EUROVOLC

# European Network of Observatories and Research Infrastructure for Volcanology

# Deliverable Report

## D4.4 Outcome of the VAAC-WS workshop

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| Work Package: | *Networking atmospheric observations and connecting the volcanological community with VAACs* | |
| Work Package number: | *WP4* | |
| Work Package Leader: | *Lucia Gurioli* | |
| Task (Activity) name: | *Connecting the volcanological community and Volcanic Ash Advisory Centres (VAAC)* | |
| Task number: | *4.4* | |
| Responsible Activity leader: | *Claire Witham* | |
| Lead beneficiary: | *Met Office* | |
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| Type of Deliverable: | *Report [X]*<br>*Prototype [ ]* | *Demonstrator [ ]*<br>*Other [ ]* |
| Dissemination level: | *Public [X]*<br>*Prog. Participants [ ]* | *Restricted Designated Group [ ]*<br>*Confidential (consortium) [ ]* |

**Programme: H2020**
**Project number: 731070**

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# Workshop on "Communication strategies between Volcano Observatories and the Volcanic Ash Advisory Centres in Europe"

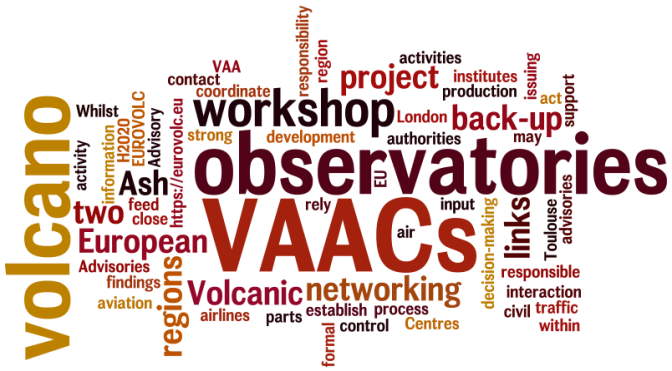
# Summary

On 5-7 February 2019, the UK Met Office hosted a EUROVOLC workshop to bring together the Volcano Observatories (VOs), Volcanic Ash Advisory Centres (VAACs) and Volcanological Research Institutes (VRI) in Europe. This activity came under the EUROVOLC Networking Activity "Connecting the volcanological community with VAACs" within Work Package 4, which is centred on networking atmospheric gas and aerosol observations. The workshop brought together ~35 leading scientists and operational staff from six of Europe's VOs (Iceland, Italy, France, Spain, Portugal and Greece) and the London and Toulouse VAACs. Seven other supporting institutions and organisations also participated.

The invited participants took part in a mixture of talks, discussions and scenario-based activities to strengthen links and coordinate interactions between the volcano observatories and the VAACs for improved crisis response. This was the first time that a dedicated meeting had been held to bring together all of the European volcano observatories with the two VAACs.

The workshop identified how VOs, VRIs and VAACs currently communicate and share information, limitations within these procedures and positive ways these could be improved. Key recommendations for future improvements in the communication procedures were defined. These include clarifying the guidance on the use of the VONA (Volcano Observatory Notice for Aviation), the need for the VONA to be sent to both the lead and back-up VAAC during events for improved back-up response, and archiving the VONAs on VO's websites. It was agreed that two-way feedback between VAACs and VOs is essential, and the VAACs should include the notification of the VOs in their back-up procedures, as well as introducing as standard a debrief process between the relevant VAAC and VO after major events. In quiet time, regular sharing of scenario information and summary status reports will improve knowledge at the VAACs. It was recognised that it is important for all VOs to participate in exercises, and for both VOs and VAACs to use exercises as opportunities to test the implementation of these recommendations and revisions to procedures.

The workshop was a resounding success with all attendees saying that it had improved their knowledge of the roles and work of the European VOs, as well as their awareness and understanding of the International Civil Aviation Organization procedures for volcanic ash. Over 95% of participants agreed that it had improved their knowledge of how the European VAACs operate and communicate. A follow up workshop to review progress and continue fostering these connections was recommended as one of the outcomes.



# 1. Introduction

The International Civil Aviation Organization (ICAO) is responsible for the global coordination of volcanic ash requirements and recommended practices for aviation. Following damaging aircraft encounters with the ash cloud from the 1991 Pinatubo eruption and a growing recognition of the hazard volcanic ash posed to aircraft, in the 1990s the ICAO established a network of Volcanic Ash Advisory Centres (VAACs). These VAACs are designated by the ICAO as responsible for issuing advisories to aviation for the current and forecast location of volcanic ash in the atmosphere. There are nine VAACs worldwide, each of which is responsible for the airspace in a defined region of the globe (see Fig. 4). The London VAAC hosted by the Met Office at Exeter, and the Toulouse VAAC, hosted by Météo-France at Toulouse, together cover all of European airspace. The volcanic ash advisories and graphics produced by the VAACs for their regions are provided to standards and tolerances set by the ICAO. In Europe, aviation regulations also require the Met Office and Météo-France to provide additional products identifying regions of specified volcanic ash concentration. The ICAO procedures stipulate that information on the status of volcanoes and signs of unrest and activity should be provided to the VAACs by the State Volcano Observatories.

In Europe, the VAACs rely on information from the volcano observatories (VOs) in their region for input to the production of the Volcanic Ash Advisories (VAAs). The two European VAACs (London and Toulouse) also act as a back-up for each other. Whilst they have close links with some volcano observatories and research institutes in their own region, links to their back-up regions are not as strong. Consequently, a workshop was proposed in the framework of EUROVOLC, Work Package 4, to establish formal contact and coordinate the interaction between the European volcano observatories and VAACs.

The workshop was held at the Met Office headquarters in Exeter, UK (Fig. 1) on 5-7 February 2019. The Met Office is the UK's National Meteorological Service and provides weather information to the public, aviation, industry and Government. As part of this role it hosts and runs the London VAAC. During the workshop participants were given both a virtual and a real tour through the Met Office's Operations Centre (including the London VAAC), and a tour around the Observations Park where a range of instruments are located.

