Volcanic Unrest in Europe and Latin America: phenomenology, eruption precursors, hazard forecast, and risk mitigation

CAMPI FLEGREI CALDERA UNREST SCIENTIFIC SIMULATION 9th-13th FEBRUARY 2014

DEBRIEFING REPORT

WP 9: Decision-making and unrest management

Task 9.6: Simulation of unrest and decision making

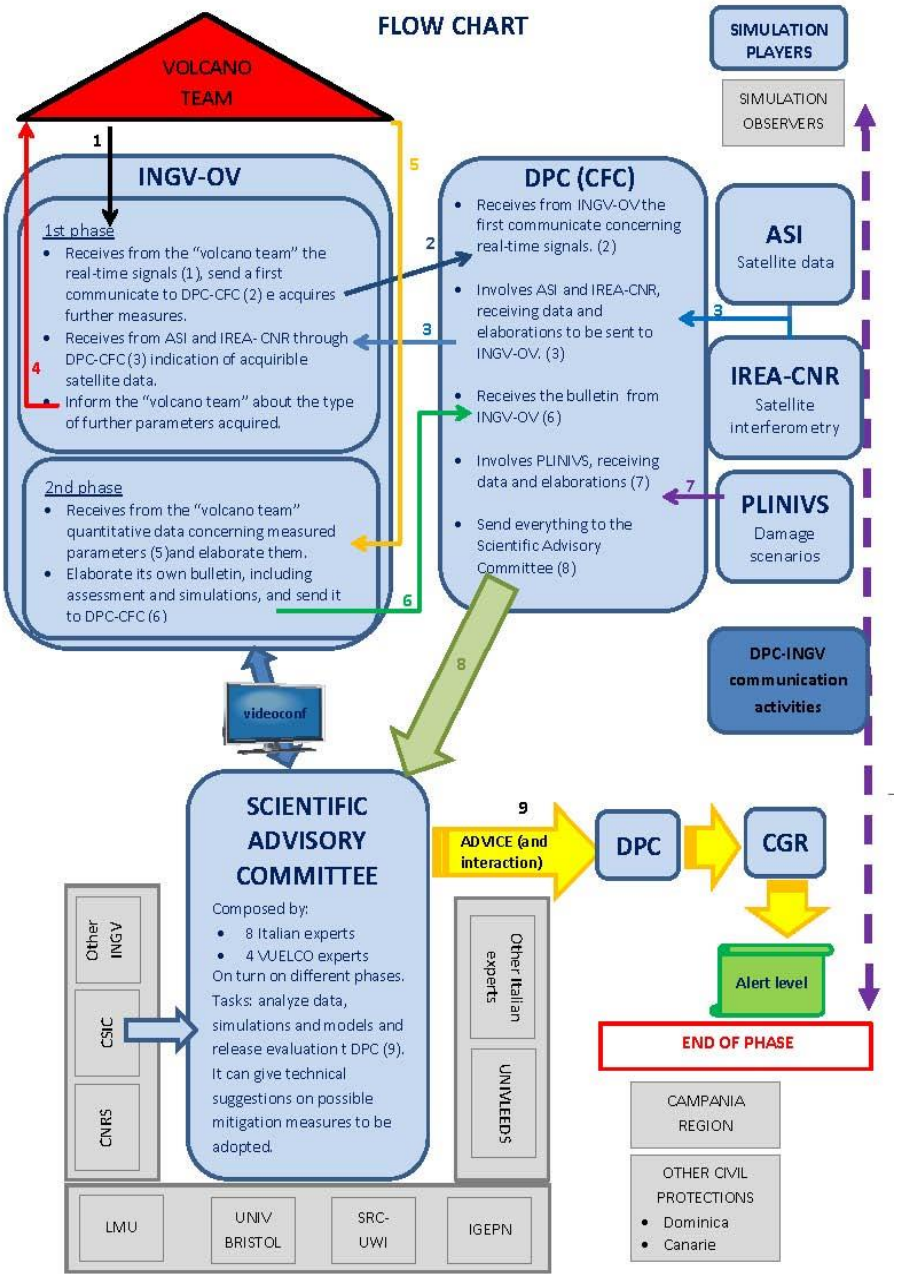
INTRODUCTION

From the 9th-13th February 2014, the second VUELCO exercise took place in Italy at the *Italian Department of Civil Protection* (DPC) linked to the INGV-Vesuvius Observatory in Naples.

The exercise goals, development program and phases, as well as the list of the several participating institutions (both local and international), were synthetized in the "Simulation Plan", elaborated together with the INGV and shared with the participants before the beginning of the exercise.

The simulation saw the participation of more than 100 people coming from scientific institutions and civil protection agencies from the following European and Latino-American Countries: Italy, United Kingdom, Germany, France, Spain (including Canary Islands), Ecuador, West Indies (Dominica, Trinidad and Tobago) and Argentina.

The following flow-chart (fig. 1) represents the working scheme of the exercise, in which a group of experts called "Volcano Team" released fictitious but plausible monitoring signals to the INGV-OV and then to the DPC, who took advantage of the contribution of other Centri di competenza (scientific and technical supporting institutions) for further analysis and of a Scientific Advisory Committee (SAC) to get to a best possible assessment of the situation.



