ID: 71

Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Español

Preferred Type of Presentation: oral

Uso de la metodología ADVISE en el contexto chileno para la gestión y reducción del riesgo por modelamientos de peligro por caída de piroclastos en el volcán Hudson.

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El estudio de riesgo volcánico presenta la dificultad de trabajar todos sus factores en conjunto como peligro, exposición y vulnerabilidad de una manera integral. Debido a esto, nace la metodología ADVISE (siglas en inglés integrAt VolcanIc risk asSEsment) elaborada por Bonadonna et al. (2021) como un método de evaluación integral de riesgo volcánico. El volcán Hudson en la región de Aysén, Chile, cuenta con uno de los mejores registros eruptivos holocenos en peligros distales, bajo esta premisa, se realiza un modelamiento numérico en el complemento TephraProb para un peligro asociado a caída de piroclastos para un escenario eruptivo subpliniano y pliniano, en el que se combina con la principal infraestructura crítica para la evacuación y el desarrollo socioeconómico categorizándolo en exposición y vulnerabilidad, además, se analiza la resiliencia para la gestión y reducción del riesgo de desastre, esto en las localidades de Coyhaique, Puerto Aysén, Puerto Chacabuco, Río Ibáñez, Chile Chico, Balmaceda y Villa Cerro Castillo. Dentro de los principales resultados para un peligro con 30% de probabilidad de ocurrencia, se puede estimar que para un evento subpliniano VRR(1) indicando que Villa Cerro Castillo tendría un riesgo alto, Coyhaique, Río Ibáñez y Balmaceda un riesgo moderado y Puerto Aysén, Puerto Chacabuco y Chile Chico un riesgo bajo, sin embargo, para un VRR(2) no cambiaría la categorización, pero sí una modificación en el rango de riesgo moderado, donde Balmaceda pasa a segundo y Coyhaique a cuarto lugar. En el caso de un escenario pliniano VRR(1) Villa Cerro Castillo presentaría un riesgo alto y Chile Chico un riesgo bajo, el resto de las localidades presentarían un riesgo moderado, por el contrario, el contexto de un VRR(2) Puerto Aysén y Puerto Chacabuco se verían afectados con una disminución en la categorización de riesgo, siendo el factor resiliencia preponderante para la disminución de riesgos ante desastres.

ID: 108

Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: oral

EXPOSURE-BASED RISK ASSESSMENT OF TEPHRA FALL ASSOCIATED TO ERUPTIONS AT MISTI VOLCANO, AREQUIPA-PERÚ

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People living in areas close to active volcanoes are exposed to tephra fall from explosive eruptions, the accumulation of which is controlled by the height of the eruption column, wind direction and wind speed. In Perú, amongst the 10 actives volcanoes, Misti volcano is located less than 18 km to the NE of Arequipa city. We estimate that >20 explosive eruptions of Misti with VEI 4-5 affected the city in the last 40,000 years.

We present here a first exposure-based risk assessment of Misti volcano performed as part of the CERG-C training of the University of Geneva, Switzerland as a proxy of the potential impact of a future eruption of Misti volcano. First, we perform scenario-based hazard tephra accumulation using Tephra2/TephraProb for a scenario based on the 2-ka eruption of the Misti complemented with analogue volcanoes. The identified scenario is of VEI 4, with modelled volumes of 0.2– 1.6 km^3, duration of 0.6– 2.3 hours, plume height of 21–24 km, and TGSD of -2– 0.2ø. Hazard assessment include probabilistic maps, probabilistic isomass maps and hazard curves. Based on available vulnerability models in literature, we analyze the potential impacts in 400,000 inhabitants living close to the Misti volcano, 210,628 buildings, infrastructure (1 water dams, 5 hydroelectrical power system), important elements for city develop. Our results highlight the need for a comprehensive risk assessment of tephra fall that takes into account both probabilistic hazard assessment and exposed elements.

