BRGM – Geoscience for a sustainable Earth
UHOH – University of Hohenheim

International Scientific Conference on Integrated Approaches for Volcanic Risk Management

University of Hohenheim, Stuttgart, Germany
11- 12 September 2012

Book of Abstracts

Editors' Note

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The following papers were presented during the International Scientific Conference on Integrated Approaches for Volcanic Risk Management either as oral or as poster presentations. Please notice, that these papers were not reviewed by the editors or an editorial board. Therefore the responsibility for the scientific content and the language lies solely with the individual authors.

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International Conference on
Integrated Approaches for Volcanic Risk Management

11-12th September 2012 - Hohenheim University - Stuttgart, Germany

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Block I

Session I: Hazard and Risk Mapping Methodologies

Chair: Sigrun Karlsdottir

The stratigraphy, volume and characteristics of pyroclastic deposits of the Oct-Nov 2010 eruption of Merapi volcano, Central Java, Indonesia

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The 2010 eruption of Merapi was the second most deadly in the historic record of this volcano, claiming over 380 lives. By relating the observations of this eruption with detailed examination of deposit stratigraphic and sedimentologic profiles, a reconstruction of the properties of the Pyroclastic Density Currents (PDCs) is presented, including the valley controlled Block-and-Ash flows (BAFs) and widespread, energetic pyroclastic surges. The distribution, volume and mobility characteristics of all types of PDC during the eruption sequence show evidence for previously unseen levels of violence, especially during the climactic events of Oct. 26 and Nov. 5. Many tephra falls interbedded with PDC units show that most dome-collapse events occurred along with and between explosive vulcanian eruptions. The 2010 eruption produced the longest runout block-and-ash flows (BAFs) yet known from Merapi, reaching 16.1 km in the Kali Gendol on Nov. 5. This runout could be explained by its large-volume (20 million m^3), around 10 times that of previous Merapi BAFs. Major avulsion of these dense BAFs to form overbank veneer deposits became more common through the eruptive sequence as the valley was progressively choked with successive PDC deposits. Spreading veneer BAFs were a particular hazard downstream of ~10 km where the landscape is less dissected. Less clear, however, is why pyroclastic surges extended up to 10 km from the vent on Nov. 5 and >6.4 km on Nov. 26. These expanded much farther from BAF margins (~2 km) than ever seen before at Merapi. In one location they were decoupled from valley-centered BAFs with high momentum, travelling initially laterally across steep valley systems, before draining downslope. At this site, on the western side of the upper Gendol at around 3 km from source, surge decoupling was apparently exacerbated by upstream collision and deflection of high-flux, hot and gas-rich BAFs against the cliffs of Gunung Kendil. The 1.4 km-long cliff face was impacted directly for the first time in 2010 events, and may have been responsible for engendering secondary fragmentation and formation of larger than normal turbulent ash-rich clouds above BAFs. These results imply that future eruption events under the present summit and upper flow-path configuration are also highly likely to generate wide dispersal pyroclastic surges and extreme hazard, especially now that dense forest has been destroyed on the upper southern slopes of the volcano.

Pyroclastic flow volume estimation by using X-band SAR: the 2010 Merapi eruption case study

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Introduction

On October-November 2010 Merapi has produced its most violent eruption in the last 100 years (VEI = 4; M_e = 4.0). The volcano emitted juvenile magma, with dense-rock equivalent volume estimation between 23 and 45 $\times 10^6$ m^3. It produced an ash column that reached more than 17 km altitude and a violent pyroclastic flow (PF) that travelled up to about 16 km in south direction towards the city of Yogyakarta.
In this work, an innovative approach based on the detection and the volume estimation of pyroclastic flow deposits is presented. In particular, we used SAR images collected before and after the event from the very high resolution SAR sensor, that operates at X band (9.6 GHz) on board of the COSMO-SkyMed satellite constellation. In order to estimate the volume of the pyroclastic material emitted, we compared a pre-eruption airborne Digital Surface Model (DSM) with a new DSM retrieved by means of SAR interferometry techniques applied to a COSMO-SkyMed data pair.

SAR data exploitation and methodology

Soon after the beginning of the eruption (26th of December 2010), the COSMO-SkyMed constellation was tasked by Italian Space Agency, to routinely acquire images over Merapi. Among the available images, we selected two pairs of SAR scenes (see Table 1 for details) that for their acquisition characteristics and temporal sampling are the most suitable for the objectives of our analysis. The first image pair temporally covers the final phase of the eruption, and can provide information about the topographic changes. The one-day temporal baseline and the spatial baseline of about 104 m of these SAR data, indicate that this image pair can be exploited for interferometric processing. Indeed, these values limit the interferometric coherence loss and allow a good accuracy in the height retrieval. For these reasons, we used these data for the post eruptive DSM extraction.

Table1: the two SAR image pairs with principal characteristics and applications.

	Date	Acquisition mode	Resolution (m/pixel)	Incidence Angle (°)	Area coverage (km)	Purpose
Pair 1	28/12/2010	Stripmap	3	26	30 x 30	DSM extraction
	29/12/2010	Stripmap	3	26	30 x 30	
Pair 2	1/5/2010	Stripmap	3	46	30 x 30	Change detection analysis
	8/11/2010	Stripmap	3	46	30 x 30	

The second images pair is composed of a pre eruption image acquired on May 1, 2010 and a post eruption image taken on November 8, 2010. These two images were exploited to evaluate the spatial extent of the PF deposits by performing a change detection analysis of SAR backscattering during the most violent phase of the eruption.
The DSM elevation difference of the surface models, the one before the eruption (by airborne SAR data) and the one after the eruption (our DSM) is shown in Fig. 1. Such difference directly reflects the 2010 PF deposits. The map in Fig. 1 clearly highlights that the highest elevation differences (white coloured pixels) are located inside the Gendol River (GR, Fig. 1), where we obtained a maximum thickness of about 75 m.
In order to validate our method and results, we compared this elevation difference with field observations kindly provided by the Centre of Volcanology and Geological Hazard Mitigation (CVGHM; Indonesia). We found that our deposits estimation are in good agreement with field observations.
A series of topographic profiles across both pre- and post- eruption DSMs were performed to better assess the elevation change. A further statistical evaluation of the accuracy of the DSM difference has also been done by taking into account the area of strongest surface changes identified by the change detection approach.

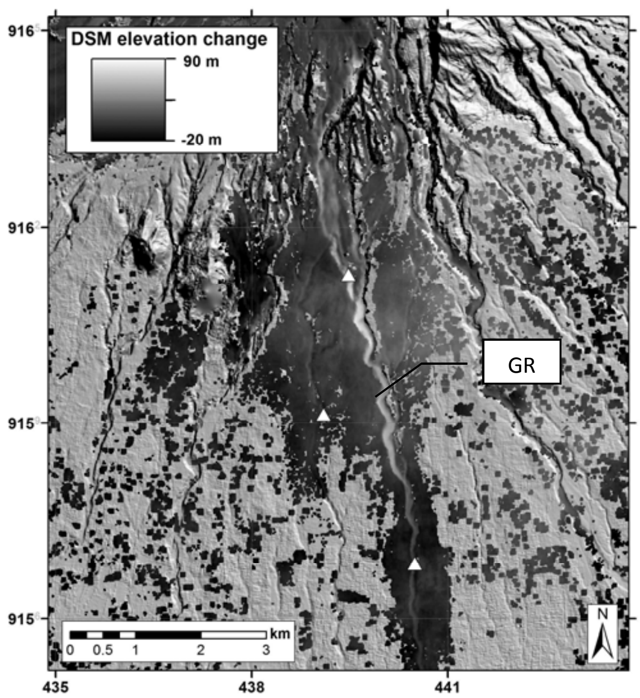

Figure 1. Elevation difference map reflecting the PF deposits. White triangles refers to the field observations points used for validation purposes.

Finally, we evaluated the volume of the PF deposits that filled up the GR. To this aim, the pixels corresponding to the canyon have been manually extracted from the GR area, aided by the change detection image and the full resolution airborne DSM. By multiplying the pixel area and thickness values and then summing the pixel volumes, we calculated a total volume of about 40 x 10^6 m^3. By considering the uncertainties of our interferometric DSM (about 10 m), we estimated a standard deviation of the PF volume around 6 x 10^6 m^3. We extend this calculation to the GR surrounding region, and a total volume of about 117 x 10^6 m^3 (±19 x 10^6 m^3) has been estimated.

Volcano-tectonic evolution of Mt. Kanlaon (Negros Island, Philippines): a contribution to the comprehension of future volcanic unrest scenarios

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Volcano-tectonic study in tropical areas is challenging due to the dense vegetation coverage and ground alteration that hide geological information. Here we analyze the volcano tectonic evolution of the Mt. Kanlaon, an active volcano located on the Negros island in the south-west Philippines. We used remote sensing data as aerial photograph, Landsat images and a 25m Digital Elevation Model (DEM) to reconstruct the chronological succession of the eruptive stratigraphic units and to achieve a detailed morpho-structural analysis of the edifice. We recognized three main periods of edifice growth and destruction separated by two main angular and erosive unconformity surfaces (see Figure 1).

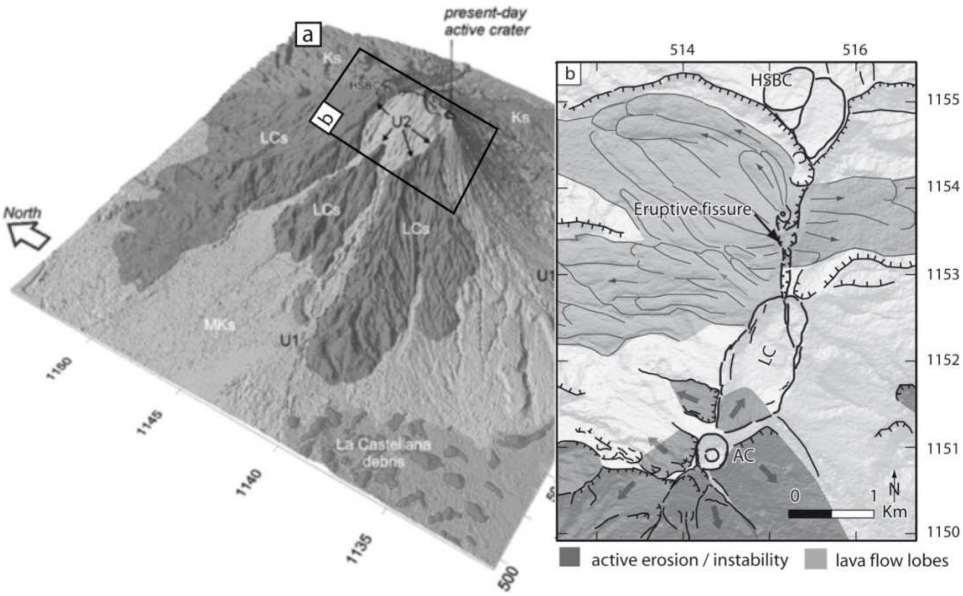

Figure 1- a) 3D Block diagram with summary of the volcano unconformities (U1 and U2) and the main stratigraphic units (highlighted in different gray-scale). b) Morpho-structural map of the summit area. Maps are in UTM coordinates.

The older unconformity (U1; Figure 1) was generated by a large debris avalanche, which extends up to 30 km away from the actual active crater in SE direction (La Castellana debris, Figure 1). The youngest unconformity corresponding to a ~15 km^2 erosive depression located to the summit area (U2; Figure 1a) and made of collapsed structures, craters and eruptive fissures (Figure 1b). While during the last decades Kanlaon exhibited frequent summit phreatic eruptions, larger explosive and effusive eruptions have occurred in the previous centuries, highlighting the necessity to better evaluate the probability of their recurrence.

Our study provides new insights for the volcano-tectonic evolution of Kanlaon and allows an improvement of the existing hazard map, adding different hazardous events numerically evaluated on the basis of their frequency and potential impact (Figure 2).

We redefine the general temporal succession of its volcanic units, and these preliminary results aim to assess future volcanic unrest scenarios. This study is part of the MIAVITA project (Mitigation and Assessment of Volcanic Impacts on Terrain and Human Activities), a European Commission FP7 Research Project for cooperation.

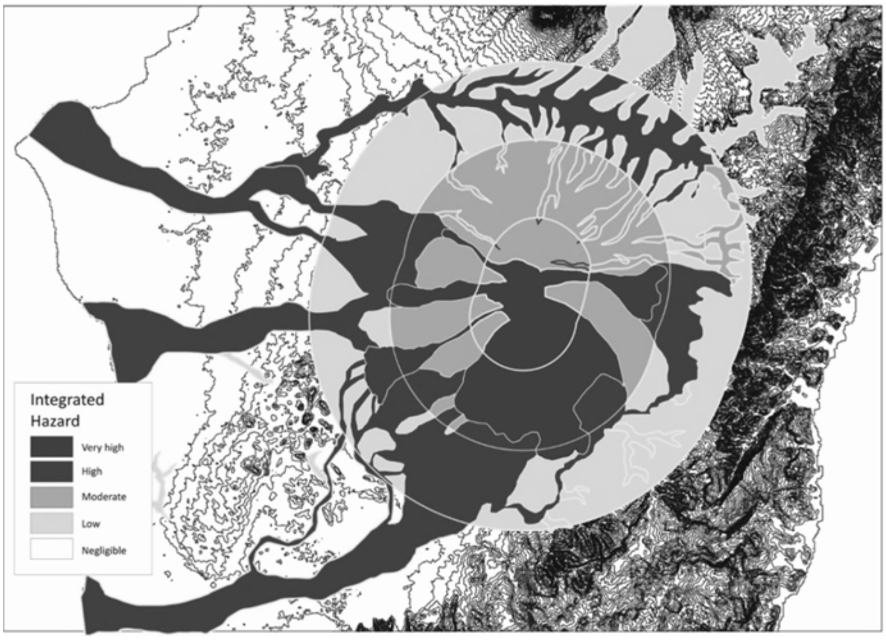

Figure 2 – Preliminary draft of the multi-hazard map of Kanlaon.

Volcanic Risk Assessment of Kanlaon Volcano, Philippines

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Philippine Institute of Volcanology and Seismology (PHIVOLCS)

Kanlaon Volcano is an active strato-volcano that occupies two provinces namely Negros Oriental and Occidental. Much of the land surrounding the volcano are basically agriculture, however, there are several large communities that are at risk to various volcanic hazards. Together with the updated volcanic hazards map, the various elements at risk need to be quantified in order to have an estimate of the possible damages. The result of this study will be useful for planners and DRR managers. Under the MIA-VITA PHIVOLCS collaborative project, there are several work packages working on the volcano science, monitoring and societal impacts of the volcano. This particular work deals with the volcanic risk assessment.

Kanlaon Volcano based on the geology, had history of very violent eruptions such as debris avalanche, large fissure eruption producing large volume of lava, pyroclastic flow and extensive lahars. Recent documented eruptions were mostly phreatic, and few events are phreato-magmatic. Various volcanic hazards map were updated under this project such as lava flow, pyroclastic flow, lahar and ash fall. These maps were used as a basis in quantifying the spatial extent of various risk elements.

In managing the exposure database, an Image Processing and GIS-based open source software called ILWIS (Integrated Land and Water Information System) was utilized in the systematic capture the various exposure element such as agriculture, aquaculture, and infrastructures, e.g., lifelines, government facilities, academic institutions and houses. Each land classifications, typology of structures and their valuation classifications were identified according to existing metadata structures being used by the Philippine government classifications, engineers, assessors, etc. Land cover classifications were initially done by image processing using a medium scale optical LANDSAT and ASTER satellite imageries. However, to minimize the misclassification and mixed classification, a post-classification cross validations were done using a high resolution Google Earth images (IKONOS/QUICKBIRD) coupled with field validations. Field validation and building typology inventory were done using real-time GPS navigation and GIS based field data encoding.

The study area has a total of 19 municipalities and has a total land area of 3,200 km^2. The study area was chosen to be large in order to accommodate the full extent lahar hazard map and significant ash fall. A cluster method approach was used in identifying similar land cover / land use and in grouping the building classifications. This technique will give an assessment that may be directly affected by the various type volcanic hazards in a relatively large study area such as Kanlaon. A volcanic impact assessment on various buildings was produced by the MIA-VITA project and this was adapted to develop a volcanic fragility curve for the Kanlaon Volcano based on various local building typology.

Applying a structured multicriteria risk mapping method in Mount Cameroon

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[1] BRGM
[2] MINIMIDT
[3] INGV

This study aims at mapping the volcanic, induced landslides and earthquake risk in Mount Cameroon in an integrated way by applying a structured multicriteria method. The proposed methodology is an adaptation of Saaty's Analytic Hierarchy Process (AHP, Saaty 1977) to risk mapping. AHP is a decision approach designed to solve complex multiple criteria problems (Saaty, 1990). After having determined the geographic entities involved in the analysis (i.e. in our study area, the villages in the Fako division of Mount Cameroon), the AHP method requires the identification of each risk component to be taken into account and a data collection. One of the advantages of AHP is to include both qualitative and quantitative criteria in the evaluation.

In a typical hierarchy process, the top level reflects the overall objective (focus) of the decision problem, which is the risk in our case. The main criteria affecting the decision are represented in intermediate levels. The lowest level comprises the sub-criteria to assess the main criteria. Once a hierarchy is set up, the decision-maker can start a prioritization procedure to determine the relative importance of each criterion in each level of the hierarchy. All identified criteria are compared against each other in a pairwise comparison matrix which is a measure to express the relative preference among the criteria. For this, numerical values expressing a judgment of the relative importance (or preference) of one criterion against another have to be assigned to each criterion. Then the entity profiles are evaluated with respect to all sub-criteria, criteria and finally the risk to create a synthesis table finally.

Such a methodology has already been applied at the Merapi volcano by CVGHM/BPPTK. The same definition and components of risk have been kept for our study and so the same hierarchical scheme. The main criteria that are considered in risk assessment are the hazard itself, exposure aspect to the threat of disaster, vulnerability aspects and capacity to face disaster. Among these main criteria, we considered that each component of the risk has an equal importance.

The use of GIS tool helps spatial analysis to address multidimensional problems such as risk assessment. A matrix was created and organized according to a specific hierarchical model as defined in the previous step, and then potential datasets were selected for each sub-criterion. This matrix included 4 main criteria and 24 sub-criteria. Hazards and Exposure criteria are based on the '*Gestion des Risques Naturels et Protection Civile (GRINP)*' project, and the Vulnerability and Capacity criteria are associated with the report on Mount Cameroon "*Socio-economic vulnerability and resilience*" written by MINIMIDT/INGV for MIAVITA project.

In the GRINP project, a zoning map of risks associated with geological phenomena in the vicinity of Mount Cameroon was produced by crossing the hazards and elements at stake in a GIS system

(Thierry and al., 2007). The elements at stake which were considered as most important were identified and mapped by the GRINP team. Therefore, in our matrix, multi-hazard levels correspond to sub-criteria to assess the Hazard main criterion. In the same way, the result of crossing each GIS layer of stakes with multi-hazard levels correspond to sub-criteria to assess the Exposure main criterion. In our study, we defined the Exposure criteria with data on the exposure of resident population, agricultural area, and number of drinking water supply stations that would be cut off if a disaster occurs.

In MIAVITA an anthropological-based perceived exposure study was carried out in Fako division of the Mount Cameroon Region by MINIMIDT and INGV. This study enabled to collect demographic and socio-economic data in several villages. Methods used in this work include a questionnaire-based survey, in-depth interviews, focus group discussions, field observations and check list to evaluate processes. Two sampling techniques were used on a geographical and population basis. For an overview of vulnerability and capacity to face disaster in this region, we took into account only the responses to questionnaires. Finally, the responses of about 1000 permanent residents were selected for analysis. As the geographical coordinates of sampled interviewees were taken using GPS and a question relative to their place of residence was asked in the questionnaire. Therefore we were able to link each person to a point in a village in our GIS project. The second step of this work was to identify indicators among the 430 questions collected in the questionnaire in order to complete the matrix for the Vulnerability and Capacity main criteria. Technically, for each village and sub-criteria, the answers of residents have been analyzed, divided into 3 classes, and then class values were estimated. This way we have identified in the Vulnerability main criterion all things that are susceptible to increase the vulnerability of an area to disaster like age of respondents, level of education, poverty level, community participation etc. And as well for the Capacity main criterion, with all things which are able to reduce the impact of disaster caused by Mount Cameroon volcano eruptions like land use planning, public awareness programs, emergency response drills, disaster management plan, insurance, public adaptation, etc.

