EUROVOLC

European Network of Observatories and Research Infrastructure for Volcanology

Deliverable Report

D13.1 Report on the WP13 TA activities during the project

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Contents

Summary

The objective of WP13 was to provide access to the Icelandic Volcano Observatory at IMO (Icelandic Meteorological Office) Research Infrastructures and thus offer an opportunity to carry out research on Iceland's volcanic areas. In this sense, IMO offered two types of field support (Field work Type 1-defined as field work in the highlands and Field work Type 2-defined as field work winter-like environment such as on glaciers and thus requiring snowmobiles and modified jeeps). The third support offered was access to IMO's facilities, scientific equipment (GPS, portable seismic sensors, etc.) and relevant existing data from IMO's networks.
Two calls for trans-national access were opened in EUROVOLC, first one in August 2018 and the second one a year later, in August 2019. In total seven proposals were received, two in the first call of which one was accepted, and five in the second call of which three were accepted. All applications were for field work type 1.

Due to travel restrictions caused by the COVID-19 pandemic in 2020, all four funded projects which were planned to be carried out during the summer of 2020 were postponed to 2021 and some needed to be modified and carried out remotely.

Introduction

Research Infrastructures offered for Trans-national access

The Icelandic Volcano Observatory (IVO) is operated within the Icelandic Meteorological Office (IMO) which is responsible for monitoring all natural hazards in Iceland. IMO operates multidisciplinary monitoring networks and strives to collect and archive multidisciplinary, research quality data on Icelandic volcanos. The high volcanic activity in Iceland has produced a wealth of data from several eruptions. In EUROVOLC the IMO is providing Trans-national access to its hitherto inaccessible multidisciplinary research infrastructure and its databases. The Trans-national access provides visitors a unique opportunity to access and use the data, as well as the below listed infrastructures to high resolution research experiments on Icelandic volcanos:

- IMO's buildings: Access to IMO's office space including access to library, computers, internet, office support and multidisciplinary data bases relevant for the activity;
- Field work: Two types of field work were foreseen: In the Icelandic highlands (Type 1) or glaciers (Type 2).
- Seismic equipment: 5 portable seismic sensors, of which 3 can be broadband, otherwise 5s sensors and 5 Reftek130 recorders available for field experiments;
- GPS equipment: 5 GPS instruments, which can be accessed for campaign measurement when not in use;
- Gas and ash equipment for field campaigns: MultiGAS, DOAS, FTIR, Optical Particle Counters;
- Support equipment: Additional support equipment needed for powering instruments and for telemetry;
- Field support systems (logistic support, jeeps, snow scooters, field support equipment).

First call for research proposals

Overview of first call

The call was opened at the beginning of August 2018 and closed at 10th of October 2018. Emphasis was placed on field work and the call specified that applications/proposals only for access to IMO office facilities and existing data bases would not be accepted.

Two proposals were submitted to the IMO Research Infrastructures in the first call:

- **EV-C1-01 Volcano tourism** (*Volcano tourism: natural hazards in Iceland and implications for tourists) submitted by Dr. Julia Crummy, at BGS, Edinburgh.*
- **EV-C1-02 APINO** (*Ash dispersal Prediction Informed by Numerical models and Observations), submitted by Dr. Mattia de'Michieli Vitturi, at INGV Pisa.*

EV-C1-01: The aim of the **Volcano tourism** project was to use Iceland as a case study to analyze underlying risk factors relating to volcano tourism. A substantial increase in tourism in Iceland has occurred since they Eyjafjallajökull eruption in 2010 and tourists have been drawn to visit eruption sites such as Eyjafjallajökull and Holuhraun. Tourists are generally particularly vulnerable in disaster situations and a need for an effective risk reduction strategy has risen. Dr. Crummy set forth a working plan using a variety of methodologies (e.g. inductive timelines) to collate data, knowledge and investigate behaviours and perceptions of tourists to better understand and reduce risk. The work plan involved both IMO and NCIP (National Commissioner of the Icelandic Police) staff members.

EV-C1-02: Project **APINO** was intended to improve the integration of data coming from both permanent C-band weather radars and portable X-band radars in operation at IMO, into the plume model *PlumeMoM*. The purpose was to develop a fast and efficient modelling of ash dispersal and deposition which could also be applicable in other volcano observatories. The goal was to create data of ash transport simulations to VAACs (Volcanic Ash Advisory Centers) for aviation safety purposes as well as to assimilate in real-time the data coming from volcano observatories to assess the local-scale hazards due to tephra fallout.

