute science for emergency and risk management if a) geological studies have been carried out to understand past activity (e.g. geochronology, volcanic deposit mapping and stratigraphy), b) volcano monitoring networks and equipment are in place to provide multi-parametric time-series data, and c) a dedicated team of scientists are tasked to maintain the networks, make observations, analyse the data, carry out research and communicate with civil protection (CP) authorities, the public and other stakeholders.

Staff at European volcano monitoring institutions (volcano observatories (VOs)) and individuals at several volcano research institutions (VRIs) have valuable experience of recent volcanic events from both operational and research perspectives. This experience is increasingly enabling the volcano community to develop good practice and build on lessons learned. Volcanic unrest and eruptions are not as frequent as some other natural hazards in Europe, so we have much to gain from sharing experiences, resources and knowledge. Projects like EUROVOLC provide a unique opportunity to share this broad operational and research experience, and to collectively enhance our capabilities and knowledge.

Perhaps the most important task of a volcano monitoring institution is to translate their data, knowledge and research into timely scientific communications for civil protection authorities and the public[1] "*A principal goal for a volcano observatory is to accurately communicate results of scientific evaluations and forecasts together with the associated uncertainties".* Communications must be useful, useable and used[2] by CP authorities, the public and others and this depends on building common understanding, language and trust over time. Ideally, scientific outputs for use by non-scientists will be co-designed by scientists and potential users to ensure that they meet user needs, and to ensure understanding. All this requires time and effort, so enhancing access to resources, knowledge, lessons learned and good practice across Europe will improve efficiency and enable all to progress together.

The overall objective of WP7 was to build European (and European Overseas Territories') capability and capacity to plan for and respond to volcanic unrest and eruptions. Task 7.1 aimed to identify lessons learned, good practice and strategies for the effective Europe-wide communication of volcanic hazard. The task was designed to include three main activities: (1) survey and consultation on hazards (and impacts) needs across Europe for civil protection authorities, (2) survey and consultation of existing hazard (and impact) communication methods, reporting style and contents for volcano observatories (3) a workshop to discuss communication challenges, identify case studies and consider innovation (lessons learned and good practice) between volcano scientists and civil protection.

The report explains the methods adopted for Task 7.1 and presents the results of the work. We present a suggested list of good practice recommendations for hazard (and impact) communication between VOs, VRIs and CP, followed by conclusions and recommendations for sustained engagement. Whilst the activities of Task 7.1 were adapted, delayed and hindered by COVID-19, a rich wealth and depth of knowledge and experience has been collated through a number of approaches (consultations, semi-structured interviews and case studies).

[1] Pallister et al. 2019, Volcano observatory best practices (VOBP) workshops - a summary of findings and best-practice recommendation, J. Applied Volcanology, 8:2.

[2] Aitsi-Semi et al. 2016, Ensuring science is useful, usable and used in global disaster risk reduction and sustainable development: a view through the Sendai framework lens, Humanities and Social Sciences Communications, 2, 16016.

2. Methodology

The research adopted a qualitative approach, with the emphasis placed on capitalising on the richness of experiences shared. The unique nature of each volcanic system and its socio-economic context, as well as the diversity of civil protection structures across Europe, means that interview participants have a diverse range of experiences, providing a rich account of lessons learned and good practice in communication between volcano monitoring institutions, research institutions and civil protection authorities. Experiences that covered emergencies (volcanic unrest/eruptions or seismic) and/or 'peace time' activities were welcomed. The aim was to seek the commonalities, however the project values all experiences as there are some that are particularly relevant to a certain setting (for instance small island states). In seeking good practice, the intention was to look for transferability to other regions, countries and even hazards.

2.1 Methods

A mixed methods approach was adopted to maximise opportunities for European VO, VRI and CP participation (local to national) in the project. The first method implemented involved consultations with WP7 participants and additional civil protection representatives at annual EUROVOLC meetings, regular WP meetings, and other forums. The second method of data collection was semi-structured interviews, designed to capture the rich and detailed information from key individuals. Qualitative interviewing is flexible and responds to the direction in which the interviewees take the interview (Bryman, 2016). The third method of data collection was the collection of case studies. It was the intention of the project to also undertake an online survey/questionnaire and the targeted recruitment of VOs, VRIs and CP participants for a workshop to derive case studies and good practice. However, neither of these activities were achieved owing to the impacts of COVID-19 on the project (see research limitations). A thematic analysis (see Bryman, 2016) was adopted to analyse the interviews, using a combination of previously identified themes (from the consultations) and emergent themes (from the interviews). The research methods applied are described in detail below.

2.2 Consultations

During the 2019 and 2020 EUROVOLC annual meetings, and WP meetings, Loughlin held consultations with individuals and groups. These consultations established the needs of civil protection authorities, and the frameworks and relationships by which VOs, VRIs and CP authorities operate in different countries across Europe. A preliminary list of civil protection frameworks was compiled for Milestone 17 in early 2019. This has now been updated (2021) in Annex 1 and Annex 2. At the 2019 annual EUROVOLC meeting a formal side-meeting was held with Italian (national), Icelandic (national), UK (national) and Azores (local) civil protection representatives to discuss the needs of CP authorities.

In addition, an integral part of the WP7 activities was weekly meetings with EUROVOLC partners. These provided opportunities to discuss and co-design the interviews and case studies for task 7.1, as well as discuss wider concerns and priorities for VO, VRI and CP interactions, and share experiences of recent and ongoing events. Whilst the content of these meetings is not specifically detailed in the results, they have been used to help identify themes in the analysis of interviews and have been important to building and sustaining the networking component of WP7.

2.3 Semi-structured interviews

A semi-structured interview is facilitated with an interview guide (a list of open-ended questions or specific topics to cover) but the interviewee has a great deal of leeway in how to reply. Overall the same questions are asked in all interviews but not necessarily in the exact way outlined on the schedule and the interviewer may follow up on points raised by the interviewee (Bryman, 2016). For the purpose of the task 7.1 interviews, two sets of interview guides (see Annex 3) were designed: one for volcano scientists (VOs and VRIs) and one for CP authorities. The interview guides were shared with participants in advance of the interview. The questions were quite general in their frame of reference, as is typical in a semi-structured interview, but the interviewer was able to follow up with further questions in response to what were seen as significant replies. The questions were designed in partnership with the WP7 group. The first iteration was by Loughlin and Duncan, building on and complementing previous questionnaires on related themes[3], and the draft was then shared with the WP7 group for comment. Based on the received feedback, the questions were revised and refined. At the end of the first few interviews, interviewees were asked to provide feedback on the questions, which was used to further refine these and ensure that they were fully understandable across different languages.

The interviews were conducted remotely (using Zoom) and each lasted between 1 – 2 hours. Nearly 22 hours of material was recorded in total. Ideally, interviews would be conducted on a one-to-one basis, however there were instances where group interviews were more appropriate. All the interviews were conducted in English. In each interview the interviewer was joined by a note taker, meaning that there were always two BGS representatives present. Following an interview, the recording was used to supplement written notes and capture direct quotations. The decision was made not to create fully verbatim transcripts due to the length of time it would take to do so relative to the resource available. Once the interview notes were completed they were sent to the interviewee for the content to be reviewed and to provide them with the opportunity to make any additional comments.

2.3.1 Participants and sample size

Sixteen senior professionals with responsibilities and/or experience of leading scientific or CP teams during a natural hazard emergency in Europe and European territories were interviewed. Most had experience of volcanic unrest and/or eruptions but where there have not been recent episodes of volcanic unrest or eruptions, participants had experience of seismic crises. Several participants are part of the WP7 group and others were recruited using a snowballing approach whereby WP7 members suggested/recruited people from outside the group (and the EUROVOLC community) to be participants.

The research aimed to capitalise on the range and richness of individual experiences across different countries and contexts. Owing to differences in institutional size and number of volcanoes, there were of course some countries with greater representation than others (see Figure 1).

[3] http://futurevolc.hi.is/sites/futurevolc.hi.is/files/Pdf/vedurstofan_futurevolc_baeklingur.pdf

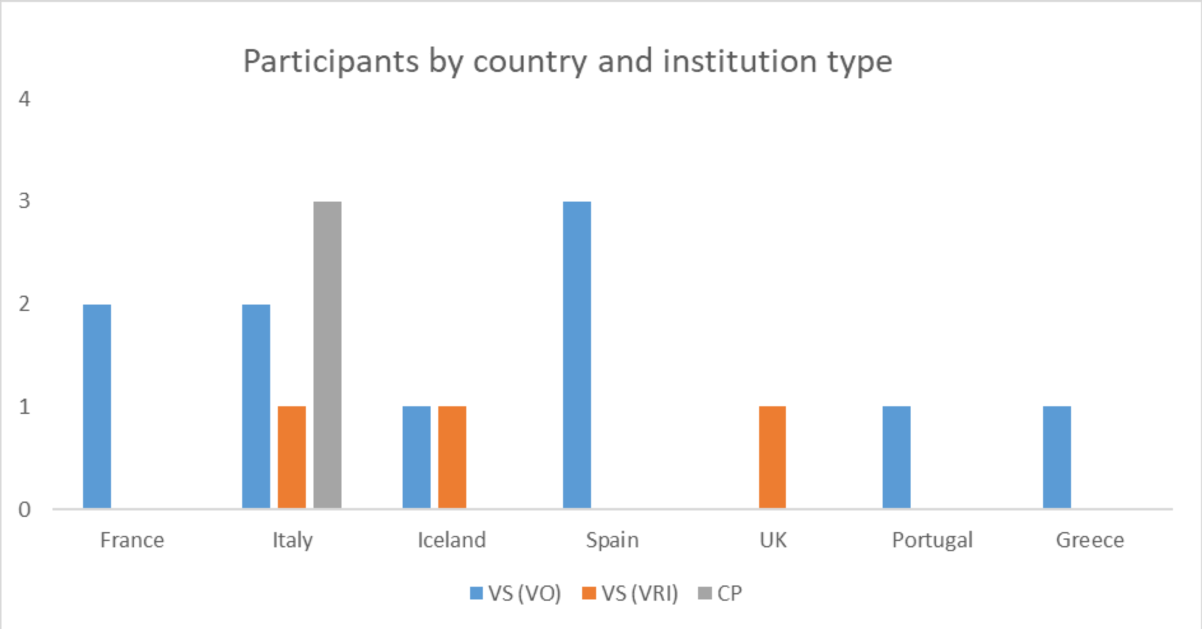

Figure 1: Interview participants according to the country they work in and whether they are Volcano Scientists (VS) from Volcano Observatories (VO) or Volcano Research Institutions (VRIs), or from Civil Protection (CP). Those from Italian civil protection were interviewed at the same time, as were the volcano observatory representatives from Spain.

2.3.2 Case studies

The aim of the case studies was to collect detailed accounts of events (unrest/eruptions/seismic crises/exercises) and emphasise the aspects of good practice in communication. The case studies were also intended to capture the impact of events on volcano observatory, research institution and civil protection staff. A template for case studies was designed by Loughlin, Duncan and Smale and shared with WP7 partners for feedback. The case studies were intended to be completed by an individual or team, and collective contributions from across institutions were encouraged. The case study template can be found in Annex 4.

3. Ethics

At the time of WP7 commencement, BGS had developed its ethics policy and procedure for research that involves people, but was yet to implement a research ethics application process. In lieu of an ethics application process, representatives of the ethics group were consulted about the WP7 work, and asked to comment on the information sheet for participants and consent form (Annex 3), as well as the WP7 team's approach to data management. The received feedback was used to amend the final documents.

The research followed the ethical principles of do no harm, informed consent, avoiding deception and the right to withdraw participation. Furthermore, a highly participatory research methodology was adopted where many participants were involved in the design of the interview guide and all interview transcripts were shared with interviewees. All interview participants came from institutions that are partners in the EUROVOLC project. All personal data collected follows EU General Data Protection Regulations (GDPR) and interviews were recorded with participants' permission. Every participant was provided with the option to remove themselves from the study up until the point of this deliverable.

4. Implementation, research limitations and impacts of COVID-19

Consultations were undertaken with science representatives and CP representatives at various EUROVOLC meetings, workshops and conferences from 2019-2020, and 16 representatives of the VO, VRI and CP community in Europe were interviewed. Although only one CP was interviewed, the consultations were undertaken with four civil protection agencies (Italy, UK, Iceland and the Azores), therefore ensuring a balance of contributions between volcano scientists and civil protection. The majority of interviews were undertaken between March and May 2020. The final four took place in October 2021 having been delayed because of the impact of COVID-19 on capacity. Ideally the interviews would have been undertaken over a shorter time period to represent a snapshot in time, with follow up interviews later in the project, but there was only opportunity for one follow up interview and this reflected a different set of experiences rather than follow up to the first interview. The availability of participants for interview during the data collection period, especially those with operational responsibilities, was affected by the occurrence of several eruptions and the COVID-19 pandemic. This especially impacted the recruitment of participants from civil protection and as a result there is greater representation of volcano scientists amongst the sample (Figure 1). However, the recent eruptions also presented an opportunity for knowledge exchange and contributed to two of the three case studies. Likewise, the pandemic also promoted opportunities for talking about emergency and risk management, and this emerged during some of the interviews, with participants drawing similarities between volcanic emergencies and the pandemic. The improvements in virtual calls (Zoom etc.) also enabled significant engagement and smooth implementation of all but one interview, which was affected by a poor connection.

Owing to the impact of COVID-19, we did not consider it appropriate to send surveys/questionnaires to CP authorities. Likewise, we were not able to run the originally intended workshop. It was intended to align with an international conference (Cities on Volcanoes) to maximise participation of the volcanology community, but this conference was postponed several times owing to COVID-19 (now to 2022).

Weekly meetings began in January 2020 but were interrupted by Covid. These picked up again between lockdowns and in the final months of the project, and have been important for establishing the future of the work of this group following the end of the project.

5. Results

5.1 European Volcanic Risk Management

The first milestone for WP7 was to document civil protection powers in each country relating to natural hazards and disasters. This has now been done officially by the EU and is available on the EU portal along with a comparison tool: https://portal.cor.europa.eu/divisionpowers/Pages/Comparer.aspx. Information and sources are made available to describe central, regional and local responsibilities Examples are given in Annex 1 for the countries participating in EUROVOLC.

The variety of institutional arrangements for understanding and managing volcanic risk across Europe is striking. For example, in most countries volcano monitoring and hazards assessments are the mandate of national institutions such as national geological surveys (e.g. Italy), or national meteorological offices (e.g Iceland). These institutions fulfil scientific monitoring and advisory obligations at local to national scale (in some cases including overseas territories and dependencies). Elsewhere, a single university may take the lead with the same local to national roles (e.g. France). In some countries, a separate institution may specialise in monitoring at particular volcanoes (e.g. Greece) providing local expertise but a national institution has responsibility for engagement with civil protection at the national scale. This diversity of scientific institutions responsible for volcano monitoring and volcano advice, is also present at a global scale.

These mandated monitoring institutions also collaborate with research institutions, sometimes very closely, ensuring that CP authorities are receiving a wider range of knowledge and expertise than would be possible from a single institution.

National CP authorities in Europe also have institutional and organisational differences. Each country has the same civil protection responsibilities encompassing planning and preparation for natural hazards events as well as emergency response at local to national scales. However, the CP system in each country is different, comprising multiple institutions that can work together in a coordinated way. The different institutions may include ministries, regional, provincial and municipality level authorities, research institutions that are part of the Civil Protection system, emergency services (police, firefighters, coastguard) and volunteers, etc. Civil Protection authorities may be based in a Ministry, such as the Ministry of Interior or Ministry of Defence. Some national level CP authorities may operate from above the ministries (e.g. Italy), so they can coordinate all the different ministries and institutions, and prepare for, and respond to, national-scale disasters.

Italian Civil Protection, for example, is part of the President's council of ministers, which means that they can take extraordinary measures during an emergency and they can enact extraordinary laws and regulations. This allows them to coordinate all the other actors and institutions. Italian Civil Protection are above the ministries in the government structure, so that they can have a coordinating role. They also have a volcanic risk section comprising dedicated geologists and technicians who are non-operational. There is a formal collaboration and communication agreement with scientific institutions outlining specific communication protocols that must be followed. Scientific institutions are part of the civil protection system, which is a really good way to reinforce the relationships and mutual understanding.

Iceland civil protection has formally integrated national and international scientific collaboration into crisis planning and response, the UK also invites international scientists to join Scientific Advisory Group in Emergency (SAGE) meetings. Some attempts to share transboundary volcanic risk assessments have been made by the UK for the Laki (Grimsvotn) eruption scenario.

5.2 Consultations

Consultation and discussions with Civil Protection authorities at various meetings identified their primary needs from volcano scientists. Each nation had different needs expressed at meetings held between February 2019 and January 2020. These were compiled into a generic list of needs and what is considered to be good practice at a joint meeting of UK (national), Italy (national), Iceland (national) and Azores (local) civil protection representatives in January 2020.

Hazards and impact (and risk) needs:

Long term (risk management)

- Contributions to National Risk Assessments (national to supra-national scale events): the exact contributions needed depends on the approach a particular country takes. Volcano scientists may be required to help identify and design scenarios suitable for national planning, these ideally would cover a wide range of impacts. A true risk assessment will need a multi-disciplinary team to consider hazards, vulnerabilities, and exposure assessments. NRAs should also include consideration of risk drivers and dynamic risk (taking into account the possible long duration of volcanic events, multi-hazards, high uncertainties and multiple sectors affected and cascading consequences). Volcano scenarios with transboundary impacts can be ‘shared’ by CP authorities in different countries.