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Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: oral

An adaptive algorithm for satellite data assimilation to simulate complex lava flow fields

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Lava flows represent the most common hazard in basaltic volcanoes. In the case of real-time application during an ongoing eruption, numerical modeling driven by satellite-derived time averaged discharge rate (TADR) is a powerful tool to estimate the likely paths that lava flows may follow and the emplacement dynamics. However, complex lava fields are challenging to reproduce due to the high number of variables that control the lava flow motion (e.g. opening of multiple vents, formation of lava tubes and associated ephemeral vents, variations in effusion rates, rheological features of lava flows). In this study, we present an optimization algorithm to model complex emplacements of lava flow fields in order to perform sequential time-step refinements by assimilating the information derived from low spatial resolution satellite imagery (e.g. MODIS, SLSTR, SEVIRI) to estimate TADR, and higher spatial resolution imagery (e.g. MSI Sentinel 2, OLI & TIRS Landsat 8/9 or Planetscope) to constrain the locations of both main and ephemeral vents. The workflow aims at automatically choosing the optimal input parameters for the numerical modeling, and the associated uncertainty, minimizing the misfit between the simulated and the observed lava flow features extracted from multi-source satellite imagery. The algorithm has been tested using the recent effusive eruption that occurred at Mt. Etna (Italy) between 27 November 2022 and 6 February 2023 as case study.

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Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Español

Preferred Type of Presentation: oral

Ground displacement monitoring of volcanoes via space-borne and airborne DInSAR systems to support Civil Protection activities

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In this work we present the Differential Synthetic Aperture Radar Interferometry (DInSAR) related activities that are carried out at the Institute of Electromagnetic Sensing of Environment of National Research Council of Italy (IREA-CNR) to monitor ground displacements on volcanoes to support the Italian Department of Civil Protection (DPC).

Thanks to the open availability of Sentinel-1 catalogues, we designed a fully automated system that, once available, processes every new SAR data acquired over every monitored volcano site. The data, for both ascending and descending passes, are automatically ingested and then processed through the well-known Parallel Small BAseline Subset (P-SBAS) DInSAR technique that allows generating the displacement time series and the corresponding mean displacement velocity maps relevant to the overall observation period. The retrieved Line-of-Sight (LOS) measurements are subsequently combined to obtain the Vertical and East-West components of the displacement, which can be straightforward interpreted and managed by the end users. This service is currently operative for the main active Italian volcanoes (Campi Flegrei caldera, Mt. Vesuvius, Ischia, Mt. Etna, Stromboli and Vulcano).

Moreover, we implemented a pre-operative airborne infrastructure that is equipped with a X-band and L-band SAR sensor. This platform, in conjunction with the already mentioned spaceborne systems, allows us to provide further information on the areas under study, with particular emphasis during emergency scenarios.

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Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Español

Preferred Type of Presentation: oral

Propuesta metodológica para evaluar el riesgo volcánico a desastres por el cambio del uso de suelo, Volcán Colima, México

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El Volcán Colima es de los más activos de México, dada su peligrosidad se han elaborado varios mapas de peligro por Suárez (1989), Suárez, Núñez y Reyes (2009), en 2003 la Universidad de Colima y finalmente la UNAM (2020), ninguno de estos ha integrado la vulnerabilidad para poder establecer el nivel de riesgo que existe en su entorno.

Las laderas y planicies del volcán presentan características climáticas, hídricas y edafológicas que han favorecido condiciones ambientales para la silvicultura y agricultura desde el siglo XVII y que se han intensificado a partir del año 2010, donde los cultivos tradicionales de maíz, caña de azúcar y bosques de pino han sido sustituidos por extensas huertas de aguacate y berries que dan gran cantidad de empleos que atraen migrantes de los estados del sur del país. La exposición de estos elementos a los peligros de la actividad explosiva del volcán, incrementan la vulnerabilidad de estas agroindustrias y de las personas que laboran en ella.

La metodología del trabajo se fundamenta en el análisis temporal de imágenes satelitales donde se determina la superficie con cambio de uso del suelo y su exposición a los peligros volcánicos, se realizaron entrevistas a habitantes y productores para establecer el nivel de percepción al riesgo. Los resultados muestran cartográficamente, los que deben ser considerados de manera urgente dentro de los instrumentos de planeación territorial a fin de que se reflejen en la gestión del riesgo a desastres que favorezca el aumento a la resiliencia de la región.