In a change from what was initially planned, the Scientific Advisory Committee was composed by the same number of scientists coming both from Italy and abroad so as to allow a widest participation of VUELCO members. It operated in fact with 12 experts: 6 Italians and 6 foreigners belonging to VUELCO.

The SAC was asked to evaluate the ongoing situation, on the basis of the bulletins delivered by the INGV-OV. After an initial examination of the report, they had a videoconference with INGV-OV in Naples, in order to ask for further details. After that they had the time (a couple of hours) to discuss and to elaborate a written report to the DPC.

Following the release of the advice from the SAC, an interaction phase occurred, during which DPC had the opportunity to ask the SAC more information and/or evaluation regarding the advice released.

This process was developed and repeated across four subsequent meetings, each time simulating increasing monitoring signals.

To provide an idea of the simulated crisis evolution, the advice released at the end of each phase by the SAC are included in this report, while the bulletins produced by INGV-OV and any other document produced are available upon request.

It is to be highlighted that, in the third phase, after releasing the advice, the DPC asked the SAC for further information. To answer some of these questions, the SAC decided to perform an elicitation, results of which are analyzed in a dedicated paragraph.

At the end of this report/document the last communication released by the volcano team is also added to illustrate the final outcome of the simulation.

SAC REPORTS

End of phase 1 - report to DPC

The SAC, based on the INGV report and videoconference, highlights that the patterns shown by available monitoring data are difficult to reconcile with a simple or singular process. In this regard we generally agree with the interpretation of the state of the volcano provided.
However, at present we are not confident with the presence of a magmatic source at 3 km depth. The source of the observed deformation should be thoroughly investigated to define its nature (hydrothermal?).
At the same time the deep earthquakes most likely indicate a magmatic origin.

We are concerned about the rapid evolution within the last month. We agree that there is an unrest. We consider at present the concurrence of a magmatic and a non-magmatic unrest.
At present we suggest to confirm the yellow level of attention. The current state is not consistent with an immediate threat of eruption.

In view of the rapid evolution of the situation we suggest:
- the comparison of data and patterns with previously monitored unrests;
- locating monitoring data on a structural map and within a conceptual model at depth;
- extending the seismic network to better image the eastern structure of the caldera;
- increasing the frequency of acquisition of temperature and geochemical data at Pisciarelli and Solfatara sites;
- providing more ground deformation data;
- comparing ground deformation data from different stations;
- comparing horizontal and vertical components of deformation;
- extending monitoring offshore (deformation, physical-geochemical data on fluids);
- including isotopic data 3He/4He;
- verifying any relationship with tectonic earthquakes in the Apennines;
- providing the focal mechanisms of the seismicity;
- revising the BET evaluation on probability of eruption and vent opening including more parameters.

End of phase 2 - report to DPC

The SAC, based on the INGV report and videoconference, confirms that the monitoring data available since the beginning of the "crisis" cannot discriminate between the two proposed origins of the current unrest, that are an active magmatic intrusion of magma in a sill-like body at 3 km depth from the main magma chamber located at 7-8 km depth, vs a pressure change in the shallow level due to fluid migration.
The current decline of the seismic activity and rate of inflation do not imply at this stage a significant change of the state of the unrest. We underline that the location of seismicity and deformation has migrated westward to the edge of the deformation area.
The present situation is still consistent with the possible occurrence of eruptive phenomena including phreatic explosions.
Therefore on the basis of science we would not recommend a change of the present alert level (orange).

In view of the current evolution we suggest the installation of:
- a permanent gravity station in the center of the main uplifted area in order to fully define the suggested injection of mass in the shallow system;
- infrasound and micro-barometers to detect signals of possible phreatic explosive events;
We also suggest keeping keep the present monitoring frequency.

Furthermore, given that the present state is consistent with possible occurrence of eruptions, it is urgent, based on available data, to model/quantify the possible volume of magma available at depth, its chemistry, as well as any conditions that may trigger phreatic explosions.

End of phase 3 - report to DPC

The SAC, based on the INGV report and videoconference, confirms that the dynamics of the unrest are rapidly changing. Based on available data there are new indications (presence of SO2, shallow and laterally migrating LP seismicity) for the involvement of magma at shallow depth (2-3 km). At the same time some of the detected signals indicate that the shallow hydrothermal system is highly perturbed.

Based also on the historical record available we cannot exclude the occurrence of a rapid evolution of the current dynamics toward eruptive phenomena over timescales of days/months. Based on available data those phenomena could include phreatic explosions and small volume magmatic eruptions. At present the area most likely to be affected by eventual eruptive phenomena appears to be the eastern sector of the caldera.

Therefore, consideration should be given for revising the current state of alert.

At this stage the DPC asked the SAC to better specify:

(1) the probabilities and uncertainties of having an eruption within the next 48-72 hrs;

(2) the type of expected event;

(3) where in the eastern part of the caldera should we expect the opening of vents.