- Contributions to local planning and preparedness, particularly around volcanoes (e.g. hazard and risk assessments, multi-hazards approaches, coupled vulnerabilities and exposures, impacts, early warning systems, consideration of risk drivers and dynamic risk, cascading consequences (e.g. associated with displacement of populations), risk perceptions and communication of uncertainties).
- Probabilistic hazard analysis and hazards maps that include the multiple potential hazards associated with volcanoes from ground fractures to gases and lahars. These scientific outputs need to be designed with users to ensure effective communication using potentially innovative methods (maps, videos etc.) and to ensure understanding of probabilities, scenarios, uncertainties etc. Maps should be dynamic with scientists able to rapidly update them when conditions change (e.g. when topography is changed due to deposition, erosion or ground deformation during an event).
- Regular joint exercises between scientists, CP authorities and other stakeholders to enhance preparedness for specific hazards and/or events (desk-based, community-based, institutional etc.).
- Documented case studies of the use of science in risk management with lessons learned, planning and preparedness (including hazard and risk communication, urban vs rural perspectives etc.).
- Regularly updated country profiles: to consider relative issues (e.g. monitoring capacity) and risk factors across Europe, transboundary consequences and to enable levelling up in terms of preparedness.
- Analyses of low frequency-high impact volcanic events: share information about the possibility of ‘extreme events’ and their potential consequences in Europe, to enable joint, pan-European planning.
- Co-designed eruption/scenario forecasting tools (e.g. event trees) to support scientific conceptual understanding, planning and preparedness for scientists, CP authorities and other stakeholders, especially at volcanoes that have not erupted for a long time. Useful at data-rich and data-poor volcanoes.

Short term (Emergency response)

- Established early warning systems, based on monitoring networks, scientific knowledge, forecasting, timely communication (e.g. alarms, sirens) and preparedness for a timely response. CP authorities also need to know about possible scenarios, events and hazards for which EWS are not effective (e.g. for phreatic explosions).
- Clear summary of status of volcano with reference to, and access to, time series monitoring data. Scientists communicate critical thresholds of concern in terms of monitoring data in a timely manner, including any changes to such thinking over time.
- Short-term forecasts: scenarios and co-designed probabilistic hazards tools (e.g. event trees) to support dynamic CP decision-making during evolving events. Methodologies ideally developed

before volcanic unrest or events occur and may require rapid expert judgement methods. Specific attention to the intensity of phenomena and timelines of intensity.

- Short-term forecasts: hazards (e.g. tephra fall, gas emissions, pyroclastic density currents, lava flow) to enable emergency mitigation actions. Forecasting of potential time and place is useful even if intensity is not yet possible (e.g. SO2 forecast tools). Combined understanding is needed of hazard intensities (e.g. tephra loading on roof) and thresholds relevant to impacts on different sectors (e.g. roof failure) but uncertainties may be considerable. Scientists and CP authorities (and other relevant partners) must clearly communicate uncertainties and appropriate use of any hazards forecasts/tools to users and ideally co-develop visualisation and communication tools.
- If scientists or their partners have these hazards capabilities, vulnerability information is also crucial – infrastructure vulnerability, social and systemic vulnerability. Vulnerability assessments should ideally be developed alongside hazards assessments during 'peace time'.
- Timely scientific evidence-based forward-looking information on evolving volcanic events and hazards (and volcanic impacts and risk where appropriate) – the data may be preliminary or incomplete but scientists must be able to provide what information there is and explain concerns, uncertainties and knowledge gaps.
- Volcanic alert levels (VALs) could be a useful indicator for CP authorities. VALs require clear understanding (preferably co-design) between scientists and CP authorities about what/who the alert levels are for, who is responsible for decisions about changing the alert levels, using what evidence and thresholds, and on what basis responses to alert levels (by CP authorities and others) are established and planned. Where they exist, CP authorities value having a VAL system linked to a range of scenarios that can be linked with actions that need to be taken by different actors to mitigate risk. Needs long-term development and dialogue (linked to forecasts, probabilistic approaches, phased responses etc.).

Communication needs

- Scientists and CP authorities at all levels need to maintain a sustained and consistent dialogue over time (before, during and after crises). Communication between CP authorities and scientists before an event helps to build understanding and mutual trust, and enables protocols for formal communication during emergencies to be developed and improved.
- CP authorities at different scales can have a tendency to wait for scientists to communicate, but they could be more proactive if, based on planning and preparedness, or as a result of co-design and co-development of tools or outputs, they are confident about what questions to ask in different situations.
- A variety of different communication styles are needed between CP authorities and scientists at different times. 'Interactive' communication is the exchange of thoughts and ideas to avoid misunderstandings (e.g. in meetings, telephone calls), 'push' communications are formal one-way notices that provide information but don't require a reply (e.g. via emails, reports, bulletins or press releases), and 'pull' communications provide group access to common information (e.g. internet sites, databases and knowledge repositories).
- In an emergency, CP authorities' need a clear explanation of what has happened, what is happening (status), and what could happen (possible future scenarios and forecasts, in the short and longer term). The difference between status and forecasts must be clearly understood and

articulated by all. Scientists need to be able to summarise scientific information to brief salient points (with reference to supporting data sets, evidence).

- CP authorities do not just need ‘good communication of science’ (this is important but can contain too much detail and jargon), they need to understand the implications of all that scientists know, or do not know, for CP decision-making. Communication of the scientist’s conceptual model may be useful. Scientists should consider the ‘So what?’ question when communicating (“There have been 48 earthquakes in the last 24 hours – so what?”).
- CP authorities sometimes just need to know what’s new, or if there is change. Scientists could be more concise when this is what is needed.
- Scientists need to make multi-parametric time-series data available and accessible. The value different data streams have in terms of their use in helping scientists with refining conceptual models, forecasting of eruptions, or forecasting scenarios or hazards, should be made clear.
- CP authorities have to summarise the scientific situation to the public because the science provides the evidence upon which CP authorities take decisions. Therefore, scientists need to help with that communication and dialogue, for example, by providing simple explanations of technical monitoring methods, their purpose and their limitations (e.g. InSAR), or the methods and uncertainties associated with short-term probabilistic forecasts.
- Some scientists are good at communication, some are not, but there is rarely ‘monitoring, evaluation and learning’ (MEL) of communication between scientists and CP authorities. Science institutions could introduce MEL to support learning and development.
- Scientific Advisory Groups are useful ways to bring together representative specialists from multiple institutions for discussions of data, evidence, hazards and impacts in near real time. Scientific evidence is subject to scrutiny by peers, independent scientists can contribute to debate and consensus can be sought. CP authorities typically attend or, in some cases, scientists in CP authorities may chair such meetings. Outputs from such groups must include simple summaries for use by CP decision-makers and others.
- Scientists should fully consider uncertainties and knowledge gaps in monitoring, hazards and forecasts, and then clearly communicate these, along with implications, to CP authorities in simple terms. CP authorities need particularly clear information from scientists about situations where there is high scientific uncertainty.
- Probabilistic information is useful for long term planning and may be useful in short-term emergency situations if uncertainties are reasonable but CP authorities and scientists must consider in advance how to communicate probabilistic information to the public
- Institutions, post-holders, relationships and mandates can change over time but the science and data underpinning it, should remain available and accessible, to enable continuity of learning over time. Knowledge platforms (e.g. catalogues) are useful for CP authorities and other stakeholders to access background information when it suits them.
- Scientists need to be able to communicate to CP authorities about volcanic activity that may have impacts from local to transboundary (pan-European or larger) scale.
- Clear, understandable messages from all scientists are needed for the media (e.g. press releases and press conferences), these should ideally follow a ‘single message’ (e.g. IAVCEI protocol) to enhance understanding and avoid potential misunderstandings among the public that may put them at risk. Ideally, any scientific disagreements should be resolved before going to the media.
- Ideally, scientists and CP authorities will jointly disseminate official scientific evidence and recommended CP actions at public meetings and to the media (e.g. at press briefings).

- Additional scientific research/evidence should be made understandable and accessible. For example, published academic papers could be summarised for non-scientists.

5.3 Interviews

What emerged throughout the interviews was that understanding the perspectives of interviewees and the experiences they shared is influenced by the structure and size of the society and the eruptive history of the volcano(es). Examples shared have touched upon a variety of geographic, geologic and societal settings, including isolated, very small islands (e.g. Ascension Island and Tristan de Cunha) to much larger societies (e.g. Italian mainland, Vesuvius and Campi Flegrei). Iceland is unique in the sense that it has a relatively small population and a lot of recent and documented historical experience of unrest and eruptions.

The results of the interviews are presented under a series of cross-cutting themes: communication process; understanding of civil protection needs; communication of hazard and risk; communicating and managing uncertainty; roles, responsibilities and capacity; relationships and trust. The experiences participants shared also extended to their interactions with other stakeholders (e.g. politicians, the media and the general public), but these are not discussed in detail in this report.

5.3.1 Communication Process

Interactions between VOs, VRIs and CP

The extent and frequency of interactions between volcano scientists and different scales of civil protection is highly variable. At the European scale, interaction between nations is most commonly through participation in EU-funded collaborative projects. These activities were viewed as having helped to facilitate long-lived, cross-border relationships. Only one interviewee discussed transboundary volcanic hazards. There has been limited interaction through direct communication with the European Civil Protection Mechanism (e.g. the European Response and Coordination Centre ERCC). Only national science organisations that are engaged in the EC DG-ECHO funded ARISTOTLE-eENHSP project[4] have regular and formalised direct contact with ERCC. EUROVOLC Task 7.2 has raised awareness of the European Civil Protection Mechanism and ERCC with scientists.

Most communication between VOs, VRIs and CP authorities occurs at the level of civil protection that is responsible for managing natural hazards and risks. The degree to which science organisations are in contact with national-level authorities ranges from almost continuous to infrequent, which largely correlates with the frequency of hazards. Depending on the structure of the civil protection system, scientists may communicate with a single central agency or across multiple government departments (e.g. the UK). Where civil protection is distributed across government, it was shared that there can be a lack of transparency in knowing *"where problems sit and whose needs are being dealt with"* (Participant 9 - VRI). Italian participants felt that a particular strength of the Italian civil protection is that the INGV is legally embedded within it, which helps to maintain continuous communication and facilitate applied projects that meet a specific civil protection need.

Regular direct contact between national science organisations and regional/local-level civil protection authorities is not typical and where interactions do occur they tend to be in the form of meetings during research projects and joint science-civil protection participation in public outreach. This interaction is

[4] http://dev.aristotle.ingv.it/tiki-index.php

less formal and often dependent on the enthusiasm and capacity of those involved. In some cases, it was noted that regional/local level civil protection authorities may be hesitant to approach national institutions.

Regional/local observatories generally have strong links with regional/local civil protection, who are typically responsible for managing hazard and risk until a situation exceeds their capacity and they request national support. Some scientists found that in these contexts, tensions can exist between the two scales of civil protection, especially if the national level becomes involved before requested, which can generate mistrust. Scientists need to be mindful of such tensions where they exist. In the case of observatories in overseas territories, scientists interact with representatives of both the local and national civil protection simultaneously.

Communication During Peace-time

Regular interaction between VOs, VRIs and CP groups during peace-time is agreed to be key to enabling effective communication during a crisis: *"I think that almost any activity that brings together scientists, people that do volcano monitoring and civil protection is interesting and it is good practice"* (Participant 7 – VO). This interaction results in the development of a common language, mutual understanding of roles and responsibilities, long-term relationships and trust between groups. Examples of peace-time communication included one-way communications such as operational reporting (in the case of VOs), and interactive communications such as participation in applied projects that meet a specific need of the civil protection, and conversations around long-term planning activities and raising awareness. Science organisations in active regions and/or those that are responsible for monitoring multiple hazards (beyond volcanic) tend to have routine contact with civil protection, which assists in developing long-term relationships (see section 5.3.7). Maintaining conversations around volcanoes where this is not the case is more difficult and often requires scientists to be proactive in creating opportunities for interaction, with examples shared including running training courses or exercises. In these contexts, investment in longer-term science was viewed as important but funding is commonly a challenge.

> *"I think it is difficult in a place where the eruptive frequency is so low … because peace time is most of the time! It is difficult to get Civil Protection to see the necessity of getting in touch with us and learning more about volcanology or what can happen."* (Participant 7 - VO)

Pre-emergency engagement between VOs, VRIs and CP was regarded as essential for establishing communication protocols and procedures, which participants often emphasised as key to enabling effective communications following an increase in activity. In particular, it was considered useful to define the format, content and timing of communications, and to agree on roles and responsibilities. Periodic review of protocols and procedures was also recommended, so that they evolve as capabilities and needs change over time.

A common theme that emerged through the interviews was the importance of testing communications in joint scientist-civil protection exercises during peace-time: "*In peace time – exercise, exercise, exercise!"* (Participant 12 – VRI). This was considered good practice and to have *"a value a thousand times greater than theoretical discussions"* (Participant 12 – VRI). Desk-top exercises based on a scenario, such as a particular hazard, unrest or eruption, using real monitoring data were recommended as particularly useful for identifying elements of interactions between scientists and civil protection that are successful and those that can be improved. It was also observed that exercises aid relationship building and the development of a mutual understanding of the challenges of analysing data and producing information products for civil protection in real-time.

Communication Following an Increase in Activity

The information needs of CP are obviously highest following a significant increase in activity or occurrence of an event, often coinciding with periods of high uncertainty as to how a situation will evolve. Frequency of operational reporting by monitoring organisations (e.g. volcano bulletins, event reports) to CP typically scales with intensity of activity, as do the number of meetings and phone calls between them. During an emergency, monitoring organisations can be in continuous contact with CP authorities, whilst the amount of time spent by individual scientists communicating with CP is largely dependent on if they hold a position of responsibility within an organisation. A mixture of one-way communications (e.g. bulletins, reports) to CP and opportunities for discussion through meetings and phone calls was considered important to ensure information generated for CP was understood. The use of written documents is advocated as they are traceable, represent a robust scientific consensus and allow for information to be delivered to multiple people/organisations at the same time. Phone calls are useful for providing information in real time but it was noted that when CP initiates phone calls they control what questions are asked. Where a VO informs multiple government departments or different levels of civil protection, it may therefore be necessary to take steps to ensure that all parties receive the same information, which can add to time spent communicating. Some scientists also expressed that they had been asked to provide personal opinions on activity in phone calls:

> *"Most of the time they* [civil protection] *asked for our personal interpretation of the activity or an update on the activity, but most of the time our personal thoughts. We try to avoid that sort of communication with them. We prefer to use written documents that can be traced and the information flow reproduced because this is one of the first sources of problems between Civil Protection, the media and the volcano observatory."* (Participant 6 - VO)

Well-established communications protocols and procedures exist between organisations with monitoring responsibilities and CP where there is frequent or long-lived activity and/or hazard events. In other cases procedures are defined internally within an organisation but do not exist between institutions, or not at all in the cases where there is no operational system in place. Protocols and procedures can be helpful in setting expectations as to what information CP can request and can also be used to manage the demand for information. For example, a common approach following an event/increase in activity is to send an event notification then to follow up with more detailed reports at pre-agreed intervals. This is especially useful at small VOs with limited capacity, as it has been found that it reduces the volume of phone calls from civil protection authorities received, thereby maximising the time to analyse data.

Use of Alert Levels

Not all VOs use alert levels. Operational alert level schemes discussed in interviews have variable structures but are all traffic-light systems designed with the purpose of guiding civil protection response actions. Some are also linked to the frequency at which observatories issue information. For example, the frequency at which volcano bulletins are published typically increases with the alert level. Civil protection participants valued the use of alert levels as *"they represent a main point of change in our risk management"* (Participant 4 - CP), whilst a view that emerged amongst scientists is that they can also be useful for establishing or clarifying roles and responsibilities. In one case it was highlighted that they can help translate science into action where capacity is an issue in civil protection but this raises the issue of who is making the decision to act.

Some scientists raised challenges in the use of alert levels. In two interviews it was noted that a common misconception can arise that they *"act as forecasts, ... that they will escalate before an event and are there to give a warning"* (Participant 9 - VRI). Another participant reflected that in their experience civil protection authorities can assume that alert levels change automatically on the basis of strict, pre-defined thresholds in monitoring data, which can impact the decision-making process.

Science Advisory Groups

Across Europe, Scientific Advisory Groups (SAGs) have different forms but all comprise experienced senior scientists who provide advice to CP intended to inform decision-making. They exist separately from VOs but should help and work with them, ideally *"[operating] as a loudspeaker of the observatory to the different levels of society"* (Participant 1 – VO). Some SAGs include participants and/or observers from civil protection, and they may be interdisciplinary, involving individuals from other relevant sectors (e.g. public health, civil aviation) that are familiar with different aspects of risk. Those involved may be formally appointed and hold long-term positions in a SAG or be invited by civil protection depending on their needs. Meetings are chaired by an independent scientist, a member of civil protection or other person in an official role. In some cases, SAG meetings may be attended by political observers, which may be beneficial in helping their understanding of scientific issues if they remain strictly observers. Experiences from interviews suggests that if political observers become active participants then this can create additional risks including; simple misunderstandings, meetings being 'taken over' and losing purpose, efforts to use scientists/meeting outputs to further political agendas, and attempts to control/influence narrative to decision makers. This can lead to a breakdown in relationships and mistrust, and managing such interactions inevitably uses up time and resources. Some examples of political censorship raised in the interviews include censoring of scientific evidence that raised new and unexpected hazards/risks. One participant also discussed attempts to use a volcano observatory bulletin as a political tool, in one case suppressing who the bulletin was sent to. An additional risk presented by inclusion of political observers that was identified by interviews is that their presence may affect the public perception of the impartiality of scientists.

In peace-time, some SAGs meet on a scheduled basis with a recurring agenda (e.g. updating hazard or risk assessments, providing information about volcano status), or may be tasked to provide scientific evidence that enables civil protection to take decisions on a particular issue. Such meetings were viewed as having the additional benefit of fostering long-term relationships (see section 5.3.7). It was also highlighted that they provide opportunities for different scientific and technical experts to interact, when they might otherwise not. During volcanic unrest and eruptions, SAGs typically meet repeatedly as the situation evolves and they may engage with a wide variety of issues. Meetings may occur as frequently as multiple times a day and can last several hours. As such they can take up significant time and resource, often involving the same individuals, which can be particularly difficult in contexts where the pool of scientists is small. However, interview participants viewed them as *"essential"* and in one case, *"the single most important element in communication between scientists and civil protection"* (Participant 5 - VRI).

A common theme that emerged between both scientist and civil protection interviewees is that scientists in meetings can tend to present more scientific detail than is required and can *"lose sight of the purpose of the meeting"*. Scientists should prepare evidence beforehand, and should only present relevant information in a clear, concise way making use of appropriate visualisations. Interview participants agreed that meetings must have opportunities for discussion, disagreement, and debate between scientists with different disciplinary expertise, backgrounds and experiences. As such there is also a need for mechanisms to be in place for reaching scientific consensus and handling uncertainty to ensure that the meeting results in an outcome that is useful and usable to civil protection. One participant recommended that where scientific discussions evolve beyond the scope of the meeting, the chair takes the opportunity to create subtasks and working groups to keep meetings on track. Ideally, meetings should result in an output, which is usually a report based on the evidence compiled and/or consensus achieved through discussion or activities. One participant recommended the construction of report templates, which can speed up the report writing process but can also help to structure meetings and make sure that the necessary points are covered.