ID: 472

Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: oral

Systemic impact assessment for complex volcanic eruption scenarios

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Volcanic impacts can extent far beyond the spatio-temporal reach of volcanic hazards, though we lack robust methods to quantify these systemic impacts. Whilst complex volcanic hazard assessments are increasingly available, significant strides are needed in the representation of complex societal networks in impact and risk assessment. Addressing this need requires a multidisciplinary approach, involving scientists and stakeholders to co-develop decision-support tools that are scientifically credible and operationally relevant to provide a foundation for robust, evidence-based risk reduction decisions.

We present the outcomes of a multidisciplinary, co-productive approach for the quantification of longitudinal volcanic direct and indirect impacts for interdependent critical infrastructure, agriculture and economic sectors. We apply the approach to an eruption scenario suite for Taranaki Mounga volcano (Aotearoa New Zealand), where nationally important industries are subject to high volcanic risk. We find that whilst the direct impact is highly variable across the eruption scenario suite, the systemic impact is largely consistent. Thus we could identify the key vulnerabilities in the region, and robustly inform the selection of risk management strategies. The complex, systemic approach developed also allowed the quantification of key indicators for emergency response during and after volcanism, such as loss of service of critical infrastructure. Further, pairing the impact assessment with macro-economic models allowed the quantification of economic disruption, thus forming an evidence-base for business cases for resilience investment. We find that approach has enhanced volcanic preparedness and resilience-building, and that the tools and knowledge produced have seen substantial uptake in practice and policy.

ID: 518

Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Inglés

Preferred Type of Presentation: oral

A methodology to qualitative assess social and physical vulnerabilities at Planchón-Peteroa Volcano, Southern Andes, Chile

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Volcanic risk assessment is a complex task that requires the analysis of both, multiple hazards and the vulnerability of the exposed elements. Vulnerability is a dynamic concept that is based on a set of physical, social, economic and environmental characteristics of a community, parameters that determine the potential impact of a volcanic eruption.

We designed a survey that was applied to each home in the community of Los Queñes, northwest of Planchón-Peteroa, central Chile, as an initial stage. The survey consists of 16 parameters to evaluate physical vulnerability of homes, and 27 social parameters, as well as 12 parameters on risk perception. Regarding physical vulnerability, the parameters evaluated are aimed at determining architectural characteristics such as: the age of the construction, modifications suffered, number of levels, height of the construction. Structural aspects are also evaluated such as: foundation, structural system, roof construction materials, other uses of the homes, as well as pre-existing damages. The social vulnerability section evaluates aspects such as: children <5, adults >70 years, presence of people with disabilities, illiterates, unemployed, pets and farm animals. Socioeconomic aspects are also evaluated, for instance: the presence within the home of telephone, internet, TV, radio, computer, refrigerator, and public services. In the risk perception section, the questions are aimed at determining the knowledge of the inhabitants about volcanic manifestations and their response in emergency case.

First results obtained are presented, which will later be integrated with various maps for different volcanic hazards to obtain risk assessment for this volcanic system.

ID: 672

Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Español

Preferred Type of Presentation: oral

Uso de volcanes análogos para el análisis de peligros: casos de estudio Volcán Melimoyu, zona austral de Chile