Figure 1: The Met Office, UK.

## 1.1 Aims of the workshop

The overall objectives of the workshop were to:

- Establish formal contact and interaction between the VOs and VAACs in Europe.
- Improve awareness amongst VOs of the International Civil Aviation Organization process.
- Strengthen the links and coordinate interactions between the VOs and the VAACs in Europe for improved crisis response, with a focus on links to VAAC back-up regions.
- Define and harmonize avenues of communication and data-sharing and possible protocols for these interactions.

To meet these aims, introductory talks were given by the VAACs, VOs, and representatives from specific initiatives and working groups (WMO, VOBP, VASAG[1]) to enhance awareness of the roles of the different institutions and organisations (Fig. 2). The total of 19 presentations is now available on Basecamp, the EUROVOLC internal website (links to individual presentations can be found in Appendix 4). Break-out discussions and activities (Fig. 3) were used to identify current avenues of communication and data-sharing and to explore possible Best Practice procedures for these interactions. Face-to-face networking and discussions throughout the workshop helped develop and build new collaborations between VOs and VAACs. The full workshop agenda is given in Appendix 1.


*Figure 2: Introductory presentations by the participants from VAACs, VOs and working groups to enhance awareness of the roles of the different institutions and organisations.*

*Figure 3: Break-out group discussions and scenario activities to identify current avenues of communication and data-sharing and possible Best Practice procedures for these interactions.*

[1] A list of acronyms is provided in Appendix 3.

## 2. Workshop participants

The focus region for the workshop was the European extent of the London and Toulouse VAACs' areas of responsibility (Fig. 4). Representatives from all the European volcano observatories, plus Cape Verde, were invited to attend the workshop. The attending 35 participants represented 15 different institutions and organisations, including the two European VAACs (London and Toulouse), six of the European VOs who report to either of these two VAACs, and seven supporting institutes. The names and contact details of the participants are given in Appendix 2. The institutions represented were:

**VAACs**

1. Météo-France / Toulouse VAAC.
2. Met Office, UK / London VAAC.

**Volcano Observatories**

1. INGV - Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Italy, representing four sections: Catania, Pisa, Bologna and Napoli.
2. IMO - Icelandic Meteorological Office, Iceland.
3. CIVISA - Centro de Informação e Vigilância Sismovulcânica dos Açores, Portugal.
4. IGN - Spanish National Geographic Institute, Spain.
5. IPGP/OVPF - Observatoire volcanologique du Piton de la Fournaise, Réunion, France.
6. IGME - Institute of Geology and Mineral Exploration, Greece.

**Other supporting institutions and organisations**

1. UCA/OPGC - Université Clermont Auvergne/Observatoire de Physique du Globe de Clermont-Ferrand, France.
2. UI - University of Iceland, Iceland.
3. Rolls Royce, UK.
4. BGS - British Geological Survey, UK.
5. BSC - Barcelona Supercomputing Center, Spain.
6. University of Firenze, Italy.
7. WMO CAeM - World Meteorological Organization Commission for Aeronautical Meteorology.

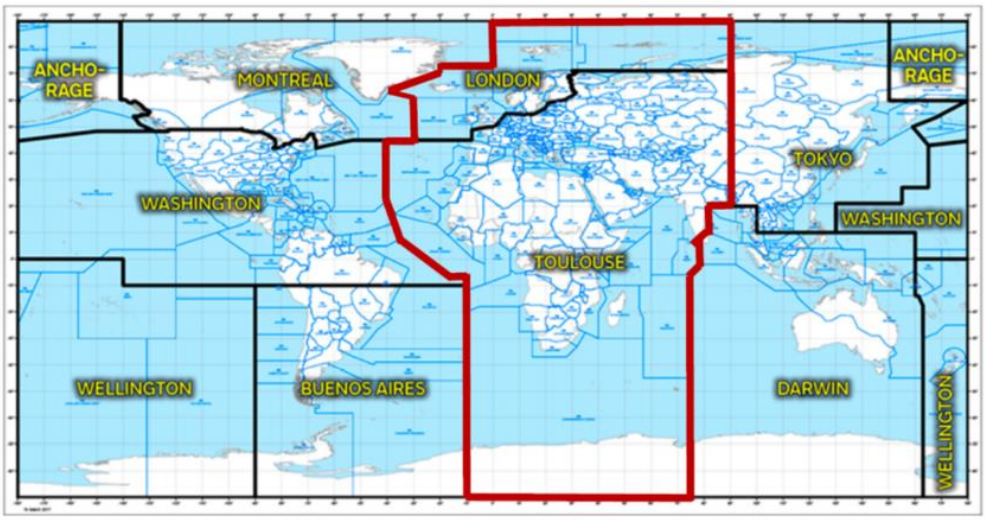



*Figure 4: Overview of the nine VAACs worldwide and their regions of responsibility. The red area outlines the regions of the London and Toulouse VAACs, which incorporate all of Europe.*

# 3. Outcomes of the workshop

To help meet the aims of the workshop, five specific desired outcomes were identified. To:

1. Document the current VO procedures for communications with the VAACs and agree Best Practice in this area.
2. Document the current use, challenges and future use of the Volcano Observatory Notice for Aviation (VONA) in Europe.
3. Enable better understanding of what the VOs can provide in terms of source term information and which key source term parameters are needed by the VAACs.
4. Produce an updated contact list of the designated VOs and VAACs in Europe, including key contact people, and a list of supporting institutions in each country.
5. Demonstrate enhanced understanding of the ICAO process.

Progress against each of these aspects is reported below.

## 3.1 Current linkages and procedures for communications and future improvements

The information flow between the different actors involved in the response to a volcanic event is complex (Fig. 5). The focus of the workshop was on the connection between the VOs and the VAACs where the **VONA** is the main communication mechanism.