This study shows an example where GIS analysis techniques combined with AHP can support the definition and calculation of spatial indicators allowing an integrated risk mapping at the scale of the entities (villages).

The MIAVITA project is financed by the European Commission under the 7th Framework Programme for Research and Technological Development, Area “Environment”, Activity 6.1 “Climate Change, Pollution and Risks".

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Coseismic landslide susceptibility analyses using LiDAR images and GISs: The case of Poás volcano, Costa Rica, Central America

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On January 8th 2009, an area of ~350 km^2 around Poás volcano was affected by a 6.2 M_w earthquake. This earthquake was the sixth event in the last 250 years that had severely affected this zone. Due to the location of several hydropower projects around the area that account for 7.2 % of the total electricity production of the country, the Costa Rican Institute of Electricity (ICE) had performed several seismological and earthquake hazard studies before. However, no previous studies taking into account the possibility of coseismic landslides occurring in the area had been done. After the effects of the 2009 earthquake, the necessity of a study of this kind became evident. A landslide susceptibility model for Poás volcano was created in response to the most recent event that triggered landslides in the area. Our study consisted of three phases 1) A post Cinchona earthquake landslide inventory which was made based on a set of high resolution LiDAR images and includes 4846 landslides. 2) A susceptibility to slide model, based on the Mora-Vahrson method (Mora et al., 1993), and 3) The evaluation of the methodology used, which for the Cinchona case resulted in an overlap of the actual landslides and the higher susceptibility zones of ~ 97%. The most important contribution of the new landslide susceptibility model developed in this study is its ability to use different locations, magnitudes and depths for the triggering earthquake and to calculate the attenuation of the peak ground acceleration for historic and hypothetical events. This new modification allowed us to obtain different susceptibility maps for the area depending of the earthquake origin data. This flexibility also allowed us to model historical events and forecast the expected results for future earthquakes. From the four landslide susceptibility models run in this study (the Cinchona earthquake, the M_w 5.5 Sarchí earthquake 1912, and two hypothetical earthquakes one on the Angel fault with M_w 6.0 and the other on the San Miguel fault with a magnitude of M_w 7.0), we determined that the Toro and Sarapiquí river canyons, the non-vegetated corridor located west from the main crater of Poás and the areas where the La Paz andesites Unit are located are always the zones with highest susceptibility to slide values. Meanwhile, the northern part of the study area, where the Río Cuarto Lavas unit outcrops presented always the lowest susceptibility values due to the low slope angles and low weathering level of its rocks. The effective use of the information generated in this study by planners and developers could reduce the impact of future coseismic landslides on the population and on the important civil infrastructure located in the study area.

Block II

Session 6: Management of Volcanic Crisis and Strategies for Disaster Risk Reduction

Chair: Marco Neri

Dealing with volcanic crises: A new handbook for volcanic risk management from MIAVITA project

Vittorio Bosi , Licia Costantini , Chiara Cristiani , and MIAVITA team.

In 2008, the European Commission funded the four years MIAVITA research project (MItigate and Assess risk from Volcanic Impact on Terrain and human Activities - http://miavita.brgm.fr), which gathered a team of international experts covering all domains regarding volcanic risk management (academic/practical and operational).

One objective of the project is the publication of a final handbook on volcanic threat management, for civil protection stakeholders and scientists of developing countries, based on MIAVITA experience. The MIAVITA handbook was born, in fact, from the idea that the contribution of all MIAVITA partners through common thoughts and workings constituted a unique opportunity to identify a list of minimum standards and best practices, relevant for risk management, that can satisfy the needs of any geographical, geological and socio-economic situation in the context of an active volcano.

This handbook aims at synthesizing these minimum standards in a practical and useful way to cover the main aspects of the volcanic risk management, such as prevention, preparedness, mitigation and intervention. The handbook, which takes into account the socio-economic, cultural and agricultural aspects, as well as cost effective monitoring and management of volcanic crisis, is particularly oriented towards developing countries. Especially in these countries, in fact, the sustainability of volcano monitoring, as well as of mitigation measures is sometime scarce, because people and governments are mainly concentrated on the life-support system.

Ideally, this handbook aims at constituting a bridge between the different stakeholders involved in risk management, improving and facilitating the interaction between authorities and scientists, which often suffers of lack of communication and common procedures.

After a short presentation of the global volcanological context on earth and the principles of risk management, the MIAVITA handbook is divided in five main sections that deals with:

- Volcanic phenomena and corresponding damage: description of volcanic events and the possible corresponding damage, to understand the dimensions and the effects of what can be expected;
- Preparation and prevention: what has to be done during the rest phase of the volcano in order to be prepared in the unrest phase, when the volcano shows some evidences of activities and to reduce at the minimum the effects, in terms of monitoring as well as of increasing coping capacities and reducing vulnerability actions;
- Crisis management: advices and good practices to ensure the best conditions for the crisis management.

The handbook will be printed in October 2012 and copies will be distributed to Civil Protection Authorities, International Organizations related to volcanic risk and emergency management, and to Scientific Institutions involved in volcanic hazard and risk evaluation and monitoring. The online version will be uploaded on various websites for a free download.

Management Crisis during the Eruption of Merapi Volcano in 2010

Surono

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Fountain-collapse pyroclastic flow in Merapi eruption on November 3, 2010

As one of the most active and dangerous volcanoes in Indonesia, Merapi volcano (2968 m) is monitored intensively by Center for Volcanology and Geological Hazard Mitigation (CVGHM) using various methods. Seismic network has established since 1982 consisting of at least 4 seismic stations. Seismic data gathered from the network and added deformation, geochemistry and geological one enable to define the pattern and level of volcanic activity. By knowing well the pattern of activity it makes easier to detect increasing activity earlier and identify the precursor lead to eruption. The volcano is well known for its nearly persistent volcanic activity characterized by the extrusion of viscous lava domes and collapse of these domes to produce pyroclastic flows and related block-and-ash flow deposits.

Merapi volcano is surrounded by densely populated area of Central Java and Yogyakarta provinces. The most dangerous and high risk is around southeast to southwest slopes, since the last 100 years pyroclastic flows due to dome collapse traveled down to these directions. In fact, more than 40,000 people living in high risk area due to volcanic eruption. CVGHM issues an early warning system in order to reduce risk from volcanic eruption. The alert is classified into 4 alert levels. Level I, it means the activity of the volcano in normal state. Level II, the activity tends to increase, though at some volcanoes eruptions might have occurred yet threaten only the area around the crater. Level III, if the trend of increasing unrest still continues and eruption might have occurred. At some volcanoes eruptions have occurred but no threatened to inhabitant area. Level IV, when the initial eruption begins to occur as ash/vapor and potentially lead to main eruption, and threaten people living nearby.

The precursor of eruption in 2010 was detected on September 20, 2010 by the significant increasing activity of volcanic earthquakes. CVGHM then raised Merapi activity on Level II from Level I to public and gave alert to people living in Hazard zones II and III to limit their activity. On 21 October 2010, the activity was raised to Level III and CVGHM prohibited people's activity in Hazard zones II and III. On October 25, 2010 the alert level was raised to Level IV since the volcanic activity became higher and might lead to eruption. CVGHM declared area 10 km within radius from the summit of Merapi need to be evacuated.

The first eruption occurred on October 26, 2010 at 17:02 (local time) generated pyroclastic flows and travelled down to 8 km into Gendol river at southern part of the volcano. This eruption then followed by several ones and on November 3, at 16:05 CVGHM ordered area within 15 km in radius from the summit need to be evacuated. An hour and half later the eruption occurred and pyroclastic flows travelled down to 9 km into Gendol river. On November 4, at 23:00 CVGHM declared area within 20 km from the summit need to be evacuated due to continuous eruption and SO2 emission in the air increased up to 100 kilotons. On November 5, the volcanic activity reached the peak and shown by the dome collapsed generating pyroclastic flows with traveling distance to 15 km from the summit and down into Gendol river.

After the eruption on November 5, the activity of the volcano seemed to decrease. On November 13, CVGHM recommended to reduce some evacuated area to 15-10 km from 20 km. On November 19, those some evacuated area reduced to 10 – 5 km. On December 3, 2010 the alert level was downgraded to Level III.

Merapi volcano 2010 explosive eruption: scientific results

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Mount Merapi is one of the most active volcanoes in the world, located 25-30 km north of densely populated area. Merapi volcano delivered its largest eruption in a century between 26 October and 4 November, requiring evacuation of more than 300,000 people. The intrusive magma erupted first on 26 October, and then eruptions occurred on 30 October, 3 November and the paroxysmal eruption on 5 November. These eruptions released large SO_2 and ash clouds, which affected local villages and international air traffic. Combined observations in real-time of phenomena associated with the main eruption and the response of a worldwide collaboration led by CVGHM, the MIAVITA European project and the USGS provided the basis for timely warnings and recommendations by CVGHM to local authorities, which saved tens of thousands of lives. Satellite data (TerraSAR, Radarsat, OMI, AIRS, Digital Globe and others), broadband and short-period seismic data, EDM, tilt and mini-DOAS data were discussed to understand the status of the volcano. Remote sensing data showed that the 2010 eruptions were much more explosive than those of the recent past and rates of extrusion much higher. Seismic data from a station 50 km south of Merapi showed in real time that the magnitude of the 4 November explosion was much larger than the 3 November explosion. This triggered the decision to extend the exclusion zone from 15 to 20 km. This multi-national cooperation proved to be of crucial importance for the successful crisis management, especially with such a large and rapidly evolving eruption. This eruption generated numerous scientific research which we gathered in a Special Issue of the Journal of Volcanology and Geothermal Research. We present the special issue main results.

Implementing Community-Based Volcano Disaster Risk Reduction Management: a Comparison of Barangay Biaknabato, La Castellana and Barangay Pula, Canlaon City, Negros Island, Philippines

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The implementation of community-based disaster risk reduction and management in two pilot communities, Barangay (community) Biaknabato, La Castellana and Barangay Pula, Canlaon City, Negros Island, in the Philippines involved programmed activities that were planned based on the resources and unique needs identified for each site. Methods included rapid rural appraisal for community profiling, individual interviews as well as group discussions to gather validated data on hazards and risks perceptions. Self-awareness approach that aimed for community consciousness building was conducted through series of focus group discussions. When information needs were determined, appropriate knowledge and skills building activities such as sessions on orientation on the new Philippine Disaster Risk Reduction and Management law (R.A. 10121 or DRRM Law 2010), hands-on activities on elements at risk and resource mapping, were identified and implemented. For the community mapping session, the initial paper-based mapping was leveled up with the use of participatory 3-D mapping approach.

During the implementation, differences and similarities in the responses, steps taken and decisions made by the two pilot sites, Barangay Biaknabato and Barangay Pula were observed. Although the set target end outputs were similar- such as (a) updated community profiles (b) documented reorganized Barangay DRRM structure with defined roles, functions and responsibilities; (c) updated barangay risk and resource map; (d) action plan during a volcano emergency, (e) planned community-initiated DRR activities such as information campaign and (f) establishment of early warning system. Initial testing of community established locally-available and indigenous communication system as well as conduct of evacuation drills were planned and implemented. The process- from methods and media used through which the targets were attained varied and were adjusted. The possible factors in the differences and similarities were looked into.

Keywords: disaster risk reduction management, community resilience, volcanic hazards, risk perception

An interdisciplinary approach to volcanic risk reduction on Tristan da Cunha

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To be successful, volcanic risk communication (and hence reduction) programmes depend both on effectively handling and explicating risk and uncertainty, and collaborating with all stakeholders at risk. A more inclusive approach to inquiry and co-production of knowledge is required.

This research project adopts an interdisciplinary approach (Fig. 1) to volcanic risk reduction on the active volcanic island of Tristan da Cunha (South Atlantic). Tristan has a relatively poorly defined eruptive record and little effective monitoring capability. Although a young volcano (~200 ka), eruptions have been numerous, with no apparent spatio-temporal relationships of volcanism. The last eruption in 1961 prompted a temporary evacuation of the island's small population. Paucity of data, uncertainty around future eruptive scenarios, recent volcanic activity and evacuation challenges facing this remote community emphasises the need for increased knowledge about the volcano, and implementation of effective risk reduction measures.

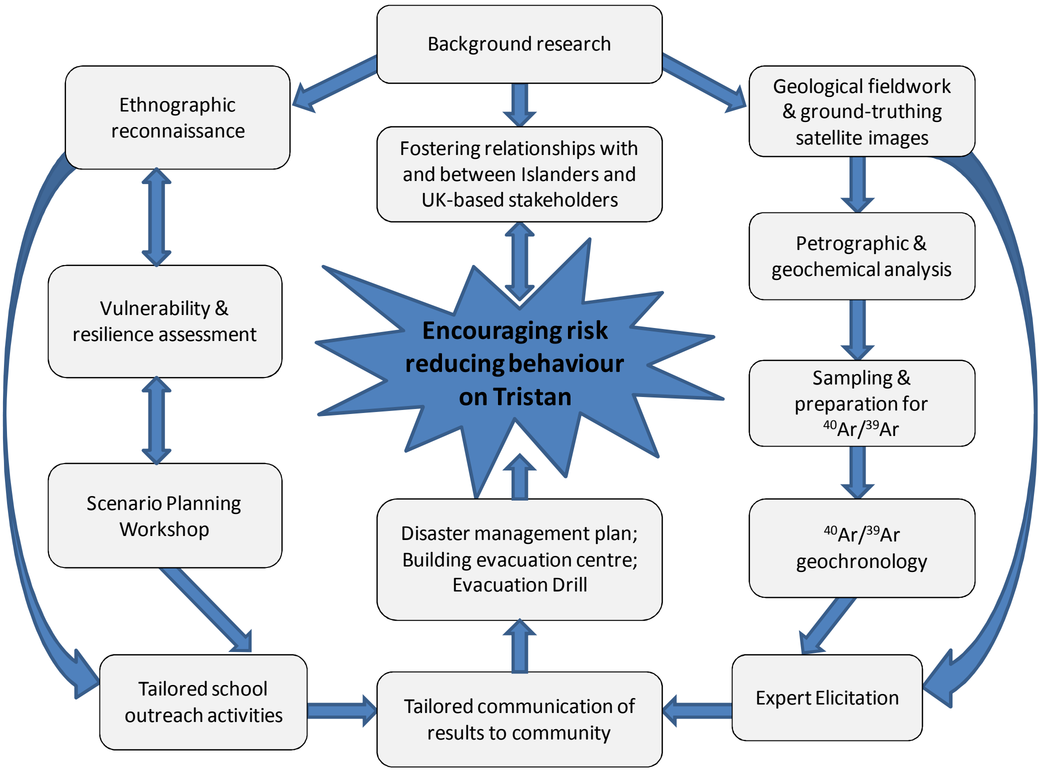

Fig. 1. Schematic of methodological approach to research.

New field observations from Tristan and a precise geochronology of the recent eruptive history (< 80 ka) are summarised. The new ages demonstrate the variability of eruption style, volume, composition and location over time, and although statistically sound, the data present significant uncertainty in terms of anticipating future eruptive scenarios on Tristan. To attempt to quantify uncertainty, datasets were administered in an expert elicitation exercise. Experts provided an objective expression of the existence, extent and significance of the uncertainty surrounding future eruptive scenarios on the island, but the severity of uncertainty proved inadequate for decision support.

In order to effectively communicate the science and uncertainty, as well as encourage implementation of risk reduction measures, knowledge of the social context and collaboration with islanders was essential. A 32 week field season permitted an ethnographic approach to investigations of the historical and present day social context. While the small population of Tristan (n = 262) are disproportionately vulnerable to the effects of volcanic eruptions due to location, the community retains inherent coping capacity held in social capital. Cultural changes manifest from 'system shocks' such as the evacuation, and from slower drivers, such as the recent introduction of modern media and communications, are acknowledged to have both strengthened and eroded resilience. It was crucial to analyse these broad drivers that determine existing characteristics, and how they have changed, in order to anticipate how they might transform in the future.

All data (results from natural, decision and social sciences) were integrated into a participatory communication strategy, focussed around a scenario planning exercise. This workshop aimed to encourage islanders to consider existing facts within the current context and reflect on plausible future eruptive scenarios, likely responses and coping strategies. A number of recommendations were produced as a result, including an updated disaster management plan and design changes to an evacuation centre. An evacuation drill was successfully completed with the whole community, and is set to be repeated annually with modifications to the hazard, scenario, and evacuation strategy. Other communication strategies were adopted to fit into the Tristan context, including customised outreach activities with the school children. For example, a film-making project provided an exceptional opportunity for children to engage with elderly islanders as they recalled the events of the 1961 eruption. This helped preserve the social memory of the eruption and responses, which is advantageous given the infrequency of eruptions on Tristan.

This research provides a template for larger-scale, longer duration, multi-researcher study that is still interdisciplinary in scope. It also demonstrates the strength of interdisciplinary research and, whilst challenging, if carefully conducted can achieve its aims. If supported by the volcanological community, increasing application of interdisciplinary approaches to volcanic risk reduction will encourage rapid transfer and adjustment of lessons learned at a wide range of volcanic settings.

Disaster Risk Reduction and resources management within Fogo Volcano National Park, Cape Verde

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In many practitioners handbooks as in many scientific publications or international directives about disasters and development, has arisen a consensus about disaster risk reduction (DRR). It should firstly better integrate socio-economical factors from daily pattern to strengthen livelihoods. Secondly, it should adopt context-appropriate measures to develop local communities' capacities in facing risks. Thirdly, it should be based on real collaboration between the different scales of action (institutional and upper levels stakeholders, local stakeholders, communities) to merge scientific, technical, political and local knowledge. If things are theoretically well-established, practically speaking difficulties remain to develop this collaboration and to find a research methodology which could combine all knowledge to help practitioners to find better solutions in DRR and in resources management.

Within the MIAVITA European research Program, the case of Fogo volcano Natural Park is highlighting specific difficulties in achieving these goals of shared management. The community living within the caldera is facing thus both volcanic risk and institutional strategies of biodiversity protection. These constraints, especially on farmlands but also on tourism development (being the second source of income), induce some conflicts between the community and external stakeholders such National Civil Protection, Natural Park Direction and the municipality of Santa Catarina.

This communication will present the main findings of Fogo case study, (1) by analyzing the complexity of natural and human context, (2) by highlighting vulnerability and capacities of different social groups living in the caldera, (3) by discussing the specific methodology applied, aiming at enhancing collaboration between researchers, practitioners and the community. It will focus on two tools of dialogue: Participatory 3D mapping and documentary film. It will finally address the scientific and action perspective for the next years, post to MIAVITA program.

Block III
Session 2: Monitoring Methods

Chair: Christian Bignami

MIAVITA - Wireless Sensor Network

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Introduction

In the past few years there has been significant research activity regarding Wireless Sensor Networks (WSN). This type of network is being used in a wide variety of scenarios. In 2004 a small testbed of a WSN was deployed at the Volcan Tungurahua in central Ecuador with the objective of monitoring volcanic activity. During three days, data was captured from the active volcano, using microphones installed in an array of MICAz sensing nodes, proving the validity of the approach [1]. In the MIAVITA project we address a different problem: the monitorization of the volcanic tremor, which is a very low frequency seismic signal caused by the movements of the magma in the interior of the crater that precede volcanic eruption.

WSN Architecture

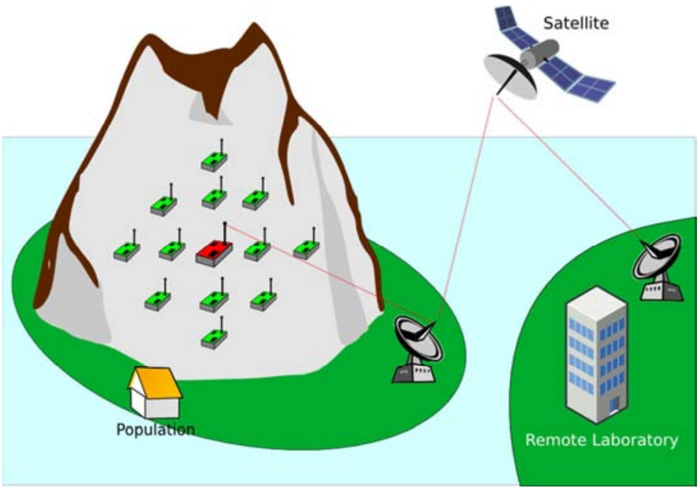

Figure 1: Wireless sensor network architecture

Fig. 1 depicts MIAVITA WSN. Seismic signals are collected at the volcano by multiple sensor nodes, using single or tri-axial geophones sensing devices. Seismic information is relayed to the sink by intermediate sensor nodes, which are responsible for data aggregation in order to reduce the network load. The central sink node acts as a bridge between the remote laboratory and the WSN. This node has two antennas, one for short range communication and a long range secondary radio. This additional radio leads to a higher energy consumption compared to normal sensor nodes. To simplify the WSN design all the nodes have a similar hardware and software architecture and the different between the sink and the remaining nodes is defined through an adequate configuration of the system and the connection of the additional antenna.