Results of first call

The evaluation of the proposals was twofold. An initial technical- and logistic evaluation was made by IMO and then forwarded to the International Scientific Review Panel (ISRP) for scientific excellence-based evaluation. The proposals were assigned scores based on several different factors. The maximum attainable score was 30 and to pass evaluation, the proposals needed to receive at least 20 points. The evaluation procedure turned out to be a bit incoherent between the different providers (work packages) requiring a second overall evaluation by the project's Steering Committee to harmonize the evaluation of all proposals received in the first call. More details of the evaluation procedure are described in EUROVOLC'S 1st Periodic Report (pg. 245-249).

After the whole evaluation procedure, the **EV-C1-01 Volcano tourism** proposal passed and was offered support, whereas the **EV-C1-02 APINO** proposal, which had requested an installation not offered in the call, did not pass the technical- and logistic pre-evaluation and was rejected. Due to maternity leave of the applicant in the volcano tourism project, the project could not be carried out in 2019 as initially planned. Its execution was therefore postponed until summer 2020.

Second call for research proposals

Overview of second call

The call opened in August 2019 and closed in October 2019. IMO's access offer in the second call was mostly the same as in the first call, with the addition of a statement saying that applications to IMO office facilities and data only would now be considered, although proposals focused on fieldwork would have priority.

Figure 1: The IMO advertisement for the opening of the 2nd TNA Call offering access to IMO's Research Infrastructure.

Since only one rather low-cost project had been accepted in the 1st call, IMO was able to accept three projects in the 2nd call, as the budget for the 2nd call was larger than initially foreseen. Five proposals were submitted for access to the IMO Research infrastructure:

- **EV-C2-015 TREMORVOLC** *(Seismic network-based monitoring of volcanic tremor), submitted by Dr. Jean Soubestre at Instituto Volcanologico de Canarias (INVOLCAN), INtech La Laguna, San Cristobal de La Laguna, Tenerife.*
- **EV-C2_025 RISK** *(Rift-parallel strike-slip faulting in northern Iceland: Signals of dyKing or tectonics?), submitted by Elena Russo at University of Milan-Bicocca.*
- **EV-C2-026 ESPADA** (*real time Eruptive Source Parameters Data Assimilation), submitted by Dr. Federica Pardini, at INGV Pisa.*
- **EV-C2-033 HERSK** (*Hekla Real-Time Seismic Network), submitted by Dr. Martin Möllhoff, at Dublin Institute of Advanced Studies, Dublin.*
- **EV-C2-034 PUFFIN** (*A combined geochemical and isotope study oF the FluIds from the Eldfell volcano, Vestmannaeyjar volcanic system, Iceland), submitted by Dr. Fausto Grassa, at INGV Palermo.*

EV-C2-015: The aim of **TREMORVOLC** was to install software tools which the applicant had recently developed in order to detect and locate volcanic tremor in an operational way as well as to provide training in the usage of these tools to local scientists. Additionally, the proposal's objective was to gain better understanding of the origin of volcanic tremor through retrospective analysis of past eruptions data.

EV-C2_025: Project **RISK** intended to use the Krafla volcano Fissure Swarm in the Northern Volcanic Zone as a case study, using the combination of new geological-structural field data along with performing a drone survey of the area to explore the nature and origin of surface fractures with transcurrent and oblique motions, parallel and coeval to rift zones.

EV-C2-026: The **ESPADA** proposal was based on the APINO proposal from the 1st call, which was rejected. Improving the APINO proposal, ESPADA additionally aimed to carry out fieldwork, visiting sites where the different observational systems of IMO (lidar, radar, ceilometer, sun-photometer, Optical Particle Counter, webcam, mobile weather station) are located, with the aim to help to evaluate how the variety of data could be used for plume characterization and modeling.

EV-C2-033: Project **HERSK** was based on previous work carried out on Hekla volcano to monitor Hekla's seismic activity in real-time. The Principal Investigator had run into logistical difficulties in a previous fieldwork experiment on Hekla's summit, mainly related to power provision. The proposed project was thus to test new ways of powering seismic stations that transmit real-time data in very challenging environments and to set up a dedicated real-time SeisComp3 machine, tuned to the Hekla microseismiscity.

EV-C2-034: The **PUFFIN** project proposed a field survey of Eldfell volcano in Heimaey (Vestmannaeyjar volcanic system), with the objective of carrying out a chemical and isotope characterization of the fluid emissions and a soil gas (CO_2) survey on Eldfell in order to investigate the origin of the gas and thus to estimate the CO_2 flux from the volcano.

Results of second call

The procedure for proposal review in the first call was revised in the second call to simplify the evaluation. In the second call, passing the technical- and logistic evaluation made by the provider, IMO was now a prerequisite for sending the proposals onward to the International Scientific Review Panel (ISRP) for scientific evaluation. The final selection of proposals required them to have received 20 points out of 30 points possible. Of the five submitted proposals four received a score of 20 or higher. However, because of the limited funds available, only three were able to receive funding:

EV-C2-015 TREMORVOLC did not achieve 20 and was therefore rejected. **EV-C2_025 RISK**, however, did achieve 20 points, but due to the limited funding available it could not be supported and as a result needed to be rejected. The other three proposals, **EV-C2-026 ESPADA**, **EV-C2-033 HERSK** and **EV-C2-034 PUFFIN** received scores above 20 and were offered support.