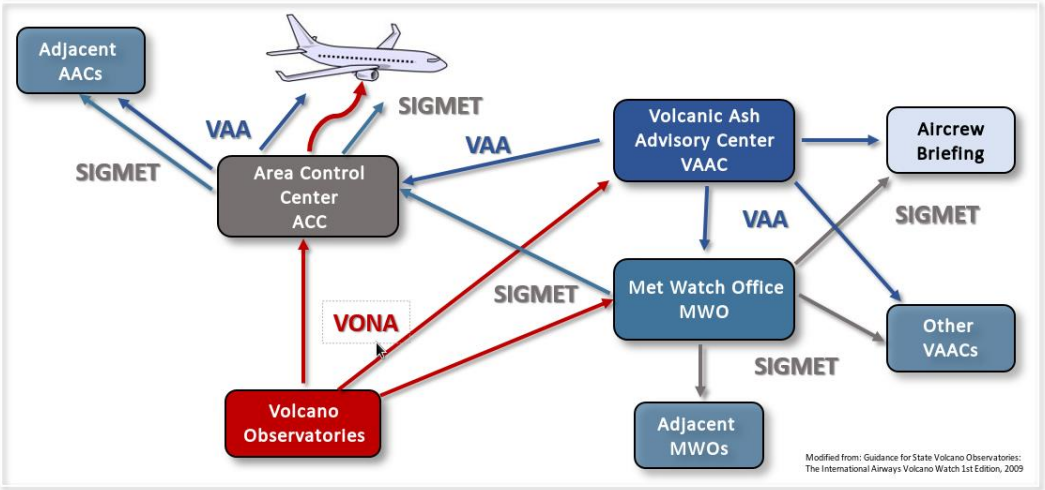



*Figure 5: Information flow between the different actors involved in the response to a volcanic event affecting aviation. Based on Guidance for State Volcano Observatories: The International Airways Volcano Watch 1st Edition (2009).*

Each VO presented an overview of their region and volcanic activity, their monitoring capabilities, how they work with other supporting institutes in their country/region and their current interactions with the VAACs. This revealed that there is a wide range of capabilities, resources, experiences and legal settings between **the six VOs represented**. While some have regular volcanic activity in their region and therefore regular experience in communicating the hazard both to local authorities and the VAAC, other VOs have not experienced a real event in recent years and therefore have had very limited contact with the VAACs. Most VOs have participated in exercises simulating hypothetical events and have in that way gained knowledge and experience in communication procedures. However, some VOs have no communication links with the VAACs and have not been involved in any exercises.

Quiescent volcanoes can be the most dangerous, so even if volcanoes are not active at the present they should be considered as candidates for exercises. In addition, such volcanoes may require more attention in case of unrest, particularly if little is understood about their potential behaviour. It is essential that both the VAACs and the VRIs understand the amount of work that the VOs, especially the smaller ones far away from the European mainland, need to face during an eruptive crisis and that demands for information and engagement are made appropriately.

From the VAAC perspective, **London VAAC** works closely with the teams at the Icelandic Met Office (IMO). A status report is received at least weekly from IMO, with a summary of activity for the 30 monitored volcanoes on Iceland. The operational meteorologists at London VAAC keep an eye on observations (e.g. satellite imagery, lightning detection systems, etc.) to detect any possible eruptions. London VAAC engages in monthly exercises with IMO to test response procedures. These are known as VOLCICE and simulate the eruption of a volcano in Iceland. Daily "what-if" scenario dispersion model runs for some volcanoes in Iceland are provided by London VAAC to IMO. There are also occasional exchanges of personnel to aid understanding of the roles that each organisation carries out. In the event of an eruption, the first notification will most likely initially come via a telephone call from IMO. Information relating to an eruption (e.g. the volcano name and number, the time of eruption, the height of the plume above the vent) is all very important in order to initiate a run of the dispersion model. As well as a telephone call, IMO will issue a VONA containing the above source-term information. London VAAC has very limited contact with VOs elsewhere in Europe however, and this is compounded by the lack of an up-to-date contact list for all the European VOs, as well as a lack of awareness by the other VOs that they can use London VAAC as a source of feedback.

**Toulouse VAAC** has a volcanic activity watch procedure, which includes a continuous watch that is coordinated with the VOs' volcano monitoring. A thorough watch is coordinated with the Italian VOs for the main active volcanoes Mt Etna and Mt Stromboli (webcam and real-time seismic signal). Toulouse VAAC also conducts continuous checking of various notifications and data sources including VONA, SACS notifications, AIREPs (pilot reports), NOTAMs, SIGMETs, and satellite imagery monitoring (MSG, NOAA ash probability). In 2018, Toulouse VAAC issued 13 operational VAAs/VAGs (10 VAAs/VAGs for Etna and 3 VAAs/VAGs for Piton de la Fournaise), participated in 4 international exercises (VOLCAZO on the 28 June and 8 Nov, for hypothetical eruptions of volcanoes in the Azores, VOLCITA on 23 October for an eruption of an Italian volcano, and VOLCEX 18, the annual pan-European Volcano Exercise, which includes both London VAAC and Toulouse VAAC), as well as in 2 bilateral back-up exercises with London VAAC.

Suggested **recommendations** for future **improvements and best practice** for communication between the VOs and the VAACs are:

- The ICAO EUR/NAT Aviation document, IAVW Handbook and all other relevant documents should be shared with all participants and also put on the EUROVOLC wiki, to ensure a common awareness of the ICAO procedures,
- Keep up-to-date contact details for all the VOs and VAACs in one accessible place. The use of unique/generic/group email addresses in this contact list is essential as private email addresses often get outdated when people change jobs or roles.
- For all VOs to get involved in exercises like VOLCEX. This is particularly important for VOs with few real eruptions, in order for them to train and maintain familiarity with the procedures.
- Each VAAC and VO should be in contact at least once per year. This is both to test communications and also maintain familiarity and awareness. More opportunities for VOs and VAACs to meet face-to-face (e.g. workshops such as this one) are desirable.

- The VRIs that work and support the VOs should be informed of the VAAC procedures and requirements so there is a wider awareness.
- There needs to be better exchange of information between VAACs and VOs on the status of volcanoes. This could be done with regular status reports, for example following the practice that is currently implemented between IMO and London VAAC.
- Feedbacks on the whole procedure during a volcanic crisis or an exercise are required from both VOs and VAACs to understand positive inputs, negative limitations and difficulties.
- A debrief process between the VAACs and VOs should be introduced as a standard procedure after major events.
- The VAACs should ensure that their back-up procedures include the notification of the VOs if lead responsibility is handed over. Ideally this procedure should be practiced annually, possibly as part of an exercise.