Fig. 2 represents the hardware components of a generic node, comprising five main blocks: sensing devices, data acquisition system, controller, communication interfaces and power management. The sensing devices are the geophones that convert ground motion into an electrical signal. The data acquisition system is responsible for converting the analogue geophone signals into the digital samples and transmitting them to the controller at 50Hz. The controller performs all the activities related to the acquisition of digital samples and transmission of packets to upper nodes through the communication interface. The controller is an ARM based embedded device. The communication interface is supported on 802.11g technology. Finally, the power management module comprises all the entities needed to power up the node. One might used a 12V battery alone or complemented with a solar panel.

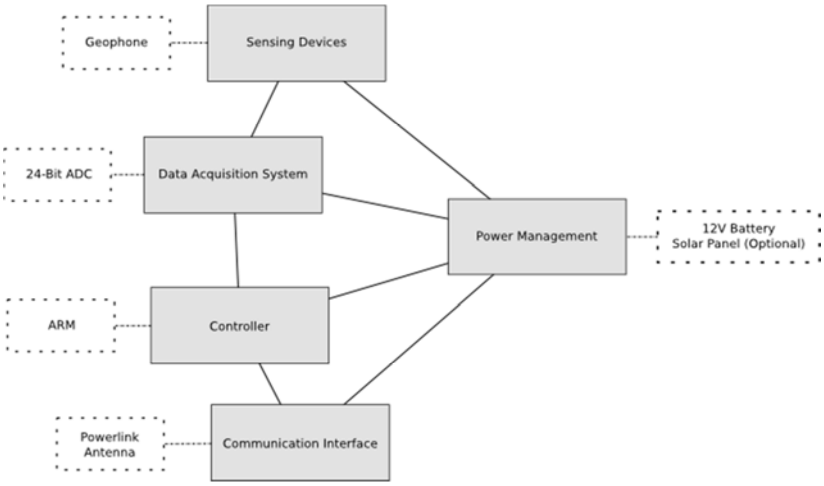

Figure 2: Wireless sensor network architecture

Although the same software modules are available in each one of the nodes they are configured differently in order to accomplish the goals they are designed to. Hence, border sensor nodes are responsible for data acquisition through SPI protocol, network packet construction and transmission. Besides these functions, intermediate nodes must also perform aggregation in order to reduce the number of packets transmitted. The sink node desegregates the packets and stores the data in order to be retrieval by the remote laboratory. Optionally, if only the sink node includes a GPS receiver, the CLOWDE protocol can be used to synchronize samples. Apart from the information storage service performed at the sink node, all the other functions are performed in the kernel level in order to provide a more efficient system. At the remote laboratory, WSN information may be retrieved and visualized in a web application. This application comprises both information about the network and the seismic data.

Reference

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Cape Verde Geophysical Monitoring Network for the Volcanic Hazards Mitigation

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Cape Verde archipelago consists of ten major and several smaller volcanic islands and it is located about 550 km off the West African coast between 15 and 17ºN. The islands lay over the African plate and rises from the depth of about 4000 m and over a 2000 m bathymetric anomaly that extends in a diameter of 1000 km, beside there are also a geoid and a heat flow anomalies, and thus they are assumed that they the superficial expression of a mantle plume. They show a weak age progression from East to West, which may be due to the relatively low rotation velocity of this region with respect to the underling mantle plume, and still due to the low velocity, some distant islands relative to each other erupted in the same time. On the other hand, the magmatism rate is very low from which results a relatively long eruptive cycle on almost of the islands. Recent results show that in almost of the islands the eruptive activity was intermittent. Therefore, the natural hypothesis is the islands are still active in the volcanic point of view. However, since the archipelago was inhabited, in the 16th century, only in Fogo, which is an active stratovolcano, it was observed eruptions. This island has a very frequent volcanic activity, with a total of 27 observed eruptions since it was inhabited, being the two last eruptions occurred on July 1951 and April 1995. The main hazards associated with Fogo Volcano are due mainly to the lavas flows and some local pyroclastic fall. Thanks to the MIA-VITA project and funds provided by the Cape Verde Government in April last year a seismic network composed of six broadband CMG-3ESPCD (60s to 50 Hz) sensors was installed there for volcano monitoring proposes, and since June this year (2012) three tilt station are operational. Brava is the younger island of the archipelago and probably still in the seamount stage, and there is very often felt earthquakes of low intensity (MMI ~ IV). The felt seismic activity in this island may be associated to the magma intrusions in depth or to the volcanic submarine activity between Fogo and Brava, which is the more plausible because the bathymetry of this region shows the existence of a dense population of volcanic cones. Therefore, in order to better understand the nature of the seismic activity, and to take adequate Civil Protection measures, two broadband CMG-3ESPCD (60s to 50 Hz) sensors was installed. The data of these two networks (Brava and Fogo) is also telemetred in real time and available on the Internet. S. Antão, in the North of Cape Verde, consists of silica-undersaturated volcanic products and minor intrusions. In this island the volcanic activity started at about 7.5 and had a restless of about 4.6 Ma and resumed 2 Ma ago, and last eruption was about 90 ka ago. There are currently several thermal water springs (up to 78 ºC), felt and recorded earthquakes, which may indicate a reactivation of magmatic plumbing system. Taking in account of the potential threat of the volcanic hazards, which is due to the very explosive activity, to the population of this islands and its importance to the Cape Verde economy (mainly the agriculture), in July 2012 a seismic network of four broadband CMG-3ESPCD (60s to 50 Hz) sensors was installed in S. Antão. The recorded data is telemetred in real time to INMG office in S. Vicente, where it is daily analysed. The preliminary results show that the seismic activity may be related to the magma intrusions.

Signs of magmatic ascent in LP and VLP seismicity and link to degassing: an example from the 2010 explosive eruption at Merapi volcano, Indonesia

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The eruptions of Merapi volcano (Indonesia) in October and early November 2010 produced a large number of earthquakes including a sustained long period seismicity (LPS), i.e., long-period earthquakes (LP), very-long period earthquakes (VLP) and tremor. We investigate here LPS that occurred between 17 October and 4 November 2010 to get insights into the volcano eruption processes which preceded the paroxysmal phase of the eruption starting on 4 November. Long period seismicity is ascribed to the excitation of fluid-filled cavity resonance and inertial displacement of fluids and magma within volcanoes. We proceed to the moment tensor inversion of a well recorded large VLP earthquake during the intrusion phase on 17 October 2010, i.e., before the first eruption on 26 October. By using two simplified models (crack and pipe), we found a shallow source for this VLP event at about 1 km to the South of the summit and less than a km below the surface. This location coincides with the area where numerous shallow volcano tectonic (VT) pre-eruptive earthquakes and long-period (LP) syn-eruptive earthquakes were observed. Moreover, we analyse the complex frequency content of more than 150 LP earthquakes that occurred during the eruption phase (29 October – 4 November). We show that most of them have a dominant frequency in the range 0.2-6 Hz. We observe significant variations of the complex frequency during the course of the eruption. We discuss these changes in terms of a variable ratio of fluid density to solid density and/or by possible conduit geometry change. Finally, we also discuss how the major explosions of the eruption have been potentially triggered by passing waves, resulting from regional earthquakes on 3 and 4 November.

Using Unmanned Airborne Platforms for In Situ Calibration and Validation of Remotely Sensed Data and Related Models for Detection and Tracking of Volcanic Emissions

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The ability of current remote sensing retrieval and transport models to detect, characterize, and track airborne volcanic emissions are often hampered by sparse in situ validation data. Chronic, pervasive, and long identified in scientific forums, this problem was highlighted by the need for operational estimates of airborne ash concentrations throughout Europe during the 2010 eruption at Eyjafjallajökull-Fimmvörðuháls in Iceland. In response to that urgent requirement, heroic ad hoc attempts were mounted in Europe to conduct airborne in situ observations with manned aircraft to validate ash concentration estimates based on remote sensing data and transport models, and to provide crucial accuracy and precision estimates for predictions of locations, trajectories, and concentrations of the drifting ash, which caused significant negative economic and air safety impacts throughout Europe and worldwide. Most recently, small UAVs (e.g., NASA, University of Costa Rica, University of Düsseldorf) are being tested for proximal SO_2 and solid aerosol observations and sampling in relatively quiescently erupting plumes as a first step toward more far ranging and higher altitude deployments into drifting volcanic ash clouds at regional scales. Nevertheless, in the aftermath of the Icelandic crisis, ash and gas concentrations from analysis of satellite remote sensing data remain systematically un-validated by in situ data. Of special concern with respect to aircraft operations are the validity of estimates of the lateral and vertical extent, concentrations, and spatio-temporal variability of drifting volcanic ash clouds provided by aerosol transport models and remote sensing techniques. In the past, such insufficiencies have centrally contributed to inadvertent aircraft encounters with ash plumes (e.g., the 1989 eruption of Redoubt Volcano, Alaska—near-fatal Boeing 747 ash encounter; the 2000 eruption of Hekla Volcano, Iceland—NASA McDonnell-Douglas DC8, encounter, severe damage to all four turbine engines). The current paucity of syn-eruption in situ data persists because of the obvious extreme difficulty of deploying and recovering samples and physical/chemical data over remote regions and at altitudes where such clouds occur, especially given the demonstrated danger to manned aircraft that such ash concentrations generally present. The issue is compounded by the comparable lack of publicly available, peer-reviewed and validated data on acceptable ash exposure thresholds within aircraft engines, although there are government and industrial efforts afoot to ameliorate that situation. Pan-European government agency efforts (e.g., DLR, British Met Office) to systematically deploy comprehensive manned airborne laboratories are progressing and couldn't be more welcomed by the scientific community, although these are most applicable for ash-dilute margins of major plumes—vent areas and volumes of heavy ash concentration are fundamentally inaccessible by current manned air-breathing craft. Electric-powered UAVs are most appropriate for these very hazardous regimes. Likewise airlines and aircraft manufacturers are mounting similar efforts (e.g., Airbus, easyJet). Within NASA, nascent resources are being brought to bear, and there exist a variety of novel technological approaches for conducting in situ validation experiments, particularly the use of specially designed unmanned aircraft to range through ash clouds, and the deployment of instrumented tethered aerostats up into such clouds, in coordination with multispectral satellite, airborne, and ground-based observations. Shared access to comprehensive aircraft engine information is strongly indicated. A brief review of related scientific issues and state-of-the-practices will be presented, as well as the prospects for future improvement. This work was carried out in part at the Jet Propulsion Laboratory of the California Institute of Technology under contract to NASA.

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Testing Data Telemetry Solutions for Volcanic Monitoring in Fogo Volcano

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Fogo Volcano was selected for a pilot test of telecommunications practices under MIAVITA Work Package 6. For this purpose, a technical solution was designed, implemented and tested, for data transmission between the volcanic monitoring stations and INMGCV headquarters in São Vicente island. A VSAT antenna was set up in Chã das Caldeiras to test the feasibility of satellite data transmission out of the caldera.

A solution was designed and implemented for real time data transmission from the new set of sensors deployed in Chã das Caldeiras, Fogo Island (Faria and Fonseca, this issue) to INMGCV Headquarters in S. Vicente Island. It is depicted schematically in Fig. 1, and discussed in detail in Fonseca et al. (2010a). The first leg consists of spread spectrum radio links from the sensors to dedicated embedded PC's (Guralp CMG-EAM) in the field; . Both Fogo island and neighbour Brava island were instrumented. The second leg consists of spread spectrum links between the embedded PC's and the Internet point of entry in Santiago island. Tall spread spectrum links are operated autonomously by INMGCV, and do not depend on service providers. A leased line from the Internet point of entry to the INMGCV Headquarters completes the link.

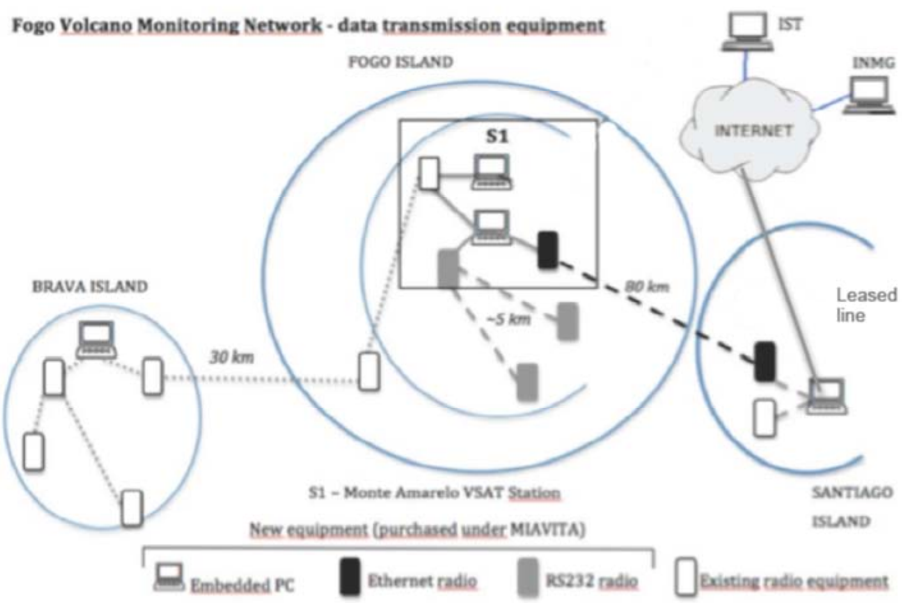

Figure 1: Schematic representation of the Fogo Volcano data transmission network, from Fogo island and neighbour island Brava till the point of entry in the Internet, in Santiago island. This equipment was partly purchased through the MIAVITA project, and partly (Brava sub-network) purchased with Cape Verde Government funds.

Figure 2: VSAT equipment deployed to test the data transmission from Fogo Volcano to IST, Lisbon. Left: VSAT antenna set up in Chã das Caldeiras, Fogo; right: VSAT antenna at IST, Lisbon.

One of the tennets of the adopted approach is that the data transmission links should be redundant, in order to preserve access to the data in real time in the event of failure of one of the links. This principle was incorporated in the design of the Fogo network. In the event of a failure of the spread spectrum/leased line link described above, INMGCV should be able to pull the data over the internet from a data server based at IST, where the data would be stored after transmission over an independent route. We set out to test the feasibility of a VSAT-based solution to provide redundant access to the data from the Fogo sensors. This attempt was plagued with difficulties from the onset. Eventually, advise from the Cape Verde Atmospheric Observatory led to the abandonment of the Ku-band, which in Cape Verde is affected by atmospheric dust to the point of being unpracticable. C-band services proved too expensive to be sustainable. Ubiquity of VSAT internet access can be a misleading notion, as the costs involved may render it prohibitive except for operations with a very large budget, unlikely to be the case for hazard monitoring in developing countries. The outcome of the VSAT tests was the conclusion that the solution is not cost effective, and any technical support is unlikely to be available in remote regions that are not attractive in market terms. Clearly, this raises an issue of corporate social responsibility, and should be taken into account by governments in the regulation of the telecommunications sector. As an alternative to the VSAT link, an IRIDIUM (Low Earth Orbit) satellite telephone service was provided for Chã das Caldeiras. The MIAVITA project is financed by the European Commission under the 7^{th} Framework Programme for Research and Technological Development, Area Environment, Activity 6.1 Climate Change, Pollution and Risks.

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CLOWDE - Cross-Layer One-Way Delay Estimation

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Using a Wireless Sensor Network (WSN) for monitoring single source events, such as volcanic activity, involves many challenges. One of these challenges is that of accurate timer synchronization of the data collecting nodes, so as to ensure that there is a consistent view of the data retrieval times. Most of the synchronisation solutions that have been proposed are either too complex to be deployed or lack an efficient hardware support that guarantees an accurate estimation of the times measured [2] [1] [3] [4]. Thus, although the use of global time reference provided by Global Positioning System (GPS) devices can solve this problem in an accurate way, GPSs are expensive and high energy-consuming devices, which preclude their use in every node. As such, more simple and energy efficient synchronisation protocols need to be designed.

In this paper we discuss a novel approach for an one-way time synchronization protocol, Cross-Layer One-Way Delay Estimation (CLOWDE). CLOWDE relies on the use of cross-layer timing information to calculate the accumulated delay since a block of data is created until it is received at the sink node. The accumulated delay is computed using the Application, Network and Link layers with 802.11b technology. At each node along a path a Protocol Data Unit (PDU), inserted between the User Datagram Protocol (UDP) header and the application payload, is manipulated in order to accumulate the suffered delay. This delay is iteratively incremented along the path until it is finally provided to the receiving application. This protocol does not add any extra packet, generating little data overhead, thus making it suitable for use in bandwidth constraint scenarios. A schematic representation of the algorithm is presented in Fig. 1.

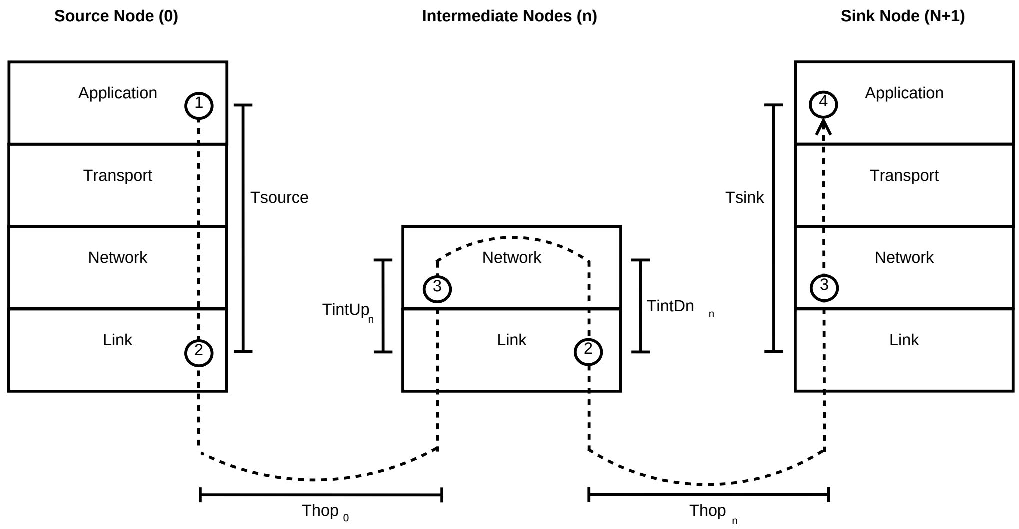

Figure 1: Wireless sensor network architecture

As the first step, the application creates a message at the source node (*Tcreation*) containing the data to be transmitted to the sink. After, the application sends the message, which must travel down the IP stack until the Link layer pushes it to the network card. This time is identified as *Tsource*. The network card will then transmit the packet to the next hop. This time, *Thop0*, comprises the propagation and transmission delay. Finally the packet reaches the sink node, where it will travel up the IP stack until it is delivered to the destination application, taking an additional *Tsink*.

CLOWDE, provides a fairly accurate estimation of the delay a message experiences through a WSN, adding no extra packets and little data overhead. Our experimental evaluation showed that CLOWDE is able to determine the end-to-end delay of most messages with an error inferior to 700µs in one hop scenarios and to 1500µs in two hops scenarios. We implemented a prototype using Acorn RISC Machine (ARM) boards running a Linux kernel and common off-the-shelf Universal Serial Bus (USB) WiFi network cards. We evaluated the delay estimations provided by CLOWDE against a highly accurate GPS clock in one and two hop scenarios. The results have shown that CLOWDE is able to pick up slight variations in the delay of each packet, providing a small error, within the tenths or hundreds of µs in one hop scenarios, where the error level stands between 1 to 10% of the delay value. For two hop scenarios, the error is higher but most of the tests still provided results with less than 10% error of the true delay value. We intend to deploy CLOWDE in a 13 node WSN for volcanic activity monitoring as part of the MItigate and Assess risk from Volcanic Impact on Terrain and human Activities (MIAVITA) project. This will provide a high load environment where the difficulties caused by retransmissions will stress CLOWDE.

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Volcanic Global Risk and Identification and Analysis Project (VOGRIPA): The use of Databases for Reducing Risk to Volcanic Eruptions

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VOGRIPA is an online, open access database of global volcanic eruptions (www.bgs.ac.uk/vogripa); see Crosweller et al, in review, for a description of the database. The database is searchable via a spatial tool and or a series of attributes, the results of which can be downloaded into a spreadsheet format.

