A lengthy volcanic crisis becomes a way of life: The 14 year eruptive process of Tungurahua Volcano, Ecuador

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The successful handling of the Tungurahua fourteen yr eruptive process is due to many factors. Monitoring started by the Insituto Geofisico a decade before the 1999 reactivation and continues. The conjoined long-term participation by IG scientists in monitoring and volcanic studies has provided an institutional memory and a thread of knowledge that is referential for making critical decisions on volcanic behavior. IG scientists, well-recognized in the community and by officials are also key contacts for conveying volcano information and for listening to concerns and the perspectives of local people. IG monitoring operations are conducted from the Tungurahua Volcano Observatory, OVT, located NW of the crater and also from the main IG office in Quito. OVT has a senior scientist and assistant who make daily diagnosis of eruptive activity, foster incoming data streams and monitoring systems, participate in emergency committee meetings, give press interviews, and provide advice to local authorities when eruptive activity increases. Some local farmers and community members have been selected as volunteer volcano observers, vigias. All participated in briefings by OVT on volcano monitoring practices and also get yearly updates at IG and SNGR-sponsored workshops. Some vigias have served for over a decade and their observations are well-trusted. Communication by UHF radio system permits observations of vigias to be recorded and compared with instrumentally-derived data. Mayors and SNGR personal also interact with OVT via this radio system. Vigias also help with installation of IG geophysical stations, their upkeep and security and at some sites they measure ash thickness and weight. The vigias are local referents on volcano issues and they are a fundamental link between OVT and local residents since they pass along critical information during crises and facilitate evacuations. The long-term eruptive activity has varied between VEI 1 to 3 levels, generally allowing the continuance of agricultural and other economic activities. Keeping the attention of authorities and the population has been aided by on-off eruptive cycles of 4 month intervals over the past few years. Instrumentation upgrades have been achieved in collaboration with JICA, USAID, NOVAC, the SNGR, the Ecuadorian NSF and cooperation with French IRD scientists provided high-quality modeling of PDCs. Incorporating data from BB seismic stations, cGPS, tiltmeters and DOAS has refined eruptive activity prognosis. Challenges for continued monitoring includes financing the overall operations, maintaining the presence of experienced scientists at OVT and having to often instruct new officials in volcanic hazard issues and their management. The IG maintains a web page where daily and special reports of volcanic activity are available and links to social media can be found. The volcano is the focus of the collaborative 3 yr STREVA project.

Thirty years of eruption at Kilauea Volcano Hawai'i: a review of impacts and mitigation strategies

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As Kilauea Volcano surpasses 30 years of nearly continuous activity, impacts from simultaneous summit and rift eruptions continue to challenge the Island of Hawaii's communities and environment. On one front, lava flows from the east rift eruption have inundated communities, destroying 214 primary structures between 1983 and 2012. On another front, elevated levels of acid gases and aerosols from the persistent east rift eruption have leached metals into domestic water supplies, affected human and livestock health, and damaged agricultural crops, native forests, and farming and ranching infrastructure. Health and environmental impacts were amplified by the onset of the summit eruption in 2008, which was accompanied by an order of magnitude increase in summit SO2 emissions and a factor-of-three increase in ambient SO2 in nearby communities. Hawai'i County was declared a federal disaster area due to agricultural losses from the effects of volcanic emissions for the period 2008-2011.

Federal and local land and emergency managers, environmental and public health agencies, scientists, and health researchers have addressed the ongoing challenges of living with Kilauea's long lived eruptions using a variety of approaches. To address hazards associated with volcanic air pollution, multi-agency web-based tools provide real-time and forecast data of SO2 gas and particle concentrations to help people minimize their exposures. Downwind facilities including a health clinic, a hospital, and a new gymnasium are planning to install air handling systems to improve indoor air quality during periods of high exposure. Ongoing health studies are quantifying asthma and lung growth rates, and respiratory symptomology in exposed populations. Federal low interest loans and grants have helped farmers and ranchers compensate for crop and livestock losses, and replace metal fencing and infrastructure deteriorated by exposure to acid gases and aerosol. Early in the east rift eruption, it was recognized that lead-bearing roofing and plumbing materials were contributing to contamination of rainwater catchment systems due to leaching by acid rain. These construction materials have largely been removed or isolated and alternate sources of water have been made more available.

As Kilauea enters its fourth decade of nearly continuous activity, the ongoing eruptions present a good opportunity to review and enhance efforts to minimize the negative impacts of volcanic eruption in Hawai'i and similar settings worldwide. An evaluation of best management practices for long-term volcanic activity can help physical scientists and multi-agency partners in Hawai'i improve their response to community impacts caused by Kilauea's ongoing activity.

Risk assessment of dieng volcano, central java, indonesia: one of efforts in mitigation of volcanic hazards

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Dieng volcano is an active volcano located in Central Java, Indonesia. Geographic position of the volcano is 07°10,5' S and 109°49,5' E, with the elevation of 2222 meter above sea level.