Elicitation report (by S. Bartolini and R. Sobradelo - CSIC):

In order to respond to the request of the DPC the SAC decided to perform an elicitation on the following questions:

1 - Given 100 cases that evolve from the present situation, what is the best guess (%) and the related uncertainty (5-95%) of how many would result in:

1a –an eruption within the next 72 hrs;

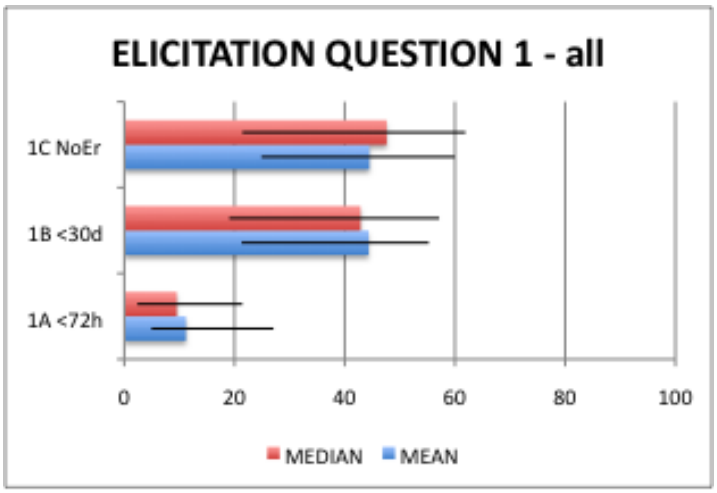
1b –an eruption within the next >72 hrs / 1 month;

1c –no eruption within one month.

The results are:

For question 1, the elicitation indicates that there is a 10% best guess of having an eruption within the next 72 hours, and 45% in the next 72 hours to a month. The best guess for the probability of having no eruption within the next 30 days is 45% as well, although there is large uncertainty around the best guess, for the probability of no eruption.

The mean and median for question



1B are very close, indicating that overall there is an agreement on this result, however, there is a small lack of agreement on question 1C (median slightly higher than the mean).

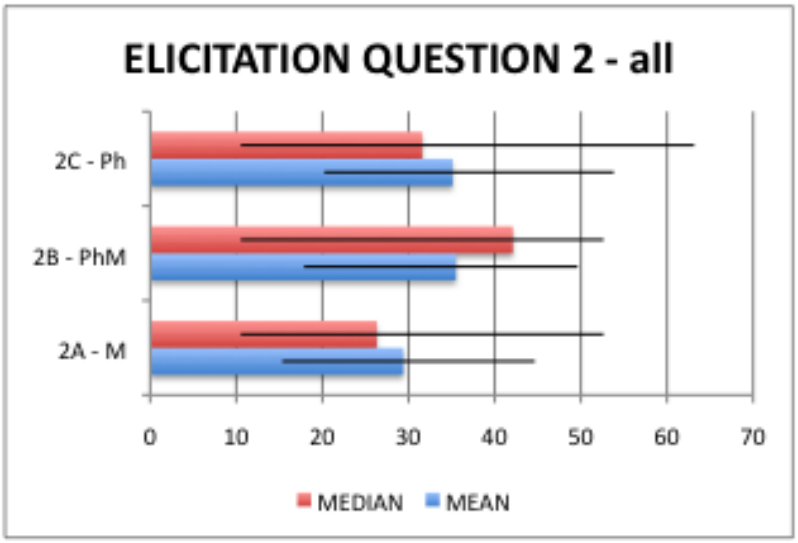
2 – Given an eruption, what is the best guess (%) and the related uncertainty (5-95%) for the following scenarios:

2a) small magmatic (include fast evolution from phreatic);

2b) small phreatomagmatic;

2c) only phreatic.

The results are:
For question 2, the best guess is rather uniform across the three options. Again, the best guess has large uncertainties and the results show less consensus (skewness) than for the results on the previous question.



3 - About question 3, the SAC indicates that the most likely location is the area between Solfatara and Agnano.

VUELCO analysis vs. Local experts analysis

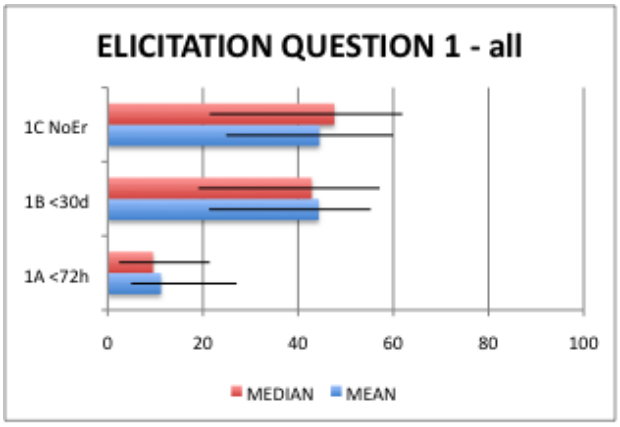
Subgrouping the elicitation experts into VUELCO and Non-VUELCO members, we get that, out of 14 participants, 6 were VUELCO members (from here on referred to as V), and 8 were Non-VUELCO (from here on referred to as NV). For question 1C, the answers are consistent across groups, but for questions 1A and 1B, V members are more keen on saying that there will be a volcanic event sometime in the next 30 days, although their results have large uncertainties, whereas NV members were more ambivalent between an eruption in the next 30 days and no eruption at all. Overall, the results are very equal for questions 1B and 1C, and rather uniform, as the median location respect to the mean is relatively close.

