ID: 66

Cities near volcanoes: the threat of volcanic hazards on expanding cities

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Cities situated in proximity to volcanoes place dense concentrations of populations, buildings, and infrastructure at risk from volcanic hazards. Past analyses of city exposure to volcanoes have considered city populations relative to the distance between geographic city centroid and nearest volcano. However, this approach falls short in capturing the true exposure of city populations, due to their irregular shape and the varied distribution of inhabitants within a city. In this study, we present a framework for more robustly evaluating the exposure of the world's cities to volcanic hazards. Using data from the Global Human Settlement (GHS) Model, we rank cities exposed to volcanic hazards based on the population exposed within the city and the proximity of the city margins to nearest volcanoes. From this, we identify cities where high proportions of the populations are exposed to multiple volcanoes. For key case studies, we map the historical expansion of city boundaries relative to volcanoes, tracing this evolution at five-year intervals from 1975 and extending to a forward-looking projection for 2030. By assessing how cities' shapes are evolving over time, we can see whether urban expansion trends are moving toward or away from volcanoes. Finally, we compare these changes to local wind directions and topographies to evaluate the evolving exposure of cities to tephra fall and block-and-ash flow hazard over time. This study provides a global perspective on the spatio-temporal evolution of the exposure of cities to volcanic hazards, highlighting areas for future research and mitigation efforts for risk reduction.

ID: 184

Stromboli, challenges and opportunities as a tourist destination

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Worldwide, volcanic sites are extremely popular as tourist destinations. Stromboli Volcano is one of the world's most active, monitored and visited volcanoes. The volcano lies on the island of Stromboli in the Aeolian Archipelago, Italy. In winter, Stromboli's population counts less than 500 residents, while in summer it can host up to more than 5000 tourists per day as cruise visitors or in holiday accommodation. Our project investigates volcanic hazard and risk perception using questionnaires and interviews. The project targets tourism stakeholders and tourists to explore their awareness of volcanic hazards and approaches to potential volcanic emergencies. It also explores the perception of tourism stakeholders on the consequences of mass tourism developed in the last 20 years. The results will help to forward possible measures to improve volcanic hazard awareness. The project has just begun, and last summer, we visited the island and started the data collection. Preliminary results indicate a concern about the island's environmental preservation and various levels of awareness among stakeholders. This project will contribute to the research on Disaster Risk Reduction worldwide, particularly on tourist destination islands.

ID: 254

The 2021 crisis at La Fossa Volcano: a case study of volcanic gas emissions near the inhabited zone of Vulcano Island, Italy

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The La Fossa volcano serves as a pivotal case study for investigating gas emissions in proximity to populated areas on Vulcano Island. Following the 1888-1890 eruption, Vulcano exhibited persistent fumarolic-solfataric activity, releasing sulfur and carbon dioxide (CO_2) from both the crater cone and the soil. Certain anomalous degassing zones on Vulcano Island have maintained stable geographic positions, but significant changes in emission rates have occurred due to the influx of magmatic gases. In these zones, soil CO_2 flux (ϕCO_2) established elevated airborne CO_2 concentrations. To safeguard human health from gas exposure, international agencies have established safety thresholds values for airborne CO_2. A recent increase in volcanic degassing has heightened the gas hazard on Vulcano Island, necessitating the evacuation of residents from Vulcano Porto.

This study underscores the significance of a monitoring system for early detection of ϕCO_2 fluctuations at Vulcano's anomalous degassing zones. Simultaneous monitoring of ϕCO_2 and airborne CO_2 concentrations has revealed variations in volcanic degassing that affect airborne CO_2 concentrations within the settled area of Faraglione. Additionally, spatial surveys for stable isotope analysis ($\delta^{13}C$-CO_2 and $\delta^{18}O$-CO_2) of airborne CO_2 assist in tracking volcanic gas injections into the air.

Utilizing an isotopic mass balance model, the partitioning of airborne CO_2 between atmospheric background and volcanic CO_2 demonstrates the impact of the increase in volcanic gas emissions at Vulcano Porto. These findings yield an estimate of volcanic CO_2 in the air and contribute to the identification of areas requiring attention for mitigating volcanic gas-related hazards on Vulcano Island.