Interviewees strongly asserted the need for scientific reports and other outputs from scientific advisory meetings to be independent, transparent and free from political influence. A participant gave examples of complications when political appointees questioned a scientific group and tried to control the message outputs by attempting to dictate the language that could be used and imposing *"red lines"*. Several interviewees pointed out the importance of winning and maintaining public trust in scientists, so transparency in any such interactions is essential and *"scientists must not be seen as an instrument of the state"* (Participant 1 - VO).

Both scientific and civil protection participants recommended the use of video-conferencing for meetings. This allows for meetings to be rapidly convened following an event or significant change in activity, and also maximises participation as attendees are not restricted by their geographical locations. Civil protection participants highlighted two particular advantages of using video-conferencing software:

> *" 1) We can have regular updates and we can chat with them* [scientists], *even if we are not in the same location.*
>
> *2) Information can be shared among them* [scientists] *because universities don't talk with research institutes and vice versa.* [Even] *inside the same research institutes, scientists do not necessarily share information with each other. We have created a situation where they can share information and discuss the data. This is one of the added values. We have created a situation where they can share information and discuss the data."* (Participant 4 - CP)

5.3.2 Understanding of civil protection needs

The three CP interviewed stated that they need information on hazards, including the ongoing situation and the different phenomena that may occur, and also some possible scenarios, with specific attention to the potential intensity of the phenomena, and vulnerability. In the long-term, the focus is on hazard and vulnerability analysis, but in the short-term they are concerned with *"how, when and what?"* It is accepted that the response to these questions might be "*vague*", but what they need is short-term scenarios and likelihoods of what is going to happen and the expected intensity of activity. The CP noted that scientific enquiry and decision-making work on different times-scales and that sometimes a timely answer is more useful than a detailed scientific response:

> *"From our experience the greatest challenges are related to the difference in mentality between us and the scientific community. They have to try to overcome their 'scientific approach' that is based on accuracy, precision of data and the time-consuming data processing. They have to overcome this kind of mentality because often we need information quickly to allow us to manage the situation in the short term"* (Participant 5 - CP)

Information needs to be understandable, concise and useful. The CP interviewed have a scientific (geology) background, but unless the complex outputs of the science are packaged in readily communicable products (e.g. like GIS) they can sometimes find it challenging to translate this information to the local authorities, or other actors in the system who have no Earth science or even science expertise. The CP need scientists to provide relevant information, and observed that during a monthly call with CP, scientists could sometimes lose sight of the purpose of the meeting and provide unnecessary information beyond an update of the last 30 days.

VO and VRI perceptions and experiences of civil protection needs were influenced by their differing experiences of interacting with CP, in turn influenced by the CP structure in their countries (see Annex 1), whether the civil protection staff had a scientific background and/or their level of experience of managing crises. The perceived needs of civil protection also vary depending on the level of CP (e.g. national, local) and the timescale of interest. Interviewees tended to have experience of engagement with national and/or local CP (see section 5.3.1). The experiences of the scientists were similar and broadly covered the same requirements of CP, with some subtle differences. The CP needs identified are summarised as follows:

- Useful and usable information: examples shared included the need to provide context to the data (i.e. the *"scientific and technical advice"*) not the raw monitoring data. What is of concern is, for example, when/where an eruption might start and end, and how the intensity of the eruption may develop in space and time ("*not whether it is a Merapi type, is it Plinian, sub-Plinian"* (Participant 1 - VO)).
- One participant reflected that in a crisis scientists can find themselves in a situation of being informally asked to provide reassurance, especially around likelihoods/probabilities ('It'll probably be ok'). Scientists may lack awareness of when informal communications are becoming risk communications, and may find themselves wanting to 'give good news' especially during prolonged emergencies. To mitigate this, it was suggested that in any informal communication, it is important for scientists to be constantly reflecting on *what* they are saying and *how* they are communicating especially when dealing with probabilities and uncertainties.
- Concise and constrained conversations: during the scientific advisory meetings it is important to constrain discussions with CP and avoid *"wild imagination discussions"* (Participant 12 - VO) because if the information does not have relevant implications (for instance) for changing the alert level or the emergency plan then it is perceived to be '*useless*'. It was suggested by a scientist that good practice for scientists is to not take offence to this.
- Clear and simple information: the information might be complex scientifically, but it needs to be "*packaged in a straightforward manner...with complexity distilled down to a simple statement."* (Participant 9 - VRI), otherwise it will not be used. A way of doing this is through the Scientific Advisory Groups (see section 5.3.1). It is important for CP to be exposed to some of the discussion around complexity, but it is about keeping it simple and answering the questions of concern (what is going on, how long it's going to last) so they can convert the information into something actionable.
- Timely information: CP need the information in real time during emergencies. If an event has happened (e.g. an earthquake) it is important to tell CP in the first communication whether there has been damage or not: "*They want to know the approximate location, if there are people nearby and if there is damage. We can do this in the first ten minutes, then we can be more relaxed [to do the rest]"* (Participant 10 - VO). Civil protection may sometimes need a quick answer, and at other times an answer to a more specific or complex problem that requires more work, e.g. through working groups or research projects.

There was a perception from some interviewees that CP want binary information with regard to, for instance, when the eruption will occur, and that the VO felt challenged when they were not able to provide this information: "*it is the problem of ones and zeros…I think the important thing is do they* [CP] *understand our limitations"* (Participant 10 – VO). In contrast, others felt that CP were comfortable with and wanted probabilistic information. Their experience is that the CP understands that scientists do not have the complete picture, that there is uncertainty and a requirement to communicate this in a way that avoids the use of overly technical language. There were two quite contrasting experiences, one from Iceland where it was felt that CP do not push for answers to questions that cannot be answered, and the opposite experience from the one of the islands. It is important to identify knowledge gaps, as civil protection may be able to help with funding to address these. The interviewees also reflected on the importance of scientists being honest and confident in saying when they do not know.

Some interviewees reflected on the fact that the needs of civil protection are not always clear. In the UK, for example, civil protection is not one single department so one of the biggest challenges is knowing who to talk to and ensuring you are talking to the right people (and not always to an intermediary). Interviewees also observed that the background and experience of civil protection plays a central role in effective communication. In Italy and Iceland, the scientific (earth science) background of civil protection clearly is seen as advantageous. In other countries/regions (e.g. France, the Azores and the Canaries) there are no civil protection staff with a volcanic/earth science background. The benefit of experience of past events is clear, for instance after the El Hierro crisis it was noted that CP were asking more informed questions regarding the situation at the volcano after their experience. Overtime, however, the knowledge developed through experience wanes due to changes in staffing and infrequency of crises:

> *"I think it is difficult in a place where the eruptive frequency is so low … because peace time is most of the time! It is difficult to get Civil Protection to see the necessity of getting in touch with us and learning more about volcanology or what can happen."* (Participant 7 - VO)

This poses challenges to maintaining, for instance, a common language between scientists and CP. To address these challenges, efforts are made to provide training to civil protection[5] (e.g. Canaries and Azores). One example was shared of the scientists attending the International Civil Protection Congress, which turned out to be an excellent opportunity to show-case the work of the VO:

> *"We had the chance to explain to people what we do and the importance of our connection with the civil protection. The congress lasted three days and it was a success…. I think most of the people who came to the congress last year do not know about the work we do on a daily basis, so it was very important. It was not our idea, it was an idea from civil protection. It was decided to do it to show how civil protection is organised and that it is not only them that react, that there are a lot of institutions like* [volcano observatories] *giving advice to civil protection, and the importance of these institutions in giving technical advice."* (Participant 10 – VO)

Permanent structures are important, for instance permanent CP positions and representation within scientific advisory groups (e.g. the National Science Committee in Greece). In many examples, the civil protection positions are long-lived, whereas the leadership positions change more frequently. Changes in leadership and administration can test well established communication processes, if the new person does not understand protocols regarding responsibility for decision-making (e.g. alert level changes). Continuity of CP staff underneath the leadership is important for building and maintaining long-term relationships with VOs and VRIs.

Even in places where permanent CP have a background in earth science (e.g. Italy), it was commented that many of those within the same civil protection system (e.g. local authorities) will not, so whatever information the science community provide to the CP needs to be packaged in a way that it can be understood by other actors. Scientists need to provide added value to what the science is saying, particularly when dealing with the uncertainty. Stakeholders, particularly those without an earth science or scientific background, need to understand the context of the status of the volcano or the monitoring parameters.

5.3.4 Communication of Hazard and Risk

Scientists from VOs and VRIs contribute to hazard assessments over a range of scales, from volcano specific to national level. Depending on the needs of civil protectant they may relate to single hazards, e.g. identification of soil CO_2 hazard for land-use planning, or take a more holistic, whole eruption approach. Generally, Civil Protection are viewed as facilitators of hazard assessment that task a single organisation or multi-institution working group/commission to carry them out. Some participants strongly asserted a strong separation of roles and that civil protection involvement should not extend

[5] Successfully winning funds for flood mapping etc. as a result (Azores)

beyond provision of a 'problem' and funding, so that the output is purely scientific. It is agreed however, that they should be included in discussions throughout to ensure that the product meets their requirements and to facilitate understanding.

Interdisciplinary approaches to hazard assessment are encouraged and may be needed. For example, in the case of understanding the likelihood of gas impacts from Icelandic eruptions in the UK, there was a need for Earth scientists to collaborate with atmospheric scientists and public health. Such hazard assessments are highly resource intensive however, and, as highlighted in the interviews, investing in such activities may not be practical and or appropriate in certain contexts. In the case of very small islands a more pragmatic approach may be more useful where conversations centre around possible future hazards and raising awareness of vulnerability. These contexts pose particular challenges as any eruption will impact the whole island, so evacuation to a different area on island is not possible: *"The smaller the island the bigger the problem because you cannot escape on foot*" (Participant 12 - VRI). As an example, for the very small islands like Ascension and Tristan de Cunha, the focus of the developing conversations with the UK government and on island has been about establishing risk thresholds and tolerances (i.e. at what point people would need to leave).

A theme that emerged across the interviews is that risk assessment is *"not as universal and comprehensive as hazard assessments"*. At the national level, in the UK extensive work has been put into the development of a National Risk Assessment (NRA) based on impact scenarios[6]. In general, scientists contribute to risk assessments through the provision of scenarios, hazard maps and models that enable the identification of areas that could be impacted. Moving from hazard to risk requires multi-disciplinary work, combining the hazard outputs of volcano scientists with exposure and assessments of vulnerability that are developed alongside, from other science and technical experts. Progress on risk analysis tended to be described more in terms of research projects. Reasons identified by participants as to why operational risk assessments are not more common included: *"… there is still a lot of work that needs to be done to define risk issues, what is acceptable risk and the methodologies for how to do that. We are good at taking a certain eruption and evaluating how large an area will be impacted and so on, but estimating risk and things like economic impacts has hardly been touched"* (Participant 5 - VRI), a lack of access to expertise in vulnerability, and a need for greater quantification of hazard to enable calculation of risk. The added complexity of the need for a holistic, multi-hazard approach was noted. Participants suggested that for a greater move towards risk. there needs to be a common language and understanding of risk within the science community that does not yet exist, and greater quantification of hazard to facilitate calculation of risk. Some participants perceive that risk assessment is solely an obligation of civil protection and *"not the responsibility of scientists"*. The CP interviewees felt that the science community has a part to play in risk assessment:

> *"At the moment we don't really talk with scientists in relation to risk assessment. We also have another obstacle to overcome, which is that we think that risk is up to the Civil Protection, whilst hazard and everything else is for the scientists. We need to clarify this together with the scientists because actually a risk assessment could be done easily by the scientific community and then the decision makers will act on them to make proper policies. We need to overcome this and I think once we do this we will have a clear way on how to proceed."* (Participant 4 - CP)

Scenarios

Scenarios are an effective method of raising awareness of potential activity, hazards and potential impacts over a range of timescales, and are useful for enabling emergency planning activities. Approaches to developing and selecting scenarios for long-term emergency planning differ across

[6] https://www.gov.uk/government/publications/national-risk-register-2020

Europe, and include; definition of the most probable eruption based on probabilistic modelling and eruption history, identification of the reasonable worst-case scenario from the event record, and selection of a worst-case and most-likely eruption case from known past events. Usually these are developed in discussion with civil protection authorities. Interviewees recommend the definition of multiple scenarios for emergency planning to maximise flexibility in a future response - *"if you anticipate you can prepare"* (Participant 1 - VO). Where this has not been the case or scenarios have focused on a single/limited number of hazards it has been found that civil protection authorities can have a fixed perception of what might happen and be *"unprepared for the diversity of scenarios"* (Participant 1 - VO). In one case an interviewee found that civil protection authorities were reluctant to accept the existence of hazards previously unknown to them and the situation led to tensions with scientists.

Once unrest or an eruption has begun, civil protection authorities typically request scenarios to help understand how the situation may evolve. Participants from civil protection stated that in these contexts they need a *"short-term scenario and the expected intensity of activity"* (Participant 4 - CP). It is considered important to include timeframes and to attach statements of likelihood, which are useful to civil protection. The provision of likelihoods is the most common way that scientists communicate uncertainty but is perceived by some to *"often [be] something scientists stumble with"* and it was noted that the "*shorter the time frame the harder it is to give likelihood"* (Participant 9 - VRI).

Both scientist and civil protection participants generally regard event trees as a useful way of presenting scenarios and likelihoods of occurrence for unrest and eruptions but they have not been developed for all volcanoes. In some cases event trees exist in the research literature but are not in operational use. Where they are, they can be either qualitative or probabilistic. Whilst probabilistic event trees may be seen as an ideal, the degree to which they are useful is dependent on the availability of data to create probability density functions.

> *" I'd say event trees are useful when each node can be characterised by a probability density function based on data, on actual data. If you don't have actual data and you put a probability density function to a node and too many nodes are filled with theoretical probability density functions [then] the answer will have an error bar that is not based on data and is a theoretical error bar ... when you lack data it is better to dig into the data or acquire new data, not to use these conditioned probabilities to construct event trees that are all theoretical. In the end all these probabilities come up with an error that is not based on something that can be validated."* (Participant 12 - VRI)

Any unrest/eruption scenario that is to be used operationally needs to represent a scientific consensus and preferably should demonstrate the divergence of opinions, e.g. through quantified uncertainty. A useful approach raised in some interviews that achieves this is through expert judgement (elicitation). This was used by the Scientific Advisory Committee (SAC) working with the Montserrat Volcano Observatory (MVO) to assess medium and long-term eruption scenarios. More widespread use has been limited as expert groups and procedures have not been established in many VOs, but some are working towards this.

Maps

The most common contribution of scientists to volcano risk management is through the production of hazard maps. Types of operational maps in use or that have been used across Europe have been developed for a variety of purposes and timescales. Maps produced by scientists in the short-term include multi-hazard maps constructed rapidly during an emergency using a volcano information tool, maps that forecast areas that may be affected by an airborne hazard (i.e. gas or ash) during an eruption, and ash dispersal forecast maps that are created on a daily basis with a three-day outlook, irrespective of whether there is activity. Long-term maps have been created for the purpose of land-use planning and to form the basis of emergency plans. During the first few years of the long-lived eruptive activity of Soufrière Hills on Montserrat between 1995-2013, much of the conversation around the volcano became about living with activity and a multi-zonation hazard map was created based on modelled outputs of hazards that was effectively used as an administration map to manage evacuations. The degree to which operational long-term maps are available is variable and strongly linked to the existence of emergency plans. Some scientists noted that committing resources to such maps is not always appropriate or practical, for example at continuously active volcanoes or on very small islands. Some observations and reflections on the development of operational maps for long-term planning included:

- There may be a need to distinguish between operational and non-operational maps where both exist as there may be potential for confusion. In Italy the Civil Protection ask for disclaimers to be applied to any hazard maps that result from projects that they fund that are unrelated to official maps used in emergency plans.
- New methods of mapping can take time to be fully adopted by the intended users. One participant noted that a new method of probabilistic mapping was *"not easy to integrate into civil protection procedures in the beginning but now they understand it and ask for this type of product"* (Participant 15 - VO). This integration was facilitated by continuous contact between scientists and civil protection.
- The timescales over which maps are made, agreed and become part of an official emergency can be years. Research, modelling, and reaching a scientific consensus, to ensure it is scientifically robust is resource intensive and lots of discussions need to take place at the local level in municipalities that will be enclosed in hazard zones.
- It is important to share maps used in emergency plans widely, once they are fully agreed upon by scientists and civil protection: *"… then exposed to the population in the media – this is the most important thing because without dissemination the maps are useless. Without dissemination, during the next evacuation, all the people … will stay at home."* (Participant 12 - VRI).

5.3.5 Communicating and Managing Uncertainty

Communication of uncertainty was acknowledged to be the most complex aspect of providing scientific information for civil protection. Participants across science institutions agreed that volcano observatories and research institutions have a responsibility to assess it and an obligation to make the limits of knowledge clear when providing information that is used to make operational decisions. Scientists from countries where there is volcano risk expertise in civil protection, felt that the existence of uncertainty was accepted. Where this was not the case, and especially where there is little/no Earth science or even science knowledge amongst civil protection authorities, they often expressed a frustration that civil protection asked questions wanting an unrealistic binary answer on which to base decision-making, especially in the short-term. A case was identified where civil protection were similarly frustrated that scientists could not provide this type of information. Discussions of uncertainty in these contexts were also observed to sometimes be misinterpreted as flaws or weaknesses in the science. Recommendations for improving such situations include creating opportunities during peace-time for discussion around extent of knowledge, monitoring capabilities, model source parameters and implications of outputs, as well as the timescales over which parameters change, can be analysed and interpreted. Such discussions also have the advantage of identifying knowledge gaps and possible opportunities for civil protection to provide funding. Civil protection participants observed that scientists were reluctant to discuss uncertainty following the fatal L'Aquila earthquake in 2009 and subsequent court case[7], but over time they are becoming increasingly willing to do so. They also emphasised that it is easier to communicate uncertainty where there is a strong framework of trust.