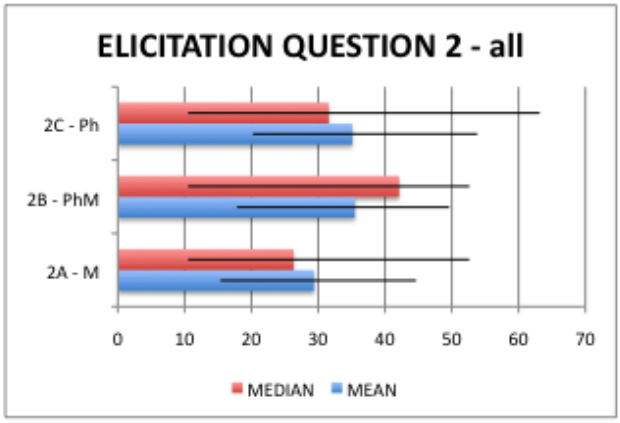
The main difference seems to rely on question 2, were V members are more prone towards the scenario of having a phreatic explosion only, leaving equal chances to either a phreato-magmatic or a small magmatic eruption. The error bars show large uncertainties and the mean deviation from the median hints lack of consensus over this result. On the other hand, NV members strongly believe that if an event is to happen, this would most likely be a phreato-magmatic eruption, and to a lesser extent a small magmatic, but they leave less

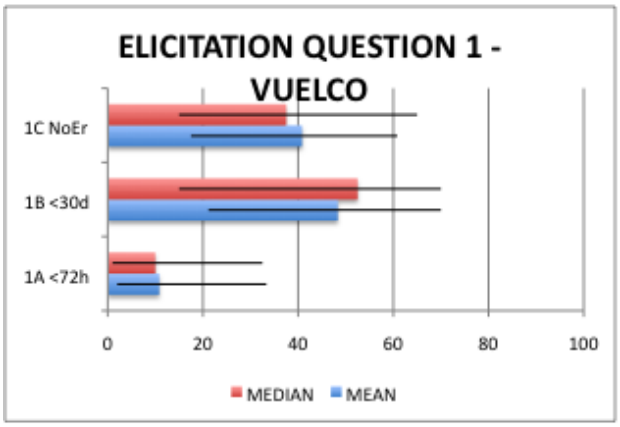
chances for probability of a solely phreatic explosion. The results show agreement across members, although with large uncertainties as well. Overall, NV members dominate, and the phreato-magmatic scenario shows as the most likely, but not far from the phreatic explosion scenario.

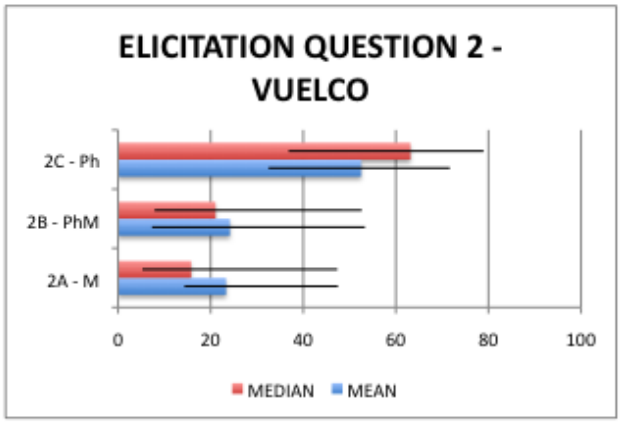
In summary, for question 1, V members were more accurate with respect to the final result (a magmatic event occurring within the next 30d), whereas, for question 2, NV members were correct in guessing the type of eruption.

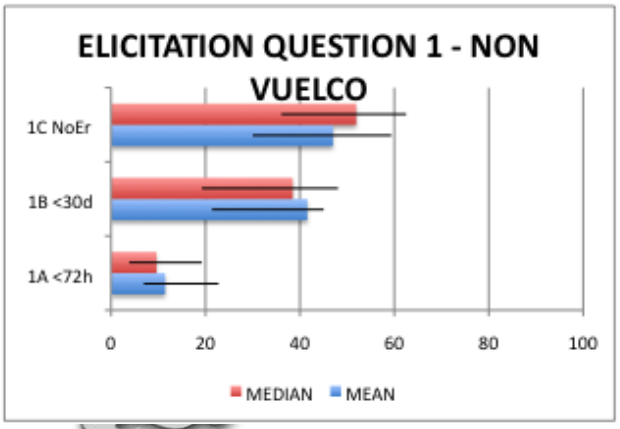
Merging both groups together, they reached a final result that was very close to the actual outcome, indicating that the expertises from both groups complement each other, and supporting the statement that having external as well as local experts, in similar proportions in a SAC can be beneficial towards the decision-making.