ID: 320

Nereidas Valley of Nevado del Ruiz volcano as a model of a medium to high enthalpy geothermal system in Colombia

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Colombia has geothermal resources preferentially associated with the active volcanic arc. However, low-enthalpy type geothermal activities are the only one developed in the country, exclusively linked to ecotourism and balneology. This work highlights the high-enthalpy type geothermal potential associated with the Nevado del Ruiz Volcanic Complex in Colombia, despite the stagnation of the project over the past decades.

The Nereidas Valley geothermal project is located on the western flank of the Central Cordillera of Colombia in the area of influence of the Nevado del Ruiz Volcanic Complex, some 35 km away from Manizales. The project began its recognition phase in the 1970s, although the environmental license was obtained only in 1994, allowing the first drilling in 1997, which reached a depth of 1469 m. The system is hosted in metamorphic rocks, which, in the case of a conceptual model, function as reservoir rock. The system seal cap layer is formed by altered metamorphic rocks and Quaternary volcanic products hundreds of meters thick. The expected temperature of the geothermal reservoir is greater than 200° C, in accordance with the temperature measured in the well.

Based on the current knowledge, it is possible to propose a medium to high enthalpy geothermal system in the region, which has great potential to contribute to the energetic transition in the country.

ID: 477

Catastrophe Bonds as a tool for efficient risk transfer and disaster relief

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Co-Existence with a volcano requires prepared and resilient societies capable of rebuilding, and funding for disaster relief is crucial in the aftermath of a volcanic eruption. The insurance gap for eruptions is, however, up to 100%. Insurance claims are complicated, and a natural disaster can quickly exhaust the (re)insurance system. It thus falls to governments and humanitarian organizations to stem the massive financial burden that comes with a volcanic crisis.

Catastrophe (Cat) Bonds are innovative financial tools that transfer the risk of natural disasters to the capital market. Private investors (typically large financial players, e.g., pension funds) buy shares of the bond, which can be traded on the financial markets and are desirable tools for portfolio diversification. If there is no trigger event during the maturity of the bond, the investors enjoy high yields. If, however, a disaster triggers the bond, the beneficiary, or sponsor, retrieves a payout in a fast and efficient manner.

In collaboration with Replexus and Howden Capital Markets, Mitiga Solutions has brought the first Volcano Cat Bond to market in 2021. Sponsored by the Danish Red Cross, it provides cover for explosive eruptions of 10 volcanoes worldwide. Payout is linked to a parametric trigger – the eruption column height - based on loss modelling for volcanic ash fallout. Currently, Mitiga is also developing a methodology to structure a Cat Bond for lava flows (details in an accompanying poster). This presentation will demonstrate the underlying concepts and catastrophe modelling for this new way of disaster relief funding.

ID: 592

Evaluación de la percepción del peligro volcánico del Misti en la población de la ciudad de Arequipa

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El volcán Misti es un volcán activo, se encuentra a 17.8 km del centro de la ciudad de Arequipa, con más de 1 millón de pobladores que viven a tan solo 12 km del cráter. El Misti presento erupciones de tipo pliniano como lo ocurrido hace 2050 años, también presento erupciones vulcanianas, entre los años 1140. Actualmente, el volcán Misti presenta actividad fumarólica esporádica.

Cabe mencionar que esta investigación se llevó a cabo durante la pandemia, por medio de un cuestionario virtual, con la participación de 5 universidades arequipeñas, logrando obtener un total de 7000 encuestas respondidas, con un 5% de margen de error, siendo la población de Arequipa de más de 1 millón de habitantes.

Se logro medir el grado de percepción de la población arequipeña frente al volcán Misti y su grado de preparación ante una erupción volcánica. Entre otros parámetros relevantes. Los resultados fueron asombrosos, ya que tanto la población que habita en zonas de alto o bajo peligro volcánico, tienen la misma percepción media frente a la ocurrencia de una erupción volcánica, así como la credibilidad frente a las autoridades para asumir sus cargos y encargarse de sus funciones en crisis es muy baja, sin embargo, el grado de confianza hacia las Fuerzas armadas es muy importante.