It is estimated that more than 39,000 people live under the threat of toxic gas posed by Dieng volcano, Central Java, Indonesia. The potential therefore exist for major loss of life, especially where large urban areas occur in proximity to dangerous volcano. With increasing of population growth, hazardous areas are likely to become increasingly developed, so raising the level of risk.

This volcano has erupted explosively at least twelve times since historical observation began in 1825. The most recent eruption occurred in 1979, 1990 and 2002, eruption characterized by phreatic eruptions followed by emission of toxic gas which caused more than 200 casualties.

Volcanic risk assessment is the examination of the risk posed to the human, natural, or built environments as a result of damaging volcanic activity. Human have a long and often tragic history of building large civilizations in close proximity to dangerous volcanoes, partly due to the vast amounts of fertile arable land that typically surround them. Volcanoes are not inherently hazardous unless people choose to live and build their societies in harm's way. As long as humans continue to settle in the shadow of volcanoes, we should continue to develop technological tools to aid us in understanding the volcanic risks we face and advance our ability to mitigate them.

Risk assessment is based on the threat of hazard, vulnerability and capacity elements. The formula for calculating the risk is: R= H x C/V.

Risk map is considered essential tools in the communication of volcanic risk between scientists, the local authorities, and the public. This research method uses both quantitative and qualitative research techniques.

A hundred and fifty people representative respondents of mixed backgrounds, sex, education, occupation, and location were interviewed and asked for vulnerability analysis.

Fatalities can be reduced if, associated with a well monitoring system, including Early Warning and land use planning, a culture of prevention is socialized within all levels of the society.

Keyword: volcanic hazards, risk assessment, mitigation

Community-based volcano disaster risk reduction: 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, and 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), and hands-on activities on elements at risk and resource mapping, were 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. 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 campaigns and (f) establishment of early warning system. Initial testing of community established locally-available and indigenous communication system (batingting and toltog) 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.

Hazard perception and quantitative exposure levels at Turrialba volcano, Costa Rica; Implications for policy and practice

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Continued exposure to the primary volcanic gases can result in a range of chronic ailments, reduced agricultural productivity, and acidification of rain and groundwater that contaminates water supplies. Indirect effects are thought to impede development and poverty reduction efforts. In Central America more than 26,000 people have died and in excess of 1 million people have been affected by volcanic disasters between 1900-2011. To reduce the impact and cost of natural hazards while increasing community resilience in the face of population growth and increasing pressure on ecosystem services, there needs to be effective communication and engagement with incorporation of local and cultural context into disaster risk reduction strategies. As governments and people respond to hazards and risk in ways proportional to their understanding and awareness, the objective of this research is to quantify local communities' exposure to volcanic hazards and to document people's hazard and risk perception.

Fieldwork was conducted January and February 2012. During this period quantitative data regarding exposure levels to SO_2 and acid gases were collected and 43 semi-structured interviews were conducted. A formal town-hall style meeting between the authorities and affected communities at Turrialba was also recorded.

Preliminary results indicate that the concentration of SO_2 up to 15 km downwind of Turrialba exceeds World Health Organisation guideline values, presenting a health hazard to people and livestock. Guideline values for the acid gases were not exceeded during the study period. The main theme to emerge from the qualitative data is concern regarding livelihoods, which is consistent with similar studies in other volcanic areas. In addition, the data strongly suggest significant levels of un- or under-preparedness despite the public education initiatives that have occurred. This is a real concern in the face of the continued gas discharge and potential for larger and life-threatening eruptions. These results imply that adjustments to hazard education and disaster management policies and practice may be required.

Although policy and legislation are essential components of risk reduction strategies, it has been found that the most successful results are achieved through community involvement and work at the local level. Therefore policy change should focus on engagement with the affected populations through collaboration with the scientific community in the design and implementation of integrated disaster risk reduction strategies. This will empower communities and stimulate them to take ownership and action. It will also serve to increase recognition of the wider range of hazards and potential impacts in the region, thereby producing effective but scientifically robust disaster risk reduction strategies that will largely be adhered to and serving to reduce community vulnerability to (volcanic) hazards.

Approaches and results from the STREVA project: 12 months into STtrengthening REsilience in Volcanic Areas.

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The need to understand both the sequence of events around volcanic disasters and the root causes of loss of life and livelihood implicitly calls for an interdisciplinary approach to research. Analyses that attempt to identify the origins and components of disasters, based on identifying all possible contributing factors have recently been termed forensic investigations.

Strengthening Resilience in Volcanic Areas (STREVA) is a five year, NERC/ESRC funded project which is examining the interaction of dynamic factors contributing to volcanic risk. For three relatively well monitored and understood volcanic settings (our forensic volcanoes), we are investigating: changing volcanic hazard processes over time; scientific knowledge and monitoring methods; the exposure and vulnerability of people and assets; the institutional capacities in place to reduce, prepare for and recover from the impact, and levels of communication between different stakeholders. By learning from our forensic settings, we will design an innovative, widely applicable risk assessment framework. We will test our approach at less well understood volcanoes (our trial settings) which are showing signs of unrest.