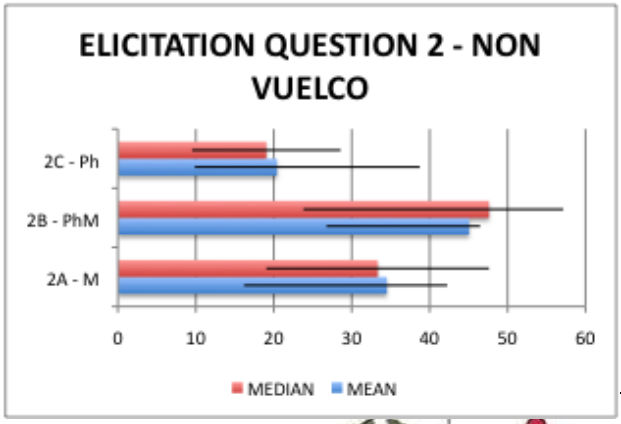




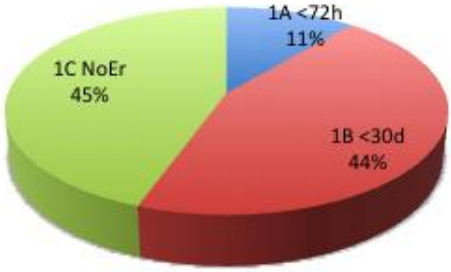




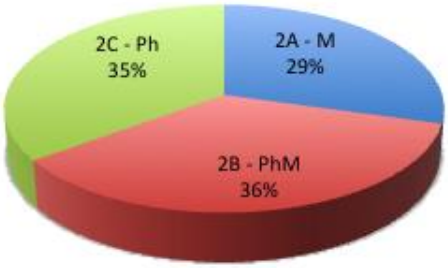




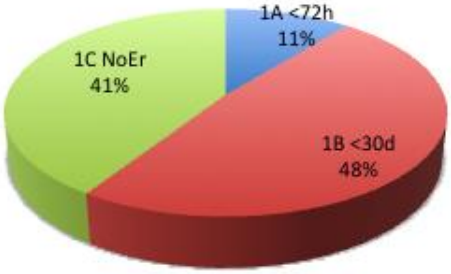
ELICITATION QUESTION 1
mean - all



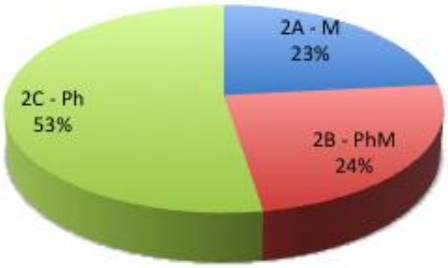
ELICITATION QUESTION 2
mean - all



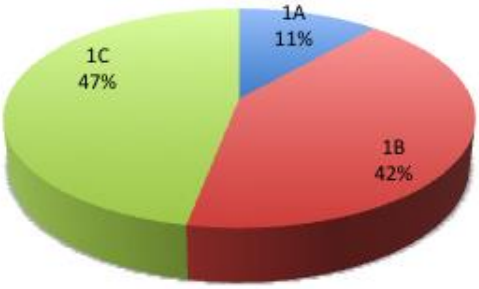
ELICITATION QUESTION 1
mean - VUELCO



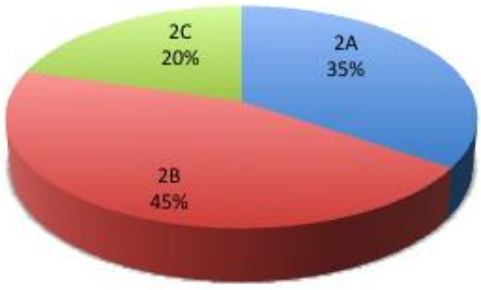
ELICITATION QUESTION 2
mean - VUELCO



ELICITATION QUESTION 1
mean - NON VUELCO



ELICITATION QUESTION 2
mean - NON VUELCO



End of phase 4 - report to DPC

The SAC, based on the INGV report and videoconference, confirms a dramatic increase in the rate of changing of the dynamics of the unrest.

The present state suggests that phreatic explosions and small scale eruptions of likely mafic composition may occur within days to weeks in the eastern side of the caldera (Bagnoli-Solfatara area). At the same time we suggest that the current high level of seismicity along pre-existing NNW-SSE and NE-SW caldera faults does not exclude the possibility of feedback effects following an eruption in the eastern side of the caldera, resulting in vent opening along those structures. The modeling of the data from the dilatometers may give an important contribution to the better understanding of the dynamics in the western sector of the caldera.

We underline that in this scenario the occurrence of small scale offshore eruptions cannot be excluded, in which case the effect of magma water interaction should be considered.

The level of alert should be confirmed as red.

Crisis outcome – (last Communication from VOLCANO team)

07.13. Volcanic activity has commenced from a location between Bagnoli and Monte Spina. Explosions have been reported along a system of fractures with a combined length of c. 100 m.