Estos resultados serán de gran ayuda para que las autoridades tomen medidas necesarias para que la población se encuentre informada en su totalidad y sobre todo preparada ante un eventual evento, como es la erupción del volcán Misti.

ID: 697

Holocene plinian eruptions recorded in Manizales, Colombia; AMS 14C ages determination, eruptive dynamic and hazard implications

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Manizales city (ca. 400, 000 inhabitants) as well as other smaller towns are settled on the western flank of the Central Cordillera of the Colombian Andes. Widely dispersed under the city, there are several pumice-rich tephra layers that suggest plinian eruptions occurring nearby. From this geological record, four layers are the most representative due to they are the thickest and most persistent in the region. To assess these layers, several analyses have been performed in order to: 1) determine the age of the eruptions, 2) define the source and eruptive dynamics associated with each of the events, and 3) give insights into the volcanic hazard for the Manizales city. The deposits were named in this study as Lower Manizales (*Lm*), Middle-lower Manizales (*Mlm*), Middle-upper Manizales (*Mum*) and Upper Manizales (*Um*) tephra layers. Mapping of the deposits evidenced that the lower layer was originated in the Plazuela volcano (~15 km from Manizales), while the others were originated in the Cerro Bravo volcano (~25 km from Manizales). The radiometric analysis indicate that the tephra layers are bracketed between ~7900 and 2650 years BP. All events were formed by plinian and subplinian eruptions, with column heights varying between 18 and 29 km. The tephra minimum volume emitted by the eruptions was between 0.21 and 0.38 km^3, and the emission rate between 21.6 x 10^7 and 3.38 x 10^7 kg/s. The results suggest that the region is strongly endangered by pyroclastic falls associated with several active volcanoes located in the Central Cordillera.

ID: 41

How many people are exposed to volcanic eruptions? Updating the VPI and PEI

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Over a billion people live within 100 km of the approximately 1,300 volcanoes thought to have been active in the Holocene. As the world's population grows, more people will likely live within harm's way of one or several volcanoes. Previous attempts to quantify exposed populations (commonly at distances of 5, 10, 30, and 100 km), such as the Volcano Population Index (VPI), largely treat volcanoes as point sources. While this approach may be suitable for volcanoes where known eruptions originate from a single vent or crater complex of a composite volcano, it is less suitable where a large volcanic edifice has multiple possible eruptive centers (e.g., shield volcano with rift zones, caldera system), or in areas of distributed volcanism (e.g., monogenetic volcanic fields). Further, it does not capture the changing threat to populations residing at different distances from the vent. We address these limitations with an updated approach to determining VPI, and the development of a new Population Exposure Index (PEI). The PEI incorporates changing life-safety exposure with distance from a volcano to evaluate population numbers of those who could be fatally affected. We present our results using updated global population data, revised volcano coordinates, and an updated fatalities dataset. Our approach improves quantification of life-safety exposure with distance from a volcano.

ID: 317

Geothermal exploration for the sustainable development and the energetic independence of small volcanic islands

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This study delves into the possibility of geothermal exploration to attain energy autonomy on small volcanic islands. Our case study is centered on the major islands pertaining to the Aeolian Arc and Pantelleria, located respectively in the Tyrrhenian Sea and Sicily Channel (Southern Italy). Importance of this issue relies on the energy challenges in the context of global energy demands and the imperative shift towards sustainable resources. This research strives to provide a comprehensive examination of the potential, benefits and potential drawbacks in adopting geothermal energy as the primary resource to establish self-sufficiency within ecosystems of small volcanic islands.

Foundation of this research is based on the present energy landscape on Aeolian Islands and Pantelleria, predominantly reliant on fossil fuels and only sporadically renewable resources. To address these challenges, a polyhedric research approach is adopted, encompassing resource assessment to identify and quantify geothermal potential, evaluation of existing infrastructure's compatibility with geothermal integration, environmental impact analysis. Investigation is aimed at assessing the environmental, social and economic implications, the technological feasibility evaluation for identifying the most suitable condition for the geothermal energy exploitation, and the analysis of legal and regulatory frameworks necessary to support and incentivize geothermal energy development.