STREVAs first forensic workshop, held in Montserrat in September 2012, brought together over 50 people; a diverse group of participants including volcanologists, disaster managers, social scientists and members of Montserratian civil society. The groups convened for two days to consider when specific moments or tipping points occurred that increased or undermined resilience; which social, economic, political and scientific components contribute the most to those changes, and, how the most important components can be evaluated, measured and monitored. Our second forensic workshop, held in Banos, Ecuador in June 2013, designed with project partners IG–EPN, focussed on how communities live with the volcano as their neighbour. This workshop also brought together a diverse group of researchers, decision makers and the public.

We will present a preview of our analyses from the Soufriere Hills forensic study, results from our second forensic workshop in Ecuador (with a focus on Tungurahua), and reflections on the value of STREVAs investigatory approach. We also discuss the lessons learned so far and our intentions for the future of this challenging interdisciplinary project.

Contribution of Volcano Monitoring to Public Health, Education, Tourism and Economic Development in Argentina.

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Volcano monitoring does not necessarily imply a research study. Monitoring involves the attention to instrumental maintenance-control, measurement and analysis for 24 Hrs, the 365 days a year. Each volcano has its own characteristics and signatures that combine the features of the cyclicity of eruptive episodes, geochemistry of magma and gas, seismicity, and deformation. To understand their behavior, not only geological and geochronological research are necessary but a permanent seismological monitoring record for at least two years even during inactivity. If previous long term monitoring had been developed, the harmful effects of the eruptions of the Volcanoes Hudson (1991), Copahue (2000 and 2012-presently active), Chaiten (2008-2009), Cordon Caulle (2011-2012) could have been diminished or prevented. The duration of the activity and the likely volumes of ash fall, based on the direction of prevailing winds, (according to the seasonal meteorological conditions, could have prevented farmers and cattle breeders to reduce exposure of livestock and crops to ashfall. Human health impacts affected a large population living in the regions of the extra-Andean Patagonia. Moreover, psychological assistance could have been planned for vulnerable families in schools and hospitals. Preventive health care, integrated with a civil protection preparedness in communication with the scientific monitoring center, should be programmed. The self-evacuations, homes and workplaces abandonment, livestock losses, tourism and flights cancellations affected the imbalance of regional economies, mainly in the Argentine Patagonian provinces of Santa Cruz, Chubut, Neuquen and Rio Negro. In 1991 the Hudson Volcano expelled between 4 to 6 km3 of ash from August 11th to 15th, leaving tephra deposits covering an area between 80,000 and 150,000 km2, one of the largest deposits of tephra in history. During 2008, Chaiten volcano ejected about 0.2 km3 (DRC) of tephra and Cordon Caulle Volcanic Complex during the first 27 hours of the start of its activity in 2011, expelled from 0.2 to 0.4 km3 of magma (DRE). The Civil Protection system, the provincial government authorities and the Nation can work in coordination with a National Volcano Observatory (still inexistent in Argentina) led by professionals and technical specialists in the various areas comprising the volcanic monitoring. During the 2011 Meeting of the VOBP and WOVO held in Sicily, it was stated that every volcano should be monitored by seismology, deformation and gas,ash and water geochemistry. None of these parameters is independently sufficient diagnostic as an eruptive volcanic forecast. The volcano monitoring in permanent interaction with Civil Protection applied to public health, education, tourism and the regional economies is an outstanding debt on Argentina society.

Mitigation system of volcanic disasters in Japan - Scheme of volcanic alert level and some case studies

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In Japan, the Japan Meteorological Agency (JMA) is responsible for monitoring volcanic activity and issuing volcanic warning for disaster mitigation. JMA monitor data 24 hours a day telemetered from equipments installed close to 47 active volcanoes selected by the Coordinating Committee for Prediction of Volcanic Eruptions. The basic idea of the volcanic warning released by the JMA links to Volcanic Alert Levels.

The Volcanic Alert Levels are divided into five stages depending on "areas that must be warned" and "responses that should be taken" for the volcano's current state of unrest: Level 1 signifies that no particular response or action is required; Levels 2-3 indicate that, while residential areas are not threatened, the volcano is off limits for hiking or climbing; Levels 4-5 reveal that residential areas are starting to be threatened by the danger of eruptions. Levels 2 and 3 are differentiated by the degree to which hiking and climbing are prohibited in hazardous areas, with the exact definitions decided in advance through consultation among local relevant organizations. Level 4 is the stage where people in need of aid during disasters are evacuated and other local residents prepare to evacuate, and at Level 5, all local residents are subject to mandatory evacuation from threatened areas. Each Volcanic Alert Level is associated with specific keywords - "5: evacuation", "4: prepare for evacuation", "3: do not approach the volcano", "2: do not approach the crater", and "1: normal". This helps ensure response compliance of local residents, mountain climbers, sightseers, and so on. The Volcanic Alert Level scheme has been put into effect for 29 volcanoes in present.