## 3.2 Current and future use of VONA

The **two main elements of communication** between the VOs and the VAACs are (i) the **VONA** and (ii) a phone call. Both Toulouse and London VAACs have experience in receiving information via a VONA from the VOs. All VOs are aware of the need for the VONA, but there are large differences in the experience with issuing a VONA, based on the activity in the VOs' regions. The most active VO present (INGV Catania) has issued more than 200 VONAs since 2008. Other VOs have no experience in issuing a VONA for a real event and have only used it for exercises, whilst some VOs have not participated in exercises and therefore have never issued a VONA. The ICAO guidelines for the use of the VONA will change from a "suggested practice" to a "recommended practice" and it will therefore need to become a procedure at each VO.

The **advantages** of using the VONA are that being in a standard format and available worldwide, it facilitates consistency and standardisation amongst all VOs. It also encourages shared expertise and capabilities and supports risk assessments and contingency planning for aviation safety. Because it provides information in written form it allows confirmation of shared verbal information and helps prevent miscommunication and language issues.

Best practice is for the VONA to be accompanied by a **phone call** from the VO to the lead VAAC. However, for those VOs issuing VONA it is apparent that there are differences in the timing of this phone call. For example, IMO will call London VAAC immediately in the case of an eruption and following the phone call will send a VONA over email confirming the details from the phone call in written form. Whereas for an eruption at Etna, INGV Catania first issues and sends a VONA to Toulouse VAAC via email and then follows up with a phone call to confirm receipt of the VONA and to respond to any questions. It was noted that sometimes there are issues with the language and misunderstanding of technical terminology during this phone call. The same procedure of sending the VONA and a subsequent follow-up phone call is used by other VOs. Concerns were raised about the length of time that might pass before the VAAC is informed about an eruption in the case where a phone call comes after the VONA, due to the time it takes to prepare and issue the VONA. However, due to different legal requirements in the different VO regions (for example in terms of contact with Civil Protection or the prefecture), it is not likely or expected that procedures can be harmonized or aligned, but it is recommended that the time taken to issue the VONA should be as short as possible. If the VONA takes time because of difficulty in observing/measuring a certain eruption parameter, then the VAAC personnel would prefer to be made aware of and share this difficulty rather than wait for a long time without any information.

The current **limitations** with the use of the VONA are partly due to unclear guidance, which leads to inconsistent use. For example, a VONA is not always issued when the aviation colour code is changed, particularly when it is "downgraded" because of a decline in activity during an eruption. The

aviation colour code is a recommended ICAO procedure for informing the aviation sector about a volcano's status, which follows a traffic-light colour scale of green, yellow, orange, red for both increasing and decreasing volcanic activity. The ICAO procedures state that notifications should be issued by the VO each time the colour code is changed (ICAO, 2014). Where aviation colour codes are not assigned to volcanoes, there is inconsistent use of blank, “unassigned” or “grey” in the aviation colour code section of the VONA. For example in Iceland, volcanoes that are not monitored adequately are given a grey colour, which is beneficial for their depiction on maps.

**Plume height** information is sometimes left blank in the VONA as there is a reluctance to include such information if there is no confidence or poor observations. Often the difficulty is related to the type of activity, for example low-energy plumes tend to vary their height continuously in time and VO staff is not sure how to communicate such variability in the VONA. It was unclear to the workshop participants whether the VONA specifies the eruption start time and/or the start of the ash emission phase, rather than (or in addition to) the issue time. It was also unclear whether the VONA should be issued during unrest phases, in situations where there is ash in the atmosphere, but the volcano has stopped erupting, or in situations with resuspended ash but no eruption (due to, for example, strong winds). The VONA cannot contain detailed information on, for example, the rapid variations in plume height, and there is an issue with the time taken to issue a VONA for short-lived eruptions, as the information can quickly become out of date. It is also unclear what type of additional information and observations are suitable for the VONA, and which should be supplied by alternative routes, e.g. grain size information. Who the end users and recipients of the VONA are is unclear to the VOs, with the current understanding that the VAAC is the only user of the VONA. It was noted that the issuance of a VONA is creating an extra workload for the VOs and there is limited use perceived for it elsewhere, for example for local airport operations. There is often little feedback from the VAAC back to the VOs on the information received in the VONA. Finally, most VONAs are distributed by email or fax and few VONAs are currently publicly available and archived, which limits accessibility.

Suggested **recommendations** for future **improvements** in the use of the VONA within Europe are:

- In a volcanic event the VONA should be sent to both the lead and the back-up VAAC. This would greatly enhance back-up procedures and would also allow the back-up VAAC to use the case as an exercise. This is particularly useful for London VAAC which responds to few real events. Follow-up comparisons of the ash dispersion results between the two VAACs would then also be possible, which in turn would enhance collaboration and communication between the two VAACs.
- The issuance of a VONA should be accompanied by a phone call to the lead VAAC, and if there is a language concern, then construction and use of a template for this call is recommended.
- All VO and VAAC personnel need to be well trained on the best practice for communication with the other organisations.
- Clarifications are needed where the VONA guidance is unclear (e.g. recording of eruption start/ash emission phase, the use of VONA in specific situations like during unrest, in situations when there is ash in the atmosphere when the volcano has stopped erupting, and for resuspended ash clouds).
- There is a need to better understand the requirements of the VONA in terms of data accuracy. The addition of an optional field for communicating uncertainty in the observations of eruption source parameters would also be useful to the end users.
- There is a need to identify which types of observations and information should be included in a VONA and which should be supplementary information sent/distributed via other channels.

- Two-way communication between the VOs and the VAACs is essential. For example, the VAAC might be able to provide information to VOs from satellite imagery that could help identify plume height.
- There is a need to define an update cycle for the VONA to avoid confusion when the volcanic activity is elevated but unchanged for a prolonged period (e.g. El Hierro type eruption).
- Archiving of the VONAs on the VO website should be a standard practice.