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El uso de volcanes análogos es una herramienta importante en la evaluación de peligros volcánicos y la gestión del riesgo de desastre, cuando hay escaso registro eruptivo y pocos datos geológicos en volcanes activos. Ejemplo de ello es el volcán Melimoyu, ubicado en la Patagonia chilena, cuya falta de antecedentes dificulta estimar robustamente la frecuencia y magnitud de futuros eventos. Con esta motivación se clasifican volcanes análogos con el método de Burgos et al. (2023) sobre 38 variables que caracterizan la composición de las rocas, morfología del edificio volcánico y el contexto volcano-tectónico. Los volcanes que cumplen estos criterios, y que por tanto son análogos de Melimoyu, son: Mocho-Choshuenco, Yanteles, Michinmahuida, Calbuco, Callaqui, Corcovado, Quetrupillán, Nevado del Tolima, Rainier, Cerro Azul, Hornopirén, Glacier Peak, Planchón-Peteroa, St. Helens, Cerro Bravo, Doña Juana, Soche, Three Sisters, Shasta y Yakedake. Los registros eruptivos de estos volcanes fueron extraídos de las bases de datos VOTW (GVP, 2013) y LaMEVE (Crosweller et al., 2012). Con este set de volcanes se estima la frecuencia y magnitud de potenciales erupciones del volcán Melimoyu, estableciéndose escenarios de peligro para balísticos, flujos de lava, corrientes de densidad piroclástica, lahares y piroclastos de dispersión eólica, que se representan cartográficamente en un mapa a escala 1:75.000.

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Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Español

Preferred Type of Presentation: charla relámpago

Utilización de PINNs en un modelo de advencción-difusión para dispersión de ceniza volcánica

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Los modelos computacionales puramente basados en datos requieren un gran volumen de estos para el entrenamiento de dichos modelos, y además necesitan una alta capacidad de recursos computacionales. En este sentido, las Redes Neuronales Informadas por la Física (PINNs por su sigla en inglés) surgen como una poderosa alternativa a estos modelos. Las PINNs son entrenadas para resolver tareas de aprendizaje supervisado respetando el conocimiento de cualquier ley física dada descrita por ecuaciones diferenciales parciales (PDEs). Estas leyes actúan como agentes de regularización que limita el espacio de soluciones admisibles, lo que permite obtener predicciones relativamente precisas para los términos desconocidos con datos limitados. Dichos agentes tienen una serie de propiedades atractivas que no están presentes en los enfoques convencionales como los métodos de diferencias finitas. El objetivo de este trabajo es proponer una metodología alternativa que permita estimar los espesores de cenizas volcánicas que se depositan a nivel del suelo, utilizando PINNS en un modelo numérico del tipo advección-difusión aplicado a la segunda fase eruptiva del volcán Hudson (45°54'S-72°58'W), Chile, ocurrida el 12 de agosto de 1991. La importancia y originalidad de este estudio se refiere a que la utilización de la herramienta PINNs permitiría reproducir de buena manera un fenómeno teniendo en cuenta un número reducidos de datos de entrenamiento. Además, las PINNs consideran lo mejor del aprendizaje profundo y el conocimiento de las PDE, permite pesar los parámetros físicos que rigen estas PDE y estudiar cómo estos influyen.

ID: 159

Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: lightning talk

Developing a national volcanic risk model framework for Aotearoa New Zealand: current capabilities and future ambitions

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Aotearoa New Zealand faces substantial strategic risks from volcanic hazards, prompting keen interest from both central and local government agencies. These agencies are actively seeking improved characterisation of volcanic risk information that meets their present and future needs. This presentation discusses efforts being undertaken to accelerate, strengthen, and coordinate the development of nationally applicable volcanic risk information through the scoping of a national volcanic risk model. Centrally, this involves developing a framework enabling the transfer of volcanic impact/risk models for the many and varied hazards posed across several different volcanoes and contexts to produce a consistent view of risk across the Aotearoa New Zealand. To facilitate this, we leveraged several major end-to-end volcano related research programmes to integrate existing hazard and risk models into a consistent risk/impact calculation framework using the open-source RiskScape™ engine. This volcanic risk model framework is used to highlight current capability and critical gaps within and across four case study areas: Auckland Volcanic Field, central Taupō Volcanic Zone, Taranaki, and Tongariro National Park. This analysis informs our current needs, priorities, and ambitions for developing a comprehensive national volcanic risk model, as well as discussions scoping other natural hazard models in a consistent approach for the country.