07.38. The eruption has become focused at a single location on the fissure. A sustained eruption column has developed with a top at an estimated altitude of 8-10 km.

07.45. Ash fall is being reported from Bagnoli to the south and from Fuorigrotta, Posillipo and Mergellina to the east of the vent.

08.02. Unconfirmed reports indicate the emplacement of pyroclastic surges south to the coast and east to Mostra d'Oltremare in Fuorigrotta.

Transmission Interrupted…

DEBRIEFING RESULTS

The last day of the simulation was completely dedicated to the debriefing.
Participants were divided into five working groups and were given a list of themes to reflect upon:

- General aspects of the simulation;
- Scientific process;
- Communication and interaction between scientists and civil protection)

The scientist were then asked to answer to the following questions:

1. Was scientific information available (structural features, past behavior, etc.) and were monitoring data provided to the Scientific Advisory Committee complete and adequate to define possible scenarios?
2. Were the probabilistic forecasting models useful to the Scientific Advisory Committee in the scientific analysis and for advice releasing?
3. Were the functioning of the Scientific Advisory Committee and the modalities of advice releasing effective?

The representatives of civil protection agencies of other Countries (Canary Islands, Dominica, Argentina), who played the role of observers during the exercise, were given the following questions to answer to:

1. What are the main differences you noticed between Italy and your Country, regarding the organization of support given by the scientific community to the civil protection (or other decision-maker)?
2. Has the general organization been successful?
3. Was the communications flow among the different groups (scientific advisory committee, INGV, Civil Protection) satisfactory?
4. Do you think it useful that “scientific advise” includes probabilistic hazard assessment?

After a one-hour brainstorming session each group was invited to report to the assembly its observations, providing strong and weak points grouped under the following themes.

GENERAL ASPECTS

SCIENTIFIC PROCESS

COMMUNICATION AND INTERACTION BETWEEN SCIENTISTS AND CIVIL PROTECTION

In some cases the comments provided are contradictory. This is a consequence of the different background and experience of participants. Here both the opinions are reported, because each one could be valid in different contexts.

It is important to remember that this was the second VUELCO exercise and that it took advantages of the first experience in Colima in November 2012.

Moreover remember that comments provided are not to be interpreted as a criticism, but as a way to point out and to understand possible troubles, in order to improve the process over the next exercises.

GENERAL ASPECTS

STRENGHTS

- The exercise was positive, very well organized and structured, with very high level of infrastructures available. No major weaknesses arose.
- The choice of focussing the simulation only on scientific aspects, instead of performing a full-scale exercise, turned out to be very good.
- The articulation between volcano group, INGV, SAC and Civil Protection was good.
- It was very useful to have a “volcano group” that played its own game.
- There was good organization of SAC: composed of a small group of local and foreign scientists (with rotating participants) surrounded by observers. In this way it was easier to tackle the root of the problem.
- Chairmanship of the SAC was excellent and the involvement of high level Italian experts was particularly appreciated.
- Running periodic exercises proved to be a good practice to recommend. It should be a recommendation for IAVCEI to perform such simulations even after or apart from VUELCO. It would be helpful to do such simulations once a year perhaps as a regional effort.
- Such simulations are very useful also for young scientists or people who have little or no experience in managing a volcanic crisis. It would help such people to observe and experience the atmosphere of a “real” crisis.
- Comparison with the Colima exercise is not really possible due to the great differences between the two exercises.

WEAKNESSES

- The size of the SAC was too large and not practical. Choose representative experts in each field to sit at the table next time.
- A few VUELCO scientists did not have the chance to be involved even once in the SAC, because of the short duration of the simulation; one day more would have guaranteed this opportunity to everyone.
- The effectiveness of engagement and integration of people outside SAC was often problematic; while endorsed, they weren’t sufficiently involved in the discussion, because the chairman was too busy with the analysis. A way to involve them more (or some other activities) needs to be found for next times.

- The “Summary report on Campi Flegrei volcanic hazard” was delivered just before the beginning of the simulation and was illustrated throughout the briefing day, nevertheless this was not sufficient to go through all different scientific aspects and implication. The participation of foreign experts should be more facilitated, providing them well in advance with more information, including a geological description of the volcano and a summary of long-term hazard assessment. (Instead of providing a wide bibliography, as was done in Colima, organizers preferred elaborating a summary report, but it was not possible to deliver it in advance although this was a precise goal).
- Some participants deem that SAC team should have the possibility to interact with the volcano team.
- Temporal evolution of the crisis was too long over the simulated time (6-7 year timeframe). On the other side, the time for evaluation was too short with respect to the long duration of the crisis.
- There was the need to contextualise the information/data flow within the given timeframe (too long). The different time periods of the crisis should have been better identified in the simulation.
- Too many phases were simulated in comparison to the short time of the simulation (if 3 days, then simulate only 3 phases).
- Some participants deem that future scenarios for simulations should be built on data from actual crises that have occurred in the past; this is likely to minimise contradictions.
- The exercise focused too much on the SAC.
- Feedbacks from the population was missing.
- Social (demographics); Economics (local economics, tourism etc); Political and Legal issues should be considered and not only the science.