Execution of funded projects

Due to the COVID-19 pandemic and thereby extensive travel restrictions in the summer of 2020, all four projects planned to be carried out during that summer needed to be postponed to the following summer, 2021. One of the projects, **Volcano Tourism** had already been postponed from the summer 2019 due to personal reasons of the principal investigator. To be prepared for the possibility of continued travel restrictions in summer 2021, a backup plan was organized involving more assistance from IMO staff. Such a plan was possible for **Volcano tourism**, **ESPADA** and **PUFFIN**, but no such plan could me made for **HERSK** since it would have required hiring a team to carry out the fieldwork, which was beyond the limit of the EUROVOLC funding. For Volcano tourism, Plan B involved IMO staff to assist identifying interviewees and connecting them with the user, who would carry out the interviews remotely. For ESPADA, Plan B was to adjust the project so that the results could be achieved through remote interaction with IMO staff who would carry out the observations and send the data to the user for processing and analysis. For PUFFIN, Plan B was that IMO staff would carry out the fieldwork and collect data to be sent and processed by the user. These backup plans would come into effect only if

the users could not travel to Iceland in the summer of 2021. In the end two of the projects, **PUFFIN** and **HERSK** were carried out by the investigators themselves in summer/autumn 2021 but two, **ESPADA** and **Volcano tourism** needed to revert to plan B. The execution of the four projects is detailed below.

Volcano tourism

This project was funded in the 1st call but postponed due to personal reasons of the Principal Investigator (PI), Dr. Julia Crummy. It was re-scheduled to be carried out in the summer of 2020 along with the accepted proposals from the 2nd call. The COVID-19 restrictions, however kept the PI from travelling to Iceland, as well as another team member, Dr. Melanie Duncan causing the access to be carried out remotely with the assistance of IMO staff member Ríkey Júlíusdóttir. The original work plan was the following:
Two two-week-long visits to Iceland in order to liaise with partners at IMO and NCIP to engage with tour operators.
The objectives of these visits were to:

- gather published and unpublished data on natural hazard events in Iceland, mitigation measures, communication and impacts on tourists and tourism since 2010;
- survey tourists, tour operators, hoteliers, transport sector;
- develop and analyse datasets and timelines of the impacts of natural hazards on tourists in Iceland.

The researching team resolved to the backup plan to carry out the project remotely. A timeline of significant natural hazard events impacts and responses from 2010 to 2021 was created using published reports, updates on the news webpages of IMO and NCIP, and literature.
In order to analyse the potential vulnerability of tourists to natural hazards, related to exposure, resources available, and communication of hazards, three volcanic areas were selected which have different hazards and relative implications to tourists related to volcanic unrest and potential activity. Additionally, travellers' experience of the unrest on Reykjanes peninsula in the 2020-21 and the March 2021 eruption on the peninsula was investigated as the vast majority of tourists arrive to Iceland through the near-by Keflavik International Airport and stay overnight in Reykjavík or Keflavík.
To gain a better understanding on how information is shared with tourists, the investigators invited participants from different tourism sectors, rescue teams, NCIP and Safetravel to fill in an online survey to gather data on the methods of communicating to international tourists on natural hazards during (i) quiescence, (ii) unrest and (iii) eruptions. The investigators also used the survey to gauge patterns of information seeking by the tourists and how that has changed over time. IMO staff member provided assistance by identifying organisations and/or individuals to be approached.

ESPADA

The ESPADA project took place remotely from the 1st to the 15th of September 2021. The participants were Dr. Federica Pardini from INGV-Pisa, Dr. Mattia de' Michieli Vitturi from The University at Buffalo, Dr. Sara Barsotti, Dr. Talfan Barnie and Dr. Þórður Arason from IMO. The group had a total of six remote meetings lasting 2 hours each on the days: 1, 3, 6, 8, 10 and 15 September. The days with no meeting scheduled were dedicated to work on what was discussed together. The scientific plan followed three main lines of activity:

1. Implementation of the latest version of *PLUME-MoM* in the *Vespa* software. The newly developed VESPA software (developed at IMO) uses automatically derived plume height estimates from the radar data to calculate the eruptive source parameters (mass flow rate,

vertical velocity and vent radius) through an inversion algorithm using *PlumeMOM*, which solves the 1D plume model equations, and atmospheric profiles from the ECMWF numerical weather prediction model. *PlumeMOM* is developed at INGV and is intended to illustrate in 3-D the steady-state dynamics of a volcanic plume, taking into consideration constant variation in distribution of particle size of the pyroclastic material ejected at the vent.