[7] https://www.science.org/content/article/italy-s-supreme-court-clears-l-aquila-earthquake-scientists-good

Effective methods for communicating uncertainty included the use of visual products. The use of videos/animations is considered particularly useful, where there is time, for demonstrating the sensitivity of models to changes in input parameters. The examples of communicating uncertainty shared were most commonly qualitative, for example statements of the likelihoods of different scenarios. Both scientist and civil protection participants indicated that ideally there should be a move towards greater usage of quantitative methods and probabilities. However, some scientists felt that civil protection did not always have a sufficient understanding/knowledge for this to always be useful for decision-making. Experience in the UK suggests that it can be helpful to have people available that can facilitate 'translation' of quantitative information to fully qualitative. Additionally, civil protection participants questioned the current readiness of the scientific community to provide useful and usable probabilistic information during emergencies, as current approaches can be too time consuming, and sometimes scientists give probabilities in terms the CP find too vague, for example, *"we have 60% probability of an occurrence of specific phenomena or scenario, plus-minus 40%"*. In these circumstances it was suggested that a useful way of expressing uncertainty would be through a simple event tree approach with rapid expert elicitation methods for capturing changing possibilities.

5.3.6 Roles, responsibilities and capacity

The roles and responsibilities of scientists and the civil protection are defined by mandates, institutional structures and protocols. After the prosecutions following the L'Aquila disaster, attention upon the role of scientists is clearly evident in the interviews. One interviewee noted that instances where the roles and responsibilities of scientists and CP are not clear can be the source of problems. Indeed, another interviewee emphasised the importance of mutual understanding of the respective goals of scientists and CP as a strategy for avoiding "*those off the record conversations where civil protection officials ask scientists questions that are beyond their remit"* (Participant 7 - VO).

Scientists have a role in providing CP with the information they need to make decisions (e.g. providing monitoring data that might be used to determine whether an evacuation is required), but it is essential to be clear about the boundary between scientific advice and the action taken by CP. Scientists should avoid being drawn into a 'what should we do' conversation with CP (or other stakeholders), which can happen in certain settings (e.g. small islands).

One participant with experience of working in small islands reflected on a lack of capacity (staffing) within civil protection to act on the scientific advice as posing a challenge, rather than a lack of willingness of the civil protection staff themselves. In this example, sometimes the observatory would end up acting on behalf of the civil protection authority in meetings with different sectors because the CP did not have capacity to attend, and the observatory would have to explain their role and responsibilities. Capacity issues extend to the VOs, and VRIs may have a central role in the monitoring of volcanic eruptions and volcanic research particularly in cases where the observatory has limited capacity. Ways to address capacity issues include, volunteers (in Montserrat, local and international volunteers helped increase capacity of the observatory, increasing knowledge in the local community and experience in the international science community) and partnerships with VRIs (in Iceland, the University of Iceland ran a seismic network that is now mostly run by the Iceland Met Office (IMO)). The increased capacity at IMO for volcano monitoring is seen as positive and important because it provides clarity on responsibility. During an emergency, the university and IMO work almost as a single unit. In Greece there is no experience of an eruption and it was emphasised that support from the European and wider international science community "*for monitoring and simulations"* would be needed when an eruption occurs. It was also asserted that in these low-frequency eruption contexts, initiatives for expert groups that can support scientists in different places are very important.

A number of interviewees reflected on the resource required for interactions between CP and VOs/VRIs, which can be extremely intensive at the beginning of a crisis. As an example, one interviewee noted that around a quarter of their time goes into communication with CP. This can also depend upon the individual's position within the organisation, with those in more senior positions being in demand. During a prolonged crisis, the resource issues become clear with over 100 meetings being held over the course of four months. Furthermore, the resource impacts upon monitoring scientists might become more hidden during a prolonged crisis, as the perception of risk reduces amongst the actors involved in the emergency over time, which reduces their workload. Those involved in the monitoring, however, have to maintain the same level of work no matter the duration of the event.

5.3.7 Relationships and trust

Procedures, protocols and mandates are the enabling tools for effective communication, but the individuals and the long-term relationships they build and maintain during peacetime underpin successful communication between VOs, VRIs and CP:

> *"At the institutional level there are agreements...At a personal level people are in contact and share information."* (Participant 15 - VO)

Whilst the leadership of CP might change, in many countries the positions of those within the CP system may be more permanent and these long-term connections are pivotal to communication. It is important to have a continuous engagement between scientists and CP. In countries where emergencies are infrequent, regular engagement during 'peace-time' proves more challenging. Engaging CP in training and research projects (e.g. European projects) was identified as a mechanism for maintaining that engagement, along with the importance of running exercises.

In small islands, where the VO is embedded in the community, or small countries like Iceland, good relationships can come easily. In these settings, the duty scientist might know all those on duty at the civil protection (important for maintaining relationships). One interviewee reflected that if there is a problem between the VO and CP then it can become personal because the relationships are quite personal, but this same interviewee felt that there are more things that work well than the things that do not. Trust emerged as central to effective communication between VOs, VRIs and CP, and whilst it might grow during a crisis, trust has to be built during peacetime. Trust also enables honest conversations about limited capacity and a "*mutual understanding of why some things [are] difficult at times*" (Participant 9 - VRI). Interviewees emphasised that it is important to be honest and scientists should feel able to say when they do not have the answer.

Through well established relationships, what became apparent to the interview team was the extent to which individuals go beyond what is expected of them within existing procedures and protocols, to make themselves available to CP outside of the traditional lines of reporting (e.g. for a telephone conversation), or through direct engagement at the local level: "*Following the protocol...However, we have been working with civil protection for long time , so occasionally get a phone call asking about something* (Participant 16 - VO).

In communication with the CP, an interviewee gave an example of where they provide "*scientific and technical advice"* on how to communicate the information to, for instance, the media, for example providing context to the number of daily earthquakes (Participant 10). Example(s) were also shared of where VOs assist CP in their wider communication role to the public, particularly when the capacity of CP is challenged (lack of staff, e.g. during the Montserrat crisis). This was underpinned by the long and trusted relationships between individuals within CP and VOs/VMIs.

In small islands, the observatory may be quite embedded in society, which poses many advantages but also challenges. For instance, during the long-lived Montserrat eruption, VO scientists needed to be *very careful* in providing their advice because they were so aware of the wider discussions regarding development, investment and economic recovery (livelihoods) of the island. Scientists were and have to be impartial and independent, but it "*was hard not to be optimistic when people wanted us to be optimistic"* (Participant 9 VRI).The importance of local observatories was also mentioned and demonstrated by (for instance) their direct interaction with the local population. It was also suggested that it empowers scientists to communicate to the population in a way that is *"not alarmist because they have a responsibility"* (Participant 12 - VRI).

5.3.8 Good practice in communication between VOs, VRIs and CP

Interview participants were specifically asked to identify what they consider to be good practice in communication between VOs, VRIs and CP. Broadly the same themes emerged across the interviews, which generally reflect the good practice recommendations gathered as part of the consultations with civil protection (section 5.2). These points have been collated, summarised and are listed below (in no particular order). Recommendations for good practice that were not previously identified during the consultations are highlighted in bold:

- Pre-crisis engagement between CP, VOs, VRIs is essential for developing trust, a common language, mutual-understanding of roles and responsibilities, goals and capacity. This enables effective communication in a crisis. Where contact is not regular, it is good practice to create opportunities for interaction, for example through scheduling regular science meetings (face to face or by video conferencing), engagement in research projects, and participation in workshops, training and conferences.

- Development of a range of scenarios of potential future activity in the long-term, which enables emergency planning and preparedness and helps to facilitate mutual understanding of potential hazards and uncertainty.

- **Embedding scientific institutions with monitoring responsibilities/responsibilities to inform CP within the national civil protection system.**

- **Regular (at least 1-2 a year) joint civil protection-scientist exercises that simulate a volcano-crisis, ideally using real monitoring data that is analysed in real-time. This identifies weaknesses and strengths in interactions and demonstrates the timescales over which data is received, analysed and interpreted, as well as what types of products can be reasonably produced for civil protection in an emergency.**

- **Communication procedures and protocols should be defined during peace-time and episodically reviewed. Reviews allow for continual improvements based on experiences from both groups and as new options become available. Establishing a framework for engagement is important, within which you can operate and comfortably say what you think. Protocols can prevent misunderstandings.**

- Channels of communication between VO/VRI and CP should be limited to maintain clear and consistent messaging

- Collaboration and co-production of products, including a dialogue about what can be produced and what is needed. This helps to ensure that products are useful and usable to CP but also that they can be reasonably produced by scientists in given timescales.

- **Scientists should use written documents, such as volcano bulletins and reports during an emergency. Written documents are advantageous as they represent a robust scientific consensus rather than a personal opinion, all actors can receive the same information at the same time, and they provide a traceable record of what was communicated to CP. These should not be used in isolation and there should also be opportunities for interactive communication (phone calls, meetings) to discuss and clarify information. Ideally, the types of documents produced should be agreed pre-crisis and designed to meet the information requirements of end-users.**

- Information scientists provide to CP needs to be understandable, concise, useful, usable, relevant and timely. Scientists should not take offence if the CP feel the information the scientists are providing is irrelevant or not useful.

- **Use of video-conferencing. This enables meetings to be convened rapidly following an event and maximises opportunities for participation and involvement, especially where people are distributed across different geographical locations.**

- **VOs/VRIs should avoid the temptation to provide reassuring statements. This is not a scientist's role. Scientists cannot provide yes/no answers, instead they need to give probabilities and likelihoods.**

- Scientific advisory groups (SAG) are essential. In science advisory meetings, scientists should communicate clearly and concisely using appropriate methods and visualisations. Information presented should be timely, useful, usable and relevant. Ideally, meetings should result in an immediate joint output from scientists and civil protection.

- **Inclusiveness and reaching consensus: try to include/invite as many people as possible and have a wider group meeting before a SAG meeting to try to refine and consolidate thoughts before going into the official meeting to help keep it on track and keep control on the length of the meeting. Debate and discussion is important but civil protection need there to be consensus for information to be useful even if it is to say we don't know/know enough yet.**

- Scientists have an obligation to make the limits of knowledge clear and communicate uncertainty in a manner that is understandable and useful to CP decision making. Expressing uncertainty qualitatively may be more useful than quantitatively, and it can be useful to have people available to facilitate the translation of complex quantitative information into more qualitative terms.

- **Scientists should be empowered to provide advice independent of political influence.**

- **Scientists should be able to communicate directly with those making the decisions, rather than going through different political levels, otherwise messages might be changed or lost.**

- **Establish methods of community monitoring (e.g. volcano observers, felt seismicity reports). This increases monitoring capacity and results can be used to add value to information products for civil protection, for example inclusion of felt seismicity reports can help identify the areas most likely to be impacted. Community engagement also helps to build public trust in institutions.**

- **Direct communication between VOs (scientists) and the local population should be supported. VOs are embedded in the context and this creates trust.**

- **Scientists should consider their choice of language, for example not referring to an eruption as 'beautiful' or 'exciting', particularly when it has caused a lot of damage.**

- **Knowledge sharing and exchange: having strong volcanology community support. For instance, at the European level, networks of scientists available to support can be critical at volcanoes with low eruption frequency where VOs may have limited experience.**

5.4. Case Studies

Three case studies were returned, which described a sequence of intense lava fountaining at Mt. Etna (16 Feb-1 Apr 2021), the Fagradalsfjall eruption (19 Mar 2021-Ongoing), and a tectonic seismic crisis (3 Nov 2019) in the Azores. Within these case studies, the authors provided a rich and detailed narrative of the emergency, and reflections, lessons learned and good practice for (1) communication and (2) capacity and resources. The full case studies and the template can be found in Annex 4. The key messages that those that completed case studies wish to emphasise to the EUROVOLC community and beyond are:

1. *"Maintain a proper and redundant communication system. Automate the availability of products for the Civil Protection* [so that they can] *follow in real time the evolution of the situation"*. - Case Study 1
2. *"Connection amongst scientists is essential, and it is natural to ask for support/exchanges/discussion with colleagues working in different institutions (also international). Exchanging experiences is a key element in our response, as often (if not always) others already have been dealing with similar situations/crisis. Volcanic crises will never be the same, but knowing how others responded, which tools, which solutions, which difficulties they encountered, is definitely a great starting point in designing our own way. Usage of numerical models remains tricky. On one side it offers a great chance to investigate scenarios, produce impact maps; on the other side various models exist producing different results and the question is always who is right? Or possibly the model simply does not perform as well as expected. Often we do not know the answer and the variability in model results might create the condition for mining the credibility of the institutions (other than creating tensions between scientists)"*. - Case Study 2
3. *"An effective operational management of volcanic crises comes from the objective application of procedures".* - Case Study 3.

6. Learning from COVID-19

COVID-19 has been a devastating experience worldwide but there are lessons to be learned by the volcanology community. As emerged during the interviews and in weekly meetings there are similarities between public health and volcanic emergencies. Both tend to be long-lived, and require rapid analysis of large volumes of diverse data types, many of which are not standardised. They are also inherently multi-hazard with complex interacting and cascading consequences. Preliminary discussions in meetings suggested that there are opportunities arising from COVID-19, including an increased awareness amongst decision-makers of the need to plan and prepare for a variety of less frequent natural hazard risks, (like pandemics and volcanic eruptions), as well as improvements in being able to operate remotely and also in/wider use of communications technology that enhance access. There are also setbacks including staff burnout, and changes which may or may not be beneficial, such as reorganisation of institutional and/or departmental responsibilities.

In addition to discussions related to VO, VRI and CP interactions during the pandemic, both weekly meeting and interview participants made observations and reflections on the management of the COVID-19 pandemic in the nations where they are based. Some reiterated points already outlined in section 5 in the context of volcano risk management, whilst other points have potential relevance for future volcano emergencies, possibly highlighting areas for further consideration. Examples include:

- The inclusion of political observers in science advisory meetings was viewed as having had a negative effect on public trust in scientists and the perception of the impartiality of scientific advisory groups. Transparency in such interactions is essential.

- Some governments were viewed as having a political agenda that resulted in the imposition of limitations on what science advisory groups could say and attempts to control messages coming out of science advisory meetings.

- Decision-makers need information that represents a scientific consensus to maximise the potential of a timely and realistic response.

- The use of scenarios for risk assessment and emergency planning is extremely useful but planning for a single scenario does not equate to being prepared for all eventualities. The more scenarios that are considered the greater the flexibility of response.

- The amplification of non-scientist voices in the media and social media with opinions that are contradictory to official advice, as well as different scientific advice between different nations during a trans-boundary crisis creates confusion and can undermine scientific advice.

7. Conclusions and Recommendations

A rich and detailed account of experiences of emergency and peace-time interactions between volcano observatories, volcano research institutions and civil protection authorities across Europe and European-territories has been captured in WP7 Task 7.1. Volcanic risk management systems are highly variable and the settings of individual volcanoes are unique, yet many of the challenges, lessons learned and recommendations for good practice that were collected were found to be common between the different contexts. Where there were differences, these presented an opportunity for knowledge exchange and learning.

The main output of this report is the experiences, lessons shared and recommendations for good practice. Through working closely together and having a good understanding of each other's needs and limitations, civil protection can be empowered to make risk management decisions based on the scientific advice of VOs and VRIs.

The key recommendations coming out of this work include:

- Use of the community developed through the EUROVOLC project to continue knowledge exchange and sharing of good practice. Other potential contributors should be identified and invitations extended to enhance opportunities for community learning.
- Create opportunities for different scales of civil protection to interact and discuss volcanic risk management.
- Development of a common understanding of risk and risk terminology, and discussion on the role of scientists in risk analysis. We should establish a multi-/inter-disciplinary community in Europe concentrating on translating hazard into risk that involves different areas of scientific and technical expertise (including vulnerability and exposure analysis).
- Recognition of the resource intensity of communications before and during an emergency, on top of the many demands placed upon volcano scientists and CP. The pandemic has only added

to the pressures on capacity, on top of the number of volcanic crises that have occurred during the time-frame of the EUROVOLC project. It is suggested that there is a need for discussions of possible strategies to increase capacity during these periods, perhaps through support of European networks.

- Recognition of the role and contributions of volcano observatories to civil protection authorities (and risk management), and the benefits of observatories being embedded in the local context
- Development and formalisation of a European network that is available on request to support other volcano monitoring institutions in times of crisis. This is especially necessary in low frequency eruption environments, where the monitoring institution may have little or no recent experience of unrest/eruption and/or where there are no well-established monitoring networks in place.
- Reflection on the management of the COVID-19 pandemic and the cross-hazard lessons learned for communication between VOs, VRIs, and CP where an event has trans-boundary impacts.

In terms of legacy, the WP7 group have agreed to continue meeting on a monthly basis. These meetings will have a theme, the first focusing on taking this report and turning it into a peer-reviewed output. Meetings thereafter will initially focus on themes that have emerged through the course of data collection for Task 7.1. COVID-19 has resulted in a number of technological advances to virtual interaction that have real benefit for sustaining networks through video conferencing and online participation. Such advances allow us to more easily sustain networking activities.

References

Aitsi-Selmi, A. *et al.* (2016) Ensuring science is useful, usable and used in global DRR and sustainable development: a view through the Sendai framework lens. *Palgrave Communications*. 2:16016 doi: 10.1057/palcomms.2016.16

Cartlidge, E. (2015). Italy's supreme court clears L'Aquila earthquake scientists for good. *Science News*. doi: 10.1126/science.aad7473

Pallister, J., Papale, P., Eichelberger, J. *et al.* 2019. Volcano observatory best practices (VOBP) workshops - a summary of findings and best-practice recommendations. J Appl. Volcanol. **8,** 2 (2019). https://doi.org/10.1186/s13617-019-0082-8

Activity meetings for D7.1

18th – 22nd January 2019, Annual Eurovolc meeting, Ponta Delgada, Azores.

- Discussions with WP participants on progress and strategy of WP7.
- Discussions and consultation with Civil Protection (Azores Civil Protection (Fire Officer), UK Civil Protection (GO Science), Icelandic Civil Protection (National Commissioner of Icelandic Police), Italian Civil Protection (Volcanoes).
- Discussions and consultation with Volcano Monitoring agencies.

27th - 31st January 2020, Annual Eurovolc meeting, Catania, Sicily.

- Discussions with WP participants on progress and strategy of WP7.
- Discussions and consultation with Civil Protection (Italian Civil Protection).
- Discussions and consultation with Volcano Monitoring agencies (Italy, Azores).