The data currently relate to large magnitude explosive eruptions (those of Magnitude or VEI 4 or greater) extending back to the start of the Quaternary; there are currently over 1800 such records contained in the database. This will be extended to include data on individual hazards as well as vulnerability in order to identify locations at high risk from volcanism, gaps in knowledge about hazards and risk, and allow scientists and disaster managers to analyse risk within a global context of systematic information.

The Large Magnitude Explosive Volcanic Eruptions (LaMEVE) part of the database has been constructed from data available in published literature and other online database resources. These eruptions were the primary focus due to their potential for large death tolls, severe societal disruption and economic losses that might be important regionally or even globally. Analysis of the data has enabled us to calculate an approximate frequency-magnitude relationship based on past activity. In carrying out this analysis, the issue of under-recording of events has become apparent. This inevitably affects the inferences you can make from the data but acknowledging these limitations is the first step. From there, efforts can be focussed towards reducing these identified gaps and therefore improving the information available. To this end, we actively encourage the volcanological community to contribute data where they feel it is missing or errors are identified.

VOGRIPA is a component of the Global Volcano Model (GVM, www.globalvolcanomodel.org) international collaboration. Both GVM and VOGRIPA are officially endorsed as a project of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI). The University of Bristol is the coordinating centre for VOGRIPA, which is an international partnership including the Smithsonian Institution, British Geological Survey, Geological Survey of Japan, University of Buffalo (SUNY), University of South Florida and Munich Re, amongst others. The partnership is intended to grow and any individuals or institutions that are able to contribute resources to VOGRIPA objectives are welcome to participate.

The Global Volcano Model (GVM) – an introduction

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GVM is an international platform for information on volcanic hazard and risk. The project, currently organised from the UK, was started in November 2011 and has initial funding for 3 years through the NERC's 'International Opportunities Fund'. The aim is to provide systematic evidence, data and analysis of volcanic hazards and risk on global, regional and local scales, and to develop the capability to anticipate future volcanism and its consequences. For example, through the establishment of international metadata standards, ambiguity in the use of global volcanic datasets can be reduced.

GVM has been set up in response to a number of recent high profile volcanic events (e.g. Eyjafjallajokull, Montserrat, Merapi) and the following global demand for risk information and risk assessment. There is a recognised need for improved international coordination and collaboration in volcanology and a harmonisation of methods. With improvements in information and data access, it is anticipated that forecasting, mitigation and emergency management can also improve.

GVM already has wide support from varied institutions around the world but is looking to extend this. It has an open access, open to all remit and welcomes input from any interested parties. The website was launched in early 2012 at www.globalvolcanomodel.org, where more information on aims and activities can be found.

Block IV

Session 3: Vulnerability and Resilience of Human Communities

Chair: Vittorio Bosi

Community Emergency Management during the 2005 Ambae Eruption, Vanuatu, SW Pacific

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Community based emergency management and self-reliance is an objective pursued globally in both developing and developed nations. It is a particularly important goal in the context of volcanic islands, where in many cases external help is not readily available in the first days or even weeks of a sudden volcanic crisis. We present a case-study where village-level and island-level community plans developed during 2002-04 through a participatory approach were tested by a recent eruption on Ambae Island, Vanuatu. A series of surtseyan explosions through the summit caldera-hosted crater lake (at c. 1400 m asl.) started at the end of November 2005 and broke a c. 90 year silence from the island volcano. Fears of deadly lahars were driven by oral traditions of past eruption events and led to the spontaneous formation of an island-level disaster committee. Following an official change in volcanic alert level, two days after the onset of activity, an evacuation of people from potential lahar paths was ordered and managed for over four weeks by this committee. Use of almost entirely local resources (transport, food, shelter, and staff) during the highly efficient operation meant that its costs were very low and only minimal external assistance was necessary. Coordination between the island-level committee and individual villages/tribal groups was generally very positive, marred only in cases where existing political disputes existed, or where there were differing interpretations of safe vs. hazardous areas. In hindsight, lahar hazards from the eruption were low; however, fears of past events, along with the long interval since the last significant events from this volcano sparked the "premature" evacuation. The local management was highly effective, although it would have been vulnerable had activity escalated, because no significant planning had been made for a possible hand-over of control to the national level. In addition, the effectiveness of local management was compromised in that national authorities (and overseas aid donors) did not fully support them throughout the entirety of the operation. Interference by an ad-hoc volunteer group of government servants with parochial Ambae interests also served to sour national-local relationships and at times disrupted due process. In addition, sensationalist local and international media coverage also served to magnify the situation and place further pressure on island level organisation.

Mount Cameroon People's Vulnerability and Capabilities in Facing Volcanic Hazards

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This study, carried out in the framework of MIVITA project, in the Mount Cameroon Region of South West Cameroon, during 2 fieldwork campaigns (December 2009-April 2010; March-September 2011), aimed at investigating the socio-economic vulnerability and resilience in risk zones mapped during the "Gestion des Risques Naturels et Protection Civile (GRINP)" project carried out in 2006 by the Ministry of Industry, Mines and Technological Development (MINIMIDT) and Bureau des Recherches Géologiques et Minières (BRGM) France. The main objective being to assess people's vulnerability and capabilities in facing volcanic hazards in previously mapped risk zones. A total of 9 instruments were developed for the collection of the required data which included Interview Guide (In-depth Interview Guide, General Questionnaire, Key-Informant Interview, Authorities Questionnaire, and Checklist for Evaluating National Policy), Anthropological Observation, Participatory Observation, Life stories, Focus Group Discussions.

Two major classes of vulnerability were depicted from the data.

Natural (threats) vulnerability: Include lava flow, ash falls, gas emissions, lahars, landslide and rock fall, earthquake, flood and acid rain), seismic (earth tremors) geomorphological (erosion), meteorological (floods, mud flow, topsoil erosion, wind),coastal (sea bank erosion and tides). The major impact categories under natural vulnerability pointed out by both community leaders and the general population was the destruction of animals, forests, water and soil by the various hazards.

Social and Manmade Vulnerabilities: Social vulnerability are classified in 7major categories namely place/location, institutional, ethno-anthropological context, psychological, literacy, demography, economy and network. Manmade vulnerability on its part was classified in four major categories namely technological, crop farming, and animal farming and architectural infrastructures.

Communities around Mount Cameroon react to natural hazards in various ways: people run out of their houses, relocate temporarily, some stay back to protect property, people protect nostril from ash and gas using common material found in the environment, rub Vaseline and oil to protect the skin and in the nostrils to prevent the inhaling of gas, women protect and provide food and equally take care of children, men assist in rescue operations, perform rituals to appease the gods and prayers for divine intervention. People are not generally equipped with adapted masks or other protective devices.

Communities around Mount Cameroon cope with natural hazards by planting trees, using sand bags and embankments to control erosion and landslide, using sand bags and improving drainage network to control flood, changing crop type, enlarging distance between houses to reduce the stress on the ground and by so doing minimizing risk of landslide, repairing affected buildings, restoring water reservoir or water sources, praying or appeasing gods or ancestors. Community members assist the victims in rebuilding their houses and providing them with other needs, allocating new farm land to those who lost theirs, transferring people temporarily to safer locations, changing house type, assistance from government, CSOs, friends, family members etc., working hard to raise income, reducing daily food intake, rescheduling debt, borrowing money from relatives or '*Njangi'* groups, change activities, engaging children in livelihood activities, save on children's education or pawning land and other goods. Very few can borrow money from banks, with a higher percentage of those who can do it being urban dwellers.

People's Vulnerability, Capacity, Response and Resilience during the 2010 Merapi eruption at local level

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Keywords
Merapi volcano, vulnerability, capacity, response, resilience

Abstract
Located in the western flank of Merapi volcano, Ngargomulyo municipality (figure 1) is placed within the zone of higher danger to volcanic hazards (8 km from the summit). The municipality experiences several volcanic eruptions in 1930, 1961, 1967, 1994, 2006 and the latest in 2010. With most of the local people are farmers (83%), natural resources, notably lands and agriculture, are crucial to people's livelihoods. A volcanic eruption may impact upon these resources and therefore hinder the villagers' ability to sustain their daily needs, through loss of food crops and cattle, damage to cash crops and decrease in incomes. Using Participatory three dimensional mapping and focus group discussions as the research tools, this article has three objectives: (1) to analyze the community vulnerability and capacity; (2) to examine community responses during the 2010 crisis; and (3) to analyze the community resilience after the 2010 crisis.

Through P3DM we can easily find which area with high number of vulnerable people such as disabled people, elderly people, pregnant women and children and plot the physical vulnerability such as brick house and wood-bamboo house. This type of map can be easily understood by community and therefore they can make a disaster plan based on this map. This tool gave opportunity to the local people who build the map and plot most of the information and to scientists and government representatives who could easily overlap their own data and plans. The capacities to face with disaster in Ngargomulyo municipality can be translated to different aspects, such as social capitals in the form of kin network, people's organizations, non-governmental organizations, cooperatives; strong local leadership with less political conflict; memories of disasters and experiences of evacuation; and transport capacity for evacuation purposes. In Ngargomulyo, people initiated community-based actions to reduce the risk of disasters since the 2006 eruption, including the formation of monitoring teams, the systematic use of a traditional warning system (such as sirens and loud speaker from the mosques), and planning for evacuation. During the 2010 pre-crisis period, each village prepared a team headed by the village chief for organizing warning dissemination, evacuation and refuge. In facing volcanic eruptions people rely on collective labor, *gotong royong*, e.g: volcano community monitoring groups and organization of evacuation by means of available "local" vehicles.

Using a participatory three dimension mapping and focus group discussions, this research revealed that "Although classified as a volcanic disaster prone area and has been prepared to deal with volcanic disaster, the village of Ngargomulyo still found difficulties in dealing with volcanic crisis. The 2010 disaster made aware that the danger of volcanoes is very difficult to predict in detail. However, the community together with local authorities and non-governmental organizations has proven that together they can deal with and recover from disaster." P3DM can facilitate an effective dialogue between local authorities, emergency managers, communities, scientists and non government organizations, including measures to reduce people's vulnerability and to enhance the capacities to face natural hazards based on the previous experiences of disaster as happened in Ngargomulyo.

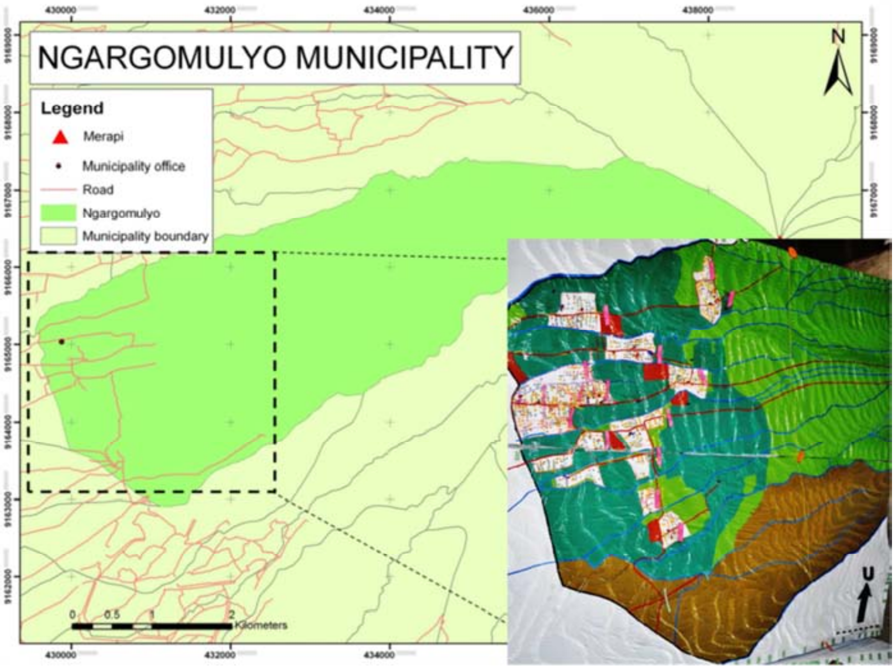

Figure 1. Ngargomulyo Municipality

Figure 2. Participatory Three Dimensional Mapping in Ngargomulyo

Socio-Economic Post Violent Merapi Eruption 2010

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In October 2010, the most active and dangerous stratovolcano of Merapi was erupted with violent explosion, produce of 130 million cubic meters pyroclastic flow. The eruptions of Merapi killed 386 people, destroyed ~3000 housings on the south flank and about 400,000 people were evacuated from the affected area. The total economic losses, such as commercial accommodation, tourism, culinary, agriculture, plantation, and livestock reached 5.5 billion rupiah.

Responding to the impacts of the *Merapi eruption,* a socio-economic study of volcanic risks has been undertaken. Socio-economic impacts are done in order to determine strategic planning and design process in life saving and life sustaining needs. Based on the data collected during 2009 - 2011, the population growth in hazard zone III and II of Merapi shows 0.9 % in Klaten, 1.8 % in Magelang, 0.9 % in Boyolali and 0.8 % in Sleman. Economic *loss* in the Sub District surrounding of Merapi during Merapi eruption was 65 % in Sleman, 6 % in Klaten, 6 % in Boyolali and 15 % Magelang. However, major damage was in Sleman especially in the villages of Kepuharjo, Umbulharjo, Glagaharjo, Argomulyo, and Hargobinangun that are is 39 % of housing, 13 % irrigation system, 31.4 % of agriculture, and 12.4 % of industry. Due to huge volcanic materials, most of population which are usually working as farmers, some of them are forced to switch profession becoming sand miners. The sand mining activities are important to support the socio-economic development of local people in the Merapi area. Socio-economic survey and hazard mitigation in Merapi play role in route to recovery in post Merapi eruption and to build a disaster resilient in the future.

Improving Ethnoarchaeological Approach and Application for Place Vulnerability and Resilience to a Multi-Hazard Environment: Mt Cameroon Volcano Case Study

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The FP7 MIA-VITA project has been designed to address multidisciplinary aspects of volcanic threat assessment and management from prevention to crisis management recovery. Within work package 5, the socio-economic analysis in the Mt Cameroon SW region of Cameroon was aimed at finding out the correct way to provide the best information to local people about the natural risks, organized preventions planning and tools to help the local ethnic groups to better perceive the risk, in collaboration with the local chiefdoms and the central government. Ancillary ethnoarchaeological information has been performed to focus the cultural interaction between Mt. Cameroon and its residents: one of the outstanding results from the study was the cultural beliefs that supernatural forces, as the god of the Mountain called Epasamoto and the god of the sea called Nyangonamuna, play a great role in the causation and controlling of natural hazards. The present work will examine in detail the influence of these supernatural forces in the perception of risk and its prevention in the region.

Keywords: MIA-VITA project, Mt. Cameroon natural hazards, socio-economic vulnerability, ethno-archaeological ancillary data, social resilience.

Far-field Geographical Effects of Volcanic Eruptions in Human History: Lessons for the Future

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Background

Explosive sulfur-rich volcanic eruptions can produce aerosol loads leading to climate responses at the Earth's surface. Volcano-induced atmospheric changes lead to cooler summers in most of Eurasia and North America, and warmer winters in the Canada, Western Europe and Siberia. Volcanically-forced climate variability result in reduced crop yields in parts of Europe and North America in historic times. In some cases, these environmental conditions appear to have exacerbated prevailing vulnerabilities, leading to epidemic disease, famine and social unrest.

The timing of historic eruptions has been reconstructed through several proxies, including polar ice cores and dendrochronology. Written sources can also help to identify the atmospheric optical phenomena (e.g. stratospheric "dry" fogs) and weather perturbations that suggest the presence of volcanic aerosols. The global effects of volcanic eruptions have been assessed using modelling. The best models simulate the spatial and temporal development of the sulfate aerosols from the sulfur injection onwards and calculate the climate response to solar forcing. However, the models display a wide range of uncertainties, mainly due to a lack of field and proxy data needed to calibration. The climatic and environmental impacts of explosive eruptions are usually identified at the local or regional scale using a single proxy. Therefore the spatial distribution of environmental disturbances remains poorly known. The improvement of our knowledge on these impacts at a broad scale will contribute to better understanding of volcanic risk in the future. The security of food supply to a growing world population is another major global challenge that needs full attention; large scale volcanic eruptions – through short to medium term climate impact - could represent a "wild card" in the progresses towards meeting such challenge.

This presentation aims at presenting the effects of poorly known eruptions that have had a great effect on global climate, environment, and sometimes on society.

Methods

We sat up a multi-proxy database on the characteristics and environmental impacts of large volcanic eruptions from Antiquity to modern history. Data collected through a wide range of techniques and methods were used to compile this database, e.g. ice cores, tree rings, marine hydrology (coral reefs, ice shelves), written sources (famines, lunar eclipses, dry fogs), etc.

Results and discussion

We have mapped the climatic and environmental effects in Europe of large eruptions of both known and unknown volcanic sources. Several examples have been analyzed in detail, especially the effects of large eruptions that occurred during the Middle-Age (e.g. 1195, 1274, 1289). Among our findings, we make the proof that the climatic and environmental effects of the “mystery” 1257 tropical eruption were greater than those given by the climate models.

Our study underlines the strong need to connect Earth scientists (e.g. volcanologists) and climate scientists with social scientists (historians, archeologists and human geographers) to study the past and present far-field impacts of large volcanic eruptions.

Keywords: Volcanic eruption, geographic effects, history, climate, dry fog, dendrochronology

Block V

Session 7: Cross Cutting Issue

Chair: Pierre Thierry

Risk assessment of volcanic eruptions in Iceland

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In Iceland there are approximately 30 active volcanoes and eruptions occur, on average, every four to five years. A large proportion of the most active volcanoes are subglacial. Volcanic eruptions pose a threat both to the infrastructure and the society of Iceland. Primary volcanic hazards include both eruptive products (i.e. ash, lava and gas) as well as jökulhlaups, i.e. glacial outbursts, and lahars. Even though primary volcanic hazards have caused minimal live loss throughout the history, the death toll due to starvation is significant. Starvation has primarily been caused by loss of livestock due to volcanic fluorine pollution. The most recent example of volcanic fluorine pollution was the 1970 Hekla eruption, when thousands of sheep were lost during the lambing season.

In the spring of 2010 two volcanic eruptions occurred in Iceland. The first one was a flank fissure eruption of Eyjafjallajökull (on Fimmvörðuháls mountain pass) lasting from the 20th of March to the 12th of April. The second eruption was in the central crater of Eyjafjallajökull and lasted 39 days from 14th of April to 22nd of May. The central crater eruption in Eyjafjallajökull, caused a dramatic disruption of international air traffic and impacted the Icelandic community, due to significant amounts of ash fall in farming areas, endangering inhabitants and livestock. Voluminous glacial outbursts reached inhabited lowland areas, cutting several sections of the main road system, destroying levees, and covering grazing land with mud and ice blocks. In the aftermath of the eruption, resuspended ash continuously affected air quality in populated areas as far as ~150 km from the volcano. Many weeks after the eruption was over, lahars made of ash and water occurred several times, threatening local farms and creating additional damages to the road system.

Following the 2010 eruptions and the eruption in Grímsvötn 2011, and based on independent evidence that Iceland is entering a more volcanically active period, the Icelandic government has financed an integrated risk assessment. Such an assessment will begin with an evaluation of potential hazards and associated risks and of the vulnerability of society. This will be followed by an estimate of the feasible counter-measures in order to prevent accidents and minimise economic disruptions and damages. The main purpose of the assessment is to increase the resilience of the Icelandic society and decrease its vulnerability. This work will be organized in accordance with the risk assessment framework of the United Nations and the World Meteorological Organization. It is estimated that completion of the assessment phase will take 15–20 years, based on a joint effort and collaboration of various institutions of Iceland. The first three years of the assessment phase, which are being financed by the Icelandic government, ICAO (International Civil Aviation Organization) and by Icelandic stakeholders in the transport and energy sector, will focus on the following tasks:

* An appraisal of the current knowledge of the eruptive activity and potential hazards

* Initial risk assessment of floods triggered by volcanic eruptions

* Initial risk assessment of explosive eruptions in Iceland

* Initial risk assessment of volcanic eruptions that may cause extensive damage to property, i.e. eruption in the vicinity of urban areas and international airports in Iceland

Preparation of the first two tasks has already taken place and these projects started 2012. In the first task, the main outcome will be a catalogue with detailed information on each active volcano in Iceland, freely available on the internet. In addition eruption precursors will be defined, and likely eruption scenarios will be described. The aim is to provide operational institutions with a support for decision making and to decrease their response time during a crisis. The overall objectives of the second task are to provide the Icelandic authorities with a comprehensive assessment of flood risk in areas prone to floods triggered by volcanic eruptions. For this second task, two test areas have been selected, Öræfajökull and Mýrdalsjökull, for which a set of flood hazard maps and flood risk maps will be developed in compliance with the guidelines formulated in the European Directive on the Assessment and Management of Flood Risks (2007/60/EC).