Essentially, the scheme works as follows. Before a volcanic anomaly occurs, relevant organizations share projections based on the volcano's past history of volcanic unrest (eruption scenario) and hazardous areas (volcanic hazard maps) and come to agreement on what criteria to use in deciding when to start evacuating people, when to prohibit people from hiking or climbing in the area, and other disaster responses. Because these procedures have to be done in the stage when the volcanic activity is calm, "Volcanic Disaster Mitigation Council" has to be established among relevant organizations at each volcano.

The Volcanic Alert Level framework was outlined in the Basic Plan for Disaster Prevention of Japanese government in 2011. The scheme has been further elaborated through linkage to evacuation plans drawn up through collaboration among members of the Volcanic Disaster Mitigation Councils made up of all interested bodies and stakeholders in the prefecture including prefectural authorities, municipalities, JMA's observatories, erosion control (Sabo) departments, and volcanologists.

In my presentation, the basic scheme of the volcanic alert level of Japan and some case studies in recent years will be introduced.

Regarding the responses of the national and local governments in the Kirishimayama (Shinmoedake) eruption, 2011

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Japanese islands are home to 110 active volcanoes that consist 10 percent of these on the Earth total. However, Japan Metrological Agency (JMA) set up a network of seismometers, telephoto cameras and angle meters only around 47 volcanoes throughout Japan for 24 hours monitoring-these 47 are selected by the Coordinating Committee for Prediction of Volcanic Eruptions, an organization of academics and related government agencies. Kirishimayama is one of these 47 and Shinmoedake in Kirishimayama erupted in 2011 making a lot of local residents flee their homes.

Kirishimayama is one of the Japan's most active volcanoes, which is located in the popular hot spa area in Kyushyu district. Kirishimayama includes Takachihonomine, Nakadake, Ohatayama, Karakunidake, Tairoike, Ohachi, and Shinmoedake. On 26th January 2011, the magmatic eruption has occurred at Shinmoedake for the first time since AD1716. Perhaps due to its long dormancy, local governments around Kirishimayama had not prepared any evacuation plans against volcanic disaster. There is not prepared any effective plan for evacuation except the one for Kagoshima-city against Sakurajima volcano according to the Cabinet Office in Japan (CAO).

A series of 2011 eruptions produced the lava fountains and flows, volcanic bomb, and ash cloud. In the maximum eruption, ash cloud reached a height of 4,000m and Miyazaki prefecture, about 50km to the east. As a result, 612 residents evacuated from Takaharu town that is located 7 km east from the crater of Shinmoedake.

These volcanic activities forced Takaharu-town to issue evacuation announcement to about 1,000 people on 30th January, based on Disaster Countermeasures Basic Act circumstances. Under such circumstances, CAO has decided to dispatch the Japanese government team which is consisted by some ministries and government offices to Kirishimayama in order to support local governments around the volcano including Kagosima and Miyazaki prefectures. The team completed 5 tasks, which includes 1) creating the guidebook for local governments on how to prepare evacuation plan, 2) preparing handbooks on how to protect own body against disaster on volcanic eruption and debris avalanche, 3) publishing the handbook on how to survive against volcanic bombs, 4) strengthening volcanic observation systems, and 5) setting the countermeasure against the damage of ash-fall especially for mitigating damages on agricultural crops. As the Japanese government team took positive measures to deal with organizing the "Kirishimayama volcano disaster management council" which is consisted from local governments, Takaharu-town and Kirhishima-city were able to settle the evacuation plan promptly in a month.

Increasing volcanic risk: the case of El Hierro, Canary Island, Spain.

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The El Hierro is the western and smallest island of the Canary archipelago (Spain). On July, 2011 an unrest began in El Hierro, and on September 10th the first serratian submarine eruption took place near La Restinga, in the south of the island. After the eruption, some periods of increased volcanic activity have been detected and the gps deformation values have not returned to the background level yet.

During the volcanic crisis of El Hierro several problems have been detected in the management process showing a clear degradation in the time response and increasing the economic crisis. Some problems are given by:

The initial strategy adopted by local authorities of the island was wrong. They considered the situation as a catastrophic event before the eruptions started, so all the efforts were conducted to demand subsides.

When the emergency plans and laws were made, the money issue was avoid of them so actually, each institution has to pay for its own bills. There is not a special money to manage long emergency operations such a volcanic crises, because the volcanic crisis was always considered like a short-term natural phenomena, instead of as a long-term natural phenomena.

At the beginning of the volcanic crisis, the response of Civil Protection was overreaction. A lot of people were sent from Tenerife and Gran Canaria to El Hierro and the cost of the operations was really high. However, during the third unrest, one of the most important, the reaction was under-reaction.

