EPOS-TCS Volcano Observations makes hazard information accessible and searchable

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EPOS-TCS Volcano Observations aims to provide long-term sustainable access to data, products, services and software presently existing at European Volcano Observatories and Volcano Research Institutions. This is built upon decades of infrastructure operated by these Observatories and Institutions, and their long-term data sets and research material. Within EPOS, this TCS will implement interoperable services to allow discovery and seamless access to this broad type of data and services.

Among the data and services provided, six partners (either Volcano Observatories and Research Institutions) are collaborating on an ambitious task: IMO, INGV, IPGP, CSIC, UAc, CNRS-OPGC (Acronym)

are working with a common goal of quantifying hazards associated with volcanic eruptions, and making this information accessible and understandable to key end-users, such as the Civil Protection and the general public.

The first step towards this goal was to perform a systematic review of available products suitable for volcanic hazard assessment and hazard communication in use at different Volcano Observatories. The main effort was twofold: 1. to list the existing material (for example maps, graphs, guidelines, manuals, visualization tools) and 2. to design standard metadata for an effective description of such material.

What do we mean with the expression "volcanic hazard products"?

Talking about hazard means talking about anything that can potentially generate adverse events and consequently create damage to the population and/or environment (Marzocchi et al.
In volcanology we mean all those dangerous phenomena that might occur in such a geological/environmental context and that can have implications for human, social and economic life. Volcanic hazards associated with a volcanic unrest and/or eruption can be many (see Figure 1): among them, the ones mostly targeted by volcanic hazard studies are: ballistics; volcanic ash and tephra; pyroclastic density currents and blasts; lahars and floods; debris avalanches, landslides and tsunamis; volcanic gases and aerosols; lava flows and domes; volcanic earthquakes and/or ground deformation; lightnings (Loughlin et al. 2016).

To quantify and visualize volcanic hazard, several tools have been developed within the research community and some of them are operational within Volcano Observatories.

The most common way to convey information on volcanic hazard is by drawing the spatial extension of one of the above-mentioned hazardous phenomena on a geo-referenced map. Different types of map exist and they differ for the type of raw data used to assess the extension of the impacted area (geological data or simulation results), the type of information plotted on the map (an intensity measure of the investigated phenomenon, or the probability of its occurrence), the temporal constrain of validity for such a map, the background map, and so on (Calder et al. 2015).

A map showing the probability of invasion due to pyroclastic density currents at Campi Flegrei (Figure 2), given the occurrence of an eruption, is a probabilistic (since it displays the probability) hazard map.

It is an example of volcanic hazard product.

Another common way to convey information on volcanic hazard is by means of Event-Trees, that are a schematic way to represent the possible behaviour of a volcano and the different possible outcomes of volcanic unrest. Event-Trees are usually drawn based on our knowledge of the historical or geological activity of the volcano studied, or of other volcanoes deemed similar to it. The schematic nature of Event-Trees helps understanding the logical step leading to different outcomes of volcanic activity, and their use during volcanic crises can help volcanologists both in critically reviewing and mutually discussing their hazard analysis, but also officials and individuals to compare volcanic risks with more familiar risks (Newhall and Hoblitt, 2002).

An example of Event-Tree for Teide-Pico Viejo stratovolcanoes is shown in Figure 3 (Martí et al. 2008).

This type of product is also a volcanic hazard product, and its use is increasing at Volcanic Observatories or Research Institutions.

With the goal of making hazard information accessible and
searchable, a review has been done across the different EU Volcano Observatories to list the most common volcanic hazard products presently available and in use. This has been done with the main goal to compile a catalogue and, at the same time, to create the conditions for a general efficient description of those products, that is formally obtained by the identification of metadata.

How can we "describe" volcanic hazard products by means of metadata?

With metadata we mean a set of data that can help in... describing other data! By listing a set of metadata for specific products (maps, table, graphs, monitoring data) we create the condition for these products to be effectively searchable (and findable) through a database. This is the best way to make products more easily found, consulted and exploited by the community.