SCIENTIFIC PROCESS

STRENGHTS

- Very good scientific data (quality, presentation, realistic, comprehensive). Plinivs data deserve a special mention, being particularly interesting and useful.
- Existence of a quite clear background model for Campi Flegrei.
- The work of the SAC has been profitable and resulted always in fully co-shared evaluations. The discussion always involved all the members of the SAC.
- The communication and information exchange was exemplary – professional, civil, democratic. Opinions and ideas were allowed to contend. Discussions were open and frank – not critical; information was shared. Where there was doubt or uncertainty, clarification was sought before arriving at the conclusions.
- The advice was solid and based on scientific data, precedence, and experience from the various scientists seated in the SAC.
- Final decisions had consensus although there were strongly dissenting opinions; no one was allowed to dominate thanks to strong chairmanship.
- The elicitation experiment performed during the third phase was positive.

WEAKNESSES

- The role of the SAC was not well exploited. It can't be just a measure of the level of dis/agreement with INGV. SAC must not be a mere evaluator of already expressed evaluations. It received from INGV a report already interpreted and had to interpret it again, resulting in time consuming and unnecessary redundancy.
- SAC should have full access to data, not only to analyses and evaluations already performed by INGV. The SAC missed analysis on continuous seismic data, spectrograms, etc.
- Too many details provided in the reports by INGV, most of which were not essential to have all information on eruption modelling. (Actually in the simulation, the reports had to include years of data, making them too

long; in a real situation it would be different; moreover the short time available for the analysis did not allow for better summarization).

- In every phase INGV should have provided the SAC with a presentation of the volcano situation, pointing out the most important issues.
- Discussion of the data inside the SAC should have been done by monitoring sector with a well-defined INGV correspondent.
- There is need of improvement of communication and strengthening of relationships between INGV and SAC scientists, to allow a better interaction over the elaboration and interpretation of data. Another option is that INGV be part of the SAC.
- SAC should include experts of similar volcanic systems (in this case calderas) to be able to provide a comparison to other systems/countries.
- It is important that INGV, SAC and CGR be seated at the same table. This may be unnecessary in the first phases, but became essential with the increasing of the crisis. DPC should be present at the table of the SAC too.
- SAC should be identified and summoned before the occurrence of phenomena. During the crises SAC meeting must be frequent and not only linked to the occurrence of new events.
- SAC was asked for advice after something actually happened, while it should have been asked for advice before the climax of the process (see phase 2). This resulted also in an unlikely lack of urgency.
- In order to improve the evaluation phase it is suggested to: define a shorter and more “readable” format for the Bulletin, include the most important information in the main part, whereas the ancillary elaborations and graphs can be still provided as appendices; define standards for scales and time-windows; include comparative tables between critical datasets (e.g. ground deformation vs seismic activity).; always include basic information on background geology/structure as well as monitoring network arrays.
- Base level of activity needs to be defined, as well as thresholds for different parameters
- Theoretical contradictions in the data interpretation arose, sometimes because information from different events were mixed.
- SAC must be supported by a technical team for additional elaboration such as GIS analyses, elicitation, etc. (Actually DPC-CFC performed a number of analyses, but they required elaboration times not compatible

with the simulation. The rapid sequence of phases in the simulation didn't allow SAC to take advantage of availability of GIS analyses).

Were the available scientific information (structural features, past behaviour, etc.) and monitoring data provided to the Scientific Advisory Committee complete and adequate for the purpose of defining possible scenarios?

- Some scientists stated that the information provided was incomplete, making it impossible for them to make specific predictions. But this is what could happen in a real situation.
- Some controversial aspects in the Campi Flegrei model appeared; more work is needed to improve possible interpretations.
- Need to improve the knowledge of the geological-structural model of the caldera (e.g. role of faults) and of volcanic history, to better interpret monitoring data.
- Need of scenarios improving (e.g. offshore eruptions, small volume mafic eruptions).

Were the probabilistic forecasting models useful to the Scientific Advisory Committee in the scientific analysis and for advice releasing?

- The SAC worked extensively on the analysis of monitoring data to understand the dynamics of the process. This approach is substantially deterministic. When compared to the probabilistic evaluations available, the SAC interpretation sometimes has resulted in contrasts (e.g. Phase 1 for probability of eruption and Phase 2 for the ongoing unrest). The final decision of the SAC was not driven by the indications of the probabilistic tools. Probabilistic models were not heavily considered in the scientific discussion. (Are they really useful in this type of exercise?)
- Probabilistic forecast models were not a formal part of the process; the outcomes from probabilistic models have been taken into account as additional information, but haven't had great importance. SAC did not give it the actual relevance.
- In the 3rd phase, in response to answer to more specific questions posed by Civil Protection, in the presence of great uncertainty, SAC decided to perform an expert elicitation; this could be the use of elicitation inside a SAC.

- Probabilistic forecasting models have been only partially useful; it showed potential for conflicting messages; it requires the capability to address the applicability.