In all emergencies Civil Protection and authorities always try to minimize the level of risk. A paternalism and over-protection are the usual behavior when they have to communicate to the population whatever kind of information before the emergency starting.

From a global point, the scientific response was the worst of all statement, event worse than politicians ones. That it is the main reason that explains the degradation in the response-time.

Some scientific groups have the same problem as Civil Protection and politicians, the paternalism, so they try to minimize the volcanic activity all the time. As a result, they lost credibility with the public. In many times, because of the bad quality of the information provided to the public, their professional profile was seriously damage.

But the real problem was the declaration of war between Spanish geologist and physics (geophysics, mathematics, etc). Along the history, the former has been the main actors, specially in Canary Island. But the problem was they were specialized in studying the past volcanic history using the petrology and other techniques but they never worked on monitoring.

Another big problem is the lack of a real scientific committee. In fact the actual scientific committee is controlled by authorities. They decide who is invited to the meeting and then what kind of information will be use and transmitted to the population. In this situation, the consensus is really difficult.

The challenge of sustained public eruption preparedness: A decade of exercises, social research and hazard mapping in Tongariro National Park

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New Zealands Tongariro National Park volcanoes produce hazardous eruptions every few years to decades. The presence of high use public walking trails and routes within this World Heritage area, gives rise to risks mostly from pyroclastic density currents, lahars and ballistics. In the long term public exposure is particularly great on the Tongariro Alpine Crossing track with more than a thousand visitors on peak summer days. In 2012 the Te Maari vent at the northern end of the Crossing reawakened after a century, producing surges and ballistics in two events. We explore the public education and emergency management, hazard map development, and social science research conducted over the last decade, during quiet periods and eruption episodes to manage this risk.

At Ruapehu, an Eruption Detection System (EDS) triggers sirens and messages automatically across the ski area, because the first eruption generated lahars may reach the ski area within two minutes of an eruption. This structural measure has been complimented with volcanic hazard education in the park. This is heavily based around hazard maps, but in recent years has been diversified to accommodate surveyed on-going moderate levels of map comprehension. In order to evaluate public response to the EDS, simulated warnings have been conducted annually at the ski areas since 2001, using designated observers. Analysis of public responses has identified issues associated with a demographically diverse public, including a minority who fail to move to safety. There is a need for diverse education media and contact points and changes to warning processes and maps.

Pyroclastic density current and ballistic hazards are present on both Ruapehu and Tongariro. Timely official warning to the public away from the ski areas remains a very challenging concept, and eruptions, especially smaller ones, are difficult to forecast. Preparedness falls heavily to hazard maps and the design and content of hazard maps has received increasing consideration with recent eruptions, highlighting several complex issues that we explore: (1) background hazard maps are used across the many potentially-active vents during non-eruptive periods, but these may not match eruptive episode hazard maps and scenarios with very elevated probability compared to the background; (2) scientists need for conservatism while constraining hazards may be in serious, direct conflict with more probable short term hazards in time-sensitive situations; (3) hazards tend to grade away spatially and should ideally be shown in a gradual probabilistically-defined way, but maps need to be simple; (4) messaging covers several severe hazards and actions, needing to be a balance between simplicity to achieve high awareness and not clutter the map, but enough detail to be meaningful; and (5) the visual representation of elements (1) through (4) on a single piece of paper that can be quickly and correctly comprehended.

Community Hazard Mapping: Buenos Aires Case Study,at the Santa Ana (Ilamatepec) Volcano

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Santa Ana (Ilamatepec) Volcano (13.853, -89.63, 2381m) is the tallest composite volcano located in the Apaneca Volcanic Field located in western part of El Salvador, Central America. It is one of six active volcanoes monitored by the Direccion General del Observatorio Ambiental in El Salvador. The volcano is surrounded by rural communities in its proximal areas and the second (Santa Ana, 13 km) and fourth (Sonsosante, 15 km) largest cities of the country. On October 1st, 2005, the volcano erupted after a months of increased fumarolic and seismic activity. It generated an estimated 10 km high steam and ash plume. Ash was deposited to the western and north-western part of the country, following the typical wind patterns for the region. Small pyroclastic density currents and major lahars were observed in the eastern part. Following the eruption, volcanic mitigation projects were conducted in the region, but the communities had little or no part on them. This project aims to create a new volcanic hazard map for the northern part of the volcano incorporating the community's knowledge with the work currently done by scientists. The work with the community took place during the first two weeks of May. At that time several meetings took place where the community members recounted past events such as the 2001 earthquake of magnitude 7.7, the 2005 eruption, and several debris flows and lahars which have destroyed the road, leaving them incommunicated for several days during the 2010 and 2011. They were asked to map the outcomes of those events using either a hillshade relief map with a topographic map of the area overlay on top of it, an image from Google Earth, and a blank paper poster size. These maps have been used to identify hazard areas, the formation of new Barrancas and Quebradas, and they will be used for model validation.