A large scale and open source approach to the risk related to tephra fallout: a case-study at Cotopaxi volcano, Ecuador

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The degree of detail at which risk can be evaluated strongly depends on the accuracy and the resolution of the available datasets. As an example, emergency management requires small-scale and detailed studies based on precise data and quantitative indicators, whereas a first semi-quantitative estimation of risk can already be used for the implementation a risk sensitive land-use planning. Despite the widespread use of Geographical Information Systems in the field of risk management, one important limitation remains the difficulty of accessing up-to-date and reliable geo-referenced datasets. In this regard, we present a method focused on the risk assessment associated with tephra fallout, based on global and free datasets.

The combination of large dispersal of tephra from volcanic plumes and constant increase of population in the vicinity of volcanoes results in a growing threat for exposed communities, including roof collapse, damage to crops, blockage of vital lifelines and health problems. One of the possible strategies for risk mitigation is therefore a risk sensitive land-use planning as a proactive measure, which requires the knowledge of both the expected hazard (frequency and magnitude) and the vulnerability of the exposed elements to this particular stress. We have assessed the risk considering five dimensions: social, physical, economic, environmental and territorial.

This method was developed and applied to the surroundings of Cotopaxi volcano, one of Ecuador's most active volcanoes located 60 km south of Quito. Based on field investigations, historical reports and the Smithsonian catalogue (Siebert & Simkin 2002), our tephra fallout hazard assessment was produced using the advection-diffusion model TEPHRA2 coupled with probabilistic methods in order to describe the aleatoric uncertainty of both eruptive parameters and atmospheric parameters (Bonadonna et al. 2005). Different eruptive scenarios were considered, including scenarios based on field data, scenarios based on the VEI scale (Bonadonna et al. 2005; Biass & Bonadonna 2011) and most likely scenario to occur in different time windows. We also carried out a thematic vulnerability assessment considering five aspects: i) social (i.e. level of education, age) and ii) physical (i.e. collapse of roofs) based on the national Ecuadorian census (Newhall & Self 1982), iii) economic (assuming agriculture to be the main source of income in this region) and iv) environmental based on the GlobCover land-cover dataset (INEC 2001) and v) territorial (mapping the access to critical facilities via the road network) using OpenStreetMap (ESA 2006). Based on literature, critical hazardous values of tephra thresholds were identified for each component of each theme (Blong 1984, 2003; Johnston et al. 2000; Stewart et al. 2006; Spence et al. 2007; Wilson et al. 2011a,b), except for social aspects for which no combination of hazard and vulnerability was attempted. In order to be combined with the vulnerability assessment, the evaluation of the hazard for each scenario was compiled as isomass maps for a given probability. Finally, new relationships of hazard, exposure and vulnerability were investigated to produce the final thematic risk maps.

Main outcomes of the semi-quantitative risk assessment include: i) the estimation of the number of building roofs to collapse, ii) the percentage of crops to be damaged, iii) an estimation of the impact on the Amazonian forest and iv) the accessibility of critical infrastructures via the road network during a crisis. Such information can be used to implement specific mitigation measures. Finally, this method demonstrates that rough estimates of the level of risk related to tephra fallout around a volcano can be provided even when no precise data is available and can be used as a framework for incorporating more detailed datasets as they become available.

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Creation of Information Management Framework in Volcanology by Means of Knowledge Engineering

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The task of volcanic hazard and risk assessment, being the main practical purpose of volcanology, simultaneously poses a theoretical claim to rethink the whole body of volcanological information, i.e., untangle the threads of reasoning, accurately select data to support or refute hypotheses, compare models, evaluate expert judgments and comprehend a domain of information in its entirety (e.g., reconstruct a full group of scenarios of unrest of volcano X). For a descriptive and language-dependent field like volcanology, this is a real challenge that urges, first of all, to structurize knowledge and, wherever possible, semantically constrain it. This is why volcanologists have adopted and use quite a range of formalized graphic conceptualizations – ontologies (e.g., McGuinness, 2007), event trees (Newhall and Hoblitt, 2002), Bayesian belief networks (Aspinall et al., 2003) and trees (Marzocchi et al., 2008) and others. Moreover, even some drawings in research papers on eruption mechanisms and dynamics or evolution of volcanic terrains, however picturesque, resemble formalized graphic notations (Branney and Kokelaar, 2003), to say nothing of higher-level conceptualizations like Miavita Project conceptual scheme (Miavita, 1996-2012). Bare scientific intuition leads researchers to use and/or create such conceptualizations but rarely tells them how this should be done.

Thereafter, some of the techniques used (like belief networks and, often, event trees) are semantically loose and, hence, may appear logically incorrect; those which are correct (i.e., ontologies), in turn, can be hardly used for decision support, but scientists nevertheless try to do so willing to support decision-making by a semantically perfect tool, and those who rely on expert judgment processing (including application of Bayesian methods) complain that the volcanological community en masse remains rather reluctant to serve as experts and needs additional training to correctly answer the questions in elicitation procedure.

To cope with these methodological difficulties, the application of knowledge organization methods in volcanology should be organized itself and a complex framework for application (and also development ad hoc) of such methods should be suggested. First of all, it is noteworthy that the considered methods fall in the field of knowledge engineering, including, in relevant aspect, even the Bayesian methods, as was shown, e.g., by Garbolino (1996). Knowledge engineering, being a part of artificial intelligence (Feigenbaum, 1984), seeks and adopts knowledge-processing techniques from all fields and disciplines, from academic science to industry.

However, the collection of knowledge engineering methods can form a working framework in a given field (volcanology) if it is "projected" on particular properties of this field and accounts for the specificity of information in it. One way to do this is to overview and classify the typical tasks, or "modeling environments" in the considered field. For the geoscience in general, this work was already done by Phenichny and Kanzheleva (2011). For the volcanology, the framework they suggest can be narrowed as shown in Fig. 1.

Among the methods listed, special attention should be paid to a method addressing the most complex type of environment (directed alternative change), the event bush. This method was suggested specially for volcanology (Pshenichny and Khrabrykh, 2002), further developed by Pshenichny et al. (2008; 2009) and Pshenichny and Kanzheleva (2011) and tested by a number of volcanological applications including the information modeling of unusual eruptive behavior of Etna (Behncke and Pshenichny, 2009). This method not only structures the knowledge in given domain but also constrains it semantically and allows, inter alia, conversion in Bayesian belief network or direct probabilistic computation (Pshenichny et al. 2005), quantitative assessment of similarity of eruptions and eruptive centers (Pshenichny et al., submitted), hazard mapping (Anokhin et al., 2012), qualitative "parsing" of physical models (Carniel et al., 2011), building of expert elicitation protocols and online collaborative work (Pshenichny and Diviacco, 2011). However, the development of entire framework of knowledge engineering methods (Mouromtsev and Pshenichny, submitted) in volcanology is essential to best relate the experience and language of researchers, available data, models and knowledge of similar objects and existing computational methods to particular task of volcanic hazard and risk assessment.

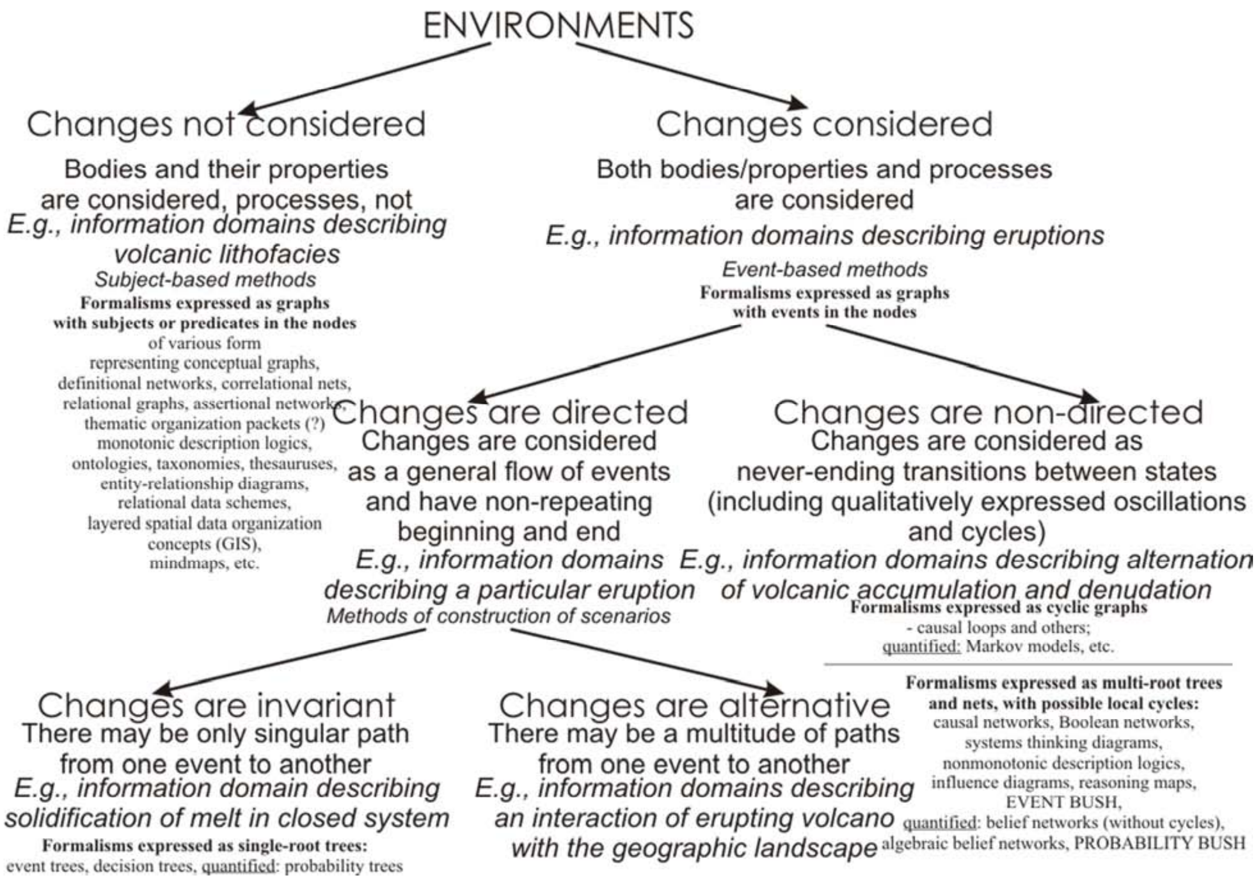

Figure 1: Information management framework for volcanology based on classification of modeling environments. Modified from Phenichny and Kanzheleva (2011).

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The role of telecommunications in volcanic risk mitigation – lessons from the MIAVITA Project

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It is a matter of consensus that effective volcanic monitoring is critically dependent on the availability of a reliable telecommunication infrastructure. Data produced by equipment deployed in the vicinity of the volcano must be transmitted with small latency – and often in real time – to the laboratory where the technical and scientific staff will process and interpret them on a routine basis. Once an emergency is declared, the communications requirements become twofold: while access to in situ data becomes even more critical in order to monitor the evolution of the ongoing volcanic process, sensitive communications are required between the volcanological laboratory on one side and the civil protection agency, the field staff and other supporting remote laboratories, on the other side. During an emergency, the telecommunications infrastructure is likely to be under stress, due to a combination of increased demand from the general public and the physical impact of the eruption. Adequate planning is therefore required in order to avoid the loss of communications when they are critical for the emergency management. In the scope of MIAVITA Work Package 6 (Communications strategies for crisis management) we started the analysis of the telecommunications requirements through the definition of a functional architecture with a high level of abstraction, to analyse in a systematic way the telecommunications workflow: who interacts, what objects are manipulated, what tasks are executed (Vazão et al., 2009). Figure 1 shows a diagram of the developed functional architecture.

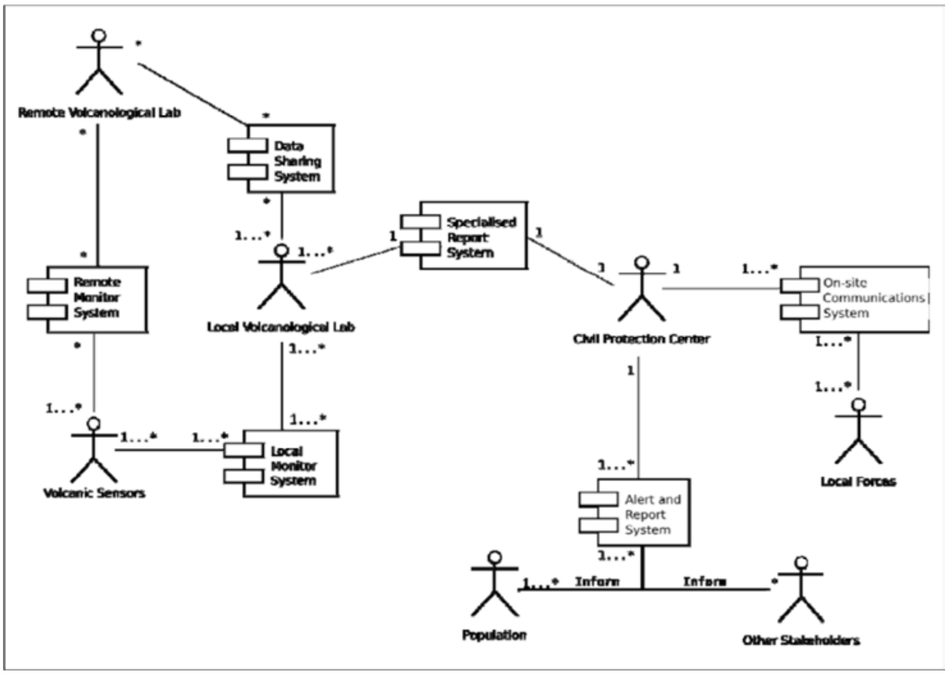

Figure 1: Telecommunications functional architecture (from Vazão et al., 2009)

The functional architecture was then instantiated to the concrete situations of the MIAVITA volcanoes, following the replies to inquiries that were prepared and sent to the ICPC partners in charge of their monitoring. Based on the replies pertaining to Fogo, Kanlaon and Mount Cameroun volcanoes, it was possible to identify a number of fragilities and recommend measures to solve or mitigate the problems (Vazão et al.,2011).

Volcanic observatories are often sited in remote areas, and the available services are affected by the "last mile" problem: given the increased capillarity of the distribution network, installation costs increase from the core (backbone) to the end site, and investments in peripheral areas where the ratio revenue/installation cost decreases sharply are often avoided or postponed. In the limit, a volcanic laboratory may be the only potential client for telecommunications services in a broad area around a volcano. Internet access may be available at the laboratory, namely through ubiquitous GPRS services, and perform adequately in routine times, thus conveying a false sense of security that can be challenged at the onset of an emergency (Fonseca et al., 2011).

Satellite communications are often described as the remedy for reliable data transmission from remote sites, requiring only an antenna and router, and a power supply. We discuss the use of VSAT for volcanic monitoring, and identify its limitations associated with the limited and market-driven availability of cost-effective services (Fonseca et al., 2010a).

Finally, we describe a hybrid solution resorting to a private radio link up to a distant point of entry into cable broadband as a suitable compromise of cost and robustness (Fonseca et al., 2010b).

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Poster Session

Lava flow invasion risk map at Mt Etna volcano

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We conducted a feasibility study for constructing the lava flow risk map at Mount Etna. Risk by lava flow is the expected value of losses (deaths, injuries, property damage and economic activity) due to the occurrence of an eruption in a particular area at a given time period. Here we propose a methodology to derive the risk by combining the lava flow invasion hazard map with the exposed value. The hazard related to lava flow invasion at Mt Etna (Fig. 1) is computed using a methodology based on numerical models for simulating lava flow paths and by considering the main volcanological structures and information on past eruptions (Cappello et al., 2011a, 2011b).

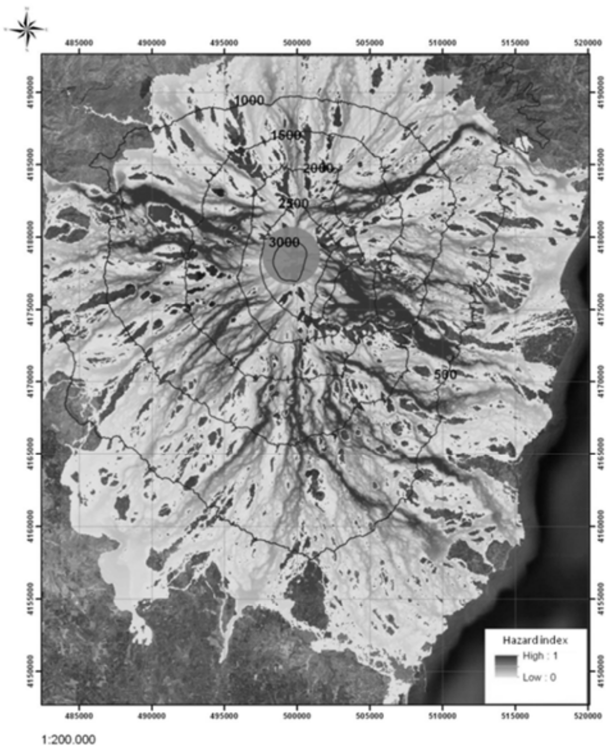

Fig. 1 – Lava flow invasion hazard map at Etna volcano. Each value represents a normalized degree obtained from the local probability of being affected by a lava flow in the next 50 years. The circular mask indicates the summit area which was excluded from our investigation.

The exposed value, i.e. the value of each of the elements at risk in a given area, is evaluated as the average of three kinds of information: (i) the socio-economic index, (ii) the anthropogenic index, and (iii) the land use index.

The socio-economic or ISTAT (Italian Institute of Statistics) index describes the socio-economic status of each city and takes into account various factors, such as population, buildings, businesses, institutions, local units and employees by municipality. All information was normalized in function of the municipal area and of the maximum value. Each resulting value was then homogeneously assigned within the municipal bounds.

The anthropogenic index indicates the presence of buildings and/or infrastructures such as roads, highways, railways and underground lines. It takes a value between zero (complete absence of buildings, roads and railways) and one (maximum presence).

The land use index reclassifies the area into land-cover types (i.e. rocks, wooded areas, agricultural enterprises, industrial areas, general infrastructure and urban areas) and assigns a weight to each class.

The final exposed value, obtained as the normalized sum of the socio-economic index, the anthropogenic index and the land use index, is finally multiplied to the hazard map to obtain the risk map by lava flow invasion at Etna volcano (Fig. 2).

Our risk map represents the first attempt to assess the potential level of risk associated to lava flows by considering both information on historical eruptions and the distribution of goods in the Etnean area. Allowing to timely visualize the areas in which there would be the greatest amount of losses in case of an eruptive event, it could be a useful tool for helping local authorities during ongoing eruptions and for the long-term planning of the territory.

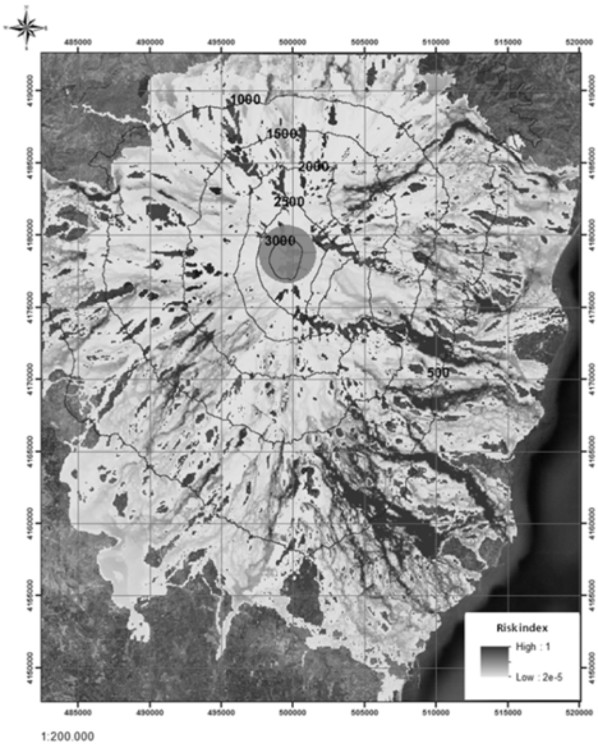

Fig. 2 – Risk map obtained by simultaneously considering the characteristics and frequency of eruptive phenomena (through the hazard map) with the social, economic and urban factors (through the exposed value). Summit area was excluded from the investigation since summit eruptions do not generally pose risk to towns located on Etna's flanks.