1st – 5th March 2021, Annual Eurovolc meeting, remote.

- Discussions with WP participants on progress and strategy of WP7.
- Discussions with WP11 and WP12 on Theme progress

~30 weekly WP7 meetings in total:

February - May 2020 (~16 meetings <30 participants)
18 March 2021 WP7 meeting
1 April 2021 WP7 meeting
September - November 2021 (including WP11 and WP12 at times) (~12 meetings <15 participants)

Annex 1 – Civil Protection authorities in Europe

The first milestone for WP7 was to document civil protection powers in each country relating to natural hazards and disasters. This has now been done officially by the EU and is available on the EU portal along with a comparison tool. https://portal.cor.europa.eu/divisionpowers/Pages/Comparer.aspx

Information and sources are made available to describe central, regional and local responsibilities.

Examples are given below for the countries participating in EUROVOLC (pre-Jan 2021).

Europe

(EU) civil protection

Whenever there is a disaster or humanitarian emergency, the EU provides assistance for the affected countries and populations.

For disasters inside the EU, the Civil Protection Mechanism facilitates and coordinates Member States' in-kind assistance. When the scale of an emergency overwhelms national response capacities and assistance is requested, the EU Civil Protection Mechanism enables a coordinated assistance from the Participating States (28 EU Member States) + Iceland, Norway, Serbia, Macedonia, Montenegro and Turkey. The Mechanism also coordinates the delivery of in-kind assistance for disasters outside the EU.

In developing countries, the EU (Commission and Member States combined) is the world's largest humanitarian donor. Funding is provided to partner organisations (mainly UN agencies, the Red Cross/Crescent movement and humanitarian NGOs) which deliver the bulk of emergency assistance, on the ground, to those in need.

The Treaty of Lisbon underpins the commitment of the EU to provide assistance, relief, and protection to victims of natural or man-made disasters around the world and to support and coordinate the civil protection systems of its Member States.

Civil protection and humanitarian aid are the main operational instruments of the EU's immediate response to disasters. These have been brought together into one Directorate General (DG ECHO) in the European Commission:

- European Civil Protection and Humanitarian Aid Operations (DG ECHO) https://ec.europa.eu/echo/who/about-echo_en

DG ECHO has a 24/7 crisis response room (ERCC) responsible for planning, monitoring, preparing, operational coordination and logistical support:

- Emergency Response Coordination Centre (ERCC)

https://ec.europa.eu/echo/what/civil-protection/emergency-response-coordination-centre-ercc_en

ERCC is a coordination hub facilitating a coherent European response during emergencies in Europe and internationally, helping to cut unnecessary and expensive duplication of efforts.

Monitoring contributions for ERCC come from:

- ESA-led Copernicus (formerly Global Monitoring for Environment and Security GMES) https://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Overview3
- INGV-led Aristotle project http://aristotle.ingv.it/
- Other
  - ECHO Director General: Monique Pariat
  - Emergency Management: Johannes Luchner
  - ERCC: Antoine LeMasson
  - Emergency Preparedness and Security: Peter Billing
  - DRR, European Voluntary Humanitarian Corps: Nacira Boulehouat
  - Civil Protection Policy: Julia Steward-David
  - Contact details: https://ec.europa.eu/echo/who/about-echo/organisational-chart_en

Portugal (Azores)

National/central

- Defining, managing and implementing policies on civil protection security border control, protection and rescue.
- Promotion of volunteering programs and civil participation.
- Integration of emergency services.
- Emergency Planning
- Risk management
- Civil Protection Logistics
- Hazard Prediction
- Relief Operations

Responsible ministries/bodies

- Ministry of Internal Affairs
- National Authority for Civil Protection (ANPC)

Regional
The Azores:

- Civil protection, fire emergency, medical emergency;
- The monitoring of meteorological, oceanographic, seismic and geological risks, and
- Assistance and monitoring of beaches, bathing areas and coastal rescue.
- The Azores Regional Civil Protection and Fire Service (SRPCBA) is a department operating under the Regional Secretariat for Housing and Infrastructures with responsibility for overseeing coordinating and supervising civil defence and fire service activities within the Autonomous Region of the Azores.

· http://www.azores.gov.pt/Portal/en/entidades/srs-srpcba/

Responsible ministries/bodies

- Regional Authorities of Azores

Local level
Municipalities are responsible for:

- The creation of municipal fire departments;
- The construction and maintenance of fire stations, and
- The construction, maintenance and management of municipal facilities and centres of civil protection.

Intermunicipal entities are responsible for:

- Same areas, under agreement with the municipalities

Parishes are responsible for:

- Participating in the municipal council of security;
- presiding over the local unit of civil protection;
- collaborating with the municipal authority of civil protection in the imminence or occurrence of a major accident or disaster. Communication Network development in liaison with the central authorities.

Sources:
ANPC Documents and Policies
Estatuto Político-Administrativo da Região Autónoma da Madeira (Law 130/99 of 29 August).
Estatuto Político-Administrativo da Região Autónoma dos Açores (Law 2/2009 of 12 January).
Law 75/2013 Legal Regime of Local Authorities
Law 50/2018 Transference of Competences to Local Governments and Intermunicipal Entities
Law 51/2018 Local Finances Legal Framework
Decree-Law No. 251-A / 2015 of December 17 Organic XXI Government Law

United Kingdom

Central
Civil Protection in the UK is primarily governed by the Civil Contingencies Act 2004.
Specific arrangements apply in Scotland and Northern Ireland.

Regional
Scotland
While civil protection in Scotland is largely a devolved matter and therefore the responsibility of the Scottish Government, certain responders in Scotland are subject to regulations and guidance by UK ministers – the Health and Safety Executive, the Maritime and Coastguard Agency and the British Transport Police.
The Northern Ireland Executive is responsible for:

- civil contingencies and oversight of civil contingencies arrangements for transferred functions
- overall policy and strategy coordination (Office of the First Minister and deputy First Minister (OFMDFM))
- national security matters, including crisis management arrangements to govern the strategic response to emergencies (Northern Ireland Office of the UK Government).

Local

England and Wales

Local authorities and "local emergency responders" including fire, police and ambulance services are required to:

- maintain a Community Risk Register
- organise Local Resilience Forums (LRF).

Regional Resilience Forums formerly provided a uniform system for LRF collaboration within regions. With the abolition of the regional government offices, "responders may now replace these regional forums with more flexible structures for multi-LRF working"[8].

The approach at local level to emergency response and recovery is based on a bottom-up approach: operations and decisions are made at the lowest appropriate level, with little input from central or devolved governments.
Category 1 responders are required to have emergency plans, including a procedure for determining an emergency has occurred.

Responsible ministries/bodies

- Cabinet Office
- Home Office
- Ministry of Housing, Communities & Local Government
- Devolved governments of the United Kingdom

Local

Local councils are responsible for practical arrangements, and the Local Government Association has set up a webpage (https://local.gov.uk/our-support/coronavirus-information-councils/covid-19-good-council-practice) with good practice relating to COVID-19.

Responsible ministries/bodies

- HM Treasury
- Cabinet Office
- Devolved governments of the United Kingdom

Sources

Cabinet Office
Home Office
Ministry of Housing, Communities & Local Government
HM Treasury
Cabinet Office

Devolved government websites:
Scotland: https://www.parliament.scot/
Wales: https://senedd.wales/en/Pages/Home.aspx
Northern Ireland: https://www.northernireland.gov.uk/

[8] https://update.cabinetoffice.gov.uk/sites/default/files/resources/Chapter-16-final-post-consultCCS_amends_16042012.pdf.

Iceland

Central
The Department of Public Security and Criminal Justice within the Ministry of the Interior is responsible for:

- Implementing the law on Civil protection;
- Policy for civil protection and security;
- Issuing regulations on civil protection alert levels;
- Preparing response plans;
- Temporary service centres;
- Security; and
- Police.

Responsible ministries/bodies
- The Ministry of the Interior

Local
Municipal authorities are responsible for:

- Fire protection;
- Civil protection committees which formulate civil protection policy and arrange civil protection activities within the Municipality;
- Examining the disaster survival capacity;
- Preparing response plans; and
- Temporary service centres.

Sources:
Civil Protection Act of 12 June 2008
The Ministry of the Interior
Association of Local Authorities, Local governments in Iceland

Italy

Central
The central government is responsible for:

- The promotion and coordination of the different administrations' (central, regional, provincial and municipal) activities;
- The declaration and revocation of the state of emergency (with the Regions);
- The adoption of ordinances for emergency interventions (together with the relevant Regions);
- The regulation of standards, and
- Operative functions.

Responsible ministries/bodies
Cabinet Department of Civil Protection.

Italian civil protection is part of the President's council of ministers, which means that they can take extraordinary measures during an emergency and can enact extraordinary laws and regulations. This allows them to coordinate all the other actors and institutions in the civil protection system. They are above the ministries in the government structure, so that they can have a coordinating role.

Italian civil protection has a non-operational volcanic risk section comprising geoscientists and technicians. Scientific institutions are part of the civil protection system in Italy. Communication protocols with volcano observatories and scientific institutions are laid out in formal agreements, and usually this means daily contact with scientific institutions. In some cases, we may need support evaluating the volcanic activity then we can call the Commissione Grandi Rischi to ask for support in the evaluation process.

Regional level

Regional authorities are responsible for:

- All the administrative functions not expressly conferred to the State (shared), in particular:
    - Prevention and preemption programmes, on the basis of national guidelines;
    - Emergency interventions;
    - Various operative functions, and
    - The organisation of volunteers.

Local level

Provinces

Provincial authorities are responsible for:

- All the administrative functions not expressly conferred to the State (shared), in particular:
    - Provincial plans of emergency, on the basis of regional guidelines;
    - The provision and prevention of risks at the provincial level, and
    - Control over the provincial civil protection structures.

Municipalities

Municipal authorities are responsible for:

- All the administrative functions not expressly conferred to the State (shared), in particular:
    - The forecast and prevention of risks at the local level, in accordance with the regional programmes and plans;
    - Rescue services;
    - Local and inter-municipal emergency plans, on the basis of regional guidelines;
    - Control over the local civil protection structures, and
    - The organisation of volunteers at the local and inter-municipal levels, on the basis of national and regional guidelines.

Sources

Constitution, Article 117.

Decreto Legislativo 18 agosto 2000, n. 267 "Testo unico delle leggi sull'ordinamento degli enti locali" (G.U. n. 227 del 28 setembre 2000 - Supplemento Ordinario n. 162) [Legislative Decree 267/2000 on the organisation of local authorities], Articles 13 and 19.

Decreto Legislativo 31 marzo 1998, n. 112 "Conferimento di funzioni e compiti amministrativi dello Stato alle regioni ed agli enti locali, in attuazione del capo I della legge 15 marzo 1997, n. 59" (G.U. n. 92 del 21 aprile 1998 - Supplemento Ordinario n. 77 (Rettifica G.U. n. 116 del 21 maggio 1997) [Legislative Decree 112/1998].

Spain

Central

State competences[9]

- Preparation of civil protection plans at state level.
- Studies of risk analysis.
- Wider research.
- Programmes and studies of civil protection for civilians.
- Management of the budget.
- Coordination and provision of ongoing learning to civil protection bodies at state-level.
- Responsibility for leading and coordinating civil protection;
- Physical protection of people and goods in the situation of serious collective risks, public disaster or extraordinary catastrophe where the security and lives of people are in danger.
- Management of severe emergencies;
- Cooperation with the Autonomous Communities in the management of serious and less serious emergencies, especially via the 'Unidad Militar de Emergencias' established in 2007.
- Issuance of planning directives for various emergency plans; including objectives, alternatives and determination of time limits to hypothetical emergency situations.
- Coordination of different plans for resource contribution.
- Provision of information for the Crisis Cabinet.
- Representation in NATO's Senior Civil Emergency Planning Committee (SCEPC).

Regional

AC competences

- Actions in the field of civil protection;
- Daily civil protection;
- Direction of activities in case of supra-local emergency.

Local

Provincial competences

- Securing coordination and provision of municipal services.

Municipal competences[10]

- Protection of citizens;
- Direction of activities in case of local emergency;
- Prevention activities at local level;
- Establishing a Service for Civil Protection (>20 000 inhabitants).

Responsible ministries/bodies

Central
National Civil Emergency Planning Committee (interministerial)
Crisis Cabinet, led by Prime Minister and Deputy Prime Ministers
Ministry of Interior
Civil Protection

[9] Art. 149.1.29 Spanish Constitution

[10] These competences shall be exercised in accordance with the conditions defined in the Regional and State laws, therefore there might be slight differences from one Autonomous Community to the other.

Sources
Spain, Disaster Management structure, Vademecum, European Commission (Under Review)
Ley 2/1985, de 21 de enero, de Protección Civil [Law 2/1985, of 21 January 1985, on Civil Protection].
Orden DEF/3771/2008, de 10 de diciembre, por la que se modifica la estructura orgánica y el despliegue de la Fuerza del Ejército de Tierra, de la Armada y del Ejército del Aire, que figura en el Real Decreto 416/2006, de 11 de abril, por el que se establece la organización y el despliegue de la Fuerza del Ejército de Tierra, de la Armada y del Ejército del Aire, así como de la Unidad Militar de Emergencias.
Ley 7/1985, reguladora de las bases del Régimen Local, Art. 25.2 [Law 7/1985, regulating the basis of Local Autonomy, Art.25.2].
Real Decreto 952/2018, de 27 de julio, por el que se desarrolla la estructura orgánica básica del Ministerio del Interior.

Greece

Central

Civil protection is a shared competence of all levels of governance. The central Government is responsible for:

- The adoption of the National Civil Protection Plan (Xenocrates Plan);
- All ministries draw up special plans for dealing with disasters;
- The General Secretariat for Civil Protection is in charge of:
    - Planning policies of civil protection and present them to the ministry of citizen protection;
    - Coordinating with all relevant ministries in order to organize preparatory plans in case of emergencies and disasters;
    - Approving regional and municipal emergency plans;
    - Providing advice to the ministry of interior on how to fund the regional and local emergency programs;
    - Organising training activities for all employees working on civil protection;
    - Maintaining a registrar of all voluntary organisations working on civil protection;
    - Promoting and supporting research projects, training and educational program on civil protection;
    - Conducting crisis management by mobilizing forces, coordinating activities, mobilising and protecting citizens and repairing damages;
    - Representing the country on all civil protection issues at the international level
    - Applying for international assistance.

The Inter-Ministerial Committee for National Planning, approves every 5 years, the National Policy for mitigating the risk of disasters.

The central coordination body for Civil Protection is responsible for following up and evaluating the annual national planning in regard to the response, recovery and rehabilitation of major catastrophes.

Regional
Regional authorities are responsible for:

- Regional special plans for dealing with disasters on the basis of the National Civil Protection Plan;

- The coordination and supervision of the work of civil protection services for prevention, preparation, response and disaster recovery within the territorial limits of the region;
- The implementation of the annual national planning for civil protection as far as the region is concerned;
- The submission of proposals for the regional civil protection for the annual national planning policy of the Inter-ministerial Commission;
- The submission of proposals to the Secretary General of Civil Protection for a decision declaring an emergency in cases of regional disasters;
- The decisions declaring states of emergency as far as small intensity local destruction is concerned, as well as the coordination of all the respective regional public or private mechanisms in order to ensure the full preparation in case of destruction and damage recovery;
- The planning and organisation of measures of prevention, awareness and response to disasters or emergencies;
- The decision on the requisition of personal services, securities and real estate;
- Cooperating with the competent bodies for the suppression of forest fires; and
- Granting of the annotation of The Hague Convention on service of documents in the region.

The metropolitan region of Attica and of Thessaloniki have additional competencies regarding civil protection:

- The planning of emergency schemes;
- The establishment of a coordinative body responsible for the handling of emergencies;
- The handling of civil protection programs;
- The planning and organization of anti-fire protection schemes.

Local
Municipal authorities are responsible for:

- Local special plans for dealing with disasters on the basis of the National Civil Protection Plan;
- The coordination and supervision of the work of civil protection services for the prevention, preparation, response and disaster recovery within their territorial limits;
- The submission of proposals for the regional civil protection, for the annual national planning policy and for the implementation of programmes, measures and actions for their territory in the frameworks of the national and regional planning;
- The provision and coordination of the human resources and materials for the prevention, preparation, response and recovery in case of destruction in their territory;
- Cleaning spaces with high garbage concentration in order to avoid the risk of a wildfire;
- Aiding and supporting the fire-corps, with any available means.

Responsible ministries/bodies

General Secretariat of Civil Protection
Ministry of Citizen Protection

Sources

Reestablishment of the Ministry of Public Order and Civil Protection and its renaming in Ministry of Citizen protection according to Presidential Decree 86/18 (O.G. 159/ 29-08-2018)
Law 4249/14, Article 113.
European Commission portal, *European Commission > Humanitarian Aid & Civil Protection > Vademecum/Greece disaster management structure* (Under Review)
Law 3463/2006 (OJ A 114/30.6.2006) 'Code for Municipalities and Communities', Articles 75-76.
Law 3852/2010 (OJ A 87/7.6.2010) 'Reorganisation of Local Government - Kallikratis Programme', Articles 94 and 186.

Related Information
Systems of multilevel governance
Relations with the EU/Representation at EU level
Subsidiarity
Bibliography
Fiscal Powers
Monitoring reports of the Congress of Local and Regional Authorities (Council of Europe)

France

Central

The President has the powers to declare a State of Emergency for the state. These allow greater executive powers in search and seizure and censorship with judicial oversight. A state of emergency was last invoked in 2015, following terror attacks in Paris.
The central government is responsible for:

- The overall legislation;
- The planning and management of crisis and incidents taking place both in France and abroad;
- Protection of the state in response to:
    - Threats of aggression.
    - Disasters of all kinds and catastrophes.
    - Environmental Threats.
- Monitoring of operations and reporting accidents and catastrophes;
- Preparation of rescue measures and co-ordination of emergency resources.

Regional and intermediate
Uniquely to this policy area, under the territorial defence regulation, France regional authorities in civil protection are known as zones of defence and security. These are used solely in the planning of emergency response and organisation. These administrative units are managed at the central level. The zone prefect co-ordinates emergency resources in the zone. The prefect has the assistance of the Interregional Civil Security Operational Co-ordination Centre (COZ).
Intermediate level
Departmental authorities are responsible for:

- Traffic police
- Public and private Emergency resources.
- Fire brigades employed at departmental level (often financed by local authorities).