Finally, it is important to note that the VONA isn't the only way the VOs can communicate information and data to the VAACs. The VONA is a concise information sharing format that is best suited for triggering response procedures and for sharing of condensed information. Best practice for VOs involves supplying **additional and updated information** during and after eruptions, and each VO is likely to have or to develop specific ways and platforms for this communication. Best practice for the VAACs is to feed back to the VO any information on derived source parameters, if available, but primarily to provide **feedback related to the VONA/information received**.

## 3.3 Source term information

The workshop sought to provide a better understanding of what the VOs can provide in terms of eruption source parameter (ESP) information and identify which key ESPs are needed by the VAACs. Both of the VAACs highlighted that the key ESPs needed to initiate their ash dispersion models are the start time and location of ash emissions, as well as plume height. Toulouse VAAC also uses information on the "scale" of the eruption and whether there are "significant" ash emissions or not.

Both Toulouse and London VAAC highlighted the importance of the **plume height** as a critical model input parameter for the issuance of the VAA. However, talks and discussions revealed that a plume height estimate is often a challenge for the VOs as it can be difficult to observe, particularly when the plume height is rapidly changing during eruptive activity. Information on the plume height is therefore not always provided in the VONA. There was also some confusion around what plume height the VAACs require, whether it is the rapidly varying plume height above the vent, or an "average" plume height estimate further downwind. It was also highlighted that often the VONA does not include enough information to perform the model simulation required for the VAA production, and the VAACs need to use scenarios and additional information based on past eruptions for some ESPs (e.g. grain size distribution and mass eruption rate). Suggested **recommendations** for future **improvements** for sharing of ESP information are:

- For the VOs to provide an estimate or best guess (and/or range) of the plume height rather than leaving this field blank in the VONA. If plume height observations are poor and/or with little confidence, additional information about the level of uncertainty should be provided to highlight this.
- The accompanying phone conversation between the VO and lead VAAC should be used to help clarify and refine the heights, especially when the plume height is varying and/or observations are limited.
- There should be a continued focus on building relationships, trust and understanding between the VO and VAACs. This is important to allow VOs to be confident in expressing uncertainties around ESP, in particular the plume height, in both the VONA and the phone conversation. VAAC staff needs to be educated about the limitations and sensible use of such data, noting that they are used to dealing with uncertainties in many other steps of the VAAC process.
- During an eruption, it would be useful for VOs to provide a timeframe to VAACs within which they might expect to have better plume height information.

- Details around the requirements and definition of the plume height needed by the VAACs must be clarified during quiet times. A case-study using different heights, obtained with the different instrumentation, as input in the VAAC dispersion models could be useful to understand differences in the observed plume height and to define and clarify the VAAC requirements.
- There is a need for better feedback between the VAACs and VOs related to plume height during an eruption. The VAACs might be able to provide information about plume height from e.g. satellite imagery, PIREPs or other sources, which could help the plume height identification at the VOs. Also, if plume heights are differing from different approaches (e.g. direct observations vs. satellite/model) a discussion of these differences is crucial to understand and find the most appropriate information to produce the VAA.
- A **summary** of which quantitative ESPs, as functions of time, each VO can provide would be useful for the VAACs.

Information on the **grain-size distribution** of ash is an ESP that is useful to the VAACs. It is currently unclear how such information should be shared between the VOs and the VAACs. The VONA is not flexible enough to include such detailed information; therefore it needs to be distributed via alternative routes. These routes and data formats need to be agreed between the VOs and VAACs.

An ideal ESP for the VAACs would be in-situ and/or derived measurements of **mass eruption rate** and ideally **ash concentration** within the plume (in space and time). This is currently a challenging research area in which several VRI are working, using remote sensing approaches, modelling, radar, drones, meteorological balloons etc. The ICAO is considering moving towards a global quantitative (concentration based) volcanic ash advisory and such information is fundamental to this approach, both for the production of the advisories and for their validation.

Sharing of **scenarios** by the VO to the VAAC, both in quiet times and during activity is very helpful to the VAAC. Scenario information could include for example likely eruption scenarios in terms of plume height. The Catalogue of Icelandic Volcanoes (http://icelandicvolcanos.is/) provides an aviation table which includes “Possible Maximum Vertical Limits” and “Most likely Vertical limits” for plume height for 33 of Iceland’s volcanoes. Such information is very useful to the VAACs for use in scenario model simulations, and in the initial phase of an eruption, if observed plume height is not available. It is hoped that the European Catalogue of Volcanoes that is under development by EUROVOLC (WP11) will be able to provide similar scenario information for additional volcanoes in Europe.

## 3.4 Updated contact list

During the organisation of the workshop it became clear that the currently available lists of VO contacts in Europe (in the IAVW handbook (ICAO, 2014) and on the WOVO website (www.wovo.org)) are very out of date. This made finding the key contacts to invite challenging. During the workshop a preliminary updated contact list for all the participating VOs and VAACs was compiled. More work is needed to complete the list, but it is foreseen that it should be available by the end of 2019. The list contains key contact people or groups at each VO and VAAC, and a list of supporting institutions in each country. Use of generic/group email addresses in this contact list is essential as private email addresses often get outdated when people change jobs or roles. It is desirable that this list is kept up to date by doing an annual (or more regular) check of the information in the list.

## 3.5 Enhanced understanding

At the end of the workshop, an evaluation questionnaire was completed by the participants to assess the content and overall success of the workshop. The results (Fig. 6 depicts a selection) show that for

**82%** of the participants the workshop significantly helped improved their knowledge of how the European VAACs operate and communicate (95% strongly agreed or agreed). **64%** reported that the workshop strongly helped improve their knowledge of the roles and work of the different European VOs (100% strongly agreed or agreed). **61%** strongly agreed that the workshop helped improve their knowledge of what the VAACs need and what the VOs can provide in terms of source term information, but 14% also reported neutrally, indicating that there are still some clarifications needed. The participants found the group discussions and scenario exercises the most interesting and useful, but the ability to network and establish new contacts was also found very useful. **100%** agreed that workshop lived up to their expectations.