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Risk assessment associated with tephra accumulation: the example of Vulcano Island, Italy

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The level of success in managing a volcanic crisis strongly correlates with the extent to which proactive risk reduction policies are implemented before an eruption. Implementing such policies requires both the knowledge of the probability of occurrence and spatial extent of likely hazardous phenomenon and the knowledge of the exposed systems (i.e. socio-economical characteristics of exposed communities, physical state of the built environment, systemic importance of critical infrastructures). In this regard, we are developing a new multi-risk assessment for the island of Vulcano (Aeolian Island Archipelago, Italy) for the implementation of proactive risk mitigation measures.

Vulcano Island is dominated by a cone volcano– La Fossa, for which a new stratigraphy demonstrating a wide range of eruptive styles during the last 1000 years has been recognized (Di Traglia 2011),. We focus our tephra hazard assessment on two scenarios that dominate the history of La Fossa: vulcanian and subplinian eruptions. The tephra hazard assessment was compiled using the advection-diffusion model TEPHRA2 coupled with probabilistic methods in order to account for aleatoric uncertainties of eruptive parameters and atmospheric patterns (Bonadonna et al. 2005, Bonadonna 2006).

Vulnerability assessment focused on physical, systemic and socio-economic aspects and on the capacity to mitigate risk. Firstly, the physical vulnerability assessment describes features of individual buildings such as building typology, roof and construction techniques. Secondly, the systemic vulnerability assessment describes the capacity of critical infrastructures to continue functioning after some level of physical damage. Thirdly, mitigation capacities were assessed in order to evaluate whether mitigation measures have been defined and implemented and actors (e.g., individuals, communities, institutions) are adequately prepared to cope with a crisis. This last part was accomplished partly through interviews of key stakeholders and the general public.

Preliminary results show how a subplinian eruption of VEI 3 would result in a 50% probability of reaching the critical threshold of tephra accumulation for structural impacts on roofs at the two locations with the highest concentration of residential buildings (i.e. accumulation of 300 kg m-2 of tephra at Porto di Levante and Il Piano, the major port and business area and residential area on the island, respectively). It also results in a 60% to 90% probability of blockage of the road network.

Similarly, a long-lasting vulcanian eruption producing similar accumulation rates of tephra observed during the most recent eruption in 1888-1890 (1.9 kg m-2 h-1) would result in impacts on roofs within 2-3 weeks if no cleaning measure is taken.

Based on simple structural parameters, we identified the most vulnerable buildings to tephra fallout. Most of the buildings at risk are located in the area of Il Piano, southeast and downwind of La Fossa and the dominant winds. The systemic study shows a lack of redundancy of some critical infrastructures (i.e. critical roads). Also, both evacuation points will be either highly exposed or very difficult to reach in case of a volcanic crisis. Results of the social vulnerability survey indicate that 81% of interviewed people (N=91) had good awareness of the last volcanic eruption of 1888 and expectations of a future eruption within 100 years, although only 14% believed and eruption was likely within 12 months. As a result, only few have taken steps to prepare and most are mixed about what authorities will advise in case of an eruption.

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Risk Map of Merapi Volcano: An Effort to Mitigate Volcanic Disaster

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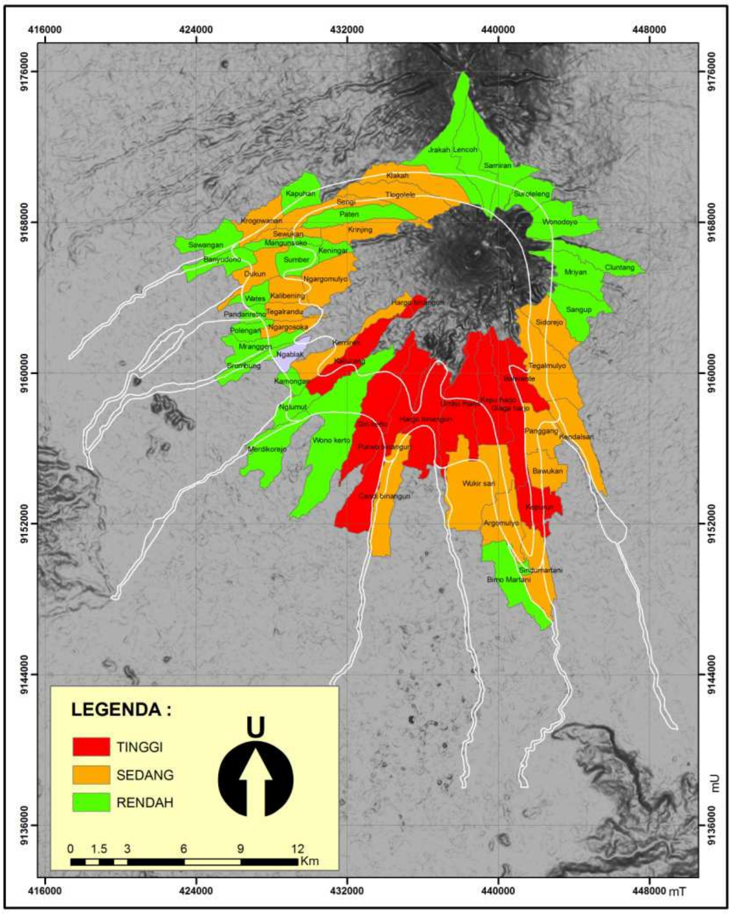
Since 20th century the population around the foot slopes of Merapi volcano boosted as shown by the economic activity and land use planning. This will certainly increase the risk causing by volcanic eruption in the future. To reduce the risk it is necessary to conduct risk assessment as a benchmark to take disaster prevention measures. Since 2009, Center for Volcanology and Geological Hazard Mitigation (CVGHM) carried out risk analysis to villages that occupy in Hazard Zones III and II. The analysis is simplified in the form of an index that includes three levels of risk, namely Low, Medium, and High and mapped in a different color gradations. The purpose of analysis is to facilitate policy makers to intervene in areas related to hazard mitigation efforts and assist people around Merapi volcano to recognize the level of risk in which they reside.

Risk assessment has several aspects: the hazard itself, exposure aspect to the threat of disaster, aspects of vulnerability and capacity to face disaster. The risk is defined as follows: $R = (H + E + V - C) / 3$, where, R is Risk, the risk assessment is determined by 4 factors which are Vulnerability (V), Hazard (H), Capacity (C) and Exposure (E). Each factor is controlled by several indicators that have different contribution in risk assessment. Contributions are referred to as an indicator weights (w) which is determined by the weight matrix of indicators. Hazard factors are associated with the threat of pyroclastic flows comes out from Merapi volcano including their travel distance and deposition. Exposure factors describe the exposure of population growth, the value of the building, and economic activity that would cost when the disaster occurs or otherwise these are able also to reduce risk. Vulnerability factors define things that able to increase the vulnerability of an area to disaster. Meanwhile Capacity factors identify activities which are able to reduce the impact of disaster caused by Merapi volcano eruptions.



Merapi Risk Map after 2010 eruption, red, orange and green colors represent high, medium and low risk levels, respectively.

To obtain primary data such as population, rural economy and infrastructure is necessary to conduct survey to all villages located in the volcanic hazard zones. The data are processed to obtain a hazard index in each village. The next step is to determine indicators, define their weight and order for risk assessment. The weight indicator is determined using Hierarchies Analytical Process (AHP) method. Indicator system is prepared for guidance in risk assessment.The eruption of Merapi volcano in October 2010 is used to validate the results of the analysis by compilation the impact of eruption to the risk index as shown on the map. The result shows a synchronicity between the three levels of risk, where the high risk index in the southern flank of Merapi volcano is corresponded to the high number of casualties and material losses due to eruption in 2010.

Since the 2010 eruption hit larger area about 3 – 10 km at western and southwestern and reached farthest 15.5 km at southern flank, it requires the revision of Merapi Hazard Map. The change of hazard maps as a base map of risk analysis led to the need for revision of the risk map, in addition as the dynamics of demography, infrastructure, socio-economic and community capacity to face the threat of future eruption of Merapi volcano.

Can Soil Suitability Curves Serve as a Possible Tool for Assessing post-eruptive Land Productivity?

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After a volcanic eruption houses can be re-built, damaged infrastructure be repaired and lost goods be replaced. The short-term recovery of arable land is much more complicated, time consuming and expensive, if even possible. In most cases, post-eruptive recovery measures for reclaiming the pre-eruptive productivity (e.g. the full removal of thicker ash layers or high-input farming) will not be applicable. Then the local population and administration should know to what extent they face a potential loss or reduction of soil productivity.

For evaluating to what extent traditional crops still can be cultivated or if newly introduced crop species or possible changes in land management practices are required to mitigate the consequences of an eruption, a new approach of easy-to-use soil suitability curves was developed in a case study for Mount Kanlaon volcano, Negros island, Philippines.

In a first step, a land suitability assessment of different ash-unaffected soils was done for several crop species. The calculated suitability indices were linked to real yield data of the study area. In a second step the suitability assessment was repeated with the same soils and crops but under the assumption of different ash coverage. The ash deposition scenarios varied in thickness and physical-chemical properties. In the next step new potential crop yields for each soil could be deduced from the change of suitability indices for the respective scenario. From it a simple crop-yield model could be developed.

In the final step, this model was transferred to a GIS where suitability indices were attributed to pedological land units characterized by a specific soil type. In combination with existing land-use maps and isopach-maps for the different scenarios it was possible to calculate post-eruptive crop yield changes for the whole study area.

With this simple approach, it is possible to estimate potential crop yield changes for the first time. But it has to be stated that this tool cannot deliver “hard” figures as to many variables determine potential crop yield. For a better accuracy, the implementation of a more detailed soil-crop-model and the calibration with real ash deposition and post-eruption yield data is planned.

Nutrient release from fresh volcanic ashes – a comparison study with ashes of the Merapi eruption in 2010

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Deposition of volcanic tephra represents an important element input to terrestrial and aquatic ecosystems (e.g. Frogner *et al.* 2001). Many ash-leaching experiments were conducted, mainly with the focus on short-term human- or environmental-toxicity, e.g. related to the immediate release of potential toxic elements into drinking water sources (Witham et al. 2001). For agricultural assessment of ash fall effects on land productivity, difficulties arise with the existing studies. The extraction procedure is not comparable to standard methods for determination of plant available nutrients since the used extractant (mostly H_2O_{deion}) in combination with a very short leaching duration comprise only the very mobile elemental fraction. In addition, to evaluate the potential beneficial impact on future crop yields the mid- to long-term nutrient release from volcanic ash has to be considered.

The aim of the present study was to compare nutrient release levels of volcanic ashes by using different extraction methods and to evaluate the importance for agricultural research questions. The experimental procedure proposed as reference by Witham *et al*. (2005) was chosen to represent existing approaches widely used in former ash leaching studies. On the other hand, methods for the determination of plant-available nutrients (NH_4-acetate exchangeable; modified RHIZO-approach after Feng *et al.* (2009)) and weatherable nutrients were used in combination with different extraction times. The analyses were performed with ashes from the 2010 eruption of Merapi, Indonesia. For this study 2 “unleached” (without contact to rain water) and 4 “naturally-leached” ash samples as well as one sample from a pyroclastic flow deposit at Gendol river valley were used. Sample collection took place right after, on day 3 and 30 after the last main eruption on 5/6 November 2010. Table 1 lists the used methods.

Table 1: Used leaching methods

method	extractant	solid-liquid-ratio	contact time	temperature
			hours	°C
Witham et al.	H_2O_{deion}	1:25	1.5 **+**	25
exchangeable	NH_4-acetate (pH 7)	1:30 (90)	0.25 (x 3)	25
“soil solution”	mix of LMWOAs	1:20	1.5 **+**	25
“artificial rain”	mix of HNO_3, HCl, H_2SO_4	1:20	1.5 **+**	25
weatherable	30 % HCl	1:5	1	> 100

LMWOA … low molecular weight organic acids; **+** … time-series with sampling at 1.5, 24, 48, 96 and 240 hrs.

For a single extraction step or the first sampling of the time series (at 1.5 h) respectively, analyses showed highly varying amounts of released elements for different ash samples within the same leaching procedure. The nutrient amounts extracted increased H_2O_{deion} < “exchangeable” < “artificial rain” < “soil solution” < “weatherable”.

Comparison of different extraction durations revealed that the major amount of an element exists as a soluble salt and was removed by the first extraction after 1.5 h, regardless of the extraction method. For longer steps the reactive strength of an extractant became more important. So the ability of LMWOAs to act as chelating agents led to a higher elemental release than with “artificial rain water” consisting of mineral acids.

Our results show that care has to be taken in choosing an extracting agent for leaching experiments. We do agree with the advantages of a standard leaching procedure for comparison purposes of different ashes. But for varying environmental research questions an adequate specific experimental design is still essential and has to be done additionally.

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Ash fall impacts on crop growth under the semi-arid climate of Argentina - a pot experiment with *Hordeum vulgare*

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In June 2011, a new eruptive phase of Puyehue volcano, situated in the Chilean Andes, started. Since then large areas of Chile and Argentina were covered with ash layers of varying thickness. Despite the fact that the currently ash affected areas were repeatedly covered with ash falls of eruptions of other volcanoes before, only little research was done about consequences of ash fall on crop growth under semi-arid climate. In addition, only few studies deal with the influence of volcanic ash on properties of the loess-derived soils of the Argentine pampa.

In the present study, the impact of fresh Puyehue tephra on growth of barley (*Hordeum vulgare*) cultivated in two Pampa soils was studied. Therefor a pot experiment was conducted for 6 weeks on the agricultural research station of Santa Rosa, Argentina. The experimental setup up consisted of two top soils with different fertility and different ash treatments. The treatments were

treatment 1: before germination 1 cm of ash on top

treatment 2: in plant development stage of three leaves 1 cm and 5 cm of ash on top

treatment 3: mixture of soil-ash in two different ratios and with two different soil types as growing media

The results show that in comparison with the controls, a reduction of biomass production could be observed. But the biomass production of plants grown in the more fertile soil was much less affected by any ash treatment than of plants grown in the soil with a lower fertility.

First chemical analysis revealed that soil chemical parameters like pH and electrical conductivity changed only slightly (not significantly) in all treatments. No inputs of salts or toxic elements due to the ash could be determined.

We concluded the differences in growth occurred mainly because of changes in physical soil properties due to a change of soil texture (water infiltration, water holding capacity) and a reduction of evaporation induced by the ash cover.

A Statistical Analysis of Temporal Trends in the Global Historical Volcanic Fatalities Record

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With at least 600 million people at risk from volcanic hazards, developing a bank of data covering volcanic eruptions and their impacts is a very useful resource in assessing and managing volcanic risk in future. We have combined and formatted databases maintained by the Smithsonian Institution, The Centre for Research on the Epidemiology of Disasters, Munich Reinsurance, and Witham (2005), in order to create a dataset that is as exact, reliable, and comprehensive as possible. A weighted average of the (up to) four fatalities figures for each fatal incident is used in numerical analyses. Based on the results of Furlan (2010), who presents a change-point model of the censoring effect in the recording of volcanic eruptions, we investigate only fatal incidents occurring in or after 1600 AD.

Our database covers the 410 years from 1600 to 2010 and details 533 fatal incidents that have caused a combined total of 278,880 fatalities, at 198 volcanoes across 38 countries. A wide range of statistical and graphical data exploration techniques have been employed, though focus here is on temporal trends.

The number of fatal incidents recorded over time is steady through the 17th and 18th centuries, then increases during the 19th and 20th. We attribute this to a combination of improved recording of volcanic events, along with real increases in the number of fatal incidents. Plotting the average number of fatalities per fatal incident over time shows a generally decreasing, though noisy, trend; an average of over 300 fatalities per fatal incident were recorded in the 17th century, falling to below 100 in the 20th. These observations are consistent with larger fatal incidents being relatively better recorded back in time, with improvements in the reporting of small incidents.

The accumulative increase in fatalities is dominated by a handful of large jumps, caused by rare fatal incidents causing many thousands of fatalities. The largest ten fatal incidents have caused 70% of all fatalities, but over half of all fatal incidents have caused 10 or fewer fatalities. Because of the distortion clearly introduced by including the largest disasters, we remove them from our analysis, and can then estimate an annual average number of fatalities, which is 200; this increases with time from approximately 95 to 300 fatalities per year.

We define a Volcano Fatalities Index (VFI) as the number of fatalities divided by the product of the number of recorded volcanic events (fatal + non fatal) and population, in a fixed time period; this value is then multiplied by 100,000 to give a rational range, and the largest ten disasters are removed. These normalisations should largely remove the effects of under-recording and population growth on the number of fatalities over time. Consequently, if susceptibility to volcanic hazards as measured by fatalities was only controlled by population and numbers of eruptions, then the VFI should be approximately independent of time if susceptibility remained unchanged.

We observe high and variable VFI values across the 17th and first half of the 18th centuries, likely due predominantly to poor data quality (related both to volcanism and to population); the reduction in the VFI over this period is probably therefore attributable ***to changes in reporting style and accuracy. However,*** the five-fold decrease seen from approximately 1800 onwards is likely a result of real decreases in populations' susceptibility to volcanic hazards. Such decreases are generally temporally linked to developments in the science of volcanology and improvements in societal resilience, and thus suggest the benefits of investments in disaster risk reduction are borne out by the fatalities record.

We hypothesise that had no progress been made in disaster and risk reduction strategies, the VFI would have remained constant throughout the 20th century. We have thus used the 1900 VFI value of 1.5 to estimate the fatalities that would have potentially occurred in the 20th century as a consequence of increased exposure due to exponential population growth. We estimate this number as 85,269, compared to the actual number of 31,728; improvements in hazard management as a whole have saved approximately 50,000 lives during the last 100 years. This figure is consistent with the known numbers of people evacuated prior to the eruptions of Pinatubo in 1991, Soufrière Hills in 1996, and Merapi in 2010 which destroyed previously-inhabited areas. ***This is prima facie evidence that science has had a major beneficial impact on disaster risk reduction.***

The scope of our results and conclusions drawn are bound by the limits of the underlying fatalities data. We have identified these weaknesses as: potential bias introduced by analysis of the fatalities population as a whole due to its heavy-tailed nature as a result of a few extreme events causing thousands of fatalities; under recording of fatalities and fatal incidents, as well as of volcanic eruptions as a whole; uncertainty in fatality figures. We have attempted to overcome the former two issues by excluding the largest disasters and normalising by numbers of fatal incidents, respectively.

Recommendations for the use of Public Communication Networks during Volcanic Events

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Introduction

During a volcanic event, Public Safety and Security (PSS) forces must ensure the safety of populations. Coordination is critical for the success of these operations, which may involve many participants: civil protection, military, government, local authorities and foreign entities. Coordination is often heavily reliant on Public Communication Networks, such as the Public Switched Telephone Network (PSTN), mobile telephone networks and the Internet. Volcanic activity monitoring, essential to the decision process, might also depend on these networks. During the volcanic event, when PSS forces need the communication infrastructures the most, these are under the greatest stress as they are also used by the population and may suffer damage from the volcanic event. This paper addresses these issues by presenting a set of recommendations that may be put into practice to increase the reliability of these infrastructures and make sure sufficient capacity is available to the PSS forces [1].

Ensuring capacity

Communications networks are designed to provide a limited capacity, which is calculate for normal usage conditions. During a volcanic event the network's capacity may be exceeded: the population will resort to the PSTN or mobile networks to reach their loved ones and enquire about their safety; the population may try to reach emergency services in order to request aid; authorities will establish their contact network in order to put rescue plans into practice. This over-usage or the destruction of parts of the network may prompt a network to crash, rendering it, or parts of it, unavailable. As such, emergency response and coordination should not rely on public networks.

When commercial networks are the only option available, capacity should be reserved for this purpose, avoiding contention with the general public. Calls from members of PSS forces should take precedence over other calls. A minimum capacity should always be available to permit fast call setup, which is essential for PSS forces [2].

Increasing reliability

The infrastructure that provides Communication Services may be destroyed during a disaster [3]. Damage may be caused by the several hazards caused by an eruption, such as lahars, heavy ash and magma flows. Increased resilience to volcanic events can be built into the network by the network operator and achieved by the users through the use of operator redundancy.