The Determining Volcanic Risk in Auckland (DEVORA) project: source to surface, scientists to society

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The monogenetic, potentially active Auckland Volcanic Field (AVF) has produced approximately 55 volcanoes over the past 250,000 years. Though the likelihood of another event occurring in any given year is low, the associated risk is very high, as Auckland is New Zealand's most populated and economically critical city. Moreover, ash fall from central North Island volcanoes could threaten Auckland's health, lifelines, and economy. The seven-year, multidisciplinary DEtermining VOlcanic Risk in Auckland (DEVORA) project began in 2008 with the major aims to 1) characterise the AVF in a Geological Model, 2) summarise the subsequent long-term volcanic hazards from eruption and ash fall events in a Probabilistic Hazard Model, and 3) assess the quantitative risk, build a risk reduction framework for emergency managers, and describe the economic and social effects of an AVF eruption on Auckland and the rest of New Zealand in a Risk and Social Model. Fostering linkages between civil defence authorities, lifeline organisations, physical and social scientists, and the public has been a crucial part of DEVORA's workplan since its inception. Five years of research in the Geology and Probabilistic Hazard themes has emphasised the need for early emergency management and lifeline involvement in the project; AVF eruptions and distal ash fall events occur more frequently and their hazards are potentially more devastating than previously thought. Mock eruption exercises demonstrate how valuable these established relationships will be when faced with the immediate deadlines and intense pressures of a potential eruption. Throughout the project, workshops, field trips, public talks, museum collaborations, school visits, research forums, and reciprocal, open lines of communication between scientists and end users have created a strong, cohesive, engaged community for DEVORA scientists to draw upon as the project concludes and Auckland prepares for the next AVF eruption.

New USGS California Volcano Observatory partners with California Emergency Management Agency for hazard identification, risk assessment, and preparedness

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The USGS California Volcano Observatory (CalVO) was established in February 2012 to improve coordination with federal, state, and local emergency managers during volcanic crises, and create new opportunities for volcanic hazard awareness and preparedness. CalVO is an outgrowth of the former USGS Long Valley Observatory but with the broader responsibility of monitoring *all* potentially threatening volcanoes in California, most notably Mount Shasta, Medicine Lake, Clear Lake Volcanic Field, and Lassen Volcanic Center in the north, Long Valley Caldera and Mono-Inyo Craters in east-central California, and Salton Buttes, Coso Volcanic Field, and Ubehebe Craters in the southern part of the state.

California is geologically diverse, exhibiting a range of volcanism resulting from subduction, crustal thinning, and extensional rifting in the northern, central, and southern parts of the State, respectively. More than ten eruptions have occurred in the last 1,000 years, most recently at Lassen Volcanic Center (1666 C.E. and 1914-1917 C.E.) and Mono-Inyo Craters (c. 1700 C.E.). The Long Valley Caldera and Mono-Inyo Craters region underwent several episodes of heightened unrest over the last three decades, including intense swarms of volcano-tectonic earthquakes, rapid ground uplift, and dangerous CO_2 emissions. Both Medicine Lake and Lassen are subsiding at the appreciable rate of 8-10 mm per year, and along with Clear Lake, sporadically experience long-period, low frequency earthquakes related to migration of magma or hydrothermal fluid. With the exception of Ubehebe Craters, all California "watch list" volcanoes support vigorous hot springs, boiling mudpots and (or) fumarolic activity, and four are geothermal power producers.

In addition to monitoring, a major component of the field-based research conducted by observatory volcanologists funnels into the creation of comprehensive and authoritative volcanic hazard assessments. Each assessment is a dynamic document, refined and updated as new data are collected and interpretations become better constrained. To maximize the societal impact of USGS volcano hazard assessments, CalVO is partnering with the California Emergency Management Agency (CalEMA), the government entity responsible for coordinating disaster preparedness, response, and recovery efforts within the state. The USGS-CalEMA partnership will result in a three-part volcano annex to the California Statewide Emergency Plan that includes hazard identification, risk analysis, and an emergency operations plan. The volcano annex will integrate natural hazard and socio-economic information in a format readily accessible to decision-makers.

Assessing Volcanic Hazards using VHub online tools: El Salvador Volcanoes Case Study

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VHub is a Cyber-Infrastructure platform where all stakeholders involved in volcanic research and mitigation can collaborate in research, modeling, data sharing, education and outreach, and communication. VHub is a community-driven Cyber-Infrastructure, and any individual working on or interested in volcanic research and mitigation can join VHub without cost. The VHub community consists of volcanologists, remote sensing experts, geographers, civil engineers, and teachers, just to name a few groups. VHub members have an array of online simulation tools dealing with different volcanic processeses at their disposal. In this project we chose three El Salvador volcanoes, Santa Ana (Ilamatepec) Volcano, San Vicente Volcano and San Miguel Volcano, as case studies to show case these tools and how VHub can be used on real life cases. We used Titan2d for show deposition and inundation zone due to debris flows at the Santa Ana Volcano; we used the Energy Cone at the San Vicente Volcano for create a kmz file displaying possible inundation areas; and Tephra2 for the San Miguel volcano to create an isopath map of a fallout deposit.