Local
Municipal authorities are responsible for:

- Fire brigades, which may be posted to the municipal level.

Municipal authorities are in charge of coherence within their local gendarmes. As such, municipalities operationalise national consultations for each policeman and gendarme to give their opinions via questionnaires, and meetings conducted by the municipalities with associations of elected officials, police union organizations and consultation structures. the Gendarmerie, representatives of municipal policemen, actors of private security and transport, experts.

Responsible ministries/bodies
Ministry of Interior
Zonal Prefect

Sources
The 1950 Ordinance and 1965 Decree relating to civil defence.
The Law of 22 July 1987 as amended by the Laws of 5 January 1988 and 28 November 1990 with respect to civil security
The Order of 24 August 2000 concerning the organisation and powers of the Directorate of Civil Defence and Security.
France, Disaster Management Profile, European Commission (Under Review)
Ministry of Interior: Policing

Related Information
Systems of multilevel governance
Relations with the EU/Representation at EU level
Subsidiarity
Bibliography
Fiscal Powers
Monitoring reports of the Congress of Local and Regional Authorities (Council of Europe)

Annex 2 – Volcano Observatories and responsible science institutions

Iceland: Icelandic Met Office (IMO)

https://en.vedur.is/earthquakes-and-volcanism/earthquakes

Scientific advice about Iceland's 31 active volcanoes is provided to Icelandic CP, the public and media by the IMO, who have multi-parametric monitoring at several frequently active volcanoes and a seismic monitoring network across the whole country. The IMO works closely with researchers at the University of Iceland, who also provide official advice to Icelandic CP, the media and the public.

Scientific Advisory Board meetings are chaired by national CP authorities (a volcano scientist) and called when necessary during seismic crises, volcanic unrest or volcanic eruptions. Participants typically include IMO, University of Iceland and other sector representatives (e.g. health, agriculture, transport) as appropriate.

Italy: INGV

http://www.ingv.it/it/

https://www.preventionweb.net/organizations/627

The INGV provides Italian CP with scientific and technical support regarding the 10 active volcanoes in Italy, as well as transboundary hazards. The INGV operates in agreement with the Department of Civil Protection. All ten Italian volcanoes are monitored using integrated multi-parametric systems but only Etna and Stromboli are frequently active. Some university researchers support monitoring efforts (e.g. University of Florence).

There is a dedicated agreement with Italian civil protection within which there are specific communication protocols. Volcanic hazards are discussed through specific formal documents, also in meetings or periodic video conferences. There is a periodic video call conference with the scientific community to evaluate the state of activity of the different volcanoes. Typically interaction occurs daily.

Sezione di Catania (Volcano Observatory of Etna)

http://www.ct.ingv.it/

Sezione di Napoli (Volcano Observatory of Vesuvius, Campi Flegrei, Ischia, Stromboli)

https://www.ov.ingv.it/ov/en/monitoraggio-sismologico-di-stromboli.html

Sezione di Palermo (volcano monitoring)

https://www.pa.ingv.it/

The 'Commissione Nazionale Grandi Rischi' (CNGR - National Commission for the Prediction and Prevention of Major Risks) is the link between the National Civil Protection Service and the scientific community. Its main function is to provide technical-scientific opinions on questions from the Head of Civil Protection and to give indications on how to improve the ability to assess, forecast and prevent the various risks. The volcano risk representative, appointed since 2017, is Professor Pierfrancisco Dellino (University of Bari). The CNGR meets at least once a year jointly to verify the activities carried out and plan initiatives. It usually meets at the headquarters of the Civil Protection Department. It remains in office for five years.

UK: British Geological Survey (BGS)

http://www.bgs.ac.uk/

https://www.preventionweb.net/organizations/402

Head of Volcanology: S. Loughlin

Head of Seismology: B. Baptie

The BGS is part of UK Research and Innovation (UKRI) and is a research centre under the Natural Environment Research Centre (NERC). BGS is able to compete for research and commercial funding. BGS provides independent scientific advice to UK government, the public, media and other stakeholders, on transboundary hazards affecting UK airspace and/or UK mainland and on volcanic activity and impacts affecting UK citizens and interests worldwide. Formal scientific advice for government is coordinated by the 'Scientific Advisory Group in Emergencies' (SAGE) chaired by the UK Chief Scientific Advisor in the Government Office for Science.

BGS also contributes to a multi-hazard weekly 'International Forward Look' for UK Government departments, primarily for humanitarian and disaster preparedness purposes. This includes volcanoes, human, animal and plant health and hydro-meteorological hazards. This supports 24/7 advice provided by BGS, INGV and KNMI to ERCC in the EC-funded Aristotle project.

UK overseas territories each have their own arrangements:

Montserrat (an island in the Lesser Antilles, Caribbean Sea)

Montserrat Volcano Observatory (MVO)

http://www.mvo.ms/

Montserrat has its own elected government (Government of Montserrat). The Disaster Management Coordination Agency http://dmca.gov.ms/ is the CP authority of the Government of Montserrat. There is also a Governor representing the UK Foreign, Commonwealth and Development Office (FCDO). MVO is operated by the Seismic Research Centre, University of West Indies. MVO advise DMCA and the Governor's Office (FCDO). FCDO has also appointed a Scientific Advisory Committee (voluntary membership) to advise them independently.

Ascension Island (an island in the south Atlantic Ocean)

Ascension Island shares a Governor with Tristan da Cunha and St Helena http://www.ascension-island.gov.ac/ Scientific and technical advice is provided by the BGS, which reports to the Ascension Island Government and UK FCDO.

Tristan da Cunha (an island in the south Atlantic Ocean)

Tristan da Cunha shares a Governor with Ascension Island and St Helena http://www.ascension-island.gov.ac/ Scientific and technical advice is provided by the BGS, which reports to the Tristan da Cunha Administrator and UK FCDO.

France: Institut de Physique du Globe de Paris (IPGP)

http://www.ipgp.fr/en

Scientist in Charge of national volcanological and seismological observatories: J-C Komorowski.

IPGP is an independent public higher education and research institute. It has a particular status, almost like a university but it is described as a 'grand établissement' because of its size, and the director is nominated by the President of France (not the government). It is a public institution, which can receive research funding but is not able to take on commercial work. It is a legal entity but also part of administrative and scientific research councils. This status is linked to the IPGP mandate to run operational national observatories and enables IPGP to receive two budgets of research funding, one direct from the Ministry of Research, Science and Innovation, and one from the research institute CNRS (CNRS personnel work in IPGP research teams).
Technical and scientific advice is provided to national civil protection authorities and the prefects (French: préfet) of the regions (departments). A prefect is the state's representative in a department or region. Formal IPGP advice has the backing of the Director of IPGP and therefore the President, so this a safeguard that enables IPP to be as independent as possible in decision making. The recently established volcanological and seismological network at Mayotte is a collaboration between IPGP, CNRS, BRGM, Ifremer and some universities. Each of the French Overseas departments has a prefect advised by the relevant volcano observatories (or monitoring network in the case of Mayotte):

French overseas departments and regions:

La Réunion (an island in the Mascarene islands, western Indian Ocean)
Réunion Volcano Observatory
http://www.ipgp.fr/en/ovpf/volcanological-observatory-of-piton-de-fournaise

Mayotte (part of the Comoros archipelago, Indian Ocean)
Volcanological and seismological network of Mayotte (REVOSIMA)
https://www.ipgp.fr/fr/revosima/reseau-de-surveillance-volcanologique-sismologique-de-mayotte

Guadeloupe (an archipelago in the Lesser Antilles, Caribbean Sea)
Guadeloupe Volcano Observatory
http://www.ipgp.fr/en/ovsg/volcanological-and-seismological-observatory-of-guadeloupe

Martinique (an island in the Lesser Antilles, Caribbean Sea)
Martinique Volcano Observatory
http://www.ipgp.fr/en/ovsm/volcanological-and-seismological-observatory-of-martinique

Greece: Institute of Geology and Mineral Exploration (IGME) now the Hellenic Survey of Geology and Mineral Exploration (HSGME)

http://www.igme.gr

HSGME is the Geological Survey of Greece. It was established (as IGME) in 1952 and operates as a public research institute under the supervision of the Ministry of Environment, Energy and Climate Change. The prime function of HSGME is to act as an advisor to the Greek government on all aspects of geosciences.

Volcano Observatory of Santorini (ISMOSAV)

https://www.santorini.net/ismosav/

The Institute for the Study and Monitoring of Santorini Volcano (ISMOSAV) is a non-profit organisation, founded in the summer of 1995, whose primary aim is to continue to maintain the operation of the Volcano Observatory and the monitoring networks, which were established under a research program funded by the E.U.

Its main target is the promotion of volcanological research on the island, more specifically how to achieve the most accurate assessment possible regarding volcanic phenomena, and the increased probability of precise forecasting of any future volcanic eruption. Members of the Board of Directors include staff from IGME, Aristotle University of Thessaloniki, University of Athens and others.

Portugal (Azores): Centro de Informação e Vigilância Sismovulcânica dos Açores (CIVISA)

http://www.ivar.azores.gov.pt/civisa/Paginas/homeCIVISA.aspx

http://www.cvarg.azores.gov.pt/civisa/Paginas/homeCIVISA.aspx

Technical and scientific advice is provided to regional and local civil protection authorities and several other governmental bodies by the Centre for Information and Seismovolcanic Surveillance of the Azores (CIVISA) which is recognised at regional, national and international levels.

CIVISA was created by the Regional government of the Azores and the University of the Azores on July 30, 2008 with the main objective of ensuring the design, development, implementation and management of a multiparametric monitoring system for geological hazards, based on knowledge, scientific and technological criteria. CIVISA benefits from close collaboration between the Research Institute for Volcanology and Risk Assessment (IVAR), the University of the Azores, and the Regional Service of Civil protection and firefighters of the Azores (SRPCBA).

Spain: Instituto Geográfico Nacional (IGN)

https://www.ign.es/web/ign/portal

VLC-Guia-Riesgo-Volcanico.pdf (ign.es)

The National Geographic Institute of Spain (IGN) is responsible for volcano monitoring and reporting in Spain, with a volcano observatory based in Tenerife for the Canary Islands. Monitoring data, maps and resources are made available on the website.

The IGN was created in 1870 and is a government agency operating under the Ministry of Transport, Mobility and Urban Agenda.

Spain: CSIC

CSIC | Consejo Superior de Investigaciones Científicas –

The Spanish National Research Council is a State Agency for scientific research and technological development, with a special legal status, its own assets and treasury, functional and managerial autonomy, full legal capacity and of unlimited duration (art. 1 Statutes – Articles of Association). Responsibilities include:

- To carry out scientific and technological research and help to encourage such research, where relevant.
- To transfer the results of scientific and technological research to public and private institutions.
- To provide scientific-technical services to the General State Administration and public and private institutions.
- To inform, attend and advise public and private entities on science and technology issues

The CSIC works alongside IGN and other institutions during volcanic emergencies.

Annex 3 – Interview guide, consent form and participant information sheet

1.1 Interview guides

Interview Guide for Civil Protection

EUROVOLC WP7

Good practice in hazard communication between volcano monitoring institutions, research institutions and civil protection:

Semi-structured interview guide for interviews with civil protection

The following questions act as a guide – in a semi-structured interview the order in which these questions will be asked may vary and follow up questions, based on your answers, may also be asked. When answering the questions please draw from your own experience (background hazards, unrest and eruptions) rather than from the experience of others.

Background information (please complete before the interview)

Question	Answer
What organisation to you work for?	
Do your interview answers represent an individual or more than one person's response?	Please tick the answer that applies: ☐ Individual ☐ More than one person
What is your current role?	
How long have you worked in your current role?	☐<1 year ☐1-5 years ☐6-10 years ☐>10 years
How many years of professional experience do you have?	☐<1 year ☐1-5 years ☐6-10 years ☐>10 years
What is your education background?	Which of the following disciplines does your education most closely align to (more than one option can be selected): ☐ Arts and humanities (archaeology, philosophy, arts, history, law, ancient and modern languages) ☐ Formal Sciences (computer science, mathematics, statistics) ☐ Natural science (biology, chemistry, earth science [geology, geoscience and physical geography], physics, atmospheric sciences, space sciences)

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	☐ Social science (human geography, economics, sociology, psychology, anthropology, political science) ☐ Engineering ☐ Medical sciences ☐ Other [Please explain] Highest level of education attained: ☐ Secondary ☐ Higher – graduate (Bachelor) ☐ Higher – postgraduate (Masters, PhD)
Do you have experience of crisis/emergency management from volcanic or other crises (please provide examples)	Please tick: ☐Yes ☐No Examples:

Questions for the interview

Relationships/Institutions

Can you provide a short (5 min) overview of your organisation?

How do you discuss volcanic hazards with volcano monitoring institutions or scientific institutions [volcano scientists]?

How do you receive scientific information in the case of an increase in volcanic activity?

In your opinion, what information do you need from volcano scientists in order to manage volcanic hazards (unrest/eruption)?

How do you engage with volcano scientists over the long-term (e.g. during "peace-time")?

How do you engage with volcano scientists in the short-term?

Methods and approaches

How do you typically request information from volcano scientists? (E.g. email, phone call etc.)

What sort of information do you ask for?

Do you have a formal communication procedure or protocol with volcano scientists?

From your experience, what is the most effective method for communicating with volcano scientists?

What approaches (e.g. methods, models and/or tools) have you used for volcanic hazard assessment at your volcano(es)?

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How are you typically involved in the design and development of volcanic hazard assessments with volcano scientists?

How do you discuss potential impacts of volcanic activity (e.g. disruption, loss of life, injuries) with volcano scientists?

How do you work with volcano scientists on risk assessments of any type/scale (e.g. local to national)?

Uncertainty

Can you tell me about a time when you've had to communicate with volcano scientists about a situation where there has been a high level or uncertainty?

What methods were used to communicate this uncertainty and were they effective?

What were the challenges?

What lessons were learned from this experience?

Resource

How much time do you spend communicating with volcano scientists during a volcanic crisis?

Using examples where possible, what information do you want to know during a crisis?

Challenges and lessons learned

From your experience, what is/are the greatest challenge(s) in communication of volcanic hazards between volcano scientists and civil protection?

Can you provide an example of when communication between your institution and volcano scientists could have been improved? How would you improve it?

From your experience, what do you recommend as good practice for volcanic hazard communication to civil protection?

3

Interview Guide for Volcano Scientists

EUROVOLC WP7

Good practice in hazard communication between volcano monitoring institutions, research institutions and civil protection:

Semi-structured interview guide for interviews with volcano monitoring institutions and research institutions

The following questions act as a guide – in a semi-structured interview the order in which these questions will be asked may vary and follow up questions, based on your answers, may also be asked. When answering the questions please draw from your own experience (background hazards, unrest and eruptions) rather than from the experience of others.

Background information (please complete before the interview)

Question	Answer
What organisation do you work for?	
Do your interview answers represent an individual or more than one person's response?	Please tick the answer that applies: ☐ Individual ☐ More than one person
What is your current role?	
How long have you worked in your current role?	☐<1 year ☐1-5 years ☐6-10 years ☐>10 years
How many years of professional experience do you have?	☐<1 year ☐1-5 years ☐6-10 years ☐>10 years
What is your education background?	Which of the following disciplines does your education most closely align to (more than one option can be selected): ☐ Arts and humanities (archaeology, philosophy, arts, history, law, ancient and modern languages) ☐ Formal Sciences (computer science, mathematics, statistics) ☐ Natural science (biology, chemistry, earth science [geology, geoscience and physical geography], physics, atmospheric sciences, space sciences) ☐ Social science (human geography, economics, sociology, psychology, anthropology, political science)

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	☐ Engineering ☐ Medical sciences ☐ Other [Please explain] Highest level of education attained: ☐ Secondary ☐ Higher – graduate (Bachelor) ☐ Higher – postgraduate (Masters, PhD)
Do you have experience of crisis/emergency management from volcanic or other crises (please provide examples)	Please tick: ☐Yes ☐No Examples:

Questions for the interview

Relationships/Institutions

Can you provide a short (5 min) overview of your organisation?

How do you discuss volcanic hazards with local, regional, national and/or European scale civil protection?

How do you communicate information to civil protection in the event of an increase in volcanic activity?

In your opinion, what information do you feel civil protection who are managing volcanic hazards (unrest/eruption) need from volcano scientists?

How do you engage with civil protection over the long-term (e.g. during "peace-time")?

How do you engage with civil protection in the short-term?

Methods and approaches

How do civil protection typically request information?

What sort of information do they ask for?

Do you have a formal communication procedure or protocol with civil protection?

From your experience, what is the most effective method for communicating with civil protection?

What approaches (e.g. methods, models and/or tools) have you used for volcanic hazard assessment at your volcano(es)?

How do you typically involve civil protection in your volcanic hazard assessments?

EUROVOLC WP7

How do you discuss potential impacts of volcanic activity (e.g. disruption, loss of life, injuries) with civil protection?

How do you contribute to risk assessments of any type/scale (e.g. local to national)?

Uncertainty

Can you tell me about a time when you've had to communicate with civil protection about a situation where there has been high uncertainty?

What methods did you use to communicate this uncertainty?

What were the challenges?

What lessons were learned from this experience?

Resource

How much time do you spend communicating with civil protection during a crisis?

Using examples where possible, what information do civil protection want to know during a crisis?

Challenges and lessons learned

From your experience, what is/are the greatest challenge(s) to communicating volcanic hazards to civil protection?

Can you provide an example of when communication between your institution and the civil protection could have been improved? How would you improve it?

From your experience, what do you recommend as good practice for volcanic hazard communication to civil protection?

3

1.2 Consent Form

You are invited to be interviewed on 'good practice for volcanic hazard communication between volcano monitoring and research institutions and civil protection' as part of EUROVOLC, work package 7.