Wireless networks are the ones most likely to be used in volcanic areas, as they provide mobility. Network operators build these networks taking into account factors such as cost, demographics and signal propagation conditions. If risk maps are used to assess antenna (base stations) placement, these will be less likely to be destroyed. Also, the number of antennas may be increased in order to provide redundancy. These techniques will increase the installation and operation costs and might not be perceived by the operators as an advantage, but will increase the likelihood of the network being usable in a volcanic event. Battery capacity for backup power may also need to be increased, in order to keep providing service during the expected power outages.

Wireless networks may exhibit blind spots, areas where coverage is non-existent. These should be identified early through surveys. If possible network operators should extend their networks to eliminate blind spots.

PSS forces can be provided with access to several networks, as the probability of at least one being available is higher. The number of blind spots might also be reduced as different operators provide distinct coverage. This can be achieved by carrying several communication devices or e.g. by using dual-SIM mobile phones.

Satellite telecommunications are an alternative to land based infrastructure, albeit a more expensive one. Data and voice services are available worldwide, and handheld devices enable their mobile use. Satellite phones will provide full outdoor coverage.

There are also radio technologies which do not require a support infrastructure, such as classic two-way radios, or that take advantage of an infrastructure when available but continue to provide some service when the infrastructure is not available, such as Terrestrial Terrestrial Trunked Radio (TETRA) [2].

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Bayesian Event Tree For Long Term Volcanic Hazard Assessment: A New Plugin in a QGIS

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In modern volcanology one of the most important goals is to perform hazard and risk assessment of volcanoes near urbanized areas. Previous work has been done to assess volcanic hazard in the form of event tree structures containing possible eruptive scenarios. Probability methods have been applied to these structures to estimate the long term probability for each scenario. However, most of the existing event tree models show restrictions not only in the eruptive scenarios, as the possibility of having volcanic unrest triggered by other forces than magmatic, but also in a free, multi-platform, and user friendly applicability. In this poster, we present a new plugin for a qGis (Quantum GIS) software, based on a Bayesian event tree structure, to perform the probability of any particular area being affected by a desctructive volcanic event within a given period of time. The Bayesian event tree accounts for external triggers (geothermal, seismic) as a source of volcanic unrest and looks at the hazard from different types of magma composition and different vent locations (as opposite to a central vent only). Volcanic hazard assessment is an important step for risk-based decision-making in land use planning and emergency management. The main steps are the following: (1) Design an extensive tree-shaped Bayesian network with possible eruptive scenarios. (2) Build a Bayesian model to estimate the long term volcanic hazard for each scenario. (3) Build a new plugin in a qGis to create a user friendly evaluation. It permits to automatically update the probabilities when new data arrive or the system becomes active and monitoring data on precursors exist.

Tristan da Cunha: trialling expert elicitation for appraising eruption hazards in an ill-defined volcanic setting

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Expert elicitation sensu lato has been used for a long time as a means for compensating for unreliable or incomplete scientific information. In recent years a more formalized quantitative basis for weighting expert judgments about uncertainties has been developed using mathematical scoring rules to determine performance-based metrics. Structured elicitation of expert opinion was first applied to volcanology using this approach in 1995 when the present eruption of Soufrière Hills commenced. The application of this technique has subsequently evolved, but is still used successfully by the Montserrat Volcano Observatory, and for assessment of future activity at other volcanoes. A structured elicitation approach serves to drive discussion between scientists around substantial amounts of data where professional interpretation is inescapable, and helps engender clarity of thought and reasoning about uncertainties. The so-called rational consensus that can be provided by this procedure is seen as invaluable for decision support and encourages the creation of 'one voice', thus alleviating any ostensible indecision amongst scientists.

Unlike Montserrat, Tristan da Cunha (South Atlantic) is an active volcano, currently with a poorly defined eruptive record and little or no effective monitoring capability. The last eruption in 1961 prompted a temporary and traumatic evacuation of the island's whole population. In common with many other poorly defined volcanic settings, contingency measures and mitigation plans are needed for responding to future eruptive activity, but this requires consideration of the range of plausible eruptive scenarios and potential hazards – within a context of considerable scientific uncertainty. One of the goals of this project was to examine the suitability and applicability of expert elicitation in a data-impoverished setting. Such knowledge, as exists, of activity at this volcano was compiled along with a needs assessment of information required by islanders and administrators, both on and off island.

The expert elicitation was conducted via a structured protocol known as the 'Classical Model' (Cooke & Goosens, 1999), customised for the Tristan hazard assessment problem by focussing on questions designed to inform civil contingency planning. Elicitations were conducted individually and in small groups in October and November 2010 among 18 UK-based experts with a variety of expertise in volcanology.

Results showed that experts are highly uncertain about whether unrest would lead to an eruption; and the likely location of future eruptions on Tristan. 'Rational' consensus was reached via a synthetic 'decision maker', which considered the most likely location of the next eruption to be the low-lying coastal strips. This has hazard implications for the islanders who reside on these coastal areas. However, the associated uncertainty around each scenario was very large (between 73-86%). The severity of this uncertainty fails to justify the suitability of this approach to decision making on-island, in terms of eruptive scenarios. However, the acknowledgement of this severe uncertainty does not indicate a failure of the exercise, but rather an objective expression of the existence and significance of that uncertainty. The results also demonstrate the need for broader and deeper understandings of incomplete knowledge, requiring different approaches that complement quantitative risk analysis.

Further, appraisal of the procedure itself highlighted some important considerations for future application of expert elicitation to volcanological problems elsewhere. Particularly in terms of the Classical Model calibration process which rewards experts for good statistical distribution characterisation over a set of calibration questions, at the expense of precision of knowledge (Fig. 1). Other expert weighting methods exist; however, the choice of approach is dependent upon a needs assessment of the decision maker, in terms of whether they want experts that are skilled in assessing the degree of uncertainty within their knowledge domain, or experts with knowledge that is best reflected by precise answers. Presented results also highlight the possibility that experts can learn how to achieve better calibration scores, and tentatively imply that experts with particular areas of expertise (especially monitoring) achieve higher scores.

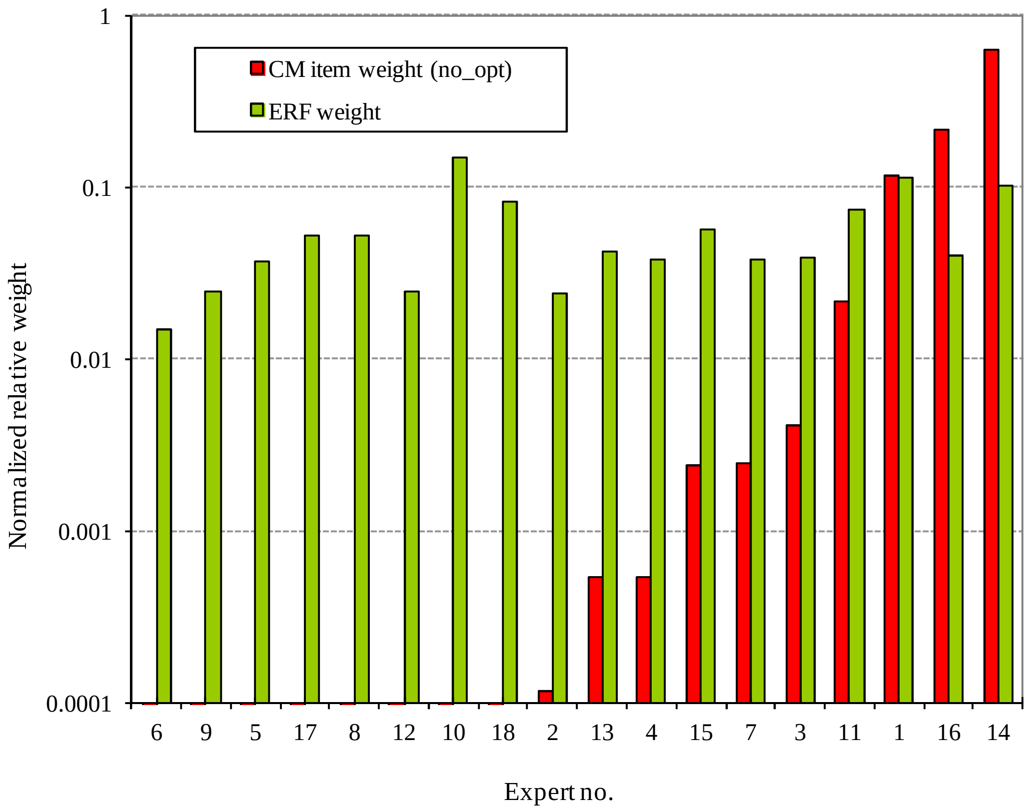


Fig. 1. A comparison of expert calibration scores derived via the Classical Model (CM) and the Expected Relative Frequency (ERF) approach devised by Flandoli et al., 2011. The normalised weights

for each expert have not been reduced in calibration power, hence experts 6-18 appear to have a zero weighting. The ERF score profile is less discriminatory within the group: the ratio of highest weight to lowest is about 10x, whereas the CM presents several orders of magnitude difference between top and bottom weights. Note that experts 1 and 14 appear among the top three under the ERF model as well as the CM, but expert 10 - the top ERF scorer – has a negligible CM score.

Mitigate and Assess risk from Volcanic Impact on Terrain and human Activities: the FP7 MIAVITA project

P. Thierry, A. Vagner, M. Fontaine and MIAVITA team

Volcanic eruptions are one of the most impressive, violent and dramatic agents of change on Earth. Volcanic emissions (gas and ashes) can widely affect human health and disturb air-traffic and little is known about their impact on agriculture. Some phenomena constitute therefore a multi-level threat to human societies and environment. Nevertheless, soils fertility, amongst other characteristics, often attracts populations, which settle on volcanoes flanks, creating, by the conjunction of hazards and population, conditions to high risks areas. Assessing and managing multi-hazard and multi-risk at volcanoes require the combination and coordination of many capabilities and instrumental techniques, and involve expertise in many various fields such as volcanology, social sciences, physics, signal processing, data analysis, agriculture and telecommunications… It needs also a strong experience in crisis management.

In EU countries, volcanic risks assessment and management are tackled through scientific knowledge and monitoring, although there is still a need for integration between all risk management components. For international cooperation partner countries (ICPCs), the risk management depends on local situations but is often less favourable. Therefore, following UN International Strategy for Disaster Reduction recommendations and starting from shared existing knowledge and practices, the MIAVITA project aims at developing tools and integrated cost effective methodologies to mitigate risks from various hazards on active volcanoes (prevention, crisis management and resilience). Such methodology has been designed for ICPCs contexts but will be helpful for European stakeholders to improve their experience in volcanic risk management. The project multidisciplinary team gathers civil protection agencies (French – DGPCGC and Italian – DPC), scientific teams in earth sciences – BRGM (F), INGV (I), IST (P), University of Cambridge (UK), NILU (N), social sciences – CNRS (F), soil and agriculture – Hohenheim University (D), Information Technologies and telecommunications – INESC-ID (P) and an IT private company – KELL (I).

The objectives are being reached through sharing/transfer of know-how, through scientific and technological developments, and through dissemination/training, and with the help of local scientists and stakeholders in Africa (Cameroon - MINIMIDT, Cape Verde – INMG) and in Asia (Indonesia – CVGHM, Philippines – PHIVOLCS).

The scientific work focuses on:

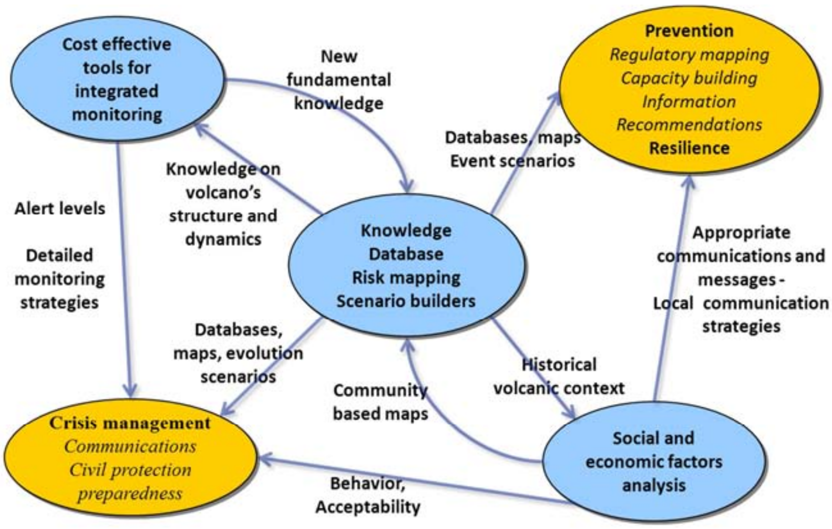
1) Risk assessment methodology based on a multi-risk approach developed at Mt Cameroon by BRGM in cooperation with Cameroonian institutions and on a decision tool already applied by CVGHM at Merapi;

2) Cost efficient monitoring tools designed for poorly monitored volcanoes (satellite+gas analysis+volcano-seismology);

3) Improvement in terms of vulnerability assessment (people, buildings and agriculture);

4) Socio-economic surveys to enhance community resilience;

5) Integrated information system (data organisation and transfers, communications) taking advantage of GEONETCast initiative.



MIAVITA conceptual frame

One of the main outcomes of the project is the final book, or handbook, on MIAVITA's experience on volcanic threat assessment and management, designed to help decision makers and stakeholders involved in volcanic risk management to handle all its aspects: prevention, crisis management and resilience.

Thanks to the contribution of all its partners through common thoughts and studies, the MIAVITA project constituted a good opportunity to identify a list of minimum standards relevant for risk management in any geographical, geological and socio-economic situation in the context of an active volcano. This work is based on the scientific state of the art and the shared experience of the different partners as well as on identified international best practices.

In particular, the goal is that any country, whatever its economic level and even with low basic knowledge about volcanoes, can identify, with the help of this handbook, suggestions for tackling the situation (monitoring, preparedness, prevision and resilience).

The principle is to present an overview of all needed information to help decision makers set up technical and organisational frame for integrated volcanic risk prevention and crisis management. Ideally, the handbook aims at constituting a bridge between the different stakeholders and Authorities involved in risk management and Scientists, improving interactions among them.

The MIAVITA project is financed by the European Commission under the 7th Framework Programme for Research and Technological Development, Area “Environment”, Activity 6.1 “Climate Change, Pollution and Risks".

Youth education to increase preparedness and awareness for volcanic hazards

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Improving hazard mitigation for volcanic eruptions is especially in global south countries a difficult task. One of the keys to improve the awareness of people for volcanic hazards is better education. Here we present a tool that could be used in educating young children (ages 6-12) to better understand the dynamics of volcanic eruptions. Intimately connected to the dynamics of eruptions is the regional dispersion and deposition of volcanic ash that destroys the infrastructure as well as farming products and is the major source of many health problems, especially of the respiratory system. Physically the transport of ash is tied to the so called mass flux of the gas ash mixture at the vent. The simulation tool (for details see Glaze et al., 1997) that was developed allows the user to enter parameters like eruption velocity, crater size, and amount of volcanic gases involved. The program then calculates the rise height of the eruption column, the lateral extend of the eruption column as well as its average temperature. The results are all displayed graphically in terms of real eruption clouds so that the user can easily assess the impact of such an eruption. Using this tool people may develop a sense for what controls the rise height of volcanic eruptions and how a potential eruption of a nearby volcano might look like.

Having such a tool is one point, being able to properly communicate and use it in terms of educating people is another, much more complex issue. The main goal of this education is to provide basic insight into volcanic dangers and a proper definition of terms independent of local cultural and social-economic background. This requires a cooperation of researchers, politicians and the affected people that is usually subject to communication problems.Trying to understand the constitution and effectiveness of the communication between these different people we use a systems-theoretical approach. Because what is reasonable for the subsystem “science” it is not necessarily reasonable for the subsystem “policy”. Moreover, what is reasonable for the subsystem “German society” with regard to volcanic eruptions will most likely not be adequate for the subsystem “Indonesian society”.

We combined the outcome of this analysis with the simulation tool to develop a teaching unit to make children more aware of the danger of eruptions. Increasing the awareness of a population at early age will change their view of natural events making them later on more receptive to arguments and alerts of scientist and politicians.

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MEDiterranean SUpersite Volcanoes: the FP7 MED-SUV project

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MED-SUV project will improve the consortium capacity of assessment of volcanic hazards in Supersites of Southern Italy by optimising and integrating existing and new observation/monitoring systems, by a breakthrough in understanding of volcanic processes and by increasing the effectiveness of the coordination between the scientific and end-user communities. More than 3 million of people are exposed to potential volcanic hazards in a large region in the Mediterranean Sea, where two among the largest European volcanic areas are located: Mt. Etna and Campi Flegrei/Vesuvius. This project will fully exploit the unique detailed long-term in-situ monitoring data sets available for these volcanoes and integrate with Earth Observation (EO) data, setting the basic tools for a significant step ahead in the discrimination of pre-, syn- and post-eruptive phases. The wide range of styles and intensities of volcanic phenomena observed on these volcanoes, which can be assumed as archetypes of “closed conduit” and “open conduit” volcano, together with the long-term multidisciplinary data sets give an exceptional opportunity to improve the understanding of a very wide spectrum of geo-hazards, as well as implementing and testing a large variety of innovative models of ground deformation and motion. Important impacts on the European industrial sector are expected, arising from a partnership integrating the scientific community and SMEs to implement together new observation/monitoring sensors/systems. Specific experiments and studies will be carried out to improve our understanding of the volcanic internal structure and dynamics, as well as to recognise signals related to impending unrest or eruption. Hazard quantitative assessment will benefit by the outcomes of these studies and by their integration into the cutting edge monitoring approaches thus leading to a step-change in hazard awareness and preparedness and leveraging the close relationship between scientists, SMEs, and end-users.

MED-SUV has entered into negotiation with the European Commission in July 2012. It shall start by the end of 2012 for a duration of 3 years.

What creates vulnerability? Systematically identifying key social and structural factors in Cotacachi, Ecuador

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If resilience is the measure of how able a community is to mitigate the effects of a natural disaster, then the inverse is vulnerability: the measure of a community's inability to resist the effects of disaster. Disaster risk reduction (DRR) is the process of transforming a community from vulnerable to resilient, yet too many DRR efforts focus on drafting plans to create resilience without first adequately assessing risk factors for vulnerability, inevitably resulting in ineffectual policies that can take years to rectify. This case study argues that comprehensive assessment of vulnerability risk factors is a requisite first step in DRR and also shows that vulnerability in any given community results from an amalgamation of social and structural inadequacies that can be methodically identified and prioritized in order to formulate location-specific and demographically targeted contingency plans.

Cotacachi, Ecuador, is a town with a population of around 15,000 permanent inhabitants, plus a significant population of expatriates and tourists. It lies in a valley east of the Laguna Cuicocha Volcanic Complex (LCVC) and is built upon an ignimbrite from the last cataclysmic LCVC eruption, about 3100 years ago. Prior to the 1980's, the LCVC was assumed to be extinct, but seismic swarms in the last 3 decades forced scientists to reconsider. Now, while scientists race to learn about the eruptive history and character of the volcano, at-risk communities struggle to develop preparatory and mitigation protocol due to a lack of local experience with volcanic hazards.

This study separated risk factors in Cotacachi into two categories: social (e.g.: income, language, religion, etc.) and structural (e.g.: infrastructure, buildings, etc.). Choosing structural factors is relatively straightforward: any physical part of a community becomes relevant. Social factor relevancy varies by study location, they could number in the dozens, but selection of only the most pertinent factors is critical for avoiding convolution. Factors in Cotacachi were selected based on their propensity to affect: perceptions and cooperation between sub-demographics, communications, resistance or ability to change, and access to tangible or intangible resources.

Social risk factors were observationally assessed based on a Semi-Ethnographic Approach (Lane 2003; Haynes *et al.* 2007). The objective was to identify sub-demographics with which people strongly identify, and subsequent contrasts which might hinder DRR activities due to impediments to communication, change, or cooperation. Through six weeks of informal and semi-formal interviewing, what was observed is that social factors converge upon one factor in particular: cultural identity (indigenous, Ecuadorian, or foreign), which can predict other outcomes (religion, income, language, etc.) and provide a summary of viewpoints and likely actions in the face of disaster.

Structural factors were assessed using a comprehensive Systems Analysis Approach (Sword-Daniels 2011) while conducting a grid-patterned walking and GPS survey of the town. No singular "convergent" or primary factor was deduced, although it appears significant to DRR efforts to note that laymen assemble buildings and electrical connections, unregulated by any accepted standard of integrity.