Historic activity and new volcanic unrest: Turrialba volcano, Costa Rica.

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The historic activity of Turrialba volcano was studied based on traveller's reports and newspapers of the 19th century. In 1864–1866, the volcano entered a period of magmatic eruptions which can be subdivided in two stages: a pre–eruptive and an eruptive stage. Ash fall reached distances of ∼115 km covering an area of 3400 km^2. By means of GIS, we estimated how a similar magmatic eruption as this, could affect the present population and infrastructure, and we concludes that the ash fall in the most populated areas of Costa Rica, this is important as a prevention measure and an analysis of future risk decision making. In 2005, Turrialba volcano increased seismic activity, gas emissions and acid rain, which affected the S, SW and W sectors of the volcano. After more that a century without eruption, on 5 January 2010 phreatic activity resumed, with emissions of non–juvenile ash which reached San José. The ash contained cristobalite and hematite, which are unhealthy. Moreover, the eruption formed a nested crater of ∼125 m x ∼45 m with a NW–SE direction, with emission of SO_2 in state of combustion and incandescence, manifested sporadic ash eruptions. In June 2011, a fumarolic area appeared with temperatures up to ∼530 °C in the NW intracrater. On 11 January 2012, a sulphur flow occurred (length 175 m), produced by the heating of the system which also led to phreatic eruptions on 12 and 18 January 2012. Another crater was formed in the eastern extreme of the NW crater.

Exchange of probabilistic volcanic hazard information between scientists and civil authorities: insights into the influence of communication format

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Until recently, most volcanic hazard assessments were constructed using largely qualitative schemes, built on expressions such as “low,” “medium,” and “high” that characterized broad classes of hazard magnitude. New probabilistic approaches to analyzing volcanic hazard have introduced ways to build more robust, high-resolution quantitative assessments and maps. Probabilistic hazard calculations based on traceable and customizable numerical variables and measures of uncertainty offer many advantages in modern high-stakes social and economic risk environments. However, it is unclear how this complex probabilistic volcanic hazard data translates and integrates into civil authorities’ decision-making practices.

A quantitative volcanic hazard analysis requires a multi-level assimilation of many different types of hazard information and a rational design of data output, processes typically performed by users in the geosciences. Yet recent eruptions have highlighted that the critical decisions that directly benefit from the outputs of probabilistic hazard analyses, such as those concerning evacuation timing, land use planning, and risk reduction measures, are most often made by end-users in civil defence and emergency management organizations. This study investigates the critical communication pathway involving the exchange of probabilistic hazard data between scientists and these civil authorities.

Probabilistic volcanic hazard information created with data generated by the long-term hazard analysis tool BET_VH (*Bayesian Event Tree for Volcanic Hazards*) is presented in various communication formats to civil authority stakeholders. Mixed social science methods are used to measure the civil authorities’ interpretation of the information and the uncertainties associated with it. The study provides insight into ways scientists can optimize communication of probabilistic volcanic hazard data in dialogue with civil authorities and other stakeholders for effective integration into decision-making and risk reduction practices.

Methods to communicate volcanic hazards information to indigenous cultures: a case study of Maori from New Zealand.

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Communicating volcanic hazards and risk to indigenous peoples living near or on active volcanic areas has focused on presenting information related to the physical process of the hazard and the impacts of those hazards. Ultimately this information is presented in the form of hazard maps and evacuation or exclusion zones. The western science based view of volcanic processes, hazard and management can cause conflict with indigenous communities that at times see this as a threat to their livelihood or cultural connections to the area. The conflict can arise from the marginalisation of the indigenous peoples cultural and spiritual belief or the differences between perceived risk and past experiences that indigenous peoples have responded to and recovered from. Questions remain on how these differing views can be breached to ensure that risk is minimised. Research into methods on how to transfer this knowledge, while maintaining cultural integrity, has focussed on the application of participatory research methods, whereby communities are directly involved in transferring their past experiences and traditional knowledge in a collaborative environment to create joint hazard maps. Methods have been extended in New Zealand to develop methodologies where research is encompassed by indigenous values, conducted by indigenous researchers and uses traditional language. This method applied is the Kaupapa Maori Approach and is being used to transfer volcanic information between volcanic researchers and Maori tribes or Iwi living under the volcano. Living in the shelter of Ruapehu, the Ngati Rangi people of New Zealands Central Volcanic Plateau have come to understand and recognise the signs and language of their ancestral mountain, developing a unique system of indicators that is being shared and transferred into hazard management maps, plans and emergency management processes. This Kaupapa Research in other situations has resulted in positive change and it is envisaged that this understanding and sharing of volcanic knowledge will result in the reduction of risk.