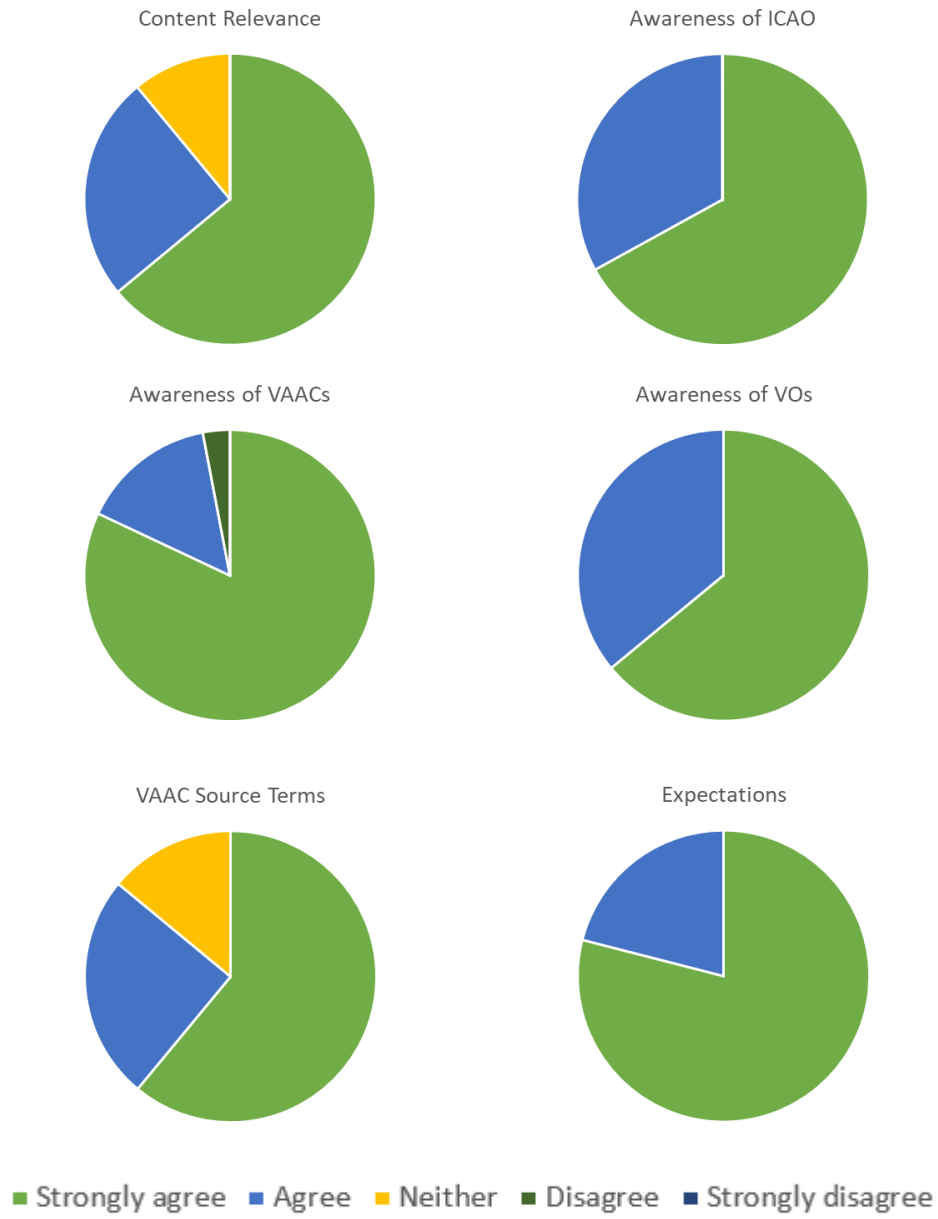



*Figure 6: Outcomes from the workshop evaluation, showing the level of participants' agreement with statements about the workshop including: the relevance of the content, increasing their awareness and knowledge of certain topics, and whether the workshop met their expectations.*

# 4. Summary of key recommendations

1. The **VONA** should be sent to both the lead and back-up VAAC during events for improved back-up response and for additional exercise opportunities. All VONA should be displayed and archived on VO websites. The issuance of a VONA must be accompanied by a phone call to the VAAC. The guidelines for the use of VONA should be updated to reflect the unclear guidance issues raised during the workshop.
2. A **two-way feedback** between VAAC and VO is essential, for example the VAAC should (i) report back on the usefulness and/or missing/inconsistent information in the VONA, (ii) provide additional information on plume height from e.g. satellite imagery or model techniques if available, and (iii) report if observation data (e.g. plume height) are differing from different approaches (e.g. observations vs. model/satellite). The VO should report its difficulties in (i) communicating (due to the language and/or the type of the eruption and/or local impediments), (ii) measuring the source parameters, and (iii) filling in the VONA and why. The VAACs should include in their back-up procedures the notification of the VOs if a handover occurs.
3. **Scenario information** (e.g. likely plume heights, expected duration) should be supplied, if available, by the VO to the VAAC both in quiet time and during activity. The European Catalogue of Volcanoes would be an ideal centralized system for such information.
4. An observed or best guess estimate (e.g. from scenarios based on previous eruptions) of the **plume height** should be provided in the VONA and ideally be accompanied by additional information about the level of uncertainty.
5. Regular **summary reports** on volcano status should be supplied by the VOs to the VAACs to improve knowledge. The frequency of these reports should commensurate with the activity of the area.
6. An assessment and a summary should be made of which quantitative **ESPs**, as functions of time, VOs can provide.
7. Introduction of a **debrief process** between the VAACs and VOs after major events.
8. All VOs should take part in upcoming **exercises**, and both VOs and VAACs should use exercises as opportunities to test the implementation of these recommendations and revisions to procedures.