The study finally endeavors to deliver a holistic view of opportunities and challenges associated with implementing geothermal energy solutions in the distinct context of small volcanic islands. The research underscores the critical importance of understanding economic feasibility and social impact of transitioning to geothermal energy captured in volcanic areas.

ID: 508

VOLRISKMAC II: Strengthening R&D&I capabilities for the development of resilience against volcanic emergencies in Macaronesia

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The VOLRISKMAC II Project (MAC2/3.5b/328), financed by Territorial Cooperation Program INTERREG MAC 2014-2020, involved seven partners from Canary Islands (Spain), Azores and Madeira (Portugal), and two participating institutions from Cabo Verde. The execution of the project activities started in January 2020 and ended on December 31, 2023, with the overall objective of strengthening R&D&i capabilities to improve the resilience respect to future volcanic emergencies in Macaronesia. The project has strengthened the volcanic early warning system in Macaronesia through the improvement of instrumental networks and the development and implementation of innovative methodologies and technologies.This was achieved mainly through the design and the implementation of innovative geophysical and geochemical instrumental networks as well as of remote optical sensors. An innovative aspect of VOLRISKMAC II has been the implementation of a petrological methodology to establish the time scales of the precursors of volcanic eruptions of Macaronesia.Additionally, the project has improved the data acquisition and transmission systems and the information processing and storage system for the data generated by the volcanic monitoring, to ensure the effective operation of volcanic monitoring systems during emergencies.Of special importance has been the generation of human capital specialized in issues of volcanic risk and resilience in the volcanic emergencies, through the transfer of knowledge, tools and technologies to and from society. It is worth noting that the project has been a fundamental piece for the scientific and technical management during the recent volcanic eruption that occurred on the island of La Palma (Canary Islands).

ID: 704

The communities around the El Chichón volcano, México: resilience and risk.

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El Chichón is the most active volcano of the Chiapaneco Volcanic Arc in southeast Mexico. It erupted explosively during March-April 1982. Three major explosive phases of the eruption caused significant damage on the environment, loss of life and generalized social disruption. The post-eruption consequential social processes continue to these days in the form of further relocation, land appropriation, and cultural and social syncretism. In this research it will be presented in detail the complex social path of some of the communities around El Chichón. Likewise, some lines of action that the communities have resumed or taken regarding their resilience and coexistence with the volcano will be presented in a participative map. Sustainable tourism and local organization projects will be enhanced.

ID: 720

Built on Hot and Steaming Grounds: Copahue's Unique Soil Conditions and Urban Development

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The village of Copahue, in Neuquén, Argentina, is located at the foothills of the homonymous volcano, and built on top of its hydrothermal system. Over the past four years, this village has served as a case study for examining the interaction between hot, degassing soils and: (i) the town's infrastructure and (ii) the daily lives of its inhabitants. To identify areas with high fluid flow we elaborated multiple map layers (diffuse CO_2 flux, soil temperature, and topography) and sets of data points (point-based thermal emissions and damaged buildings). We evaluated the physical damage on assets by (i) performing a visual recognition of the various impacts of hydrothermal gases on buildings, (ii) measuring indoor concentrations of CO_2 and H_2S, and ambient temperature, (iii) collecting audiovisual material along with anecdotal information provided by the Copahue community. The data was gathered throughout four campaigns, conducted yearly from 2019 to 2022. By combining the results of diffuse CO_2 flux measurements from all the campaigns, we created a probability map of high gas emissions within the town. This map has been cross-referenced with the results of the physical damage assessment. Our findings revealed a high density of damaged buildings in proximity to high gas emission areas and thermal lagoons exploited as a touristic resource. Considering the concentrations of CO_2 and H_2S and the exceedingly high ambient temperatures found in some of these buildings, our future endeavors will focus on establishing an indoor monitoring network of quality and ambient temperature.