Volcanic activity and environment: Impacts on agriculture and use of geological data to improve recovery processes

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Volcanic eruptions are dramatic events that can significantly affect the livelihood of surrounding populations, in particular since the fertility of volcanic soils results in them often being used for agricultural purposes. Therefore, when volcanic crises occur, the livelihood of farmers can be strongly affected. The actions taken both by farmers and the authorities during recovery phase from a volcanic eruption are important and will have a strong influence on the ability of local population to regain their financial equilibrium and independence. This study evaluates factors that are critical in the improvement of recovery processes for agricultural areas affected by natural hazards, and in particular volcanic activity. Work was carried on the basis of sites visits, focusing on interviewing scientists involved in the crises and/or local residents and authorities, as well as documentary reviews of past case histories of the handling of natural hazard crises. Four main field visits were carried out: Mts. Pinatubo and Mayon (Philippines), Mt. Unzen (Japan), Mt. Taranaki and heavy snowfalls of 2006 in South Canterbury (New Zealand) and Volcan de Turrialba (Costa Rica). The study reveals that scientists collect information throughout a volcanic crisis that can be used effectively to improve recovery response times in agricultural areas. In order to contribute positively to the recovery of an area, the information supplied needs to be relevant to the area affected which implies a pre-existing knowledge of the specifics of the region depending on the type of crops or animals being raised, as well as of the climatic and seasonal components. In addition, it is important to have already established trusted communication channels between scientists, authorities and local communities through which this information can be transmitted to ensure efficient exchanges of this information. The case studies also show that communities that are organised around a strong support network achieve higher levels of resilience and thereby fare better not only throughout the emergency phase but also at recovery stage.

Sequence of the 1822 AD Eruption and Management for Hazard Mitigation of Usu Volcano, Hokkaido, Japan

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The 1822 AD (5th Year of the Bunsei Era) eruption of *Usu* Volcano, was reviewed based on chronicles of the Buddhist priests and local government *Samurai* officials. The sequence of the eruptions which occurred before instrumental monitoring systems were equipped, are reconstructed based on documents and drawing by the eyewitness. Two native villages *Usu* and *Abuta*, each of which had 350 residents, were located 4 to 4.5 km from the central part of Usu volcano. The eruption in 1822, the second biggest among ten historic eruptions of the volcano, caused more than 80 casualties.

Earthquake swarm started at 0200 hour on March 10. The director of the local officials *SHIGEMATSU Ban-uemon* recognized that this seismic activity could be a precursor of an eruption, based on the experience of an old native of Abuta. He suggested residents and priests of Zenkoji Temple in *Usu* to prepare for an eruption and evacuation. 60 hours later, the first explosion commenced at 1400 hour on March 12. He ordered to evacuate from neighboring villages to Furebetsu and Benbe villages, without delay. In the early morning on March 19, pyroclastic surge and pyroclastic flow covered the flank of the volcano. Ash fell 15cm in thickness in *Muroran* (22 km SE of the volcano), and teacup size pumice fell in *Shiraoi* (42 km E). Because of heavy rain in the evening on March 22, many (native) refugees returned their home. These residents and others who did not follow the order of the officials were staying in *Abuta*.

At 0700 hour on March 23, pyroclastic flow and surge attacked *Abuta* village and fall-out ash reached as far as *Akkeshi* (330km E). Local officials rescued the sufferers since the afternoon, but more than 80 were killed including government horse herdsmen, merchants as well as natives. The officials made inspection of the devastated area on March 24, 27, and 29, to identify and recover casualties, closed the traffic of southwestern foot of the volcano since March 24.

Fall-out ash at the place of refuge *Benbe* and *Rebunge* on April 5 to 7 made drinking water unavailable. While *Ban-uemon* arranged young and elder refugees to move farther safer shelter, he also arranged fishermen to stay in *Rebunge* and continue their work.

According to the report that *Ban-uemon* recorded 4 months period, explosive eruptions occurred on April 25-26 (fall-out ash reached 230km SSE), May 8 (pyroclastic surge), June 2, 18 (ash reached 140 km SSW), and July 3 (ash reached 220 km S).

Volcanoes on borders: Potentially explosive geopolitical agents

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This poster provides an overview of an ongoing project examining the science and policy questions that relate to volcanoes on international borders. Volcanic eruptions are frequently transboundary events: this was demonstrated clearly for Europeans during the 2010 eruption of Eyjafjallajokull. Aviation technology is perhaps particularly vulnerable to these transboundary effects, but there are also a large number of volcanoes globally that are on or close to international borders. These include Nabro and Mallahle in Eritrea, Paektu or Changbaishan on the North Korea - China border, and numerous Andean volcanoes (for example, between Argentina and Chile). A large eruption at any of these volcanoes would affect two or more countries in its immediate impacts (ash fall, pyroclastic currents). We use qualitative social scientific methods and GIS to examine some of the implications of this for global eruption management, both in terms of scientific diplomacy and political issues.