Were the functioning of the Scientific Advisory Committee and the modalities of advice releasing effective?

- Role of SAC was unclear, particularly whit reference to Phase 2, when it was summoned after the crisis had already passed.
- It is necessary to define the role of the SAC on forecasting (e.g. ash dispersion models were not used because no prediction was requested on the matter).
- The reports released to Civil Protection by the SAC should be longer, more descriptive and comprehensive of what had happened and of what can be expected in the medium-short period. It should also provide the probabilities and magnitude of expected earthquakes in the short period.
- Scientists should quantify information they release; terms like: “high”, “low”, “shallow”, “deep”, “rapid”… need to be specified.
- Need for agreement on a glossary of geological terms (i.e. what is a phreatic eruption, what is a magmatic vs geothermal unrest).

COMMUNICATION SCIENTISTS-CIVIL PROTECTION

STRENGHTS

- During the different phases, the interaction with Civil Protection was very important, because it allowed SAC to learn to understand the needs and expectations of Civil Protection.
- Clear definition of the role of scientists, of the Civil Protection Emergency Offices and of final decision makers.

WEAKNESSES

- More interaction between SAC and Civil Protection would have been desirable; this would have allowed the Civil Protection to be more precise on the requests and would have reduced chances for advice misunderstandings.

- SAC lacked feed-back from Civil Protection (what was happening on site, information about operational actions, decision to increase the alert level).
- Need of more synergy and collective participation and responsibility.
- Civil Protection should be more precise in its request and put more pressure asking what is needed: timing, format and content. A predefined format could be helpful.
- It is important that, at least starting from the transition from alert level 2 to level 3, the relationships between INGV, SAC, CGR and Civil Protection should be fully coordinated and integrated to the definition of common advise.
- Communication with media was poorly explored.
- The pressure from outside (politicians, media, population), as well as the possible presence of dissident scientists, was not considered.
- Keep the general population informed at all stages of the crisis. Manage information flows, avoid rumors that may result in crisis management issues (litigation, commission of inquiry).
- The simulation of alert level change (most delicate moment) was not simulated.
- Social (demographics), economics (local economics, tourism etc.), political and legal issues must be considered in making the decision (not only the science).
- The alert level system is too rigid; only 3 alert levels seemed to be too few for the management of a crisis at Campi Flegrei.

CIVIL PROTECTION COMPARISON

MAIN SIMILARITIES/DIFFERENCES BETWEEN ITALY AND OTHER COUNTRIES WITH REGARD TO SCIENTIFIC SUPPORT AND DECISION MAKERS

- **SPAIN**:

  <u>Similarities</u>:

✓ Spanish and Canary Islands Volcanic plan are similar in operations: there is a scientific committee and a steering committee of civil protection.

<u>Differences</u>:

- ✓ Spanish scientists are called by Civil Protection and one of the CP members serves as secretary and participates on the Scientific Committee. (This was the practice in Italy before L'Aquila earthquake).
- ✓ INGV releases a bulletin with specific information that is supplied to the scientific committee. Most Spanish scientific groups do not provide information; info is limited to the meeting while trying to reach a consensus on the situation.
- ✓ The Spanish Scientific Committee, in contrast with Italy, does not propose alert levels to Civil Protection. (the Canary CP representative considers this as an immediate recommendation for implementation in Spain).
- ✓ In Spain, reports that are given by scientists to Civil Protection, provide an extensive description of the volcanic situation which details anomalies, deformation, seismicity and geochemical and gives probabilities of the magnitudes of the expected short-term earthquake. However, rarely is this accompanied by a report of the probability of occurrence of an eruption and/or the type and when and where.

- **DOMINICA**:

  Similarities:

- ✓ Emergency management protocol and principles are similar to Italy, Spain and Argentina.
- ✓ Disaster management is a national security issue and depends on the comprehensive disaster management strategy.
- ✓ Emergency management is based on the following groups: executive/policy, operational, information/media, administration and support.

  Differences:

- ✓ There are no universities, research institutes or established observatories on the island. Dominica relies on the regional agency SRC/UWI for the monitoring & advice on seismicity/volcanology.
- ✓ The monitoring network is not as robust and dense and monitoring is not run on a 24/7 basis on island (monitoring SRC is in Trinidad), because of limited human and technical resources on island and at SRC.

List of materials collected and documents produced for the Campi Flegrei volcano exercise:

- Summary report on Campi Flegrei volcanic hazard.
- Campi Flegrei exercise plan.
- For almost each phase of the simulation:
  - ✓ Monitoring parameters outcomes from volcano group;
  - ✓ First rapid communication of event from INGV;
  - ✓ Surveillance bulletin from INGV including hazard evaluations;
  - ✓ Report on satellite data from IREA;
  - ✓ Report on satellite data from INGV;
  - ✓ Report on damage scenarios from Plinivs;
  - ✓ Report of probabilistic forecasting model from CSIC;
  - ✓ Advice from SAC;
  - ✓ Press release (only for the first phase).
- Photographs collection.
- Debriefing report.

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