Accepting that DRR policies must be formed with consideration to the idiosyncrasies of a specific location, then identification of specific risk factors is a pre-requisite for further DRR work (Tobin and Whiteford 2002). Now that the primary and secondary social and structural risk factors in Cotacachi have been identified, the first steps can be taken towards customizing DRR efforts for the town and its people. Further assessments should include the degree to which each factor effects cooperation, communication, and change, and ideal methods for communication with and amongst sub-demographics. With all risk assessments in order, plans can finally be made for how to address vulnerability risks in Cotacachi and bring the community closer to a state of resilience.

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Recent Research Activities for Potential Volcanic Risk in Korea

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In 2010, a series of volcanic eruption of Mt. Eyjafjallajokull in Iceland put a hold on the air travel in the continent of Europe and affects all over the world. Besides this direct impact, numerous indirect effects were found from the aftermath. In January of 2011, another series of eruption from Mt. Shinmoedake, Kyushu, Japan also alerted Japan and the world. With these series of events, the reports from Chinese seismologists since 2002 have drawn an attention and initiated discussions on the possibility of the eruption of Mt. Baekdu which is located on the border of North Korea and Machuria, China. It was found that Mt. Baekdu has history of eruptions more than 10 times since 10th century and its strongest one in 10th century was believed to be about 1000 times that of Mt. Eyjafjallajokull.

Unlike Japan that has active volcanoes more than 100 and eruptions of various size every year, Korea has thought of belonging to volcanic risk free zone; however, the global effects from the eruption of Mt. Eyjafjallajokull and the possibility of the eruption of Mt. Baekdu initiated the scientific study on volcanic risk and mitigation in Korea, which leads to the establishment of Volcanic Disaster Preparedness Research Center (VDPRC), Korea in 2012. VDPRC has recently initiated research programs in various aspects including (1) development of volcanic risk assessment and (2) mitigation measures, (3) development of response and preparedness system based on IT and (4) international collaboration program.

The eruptions of volcanoes may be either effusive or explosive, and Mt. Baekdu is likely explosive, based on the eruption records. There is a strong possibility that pyroclastic density current and flood in larger scale can devastate the region of China and North Korea close to Mt. Baekdu. And the waters over 2 million tons in the caldera of Mt. Baekdu would make the explosion fiercer, would generate volcanic ash plume of larger and denser scale. Once it happens, the ash can sweep the part of Korean peninsula and travel across the East Sea to Japan and to the Pacific.

Other than Mr. Baekdu and many volcanoes in Japan, China also has several active volcanoes on the region close to the eastern coast of China, which are potential hazard to North-East Asia region; however, the study regarding the effects of volcanoes in this region has not been closely investigated.

Therefore, it is very essential to establish the international collaboration and the cooperation in the research of volcanic risk in North-East Asia.

Block VI

Session 5: Information Management and Decision Support

Chair: Surono

Development of a scenario builder tool for volcanic risk assessment and application to Mount Cameroun

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One of the objectives of the MIAVITA project is to develop a conceptual frame for the risk assessment of inhabited areas exposed to various volcanic hazards. The present communication aims at presenting a scenario-building tool that would take into account the succession of volcanic, seismic, gravity and hydro-geological events and, consequently, analyse the impact of such events on people, physical elements (e.g. buildings, agriculture) and various functional systems composing the exposed community.

As several scenario software tools are available in the field of seismic risk, such an approach proves less straightforward in the case of volcanic risk: the main difficulty resides in the crossover of several types of geological phenomena and exposed elements, each combination of them usually relying on specific damage mechanisms. Therefore, before building a risk assessment tool, the first step comprises the careful definition of all damaging phenomena, damage mechanisms and exposed elements that may be potentially involved in a volcanic eruption. For the analysis of complex systems of components, the object-oriented paradigm is a convenient approach and enables to clearly represent the hazard phenomena and the vulnerable elements as a set of well-structured *classes* that are assigned specific *attributes* (i.e. properties) and *methods* (i.e. functions): such an approach has been previously used in the frame of a seismic risk analysis (Cavalieri et al., 2012) and has been adapted to the case of volcanic, by adding new hazard classes and damage mechanism corresponding to the specificities of volcanic risk. The definition of classes of objects is then used to draw UML (Unified Modified Language) diagrams that represent the successive steps of a risk scenario computation, from the definition of the hazard phenomena to the estimation of physical and functional damage of the exposed elements.

A software tool developed by Cavalieri et al. (2012) in the frame of the SYNER-G FP7 project has been used as the “core engine” for the MIAVITA scenario-builder tool: the changes that were implemented enable to compute the impact of several volcanic events on a wide range of exposed elements (e.g. buildings, lifelines, road network, cultivated areas, emergency centres…). A non-negligible feature relies also in the ability to build a scenario composed from different successive volcanic events (e.g. tephra fall, pyroclastic density current, debris flow, lahar…), thus adding a temporal dimension in the computation. A few probable scenarios have been elicited for the Mount Cameroun area and they were implemented in the risk assessment tool in order to get a robust and quantitative estimation of the impacts of different volcanic events. Using sets of fragility curves previously compiled by Jenkins & Spence (2009), the software tool yields probabilistic results for some indicators such as the number of casualties or collapsed buildings, the area of damaged cultivated fields or the connectivity loss in the road network.

The MIAVITA and SYNER-G projects are financed by the European Commission under the 7th Framework Programme for Research and Technological Development, Area “Environment”, Activity 6.1 “Climate Change, Pollution and Risks"

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Communication and Volcanic Disaster Management: A case study of Mount Cameroon

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Communications are a major, vital and unavoidable component in disaster management and in any emergency. Communication systems as radio, TV and telephone can be easily disrupted during a volcanic ash fall, landslide, flood, earth tremors and may even fail completely. Much more important, communications used during a crisis scenario, if not properly coordinated, may render all the related emergency activities useless. This study helps to improve the strategic planning and coordination of the communication among the several stakeholders during disaster outbreaks, reducing rumour mongering/alarmist-information, and increasing stakeholders' credibility in disaster management/monitoring.

The coverage of this study is multi-organisational, including the main communication structures operating in the Mount Cameroon area, South West Region of Cameroon.

This study, carried out from June to July 2011, in the Mount Cameroon region, in the framework of the MIA VITA project, reveals that disaster communication is under the coordination of the Committee on Disaster Management for the South-West Region. The committee uses various means of communication to exchange information with the various task forces. These means of communication range from cellular, fixed phones, Internet to correspondences, hand mail, press release, conferences to group discussions. They can instantly benefit from advanced communication systems like satellite communication from the army as well as transportation systems via helicopters and boats. However, most of the task forces that constitute this committee are not equipped with direct satellite communication systems and rely on cellular phones whose antennae and cables are apparently vulnerable to disasters. No Amateur Radio was identified and satellite phone was still very rarely used except by few operators like TV operators, telephone and Internet operators who use it for in-service needs or quite occasionally. Certain communication structures were in themselves potential victims to disaster outbreak like landslide because they are constructed on top of high hills. Communication operators are highly implicated in disaster communications and could take prompt initiative to cover and communicate on disasters. The main difficulties faced by these operators are the vulnerability of the equipment they use, lack of protective devices and means of transportation coupled with the poor road network. Another major problem revealed by the study is that virtually 95% of communication operators in the study area never received training on how to use communication during crisis event. The western end of the mountain like Idenau and the behind part of the mountain like Bomboko villages are not reached by local and national radio stations' signals. Only foreign stations like RFI, BBC or Radio Malabo are being successfully tuned there.

The Use of the REDAS Software for Volcanic Disaster Mitigation: the Canlaon Volcano Experience

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Local government officials need to be equipped continuously with tools and knowledge on how to better address volcanic hazards. This situation becomes more crucial in developing countries like the Philippines, especially in its rural areas, where technology development could sometimes take time to catch up. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) earlier developed an earthquake hazard simulation software called the "**R**apid **E**arthquake **D**amage **A**ssessment **S**ystem" (REDAS). It can simulate earthquake hazards such as ground shaking, liquefaction, earthquake-induced landslide and tsunami. The REDAS software has since developed into a multi-hazard tool by being able to display volcanic and hydrometeorological hazards. Elements-at-risk are also built in the software enabling users to view the risk data vis-à-vis the hazards. Since 2006, PHIVOLCS has trained 31 provinces, 204 cities/municipalities and ten government institutions on the use of the software as a tool for mainstreaming disaster risk reduction into development planning process. A key part of the REDAS training module is teaching the participants how to build their own database using GPS or ordinary local maps.

As part of the MIA-VITA project, the REDAS software was provided to towns and cities around Canlaon Volcano. Invited participants to the five-day training were the city planners and disaster risk reduction officers. The software allows the users to view their hazards and overlay population centers. A workshop allowed them to identify the key land uses and identify problems and possible solutions. By seeing the spatial expanse of the hazards in their communities, local officials see a holistic view of the problem. In the exercise, the local officials of the cities of Canlaon, Murcia, Bago and La Carlota identified the following solutions to volcanic hazards. For example, the City of La Carlota offered solutions such as the importance of public information and education campaigns and the plan of putting up of signage and markings on volcanic danger zones. On a provincial level, for example, the province of Negros Occidental where more threatened communities are located have offered the following proposed actions: 1) close coordination between emergency responders and planners, 2) conduct of community assemblies, 3) conduct of drills, trainings and continuous review of plans, and 4) establishment of early warning system. The proposed actions are: 1) continued and sustained advocacy, 2) tapping mass media for public information and education, 3) Capability building and 4) putting up effective communication system to enhance the warning setup.

The provision of this tool is the first step in capacitating the local government units in the Canlaon Volcano area. However, future coaching is suggested to guide them on other possible solutions. Letting the results sink in is a prelude for these officials in volcanic hazard-prone areas to re-think current land use plans and together with neighboring communities and their provincial government, explore possible solutions to volcanic threat. Convincing them is easy because the software helps them visualize the real threat easily.

For the REDAS software, future development includes possible inclusion of volcanic, rain-induced and flood hazard simulation. An important REDAS module is the module developing the exposure database of a particular community. Fragility curves related to earthquake, flood and severe wind for the Philippines are presently being developed by the Philippine engineering community and the results will be used to enhance the multi-hazard risk assessment capability of REDAS.

How can information systems help in volcanic risk management?

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Efficient volcanic risk management requires prevention, crisis management and recovery tools that enable users to assess risk during the rest period, to optimize response capabilities during the crisis and to help for recovery after a disaster. Within the MIAVITA project, we investigated how two types of information systems can help in volcanic risk management: (1) WebGIS, designed to enable users to visualize a very complex database of volcanic and geological hazard and risk maps and (2) scenario builder tools intended to assess the potential damages induced by a hypothesized adverse event. The concepts tested within this study were tested over the Mount Cameroun Area, taking advantage of a previously undertaken field survey and hazard mapping study (Thierry et al., 2006).

WebGIS are intended to provide users not familiar to GIS tools with the possibility to visualize the content of a complex database. Key users requirements here relate to the need for a structured and flexible GIS-database, but also to the need to manage user's privileges differently according to their profile, the status of the volcano and the capabilities of the system to manage queries. Finally, different status for data is acknowledged, from data than can only be interpreted by experts (e.g. some complex remote sensing products) to data that can be disseminated to any users (e.g. a regulatory hazard map). The tool developed by KELL was based on open source resources. While the developed tool is able to provide users with enough flexibility to respond to the users' requirements, it is necessary to own expertise in WebGIS to manage such tools in the long term in local volcano observatory.

Unlike the seismic risk for which the main obstacle to the development of scenario-tools is the complexity of the damage functions of the building to a peak ground acceleration, the volcanic risk scenarios face three specific challenges: (1) human and economic damage are not only related to the collapse of buildings, but to a large number of geological phenomena (lava, pyroclastic flows, landslides, lahars, etc ...) that can affect a multitude of exposed assets (people, building, agriculture, large regional functions…) (2) the many features of damage to integrate into a tool are also very heterogeneous and are poorly constrained by observations, (3) the tool should be able to take into account a multitude of successive or simultaneous events during the sequence of an eruption. The temporal dimension of the event is thus more complex than in the case of an earthquake scenario tool. Finally, such tool is only able to address direct damages and will hardly provide any useful information with respect to potential indirect damages such as for example diseases due to water supply disruptions.

These investigations undertaken within the MIAVITA project suggest that information systems can provide authorities and users not familiar with GIS with useful information that can help assessing the risk, but also to prepare for potential future crisis.

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The Durations of Icelandic Volcanic Eruptions: Controls and Forecasts

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The 2010 Eyjafjallajökull eruption in Iceland rapidly gained notoriety when it disrupted air traffic over western Europe, resulting in an economic loss of approximately two billion Euros (Gislason et al. 2011). At the time of the eruption, the questions “How long will this disruption last?” and “When will the eruption end?” were commonly asked, highlighting a need for further research into the durations of volcanic eruptions. This work uses historical well-documented Icelandic eruptions to further our understanding of the factors controlling eruption duration and aims to devise a model that can be used to forecast the likely duration of future eruptions in near real-time.

Iceland is situated on a spreading plate boundary between the American and Eurasian plates, causing a zone of active rifting across the country. Volcanism on Iceland is a manifestation of this tectonic setting along with its interaction with the Iceland mantle plume, meaning volcanic activity is diverse, and includes nearly all volcano types and eruption styles known on Earth (Thordarson & Höskuldsson 2008, Thordarson & Larsen 2007).

A dataset of historic eruptions with well-documented start and end dates has been compiled for Iceland and the eruption durations have been investigated. The dataset was separated into basaltic and non-basaltic activity and then further into eruptions characterised by purely explosive activity, purely effusive activity and those that are a combination of the two (Thordarson and Larsen’s (2007) mixed eruptions). Based on this we found that the distribution of observed durations varies with the style of volcanic activity and is affected by the position of the volcano in relation to the actively spreading rift zone. Specifically, 56 % of basaltic eruptions from volcanoes situated inside the rift zone lasted less than 10 days compared to only 6 % of those from volcanic systems situated outside this rift zone (Figure 1). The main difference between these settings is the crustal properties; the crust inside the rift zone is younger, hotter and thinner than the crust outside the rift zone. Such variations may reflect a petrological control on eruption durations.

A statistical forecasting model has been developed that fits theoretical distributions to the observed duration data and uses survival analysis to state the probability of a current or future eruption having a duration equal to or greater than a specified time. Preliminary results of this model are promising, however the 95 % confidence intervals calculated for the results are currently large, indicating that further work is required.

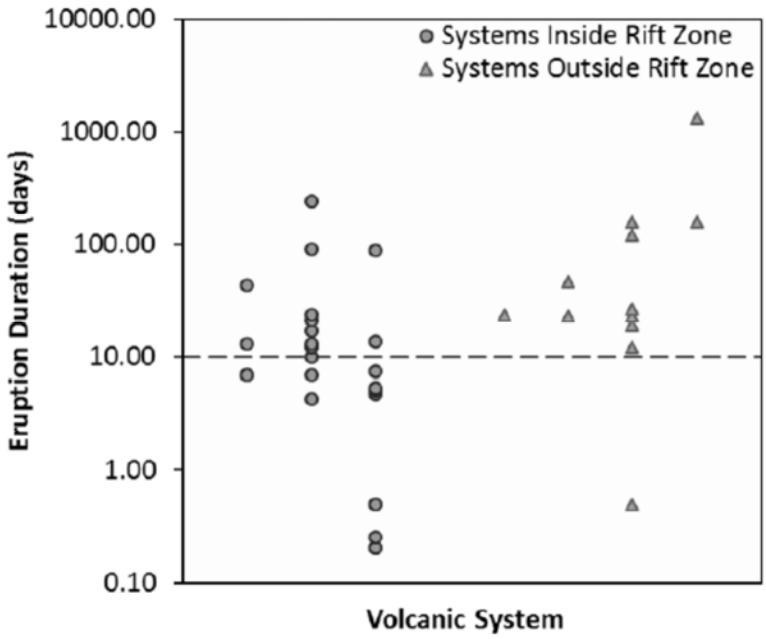

Figure 1: Plot showing variations in the distribution of volcanic eruption durations from volcanic systems situated inside (circles) and outside (triangles) of the active rift zone on Iceland. Dashed line represents eruption duration of 10 days.

In conclusion, variation in Icelandic volcanic eruption durations has been found on a regional scale indicating a possible petrological control on eruption duration. A statistical eruption duration forecasting model with promising preliminary results has been developed. This model could be applied to other active volcanoes around the world once reliable duration datasets have been compiled and will greatly benefit emergency response planning.

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Monitoring Volcanic Gases and Particles using Infrared and Ultra-Violet Imaging Cameras

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Emissions of volcanic gases and particles cause serious health and ecological hazards to communities living near restless volcanoes. Because of the inherent risk presented when attempting to make quantitative measurements at volcanoes, remote sensing has become the tool of choice. Recently, rapid sampling wide field-of-view imaging cameras have become available for measuring SO_2 and ash particles. These cameras operate in the infrared (8–12 µm is typical), and the ultra-violet (280–340 nm) and can provide mass loading estimates of gases and particulates in erupting and dispersing volcanic plumes. The rapid imaging capability permits estimates of plume rise rates–useful information for plume models used to forecast the movement of volcanic emissions. Spectral sampling is achieved by using filters placed in front of, or behind the camera lens, and allows discrimination of gases (water vapour and SO_2) and quantification of ash mass and effective particle size. These data are useful for assessing health (e.g. respirable particles) and for estimating volcanic source-term parameters (e.g. mass eruption rate) for input to dispersion models.

Results are presented from several different volcanoes where gases and particles are abundant and discussed in the context of volcanic hazard mitigation and warning. These novel instruments may be used at restless volcanoes to complement other measurements (e.g. seismic, infrasound), as quantitative webcams, to provide initial conditions for models and for use in validating satellite data.

Analysis and Prevention of Natural Hazards in DRC: A United Nations (U.N.O.P.S.) Pilot Project

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The creation by the UNOPS of a “Hazards Management Unit” in Eastern Congo is the first project completely dedicated to Natural Disasters Management by the United Nations. In particular, the city of Goma is considered, in function of the several natural hazards existing in and around the city, as the most dangerous place to live in the world. The exponential increase of its population (250,000 in 1995, 400,000 in 2002 and 1,100.000 in 2011), the complete lack of infrastructures and city plan, make the city prone to any kind of disaster. The 2002 eruptive event of Mount Nyiragongo destroying part of the city (only 13%) and leaving 130,000 homeless is just one example. Obviously the city is fast growing and expanding towards the volcano.

The U.N. “small” team has first of all identified the different hazards existing all around the region: namely volcanic, seismic, deadly ground-soil CO_2 gas emanations (locally called “mazuku”), rain-plume interactions giving origin to extremely acid rains (up to pH 1), naturally poor water quality and finally the existence of a “killer lake”. All these treats will be discussed during the talk, explaining the different interactions between people and the local environment.

The project must (i) support the local volcano observatory (GVO), through institutional, technical and scientific support; (ii) facilitate and sometime supporting the coming of international scientists in DRC, whose projects fit the needs of the GVO or the stage abroad of GVO scientists; (iii) correctly a clearly informing local authorities and humanitarian agencies and ngo's about the current activity of the volcanoes/earthquakes/lake; (iv) to produce and apply a “Contingency Plan” for the city of Goma in function of different eruptive scenarios; (v) to produce thematic hazard maps to be distributed to local autorithies and humanitarian agencies; (vi) to start a didactic project in primary and secondary schools to “how to live with active volcanoes” and (vii) producing a complete inventory at regional scale of the different hazards present in the area.

One of the major problem is the difficulty to get funds (1,5-2,0 M USD/year), the search for donors, to increase the understanding that PREVENTION is more important than RESPONSE and how to assure and produce a certain visibility to donors through reports and results. The other problem is the volatility of the security in eastern Congo and especially in the city of Goma, that makes extremely difficult the work at any possible stage, from field work to the security of the seismic and ground deformations stations.

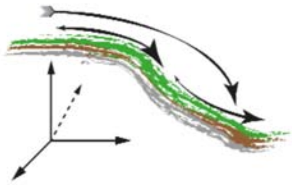
The UNOPS Project in Goma is a pilot project that should/could be reproduced all over the word in developing countries through the agreements between international agencies/ngo's and political (civil Defence) and scientific institutions working in major geo-hazards.

Upcoming Events

Soil in Space and Time
– Divisional Conference of all Commissions and Working Groups of IUSS Division I

Date: **September 30th – October 4th 2013**

Venue: Ulm University, Germany



More information: https://iuss-division1.uni-hohenheim.de

20th World Congress of Soil Science (WCSS)

Date: **June 8 – 13th 2014**

Venue: Jeju, Korea

More information: http://www.20wcss.org/

Location Plan