As mentioned in the previous section, a variety of products exist to quantify/visualize/communicate volcanic hazard, making the task of unifying their metadata challenging. Despite this variety, a first attempt has been done to identify the basic metadata for these type of products. A version 1.0 of these metadata has been created within the EPOS - TCS Volcano Observations (as shown in Figure 4). The list includes all those descriptors that will allow the identification of a specific product unequivocally.

Metadata for volcanic hazard products are structured on four main domains: general descriptors, type of hazard described, geographical coverage and temporal descriptors. For example:

- Descriptors regarding the functionality of the product (i.e. which is its main use) is under the domain “General descriptors”.
- The identification of which intensity measure (e.g. pyroclastic density current temperature) is used to describe the impact of a specific hazard is under the domain “Type of hazard described”.
- The volcano for which the product is applicable (e.g. Mt. Etna) is under the domain “Geographical coverage”.
- The time of validity (e.g. 48 hours) of a given forecast map for tephra accumulated at the ground, based on the wind forecast for the next 48 hours and on a given eruptive scenario, is under the domain “Temporal descriptors”.

Finally, in Figure 5 we show an example of volcanic hazard product (panel A, displaying the map of the probability of tephra accumulation at ground in 24 hours, given an eruption of VEI=6 size occurring at Öræfajökull volcano in Iceland), and how it is possible to unequivocally describe it by the Metadata scheme proposed
The newly developed metadata will be adopted to implement the search and query of volcanic hazard products through the EPOS web-service. In this way any potential user interested in information and products on volcanic hazards for European volcanoes will easily find them, download them and use them, respecting the ownership of the authors and the scientific and/or legal conditions under which the products is valid.

The Volcano Observatories in Europe together with the European Research Institutes will continue to produce new and innovative products in the future that will support the difficult task of assessing and communicating volcanic hazard.

Needless to say that the metadata structure will be updated to either account these new volcanic hazard products, or to further detail the description of the products already listened.

Overall, the work carried out so far by the “Hazard” sub-task of WP11 “Volcano Observations” is aimed at facilitating the access to research and operational products, which is considered a vital objective for building a science at the service of the community. WP11 accepted the challenge of fostering the integration of scientific knowledge for a general public understanding. In this vision, EPOS is the fundamental infrastructure that will make this real and achievable in the next years.

1Acronyms
IMO – Icelandic Meteorological Office, Iceland
INGV – Istituto Nazionale di Geofisica e Vulcanologia, Italy
CSIC - Consejo Superior de Investigaciones Científicas, Spain
UAc - University of the Açores, Portugal
IPGP - Institut de Physique du Globe de Paris, France
CNRS-OPGC - Observatoire de Physique du Globe de Clermont-Ferrand, France

2Figure 1. Sketch of possible hazardous phenomena of volcanic origin, mostly associated with eruptions. However, some of them, such as lahars and debris avalanches, can occur even when a volcano is not erupting. Adapted from Myers B. & Driedger C. (2008), Geologic hazards at volcanoes: U.S. Geological Survey, General Information Product 64, 1 sheet [http://pubs.usgs.gov/gip/64/]

3Figure 3. Event-Tree designed for Teide-Pico Viejo stratovolcanoes (Tenerife, Canary Islands, Spain) during the Exploris project. From left to right, the logical steps leading to hazardous outcomes are represented. In particular, we start from a generic unrest event, which can lead or not to Sector failure. In
case of no sector failure, eruption may or may not develop, and if it does, it can be from a central vent or from a flank. Different hazardous phenomena are expected accordingly. In case of sector failure, a flank eruption is expected, again with different possible consequent hazardous phenomena. The numbers indicated in each branch represent the 5th-50th-95th percentiles of the probability distribution describing each branch. Modified after Marti et al. (2008).