ID: 171

Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: lightning talk

Multi-purpose searches for analogue volcanoes using PyVOLCANS: preliminary findings at Volcán de Fuego (Guatemala)

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Analogue volcanoes, or volcanoes that are considered similar enough as for data to be considered (partially) exchangeable amongst them, are increasingly being sought by volcanologists, especially in the context of volcanic hazard assessments. Data are scarce for many volcanoes worldwide, which significantly complicates the quantification of volcanic hazard, from eruption forecasting and frequency-magnitude relationships, to the spatiotemporal occurrence and intensity of hazardous phenomena (e.g. lava flows).

Python VOLCano ANalogues Search (PyVOLCANS) is an innovative, open-source software tool (https://github.com/BritishGeologicalSurvey/pyvolcans) that enables users to generate multi-purpose, customised sets of analogues to try to tackle data scarcity in their specific context. PyVOLCANS uses global databases, namely the Volcanoes Of The World (VOTW) and two volcano-morphology databases, to calculate a measure of total analogy (similarity) between any two volcanoes in VOTW, based on a (user-defined) weighted-average combination of five volcanological criteria: tectonic setting, rock geochemistry, volcano morphology, eruption size and eruption style.

Here, we present some preliminary results of the application of PyVOLCANS to Volcán de Fuego (Guatemala). These results include quantitative comparisons between expert-derived and PyVOLCANS-based sets of analogues, one key feature of the tool. The multiple purposes of identifying analogue volcanoes encompass finding complementary information to assist with different components of the volcanic hazard assessment (e.g. paroxysm occurrence). We initially explore how well the VOTW-based, ‘geological analogues’, can point towards volcanic systems that exhibit, or have exhibited, eruptive behaviours similar to that currently observed at Fuego. Importantly, this PyVOLCANS-driven process can guide enlarged searches in additional volcanological datasets (e.g. WOVOdat, eruption-chronology datasets).

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Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: lightning talk

Improving our ability to forecast volcanic ballistic projectile hazard through statistical metamodelling

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Volcanic ballistic projectiles (VBPs) are the most common cause of fatality for both tourists and scientists on volcanoes. To understand this risk and inform appropriate risk mitigation measures, hazard and risk assessments are often conducted. Numerical models of ballistic trajectories are essential tools for assessing hazard and risk from VBPs. However, these models are often time and resource intensive and not ideal for getting results quickly. Additionally, parameterisation and calibration of models is somewhat difficult for VBP, even retrospectively, due to few fully mapped ballistic fields and spatial relationship data. Statistical metamodels can synthesise a large number of retrospective numerical model results, finding relationships to volcano and expected eruption style, thus providing prospective forecasts including uncertainty quantification. These models can also be precalculated, allowing immediate risk assessment. Here we present preliminary results of a metamodel for VBP spatial distributions and expected hazard intensities, trained on a database of numerical simulations that were parameterised and calibrated using a catalogue of published input parameter values and mapped distributions. Precalculating VBP hazard models to produce prospective hazard forecasts will make them more useful, useable and used.

ID: 703

Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: sin preferencia

Preferred Type of Presentation: charla relámpago

Monitoring and Quick Reconnaissance of Physical-Chemical Characteristics at Hazardous Volcanic Lakes using Autonomous Vehicles

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Working on volcanic lakes is always a challenging task. Generally, measuring physical parameters like dimensions, bathymetry, and turbidity, or obtaining water or sediment samples for chemical and biological studies, requires bringing rafts, boats, life vests, trolling motors, ropes, sonar and other pseudo-portable equipment. This can be complicated on regular ambient temperature lagoons and even more difficult or impossible at active hot acidic lakes.

As an alternative, we have started using portable commercial and custom-made UAV's (Unmanned Aerial/Aquatic Vehicles) to carry small pieces of equipment such as sonars, temperature and conductivity loggers, gas sniffers, water sampling bailers, underwater cameras and total dissolved solids (TDS) meters.

We compare the pros and cons of different methodologies in obtaining the same physical measurements, such as bathymetry or temperature, and also consider the best strategies for regular monitoring versus quick reconnaissance trips to a volcanic lakes.