# 5. A roadmap for future changes and improvements in communication and data-sharing

A detailed timeline for the implementation of the recommendations in Chapter 4 is being drawn up, but more time is needed to finalise and agree on the timeline with the VOs and VAACs. The remaining timeframe of the EUROVOLC project (~2 years) provides us with a great opportunity to work on implementing some of the proposed changes and key recommendations. The European VOLCEX volcanic ash exercises in 2019 and 2020 will also provide good opportunities to test revisions to procedures and communications. The lessons learnt from these VOLCEX will be shared more widely within the VO/VAAC community of EUROVOLC.

The feedback and recommendations regarding the VONA will be fed into an existing VASAG activity that is looking at improving the use of the VONA. Three members of the VASAG activity were present at the workshop so the ideas presented in this report will be immediately taken forward. The report and the recommendations will also be shared with the representatives from the VOBP, VAAC BP and VASAG groups to enable pertinent points to be cascaded to these bodies and shared more widely with the international community where relevant.

It was widely acknowledged by the participants that a **follow up workshop** to review progress would be extremely useful. Discussions are underway as to how this might be arranged.

# Reference list

Guidance for State Volcano Observatories: The International Airways Volcano Watch 1st Edition – December 2009 http://www.wovo.org/assets/docs/gvo2009s.pdf

ICAO, 2014, Handbook on the International Airways Volcano Watch (IAVW), Second Edition — 2004, Doc 9766-AN/968, https://www.icao.int/publications/Documents/IAVW%20Handbook%20Doc%209766_en.pdf

# Appendices

## Appendix 1. Workshop Agenda

### Day 1: Tuesday 5th February, Conference Room 3&4

**10:00 10:30 Arrival, registration and coffee/tea**
**10:30 10:45 Welcome and practical information**
**10:45 12:30 Introduction to Current Working Groups**

| | | | |
|---|---|---|---|
| 10:45 | 11:05 | Overview of the EUROVOLC project and WP4 | Lucia Gurioli and Mathieu Gouhier, UCA-OPGC |
| 11:05 | 11:30 | Volcanic Services for International Aviation | Ian Lisk, WMO president of Aeronautical Meteorology |
| 11:30 | 11:50 | Volcano Observatory Best Practice workshops | Sara Barsotti, IMO |
| 11:50 | 12:10 | VAAC-Best Practice workshops | Mark Seltzer, London VAAC |
| 12:10 | 12:30 | Introduction to VASAG | Claire Witham, Met Office |

**12:45 12:55 Warm up activity**
**13:00 14:30 Lunch**
**13:50 14:30 Optional walk**
**14:30 16:45 VAAC Introductions**

| | | | |
|---|---|---|---|
| 14:30 | 15:30 | London VAAC introduction & "Virtual Tour" | Anton Muscat, London VAAC |

**15:30 16:00 Coffee break**

| | | | |
|---|---|---|---|
| 16:00 | 16:45 | Toulouse VAAC introduction | Thomas Marmigere, Aeronautical Forecaster VAAC Toulouse |

**17:00 19:00** Street reception with Finger Food & Drinks, Ice breaker activity & Tour of the Operations centre

## Day 2: Wednesday 6th February, Conference Room 3&4

**9:00 09:30 Arrival and coffee/tea**

**09:30 12:00 Volcano Observatory Introductions**

| | | | |
|---|---|---|---|
| 09:30 | 10:00 | Introduction to the Icelandic Meteorological Office | Sara Barsotti & Björn Sævar Einarsson, IMO |
| 10:00 | 10:20 | The volcano monitoring and forecasting for aviation safety at INGV Osservatorio Vesuviano | Giovanni Macedonio, INGV-Napoli |
| 10:20 | 10:40 | The volcano monitoring and forecasting for aviation safety at INGV Osservatorio Etneo | Mauro Coltelli, INGV-Catania |

**10:40 11:00 Break**

| | | | |
|---|---|---|---|
| 11:00 | 11:15 | The INGV scientific activities and projects for enhancing the volcano monitoring and forecasting for aviation safety | Daniele Andronico (INGV-Catania) and Matteo Cerminara (INGV-Pisa) |
| 11:15 | 11:45 | Introduction to Observatoire Volcanologique du Piton de la Fournaise (OVPF), Réunion | Philippe Kowalski, IPGP / OVPF |

**12:00 13:00 Lunch**

**13:00 13:30 Tour of the Observations Park**

**13:30 15:00 Volcano Observatory Introductions (cont.)**

| | | | |
|---|---|---|---|
| 13:30 | 14:00 | Introduction to Centro de Informação e Vigilância Sismovulcânica dos Açores | Adriano Pimentel, CIVISA |
| 14:00 | 14:30 | Introduction to the Spanish National Geographic Institute (IGN), Consejo Superior de Investigaciones Cientificas (CSIC) and the Canary Islands Volcano Monitoring Program | María José Blanco & Alicia Felpeto, IGN |
| 14:30 | 15:00 | Introduction to Institute of Geology and Mineral Exploration and Santorini Volcano Observatory | Georgios Vougioukalakis, IGME |

**15:00 15:05 Fire alarm test**

**15:05 15:30 Introduction to VONA**

| | | | |
|---|---|---|---|
| 15:05 | 15:30 | An assessment of the current use of the Aviation Colour Code and VONA in communicating volcanic behaviour: Open questions and plans for the future | Sara Barsotti, IMO |

**15:30 16:00 Coffee break with cake**

**16:00 17:30 Break out groups:** "*Current avenues of communication and data sharing*" In Conference Room 1,3 and 4

**19:00 Workshop dinner at Jurys Inn, Exeter**

## Day 3: Thursday 7th February, Conference Room 3&4

**09:00 09:15 Arrival**

**09:15 10:30 Complementary information and data usage**

| | | | |
|---|---|---|---|
| 09:15 | 09:55 | Ash and Jet Engines: Developments Since 2010 | Rory Clarkson, Rolls Royce |
| 09:55 | 10:15 | Updates to the ESP database | Sam Engwell, BGS |
| 10:15 | 10:35 | Infrasound monitoring of active volcanoes: state of the art and future perspectives | Emanuele Marchetti, University of Firenze |