2. Development of an inversion procedure aimed at retrieving the Total Grain Size Distribution (TGSD) of the solid particles forming an eruptive mixture from satellite data. The inversion is done using the toolkit *Dakota* and the codes used to stimulate the release and transport of volcanic ash are *PLUME-MoM* (eruptive column model) and *Hysplit* (tephra transport and dispersion model). During the project the team worked on the meteorological data to be use in this procedure and did some tests of inversion with *Dakota*. The conclusion drawn was that, since satellite retrievals of volcanic ash clouds account for the fine ash only (particles with diameter less than 15 micron), the inversion should consider only the finer particle classes of the TGSD (i.e. those included in the satellite retrievals).
3. Use of *PLUME-MoM* to simulate gas rich plumes in order to retrieve SO_2 fluxes at the volcanic source. The team carried out tests and obtained good results by comparing the fluxes from *PLUME-MoM* with those from differential optical absorption spectroscopy (DOAS) measurements on gas.

HERSK

The project focused on future-proofing the HERSK network on Hekla and establishing appropriate methods of powering the stations in extreme conditions. Because of the COVID-19 pandemic, the office component of the project was mainly carried out in home offices and fewer days were thus used at the IMO than initially foreseen. Team members were Dr. Martin Möllhoff (PI, DIAS), Dr. David Craig (DIAS) and Bergur H. Bergsson (IMO).

The access included:

- project discussion with technical and scientific staff at IMO offices;
- fieldwork preparation with technical staff at IMO;
- a general servicing of the HERSK network;
- migrating the electronics infrastructure of the two stations at Hekla summit (HS1 and HS2) into a sheltered hut;
- establishing what type of power generation is most suitable in the long-term for the individual HERSK station locations;
- installation of a new temporary additional station near the south-eastern flank of Hekla;
- upgrading of station HES which is located northeast of Hekla;

Figure 2: Servicing HERSK installation HE1 located on the eastern slope of Hekla. Martin Möllhoff stands by the pinwheel. (Photographer: Dr. David Craig).

PUFFIN

The PUFFIN TNA project was carried out from the 28th of June to the 5th of July 2021. The team in the field was composed of Dr. Fausto Grassa (P.I., INGV), Dr. Melissa Pfeffer (local host, IMO) and Axel Ólafsson (IMO).
The main objectives of the project were,

1) mapping the ground temperature and diffuse gas emissions from soil at Eldfell;
2) a better definition of the magmatic component of fluids emitted from the fumaroles and
3) a quantitative estimate of the carbon dioxide emissions into the atmosphere.

The team performed 4,5-days of fieldwork at Eldfell volcano. More than 400 ground temperature measurements were made with a thermocouple at a depth of 10 cm and CO_2 flux through the soil using a closed-chamber portable CO_2 flux meter. Two areas were measured: the edifice of the volcano on an area of about 0,5 km^2 and south of the edifice where the fissure zone extends on an area of about 0,1 km^2. The grid was 50 meters and a nested higher resolution grid of 5 meters was used on the summit.

Figure 3: Dr. Fausto Grassa carries out fieldwork at Eldfell volcano. (Photographer: Dr. Melissa A. Pfeffer).

On some selected sites with a sufficiently high CO_2 flux and/or high temperature the team also collected soil gas samples for main chemistry (3 samples) and C isotope analysis (12 samples). Two samples of air were collected at the summit for $d^{13}C_{CO2}$ analyses to calculate the mixing of the ground fluids with the atmosphere. In-situ multi-component gas measurements of fumarole gases were performed with a portable MultiGas instrument at three selected sites. The MultiGAS measured concentrations of SO_2, H_2S, H_2, CO_2, and H_2O in the free air. An evaluation of the total CO_2 output from soil is still ongoing. The evaluation of the MultiGAS data is also still ongoing.

Conclusions

Despite of the adverse effects of the travel restrictions caused by the pandemic, the work package was able to execute all of the funded project in the final 5 months of the project, justifying the need for a lengthy 10-month-extension of EUROVOLC. All projects have made valuable achievements, which have been described in their reports. All PIs have promised to make the data collected openly available according to the agreements they signed at the time of funding.

The users who were able to travel to Iceland had access to the research infrastructure of the IMO, which otherwise would not have been accessible to them.

Some were young researchers, two PIs were women, all involved interaction or collaboration with local researchers helping to create connections between researchers across Europe.

The collaboration between users and a variety of IMO staff has also created and strengthened international connections and forged ties for younger generations of scientists into the international community of VOs and VRIs which will be beneficial throughout their career.