Additionally, we describe the use of customized heat and/or acid resistant UAV's to work at particularly challenging sites such as the hyper-acidic crater lake at Volcan Poas, Costa Rica, and the very high temperature geothermal Boiling Lake in Dominica.

The implementation of these technologies can reduce the exposure of field personnel during sampling tasks, and simultaneously offer an increase in precision, quantity and quality of the data collected during sampling campaigns in active volcanoes.

ID: 127

Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: poster

How well do concentric radii approximate population exposure to volcanic hazards?

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Circular footprints have often been used to estimate regional to global population exposure. Although this approach simplifies many challenges of hazard modelling, it has never been compared to exposure obtained from hazard footprints. Here, we compare hazard and population exposure estimated from concentric radii of 10, 30 and 100 km with those calculated from the simulation of dome- and column-collapse pyroclastic density currents (PDCs), large clasts, and tephra fall across Volcanic Explosivity Index (VEI) 3, 4 and 5 scenarios for 40 volcanoes in Indonesia and the Philippines. We found that a 10 km radius - considered by previous studies to capture hazard footprints and populations exposed for VEI ≤3 eruptions - generally overestimates the extent for most simulated hazards, except for column collapse PDCs. A 30 km radius – considered representative of life-threatening VEI ≤4 hazards - overestimates the extent of PDCs and large clasts but underestimates the extent of tephra fall. A 100 km radius encapsulates most simulated life-threatening hazards, although there are exceptions for certain combinations of scenario, source parameters, and volcano. In general, we observed a positive correlation between radii- and model-derived population exposure estimates in southeast Asia for all hazards except dome collapse PDC, which is very dependent upon topography. This study shows, for the first time, how and why concentric radii under- or over-estimate hazard extent and population exposure, providing a benchmark for interpreting radii-derived hazard and exposure estimates.

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Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

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Preferred Type of Presentation: poster

Understanding pyroclastic density current timescales and evacuation timescales at Volcán Fuego and Volcán Santiaguito, Guatemala.

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PDCs are one of the deadliest volcanic hazards, owing to their high mobilities and complexity of mitigation strategies. On June 3rd, 2018, a paroxysmal eruption at Volcán de Fuego (Guatemala) triggered a PDC which killed as many as 2,900. On May 9th, 2014, a dome collapse at Volcán Santiaguito (Guatemala) produced a PDC with a runout of 7 km, passing fincas and Santiaguito's observatory. Both events highlight the potential for loss for communities situated in the path of PDCs. This study combines VolcFlow-simulated PDCs with timed evacuation routes and local perspectives to understand risk and evacuations around Fuego and Santiaguito. Simulated PDCs reached maximum speeds of 250 km/h at Fuego and 200 km/h at Santiaguito, with PDCs at Fuego reaching communities closest to the volcano in 7 minutes 30 seconds. PDCs reach more distal runouts at faster speeds at Fuego than Santiaguito, due to Fuego's narrow barrancas constraining PDCs, increasing speeds and runouts. Santiaguito's ríos are wider and shallower, producing slower PDC speeds of smaller runouts. Maximum evacuation speeds (on foot) for communities were much slower than PDC timescales, reaching 4 km/h at both Fuego and Santiaguito. Local perspectives highlight barriers to timely evacuations and the role of national institutes INSIVUMEH and CONRED in aspects of risk mitigation. Findings reveal future risk mitigation should consider PDC timescales in informing evacuation timescales. Communities may evade loss if evacuations begin before PDC descent. Findings also highlight the importance of coordination between risk mitigation groups and communities, to reduce Guatemala's volcanic vulnerability.

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Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: poster

Probabilistic volcanic hazard and impact assessment for the Auckland Volcanic Field, Aotearoa New Zealand

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Volcanic eruptions can be particularly complex events capable of producing multiple hazards simultaneously and/or consecutively, causing eruptions to have compounding impacts on society. Comprehensive volcanic risk assessments are, therefore, required to inform appropriate disaster risk and resilience strategies. We present a conceptual framework for probabilistic volcanic multi-hazard impact assessments of societal elements. We develop this framework within a case study of the Auckland Volcanic Field (AVF), Aotearoa New Zealand, utilising existing eruption scenarios. This probabilistic approach will reduce the potential for bias that scenarios inevitably suffer from, and allow easier comparison with other similarly assessed risks (e.g. seismic).