**10:35 11:00 Coffee break**

**11:00 12:30 Break out groups:** *"Scenario Exercises To Define Best Practices for Communication"* in Conference Room 1

**12:30 13:30 Lunch**

**13:30 13:45 Workshop photo**

**13:45 15:00 Next steps discussion and wrapping up**

**16:45 18:15 Exeter Cathedral Guided Roof Tour with a view of Exeter at Sunset (optional)**

# Appendix 2. List of Workshop Participants

| Name | Institution | Email |
|---|---|---|
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# Appendix 3. List of acronyms and abbreviations

AIREP – Air Report of in-flight weather conditions such as wind and temperature

BGS - British Geological Survey

BP – Best Practice

BSC - Barcelona Supercomputing Center

CIVISA - Centro de Informação e Vigilância Sismovulcânica dos Açores

CSIC - Consejo Superior de Investigaciones Cientificas

ESP – Eruption Source Parameters

EUR/NAT - European and North Atlantic

IAVW - International Airways Volcano Watch

ICAO -International Civil Aviation Organisation

IGME - Institute of Geology and Mineral Exploration

IGN - Spanish National Geographic Institute

IMO – Icelandic Meteorological Office

INGV - Istituto Nazionale di Geofisica e Vulcanologia

IPGP - Observatoire volcanologique Institut de physique du globe de Paris

MSG - Meteosat Second Generation series of satellites

NOAA - National Oceanic and Atmospheric Administration

NOTAM - Notice to Airmen

OPGC - Observatoire de Physique du Globe de Clermont-Ferrand

OVPF - Observatoire volcanologique du Piton de la Fournaise

PIREP – Pilot Report of in-flight atmospheric conditions

SACS – Support to Aviation Control Service (http://sacs.aeronomie.be/)

SIGMET - Significant Meteorological Information

UCA - Université Clermont Auvergne

VAA – Volcanic Ash Advisory

VAAC – Volcanic Ash Advisory Centre

VAG - Volcanic Ash Graphic

VASAG - Volcanic Ash Science Advisory Group

VO – Volcano Observatory

VOBP - Volcano Observatory Best Practice Workshop

VONA – Volcano Observatory Notice to Aviation

VRI – Volcano Research Institute

WMO - World Meteorological Organization

WOVO – World Organization of Volcano Observatories

## Appendix 4. Links to workshop presentations

Below are links to all the presentations from the EUROVOLC VAAC-VO workshop.

Agenda https://public.3.basecamp.com/p/tGhy1gtsJpJAEkogyoQhvu6z
1_Introduction_to_EUROVOLC_LuciaGurioli&MathieuGouhier.pptx
https://public.3.basecamp.com/p/Mbz55BQoqKAGdVMnYyiWcAE6
2_Overview_of_WMO-ICAO_activities_and_processes_IanLisk.pdf
https://public.3.basecamp.com/p/9nA2ZG3Aj7GZQAfpaJefqfbe
3_Introduction_to_VOBP_SaraBarsotti.pptx
https://public.3.basecamp.com/p/CjyDPc6kYCzDTvbDBkxrw9EP
4_Introduction_to_VAACBestPractice_MarkSeltzer.pptx
https://public.3.basecamp.com/p/BwRYC5sQMZQqwSfjYC7VDd3J
5_VASAG-Introduction_ClaireWitham.pptx
https://public.3.basecamp.com/p/7LJmrBGrcMypbDJhjbFQpMat
6_Overview_of_LondonVAAC_AntonMuscat.pptx
https://public.3.basecamp.com/p/6YBNKkmvkH5SMAP26hPehjSz
7_Overview_of_ToulouseVAAC_ThomasMarmigere.ppt
https://public.3.basecamp.com/p/NTRmGaWhrqA1ZvPuyPy9Ch6T
8_Introduction_to_IMO_SaraBarsotti.pptx
https://public.3.basecamp.com/p/CWTWwf17pT7rW4ucRiNjb2hr
9_Introduction_to_INGV-OsservatorioVesuviano_GiovanniMacedonio.pdf
https://public.3.basecamp.com/p/ybRiwrZdepo25xdgPFG1T8TK
10_Introduciton_to_INGV-OsservatorioEtneo_MauroColtelli.pptx
https://public.3.basecamp.com/p/96QCD8st8ReYyXzVeVHGBQUp
11_INGV_Scientific_activities_DanieleAndronico.pptx
https://public.3.basecamp.com/p/71yoo26A59vwUFnqCctShmm5
11_INGV_Modelling_Actitivies_MatteoCerminara.pdf
https://public.3.basecamp.com/p/p5c4ro1EPL58rsvFQuDxMqq2
12_Introduction_to_Piton_de_la_Fournaise_VO_PhilippeKowalski.pptx
https://public.3.basecamp.com/p/LpLvmzTpr3rXcYATeRzHsqPy
13_Introduction_to_Azores_VO_CIVISA_AdrianoPimentel.pptx
https://public.3.basecamp.com/p/WDetR7CoEjL5wLe9C6PnS1eq
14_Introduction_to_CanaryIslands_VO_IGN_CSIC_AliciaFelpeto&MariaJoseBlanco.ppt
https://public.3.basecamp.com/p/CuPE59NHSuHb87ddaYotg9ae
15_Introduction_to_SantoriniVO_ISMOSAV_IGME_GeorgiosVougioukalakis.pptx
https://public.3.basecamp.com/p/46M4y91fRUQUXMcvvQmN7SZa
16_Introduction_to_VONA_ColourCode_SaraBarsotti.pptx
https://public.3.basecamp.com/p/WXbyNtFMnrasacCXh1yDcBTH
17_AshandJet EnginesDevelopmentsSince2010_RollsRoyce_RoryClarkson.pdf
https://public.3.basecamp.com/p/Jip7fh2JpG4qR4N62gDSpQVB
18_UpdateOnESPdatabase_SamEngwell.pdf
https://public.3.basecamp.com/p/MrXXfvFBncNovSkPgKELfdVs
19_InfrasoundProject_Emanuele Marchetti.pdf
https://public.3.basecamp.com/p/RxcLG2dFx5vUgVDyJCStC9GD