Consent

- ☐ I agree to be interviewed as part of EUROVOLC WP7.
- ☐ I have read and understood the information for participants. I have had the opportunity to email questions about my participation.
- ☐ I understand that my participation is voluntary and I have the right to withdraw my data/participation up until the publication of project outputs [reports, peer-reviewed papers and presentations]
- ☐ I consent to my interview being recorded
- ☐ I understand that all data provided, including personal information (name and email address), will be stored in accordance with UK Data Protection Act 2018 (the UK's implementation of the General Data Protection Regulation [GDPR])
- ☐ I understand that the information I provide will be published as several outputs and all efforts will be made to ensure that my responses are not identifiable (unless I state otherwise – see below)
- ☐ I understand that I have the right to receive a copy of my interview transcript and any of the outputs

In the outputs, participants can choose whether to (please tick one box below):

- ☐ Remain anonymous and non-identifiable in all publications, although please be aware that the nature of the examples you provide may make either your organisation or you identifiable to those familiar with these examples
- ☐ Have only their organisation identified
- ☐ Have their name and organisation identified.

Name	
Signature	
Email address	

Contact details of WP7 lead

Name: Sue Loughlin

Address: British Geological Survey, Lyell Centre, Research Avenue South, EH14 4AP

Email/telephone: sclou@bgs.ac.uk / 0131 667 1000

1.3 Participant Information Sheet

Information for participants

You are invited to be interviewed on 'good practice for volcanic hazard communication between volcano monitoring and research institutions and civil protection' as part of EUROVOLC, work package 7.

Project information: The European Network of Observatories and Research Infrastructures for Volcanology (EUROVOLC) is a three-year funded (2018-2021) EU Horizon 2020 project with the primary objective of networking people, approaches and infrastructure across European volcano observatories. Work package 7 (collaboration between volcano monitoring institutions and European Civil Protection agencies for management of volcanic hazard) aims to facilitate sharing and promotion of good practice in hazard communication, including process, methods, products and uncertainty. In meeting this aim, we aim to capture and share the experiences of volcano monitoring institutions, research institutions and civil protection agencies across Europe through a combination of an online survey (questionnaire), interviews and invitations to submit case studies.

Interview participants ('interviewees'): volunteer representatives from volcano observatories, research institutions and civil protection with experience in dealing with volcanic crises (unrest and/or eruptions). For those countries where unrest and/or eruptions occur less frequently, tectonic seismic crises can be used as examples instead. The aim is to capture the range of experiences, so the number of participants interviewed per organisation is not as important as ensuring that those with the key experiences are interviewed. It is anticipated that one or two people per institution will interviewed, but where there are more volunteers they will be included.

Interview process: Interviewees will be interviewed remotely via a suitable communication system (e.g. Skype or Zoom) and will be provided with a copy of the interview topics before the interview. In order for the interviewer (Melanie Duncan or Sue Loughlin) to be able to listen and follow up with questions, your interview will be recorded and used after the interview to ensure notes are complete. You will be provided with a copy of the notes and the interviewer may follow up with you regarding clarification of some of your answers. The interview will likely last 1-1.5 hours, depending on your schedule, and will be conducted in English.

Benefits of participation: your participation is invaluable to meeting the aim of work package 7. The inclusion of your interview will ensure that we effectively represent past and current approaches across Europe and a wide range of experiences. You will be invited to participate further in the collective learning related to this WP.

Risks of participation: there are no foreseeable risks with participation. All questions are optional, including whether you want to provide personal information. Your participation is voluntary and you have the right to withdraw yourself and the data you provide up until the point of first output. The first output (deliverable) for this work is June 2020.

Data collection, retention, sharing and confidentiality: All data will be collected and stored in accordance with UK Data Protection 2018 (the UK's implementation of the General Data Protection Regulation [GDPR]). Data retention will be limited to the duration of the EUROVOLC project (ending January 2021) plus one calendar year to allow time to write up outputs. Personal information collected is limited to your organisation, job role, time in role and education, plus the option to provide contact information. Your interview transcript will only be accessible to you and to BGS WP7 staff (Melanie Duncan and Sue Loughlin) in order for them to analyse and summarise your responses in conjunction with those of others. The analysis of the data/information you provide will be included in the EUROVOLC WP7 report deliverables and any subsequent peer-reviewed publications and presentations (e.g. conference presentations). Any inclusion of your survey contributions within these outputs will be anonymised, unless you state otherwise (please see the consent form); however, whilst all efforts will be made to ensure you are not identifiable, the sharing of certain examples and countries may make individuals identifiable. All reports, publications and presentations ("outputs") will be openly available via the EUROVOLC website. There is also the option to provide a contact email address should you wish your interview notes, survey responses and/or any of the subsequent reports, publications and presentations sent to you. Within a year of the interview we will contact you to revisit whether you would still like to be updated about progress, or instead if we should remove your email address from our system.

If you have any questions before or after the interview, please contact Sue Loughlin (sclou@bgs.ac.uk) and Melanie Duncan (md@bgs.ac.uk) (WP7).

Annex 4 – Case Studies

2.1 Case study template

EUROVOLC WP7 Task 7.1

EUROVOLC WP7 Task 7.1 case study template

We invite you to contribute a case study using your professional experience on communication between volcano observatories, research institutions and civil protection during events. Please use an example of **one of the following:**

- ☐ an episode of volcanic or seismic unrest,
- ☐ unrest/eruption
- ☐ simulation/exercise

Please use the template below to complete your case study. The objective is to describe the event (section 1), reflect on good practice and lessons learnt in terms of communication (section 2), reflect briefly on capacity and resource (section 3), a key message (section 4) and any learning from Covid-19 (section 5).

Particular points of interest include:

- What type of information was requested and/or used by civil protection?
- What type of information did you provide during the event?
- How did you work with civil protection and/or other scientific institutions to design and create useful scientific outputs and materials?
- What specific methods and approaches did you use?
- How did you manage the communication of uncertainty?
- Was there any information civil protection wanted or needed that could not be provided?
- How did your communication change over time?
- To what extent was communication between volcano observatories, research institutions and civil protection authorities structured (e.g. formal protocols) and unstructured (e.g. informal telephone conversations)?
- Would you do anything differently?

We are keen to capture experiences across institutional levels, from local to national and encourage collaborative responses (e.g. several different institutions completing the same case study) at your discretion.

1

EUROVOLC WP7 Task 7.1

Case study template

Title of case study:	
Country:	Event/Volcano(es) [including dates where applicable]:
Name of person(s) completing the template:	Contact details (optional):

1. Detailed description (1000 words/~2 pages)

Please use this space to describe your case study. If you require more space then please use it, the 1000 words is just a guide. Your description should include an overview of what happened, key agencies involved and key interactions over time, communication between volcano monitoring institutions, volcano research institutions and civil protection, scientific outputs including methods and approaches.

2. Reflections, lessons learned and good practice: communication

Please use this space to reflect on communication between volcano observatories, research institutions and civil protection, and lessons learned during the event. Reflections could include things such as:

- *What were the challenges and how these were overcome (or could be overcome in the future)?*
- *Any examples of communication between volcano observatories, research institutions and civil protection that you would consider to be good practice?*
- *What was the most effective scientific information/communication to enable decision making by others?*

3. Reflections and lessons learned: capacity and resources.

Please use this section to describe the response capacity and resources that were required during the event (case study).

Things you could mention include:

- *Number of institutions involved, number of scientists involved (and any international support contributed).*
- *Impact on scientists and civil protection authorities (e.g. ability to maintain normal responsibilities, health, etc) and any mitigation measures to address this.*
- *Any thoughts on particular challenges faced by volcano observatories, research institutions and/or civil protection in terms of capacity/resource during events (and any possible solutions).*

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4. What is the key message (or messages) from this case study that you would like to emphasise within the EUROVOLC community and beyond:
5. Please complete this section if your case study timeline overlaps with the Covid-19 (Coronavirus) pandemic (December 2019 – present), or if there have been changes as a result of Covid-19. *Things you could mention include:* • *Impact of the pandemic on your engagement with civil protection.* • *Impact of the pandemic on your ability to communicate with civil protection.* • *Learning and/or benefits transferable to volcanic events from Covid-19 experience.*
References: END

Thank you for taking the time to complete this case study. Your examples shared will be invaluable to the completion of the tasks.

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2.2 Completed Case Studies

Case Study 1:

EUROVOLC WP7 Task 7.1 case study template

We invite you to contribute a case study using your professional experience on communication between volcano observatories, research institutions and civil protection during events. Please use an example of **one of the following:**

- ☐ an episode of volcanic or seismic unrest,
- ☐ unrest/eruption
- ☐ simulation/exercise

Please use the template below to complete your case study. The objective is to describe the event (section 1), reflect on good practice and lessons learnt in terms of communication (section 2), reflect briefly on capacity and resource (section 3), a key message (section 4) and any learning from Covid-19 (section 5).

Particular points of interest include:

- What type of information was requested and/or used by civil protection?
- What type of information did you provide during the event?
- How did you work with civil protection and/or other scientific institutions to design and create useful scientific outputs and materials?
- What specific methods and approaches did you use?
- How did you manage the communication of uncertainty?
- Was there any information civil protection wanted or needed that could not be provided?
- How did your communication change over time?
- To what extent was communication between volcano observatories, research institutions and civil protection authorities structured (e.g. formal protocols) and unstructured (e.g. informal telephone conversations)?
- Would you do anything differently?

We are keen to capture experiences across institutional levels, from local to national and encourage collaborative responses (e.g. several different institutions completing the same case study) at your discretion.

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Case study template

Title of case study: 2019-2020 seismic unrest W of Faial Island, Azores Archipelago	
Country: Portugal	Event/Volcano(es) [including dates where applicable]: Seismic swarm W of Faial Island, 03 Nov. 2019 – 08 Jul. 2020
Name of person(s) completing the template: Rita Carmo/Rui Marques/Rita Silva	Contact details (optional): rita.l.carmo@azores.gov.pt rui.tf.marques@azores.gov.pt rita.as.marques@azores.gov.pt

1. Detailed description (1000 words/~2 pages)

Please use this space to describe your case study. If you require more space then please use it, the 1000 words is just a guide. Your description should include an overview of what happened, key agencies involved and key interactions over time, communication between volcano monitoring institutions, volcano research institutions and civil protection, scientific outputs including methods and approaches.

On 3 November 2019, a seismic swarm of tectonic origin started in an epicentral region located in the sea, between 25-35 km W of Faial Island. Until 8 August 2020, CIVISA registered 7157 earthquakes of low magnitude, 67 of which were felt by the nearby population of Faial Island. The most energetic earthquake reached magnitude 4.7. The 8 events registered with magnitude equal or above 4.0 were felt with a maximum intensity of IV/V (Mercalli Modified Scale) on western parishes of Faial Island and were also felt on Pico and São Jorge islands. No damages or victims occurred. Macroseismic information was obtained through macroseismic surveys made by phone calls for the population of the affected islands and also through the Azores Quake app that CIVISA, made available a few days after the beginning of the seismic swarm.

CIVISA always kept the Azores Civil Protection (Serviço Regional de Proteção Civil e Bombeiros dos Açores, SRPCBA) informed about the evolution of the situation, by phone calls, videoconference meetings, either by reports. When the seismic swarm started, the President of CIVISA called directly the President of SRPCBA, and then situation reports were sent twice a day, at 09:00 and at 21:00, being always preceded by a phone call from President of CIVISA to the President of SRPCBA. Also, for all the felted earthquakes reports with the macroseismic information were sent to the SRPCBA.

2. Reflections, lessons learned and good practice: communication

Please use this space to reflect on communication between volcano observatories, research institutions and civil protection, and lessons learned during the event. Reflections could include things such as:

- *What were the challenges and how these were overcome (or could be overcome in the future)?*
- *Any examples of communication between volcano observatories, research institutions and civil protection that you would consider to be good practice?*
- *What was the most effective scientific information/communication to enable decision making by others?*

The SRPCBA presidency changes whenever the Azores Regional Government changes (every 4 years). This means that periodically, CIVISA needs to reestablish its communication with the new presidency

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members and other new staff, in order to adjust communication protocols. This can be even more difficult if we are in a quiet phase when the communication between CIVISA and SRPCBA is not so frequent. When the seismic swarm W of Faial Island started, CIVISA and SRPCBA understand that a proper communication was fundamental. CIVISA kept always informed the SRPCBA by phone calls (directly to the President) and by videoconference to decide the information that should be disseminated to the journalists, and by situation reports sent twice a day, at 09:00 and at 21:00. In addition, an intranet webpage, updated on a real time bases, was made available to give access to epicentral locations, magnitudes and several statistical products that allowed SRPCBA to follow the situation.
3. Reflections and lessons learned: capacity and resources. *Please use this section to describe the response capacity and resources that were required during the event (case study).* *Things you could mention include:* • *Number of institutions involved, number of scientists involved (and any international support contributed).* • *Impact on scientists and civil protection authorities (e.g. ability to maintain normal responsibilities, health, etc) and any mitigation measures to address this.* • *Any thoughts on particular challenges faced by volcano observatories, research institutions and/or civil protection in terms of capacity/resource during events (and any possible solutions).* In this case study two institutions were directly involved to give scientific and technical advice to SRPCBA, the CIVISA and the IVAR (Research Institute for Volcanology and Risk Assessment; University of the Azores). Currently, CIVISA comprehends 25 workers, although this team is complemented by the IVAR staff and together reach almost 45 elements. In the case study described, about 16 workers were directly involved, the majority of which were dedicated to seismic data analysis (7 work by shifts). Others analysed the macroseismic information, as well, sent the situation reports to SRPCBA. A team dedicated to Information and Communication Technologies maintained our server infrastructure, computer network and telecommunications systems functioning, as well deployed a seismic station during the unrest to strengthen the seismovolcanic surveillance. The President of CIVISA kept the President of SRPCBA always informed. The CIVISA teams are very small which implies that all its elements have important roles in the operational part. The absence of one of the elements may have major implications in terms of the response capacity. Nevertheless, during the seismic swarm W of Faial Island, there were no problems regarding the number of workers involved and the work went as planned. Some problems occurred due the increment of number of accesses to the IVAR/CIVISA webpage by the population, which was looking for information and during the submission of macroseismic questionnaires for the most energetic seismic events (felted by a higher number of inhabitants).
4. What is the key message (or messages) from this case study that you would like to emphasise within the EUROVOLC community and beyond: Maintain a proper and redundant communication system. Automate the availability of products for the Civil Protection follow in real time the evolution of the situation.
5. Please complete this section if your case study timeline overlaps with the Covid-19 (Coronavirus) pandemic (December 2019 – present), or if there have been changes as a result of Covid-19. *Things you could mention include:*

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- *Impact of the pandemic on your engagement with civil protection.*
- *Impact of the pandemic on your ability to communicate with civil protection.*
- *Learning and/or benefits transferable to volcanic events from Covid-19 experience.*

The seismic swarm W of Faial Island overlapped the COVID-19 pandemic. With the evolution of the pandemic in Portugal mainland, the CIVISA, together with the IVAR, carried out a LIVEX exercise between 12 March and 14 March 2020, called EXODUS/20.01. The main objectives were to test the capacities of all workers to perform their tasks using remote working during an eventual closure of the University of the Azores facilities.
When the first case of COVID-19 was confirmed in the Azores, on 15 March 2020, the CIVISA/IVAR were already in remote work and remained like that until September 2020.
Some challenges arose, such the importance of guaranteeing the specific technical conditions for each worker perform their tasks independently and remotely in their home and the creation of distribution circuits and installation of equipment in workers' homes. During the exercise, there was a need to increase the bandwidth to respond to the constraints caused by the remote access of workers to the server infrastructure, in order not to restrict access to data from the permanent monitoring networks (geophysics, geochemistry, geodetic and geotechnical), warning and alert systems and information dissemination services to civil protection entities, companies and the population in general. This need was quickly suppressed, as the service provider promptly responded to the request.
For this reason, CIVISA kept its statutory object, "(...) to ensure the monitoring and assessment of geological hazards in the Azores, to technically and scientifically advise regional and local civil protection authorities, among others, in the mitigation of risks that may threaten the safety of people and property", as well as others obligations defined under protocols and service provision contracts.

References:

END

Thank you for taking the time to complete this case study. Your examples shared will be invaluable to the completion of the tasks.

Case Study 2:

EUROVOLC WP7 Task 7.1

EUROVOLC WP7 Task 7.1 case study template

We invite you to contribute a case study using your professional experience on communication between volcano observatories, research institutions and civil protection during events. Please use an example of **one of the following:**

- ☐ an episode of volcanic or seismic unrest,
- X unrest/eruption
- ☐ simulation/exercise

Please use the template below to complete your case study. The objective is to describe the event (section 1), reflect on good practice and lessons learnt in terms of communication (section 2), reflect briefly on capacity and resource (section 3), a key message (section 4) and any learning from Covid-19 (section 5).

Particular points of interest include:

- What type of information was requested and/or used by civil protection?
- What type of information did you provide during the event?
- How did you work with civil protection and/or other scientific institutions to design and create useful scientific outputs and materials?
- What specific methods and approaches did you use?
- How did you manage the communication of uncertainty?
- Was there any information civil protection wanted or needed that could not be provided?
- How did your communication change over time?
- To what extent was communication between volcano observatories, research institutions and civil protection authorities structured (e.g. formal protocols) and unstructured (e.g. informal telephone conversations)?
- Would you do anything differently?

We are keen to capture experiences across institutional levels, from local to national and encourage collaborative responses (e.g. several different institutions completing the same case study) at your discretion.

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Case study template

Title of case study: Eruption in Fagradalsfjall	
Country: Iceland	Event/Volcano(es) [including dates where applicable]: Fagradalsfjall (24 Feb 2021 – ongoing)
Name of person(s) completing the template: Sara Barsotti	Contact details (optional): sara@vedur.is

1. Detailed description (1000 words/~2 pages)

Please use this space to describe your case study. If you require more space then please use it, the 1000 words is just a guide. Your description should include an overview of what happened, key agencies involved and key interactions over time, communication between volcano monitoring institutions, volcano research institutions and civil protection, scientific outputs including methods and approaches.

What happened:

The eruption in Fagradalsfjall (Iceland) commenced on the 19th of March 2021 and it has been preceded by a long unrest phase which affected the entire Reykjanes peninsula since December 2019. A series of magmatic intrusions accompanied by elevated seismic activity occurred in the central and western part of the peninsula over this period. Three intrusions occurred north of Grindavík (a small town in the southern coast of the peninsula), one at the westernmost tip of the peninsula and one at Krýsuvík volcanic system. More than 44,000 earthquakes have been manually checked and over the entire period 760 earthquakes had a magnitude >M3; 78 above M4 and 8 above M5.

On the 24th of February 2021 marked the beginning of the magmatic dyke propagation which ended with the onset of the eruption on the 19th March. The magmatic corridor was identified between Keilir mountain and Fagradalsfjall for a length of about 7 km. Both cGPS and InSAR data confirmed the presence of magma at a depth of 4-6 km, as also supported by the seismic data. The eruption started during the night of the 19th of March in the middle of a valley in Fagradalsfjall. A fissure eruption started in the area producing lava flows and releasing gases. The eruption continued for six months almost with no interruption getting to a total volume of 1 km3 of lava. However, it is now in a phase of pause which is lasting since 19th of September. Over these six months the small eruption went through several phases characterized by different eruption styles, intensities, and associated hazards. Lava flows, gas pollution, openings of new fissures, bombs ejection, local grass fires have been the main hazards which characterized the eruption. Some of them had a very local impact, others impacted a larger area (mainly due to gas release). Constant lava outpouring, frequent lava fountaining, intermittent activity have been alternating at Fagradalsfjall. Currently there are no evidence of activity at the surface, but a renovated seismic activity let suggest that magma is still adjusting at depth and it cannot be excluded the eruption will start again in Fagradalsfjall or at other locations in the area.

Key agencies involved and key interactions over time:

Volcanic crises in Iceland are coordinated by the Icelandic Civil Protection and the main players are representatives of the Icelandic Meteorological Office, University of Iceland, the Environmental Agency of Iceland. A Scientific Advisory Board is activated by ICP whenever a volcanic crisis starts. This time, given the vicinity to inhabited areas and the potential for infrastructures exposed, more agencies have been invited to attend the meeting. Scientists from other Universities or RIs (from Iceland and

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abroad) also took part to the discussion. Very important was the presence of representative from the Directorate of Health which took care of preparing informative material on impact on health because of volcanic pollution. Several meetings were held during the unrest phase, scientific meetings to review the monitoring data and assessing the current situation; and meetings with stakeholders aimed at informing about potential scenarios and impact. Daily meetings were held in the beginning of the eruption which involved those responsible for managing the access to the eruption site, i.e. rescue team, local police, representatives of the municipalities and scientists. Since the eruption kept running such meetings are held twice a week. For several months, weekly meetings were held to keep informed the aviation sector, but because of the minor impact on aviation operations since July these meetings have been stopped.

Communication between volcano monitoring institutions, volcano research institutions and civil protection

The main vehicle of information exchange amongst these three groups has been the Teams chat created for the scientific meetings (and well-practiced during Covid time). People kept posting information, new data, observations, results through this chat any time of day and night. Then, of course, the regular meetings have been the place where a direct discussion took place. Direct phone calls and emails have been used in time of emergencies (e.g. when the eruption started) but also as the official ways in accordance to our contingency plans. At the end of the meeting a smaller group of people were dedicated to finalizing the message to be issue as news on both CP website and IMO's (plus social media).

Scientific outputs including methods and approaches

Raw data, plots, maps, tables, every format has been used to shared information with the CP. The scientific meetings had always a clear structure, often it followed: 1. Monitoring data (seismicity, deformation, geochemistry + satellite detections, direct observations, weather conditions, other), 2. Scenarios, 3. Hazards. Prior the eruption the meetings also focussed on 4. Monitoring needs, 5. Preparedness. Model results for lava flow invasion and gas pollution were also presented. Prior the eruption the results from long-term hazard assessment studies were shown, and scenario-based lava flow (for hypothetical eruptive fissures) were produced on-demand. IMO and UI worked with CP to prepare danger area maps to inform people (tourists/visitors) where to go, which areas to avoid, and which hazards were accounted for when preparing such maps. In defining scenarios (how a situation might evolve), we often listed the possible outcomes given the current situation, leaving space for uncertainty.

2. Reflections, lessons learned and good practice: communication

Please use this space to reflect on communication between volcano observatories, research institutions and civil protection, and lessons learned during the event. Reflections could include things such as:

- *What were the challenges and how these were overcome (or could be overcome in the future)?*
- *Any examples of communication between volcano observatories, research institutions and civil protection that you would consider to be good practice?*
- *What was the most effective scientific information/communication to enable decision making by others?*

A general comment is worth to be mentioned. The eruption in Fagradalsfjall was very similar, in terms of expected volcanic hazards, as the last eruption in Bárðarbunga (2014-2015). In this sense all the lessons we learnt at that time, turned to be very useful to respond quickly to the current event (monitoring and modelling setup for example). Of course, this event was special in its location and

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accessibility, posing new challenges in terms of allowing a safe access to the area, as well as assessing potential impact in the most inhabited region of Iceland.

Communicating uncertainty is challenging, but more and more this is discussed and explained. Why there is uncertainty? How does it affect the scientific conclusion? How this translates it into actions? A couple of examples from the eruption in Fagradalsfjall come from the lava flow hazard and gas pollution hazard.

Lava flow hazard: Civil protection and stake-holders often asked for a "prediction" of lava flow propagation. However, the setting where the eruption took place (i.e. within a valley) and the way the lava field was fed (a lot of internal channels, few ponding areas) made the initialization of the lava model difficult and uncertain. The strategy of investigating the "worst case scenario" (i.e. assuming all volume released at the edge of the pre-existing lava field) was adopted and explained to the people working at the eruption site. So a plethora of maps (for different lava origin) was shown at the meeting with stakeholders on a weekly basis. In addition, a specific meeting was dedicated to explaining how the model works and the type of results is possible to get out of it. A dedicated group of people (including IMO, UI, Verkis engineering company) worked around the lava flow issue, as more than one model was available and different results were produced. The main purpose was to harmonize the interpretation of the results for the **long-term hazard assessment**. This task is (still) pretty difficult and ongoing.

Gas pollution: the highly temporal variability in gas fluxes, small domain, low height injections, made the forecast of SO2 at the ground very challenging. The model adopted was quite good in anticipating the timing and occurrences, but often the intensity of the event was wrongly predicted when comparing with the stations at ground. This brought IMO to decide to show a multitude of maps: 1. Deterministic hourly forecast with intensities; 2. Qualitative impacted area over 6 hours window; 3. Qualitative impacted area over 24 hours window. People were then encouraged to check the monitoring network of SO2 whenever the volcanic plume was forecasted to reach their area and location.

I think then a lesson learnt is that to deal with uncertainty we tried formally to address it showing different results and realization (plethora of maps) after the methodology behind them was explained. Based on such results decisions were taken on closing/opening paths to the eruption site, installing/removing instrumentations in the area.

3. Reflections and lessons learned: capacity and resources.

Please use this section to describe the response capacity and resources that were required during the event (case study).

Things you could mention include:

- *Number of institutions involved, number of scientists involved (and any international support contributed).*
- *Impact on scientists and civil protection authorities (e.g. ability to maintain normal responsibilities, health, etc) and any mitigation measures to address this.*
- *Any thoughts on particular challenges faced by volcano observatories, research institutions and/or civil protection in terms of capacity/resource during events (and any possible solutions).*

As this eruption occurred so close to the Reykjavík capital area, a large of interest was dedicated to it, its evolution and potential impact. In this regards many working groups were created by the CP. For

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example, groups worked on impact on energy production/distribution; communication infrastructure; designing of protective infrastructures/barriers; roads; residents' lives; ground water. In this way, responsibilities were assigned, and the load distributed. However, sometimes it was hard to keep track on what all different groups did and how they were sharing data amongst themselves.

At the IMO, in the aftermath of Bárðarbunga eruption, a person dedicated to the communication to the public was hired. This made a difference in our capability of dealing with requests from the media both local and international, as well as in managing the publication of news on our website and social media.

Of course, in the beginning of the eruption people has been working day and night to make sure the response for monitoring and following the events was optimal. But luckily the eruption also gave some breaks with some quiet eruptive periods during which people could rest and breath. But I honestly believe that it is just hard to tell scientists to be at home and rest while an eruption has just started and so many things need to be done. I guess the only way would be to prepare well in advance the onset of an eruption.

A great effort has been done in the first month and half by the rescue team that was patrolling the area (day and night) to guarantee no accidents in the area. For example, more than 150 persons were involved in managing the access the first weekend of the eruption, in the following weeks 40-75 people took shift on a daily basis to control the area and offer assistance and intervene in case of accidents. Numbers reduced when the summer came, and the walking path and the access became easier.

4. What is the key message (or messages) from this case study that you would like to emphasise within the EUROVOLC community and beyond:

Connection amongst scientists is essential, and it is natural to ask for support/exchanges/discussion with colleagues working in different institutions (also international). Exchanging experiences is a key element in our response, as often (if not always) others already have been dealing with similar situations/crisis. Volcanic crises will never be the same, but knowing how others responded, which tools, which solutions, which difficulties they encountered, is definitely a great starting point in designing our own way.

Usage of numerical models remain tricky. On one side it offers a great chance to investigate scenarios, produce impact maps; on the other side various models exist producing different results and the question is always who is right? Or possibly the model simply does not perform as well as expected. Often we do not know the answer and the variability in model results might create the condition for mining the credibility of the institutions (other than creating tensions between scientists).

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5. Please complete this section if your case study timeline overlaps with the Covid-19 (Coronavirus) pandemic (December 2019 – present), or if there have been changes as a result of Covid-19.

Things you could mention include:

- *Impact of the pandemic on your engagement with civil protection.*
- *Impact of the pandemic on your ability to communicate with civil protection.*
- *Learning and/or benefits transferable to volcanic events from Covid-19 experience.*

As already mentioned, the tools adopted during the pandemic turned to be of great use for sharing the data within a large group of people, in an interactive way and keeping the discussion live at any time. The Teams chat became our main platform to inform, update, distribute information and news. Also, the facility of calling for remote meetings is something that was learnt during the covid time. Almost all SAB meetings have been held remotely, sharing screens, exchanging images in the chat, etc. For sure this "technology" helped in speeding up the response. This also facilitated the participation of people from other countries to attend such meetings.

In addition, the eruption started when the social restrictions in Iceland were still valid. In this sense the thousands of people visiting the eruption on a daily basis at the beginning of the eruption, were warned against volcanic hazards as well as covid hazard. Along the walking path, initially there were indications to maintain the minimum distances between individuals.

References:

https://en.vedur.is/about-imo/news/the-small-eruption-in-fagradalsfjall-celebrates-six-months

Barsotti, S., Oddsson, B., Gudmundsson, M. T., Pfeffer, M. A., Parks, M. M., Ófeigsson, B. G., ... & Vogfjörd, K. (2020). Operational response and hazards assessment during the 2014–2015 volcanic crisis at Bárðarbunga volcano and associated eruption at Holuhraun, Iceland. Journal of Volcanology and Geothermal Research, 390, 106753.

END

Thank you for taking the time to complete this case study. Your examples shared will be invaluable to the completion of the tasks.

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Case Study 3:

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EUROVOLC WP7 Task 7.1 case study template

We invite you to contribute a case study using your professional experience on communication between volcano observatories, research institutions and civil protection during events. Please use an example of **one of the following**:

- ☐ an episode of volcanic or seismic unrest,
- ☐ ***unrest/eruption***
- ☐ simulation/exercise

Please use the template below to complete your case study. The objective is to describe the event (section 1), reflect on good practice and lessons learnt in terms of communication (section 2), reflect briefly on capacity and resource (section 3), a key message (section 4) and any learning from Covid-19 (section 5).

Particular points of interest include:

- *What type of information was requested and/or used by civil protection?*
  During the eruptive sequences which last between February and April 2021, the Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo (INGV-OE) following the operational procedures constantly informed the Department of Civil Protection (DCP) about the eruptive activity. The information requested by the DCP related to short-time multi parametric reporting on each single eruptive episode of the sequence and monthly-meeting. In the monthly meeting INGV–OE provided to DCP a large multi parametric overview of the eruptive sequence and potential scenario. The latter information was used by DCP to define the later level which eventually lead to convey the National Natural Risk Committee.

- *What type of information did you provide during the event?*
  As reported in the previous point, the information provided by INGV consisted of multi-disciplinary reporting and periodic and no-scheduled meeting. Together, VONA (Volcano Observatory Notice for Aviation) reports were issued for each of the paroxysmal events of the sequence.

- *How did you work with civil protection and/or other scientific institutions to design and create useful scientific outputs and materials?*
  Following agreed procedure between INGV and DCP, there was/is a constant interaction between the parties.

- *What specific methods and approaches did you use?*
  The method and approach relied on the multi-parametric observation of monitoring parameters. These after to be in real-time analysed and inputted in numerical model, converge in the 24/7 operational room and in the Early Warning System.

- *How did you manage the communication of uncertainty?*
  Uncertainty on the eruptive scenario was not quantitatively estimated but it was qualitative considered based on the synoptic framework of the monitoring data, statistic approach and historical past-eruptive sequences.

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- *Was there any information civil protection wanted or needed that could not be provided?*
  Not
- *How did your communication change over time?*
  Communication between INGV and DCP follow defined protocols and it's not changed until it is specifically reviewed by a dedicated committee. However, a straight informal communication between DCP and the Director and Head of Volcanology and Geophysics of INGV-OE frequently occurred.
- *To what extent was communication between volcano observatories, research institutions and civil protection authorities structured (e.g. formal protocols) and unstructured (e.g. informal telephone conversations)?*
  As detailed in the previous point communication follow specific protocols. Moreover, multidisciplinary report are also available in the INGV-OE web-site soon after they are sent to the Civil Protection. INGV also spreads all the reports using several social network channels.
- *Would you do anything differently?*
  The present Operational procedures is in a good shape, however is taking in to account to improve it based in the experience. In concern with DCP the outreach communication towards society could be improved.

We are keen to capture experiences across institutional levels, from local to national and encourage collaborative responses (e.g. several different institutions completing the same case study) at your discretion.

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Case study template

Title of case study:	
Country: Italy	Event/Volcano(es) [including dates where applicable]: Etna – 2021
Name of person(s) completing the template: Giuseppe Salerno and Simona Scollo	Contact details (optional): giuseppe.salerno@ingv.it ; simona.scollo@ingv.it

1. Detailed description (1000 words/~2 pages)

Please use this space to describe your case study. If you require more space then please use it, the 1000 words is just a guide. Your description should include an overview of what happened, key agencies involved and key interactions over time, communication between volcano monitoring institutions, volcano research institutions and civil protection, scientific outputs including methods and approaches.

Between 16th February and 1st April 2021, Mt Etna experienced an intense sequence of 17 frequent lava fountains from the South East Crater (SEC). Each paroxysm lasted few hours producing lava fountains reaching maximum heights of 1,500 m and eruption columns that often rose to more than 10 km above the sea level. Heavy tephra fallout affected many sectors of the volcano and in particular the eastern of the volcano, fine ash spread to hundreds of kilometres from Mt Etna. Each paroxysmal episode was coupled with lava flows which were mainly dispersed to the eastern flank in the Valle del Bove. Isolated pyroclastic flow occurred on 16, 24 February and on 24 March due the collapse of hot pyroclastic material on the steep flanks of the SEC. Over the two months of eruptive activity the bulk DRE was of ~52.5 x 10^6 m^3 of 33 x 10^6 m^3 of lava and 19.5 x 10^6 m^3 of pyroclastic material.

2. Reflections, lessons learned and good practice: communication

Please use this space to reflect on communication between volcano observatories, research institutions and civil protection, and lessons learned during the event. Reflections could include things such as:

- *What were the challenges and how these were overcome (or could be overcome in the future)?*

  There were two main challenges:
  - (i) The evolution timing of the eruptive episode from strombolian to lava fountains, in terms of communication for DCP: this issue was overcome standardised by stating an INGV operational protocol for the personal on duty;
  - (ii) The evolution timing of eruptive episode was quite fast and in some cases it represents and challenge for the effective communication between the h24/7 Operational room and the volcanologist/geophysicist on duty. This was solved by developing specific platform for the communication and compilation of reports between the three parties

- *Any examples of communication between volcano observatories, research institutions and civil protection that you would consider to be good practice?*

  following the INGV/DCP procedures, example of communication used are:
  - (i) INGV communicate that a change in the monitoring parameters has been observed
  - (ii) INGV communicate that a Stromboli activity is taking pale at the SEC crater

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(iii) INGV communicate the strombolian activity has gradually evolved to lava fountains, based on model volcanic clouds will dispersed towards, eg. north

(iv) INGV communicate that lava fountain ended

- *What was the most effective scientific information/communication to enable decision making by others?*
  (i) The monthly period meeting and the National Natural Risk Committee Meetings in which level alert were defined

  (ii) Over the two-months of eruption a consistent mass of tephra was persistently present in several towns in the eastern flank of the volcano (~ 2Kg/m2 at ~10km). The quick communication of the modelled plume-dispersal was extremely helpful to the DCP, to promptly communicated the hazard to the local authorities.

  (iii) A detailed report on the eruptive activity issued by INGV for the Italian Government to discuss the opportunity to declare the Emergency State on eastern Sicily due the eruption.

3. Reflections and lessons learned: capacity and resources.

Please use this section to describe the response capacity and resources that were required during the event (case study).

Things you could mention include:

- *Number of institutions involved, number of scientists involved (and any international support contributed).*
  Number of institutions involved: INGV OE and Palermo.
  Number of institutions involved: n/a
  No international support

- *Impact on scientists and civil protection authorities (e.g. ability to maintain normal responsibilities, health, etc) and any mitigation measures to address this.*
  The intense eruption was an opportunity to apply the operational procedure in stressful condition. To face the overload a second volcanologist on duty was dedicated for field observations, with a great benefit for managing the eruption.
- *Any thoughts on particular challenges faced by volcano observatories, research institutions and/or civil protection in terms of capacity/resource during events (and any possible solutions).*

4. What is the key message (or messages) from this case study that you would like to emphasise within the EUROVOLC community and beyond:
   An effective operational management of volcanic crises comes from the objective application of procedures.

5. Please complete this section if your case study timeline overlaps with the Covid-19 (Coronavirus) pandemic (December 2019 – present), or if there have been changes as a result of Covid-19.
   Covid-19 did not affect monitoring activities/duties.

Things you could mention include:

- *Impact of the pandemic on your engagement with civil protection.*
  No impact.
- *Impact of the pandemic on your ability to communicate with civil protection.*
  No impact.

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• *Learning and/or benefits transferable to volcanic events from Covid-19 experience.* n/a
References: END

Thank you for taking the time to complete this case study. Your examples shared will be invaluable to the completion of the tasks.