We use existing dynamic eruption scenarios for the AVF, which include multiple volcanic hazards and transitions in eruptive style, for which we have relative likelihoods at every location in the field based on the matching of environmental factors and eruption styles. We combine these with detailed location-specific modelling of hazard phenomena to produce pseudo-probabilistic hazard and impact estimates. We anticipate producing results that can be interpreted as the site-specific probability of various hazard impacts, including combinations of hazard impacts arising from the entire suite of scenarios, weighted by likelihood of occurrence. The results of this framework application should inform short- to long-term planning and mitigative strategies in Auckland, and for nationally significant sectors. The framework and case study will be incorporated as a module for broader national volcanic risk assessment and management frameworks.

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Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: poster

A new probabilistic ash hazard and risk model for Aotearoa New Zealand

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RiskScape® is open-source software to deploy deterministic, stochastic or probabilistic, single- or multi-hazard risk assessment models. A key feature of RiskScape® is its geospatial capabilities that allow geoprocessing and spatial sampling, and for hazard and exposure information to be geographically combined. Risk functions (fragility or vulnerability) are called within workflows or 'pipelines' to allow quantification of impact and risk. A new probabilistic ash hazard and risk model for Aotearoa New Zealand has recently been deployed within RiskScape®.

This model will be utilised along-side earthquake, landslide and extreme weather models to develop a more complete picture of Aotearoa's natural hazard risk. The model contains a catalogue of 60,000 ash fall simulations from six volcanic centres. Event probabilities have been assigned by matching the events to a national volcanic hazard model based on formal expert elicitation. Probabilities may be updated as a volcano shows increasing or decreasing signs of activity or unrest. Simulations can be subsetted by magnitude, season or environmental conditions. A suite of local and international vulnerability functions for building damage, agricultural productivity and clean-up are included. The model contains national building and infrastructure exposure, but users can also use their own asset information to analyse risk to a portfolio or region.

Potential users range from insurers through to utility providers and local emergency management groups. The model may be used to understand long-term risk or be used dynamically within a crisis. The approach here could be applied to other volcanic regions worldwide by utilising existing hazard and exposure information.

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Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Español

Preferred Type of Presentation: póster

Quantifying Volcanic Hazards: A Probabilistic Analysis of the Tacaná Volcanic Complex

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The Tacaná Volcanic Complex (TVC) is located on the Mexico-Guatemala border. Recent geological investigations have significantly improved our understanding of its stratigraphy and have enabled the reconstruction of its eruptive history over the past 42,000 years. Nevertheless, a critical gap remains in our ability to assign magnitudes or other size-related metrics to its various eruptions. In this study, we introduce a novel parameter, the Eruption Impact Parameter (EIP), designed to quantify the relative size of eruptions based on the dispersal area of potentially hazardous volcanic materials. The EIP is tailored to maintain the ordered property essential for the statistical analysis of volcanic events. Given the uncertainty regarding the completeness and stationarity of the eruptive series over the entire 42,000-year record, we assess the independence of non-coincident censored intervals separately. Subsequently, we focus on the most recent censored interval, which is likely to be the most complete and is characterized by EIP 2 events. Using a mixture of exponential distributions, we calculate probabilities related to moderate future eruptions within this EIP range. To address intervals with EIP >2, where data completeness remains uncertain, we adopt an extreme value approach using a Non-Homogeneous Generalized Pareto-Poisson Process model. This approach allows us to estimate probabilities of occurrence and, consequently, assess the volcanic hazard associated with major eruptions. Our analysis leads us to the conclusion that moderate eruptions within the TVC could pose a significant hazard to the growing fixed and mobile population in the vicinity of the volcano.

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Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Inglés

Preferred Type of Presentation: póster

Deep Approximations for Continuous Volcano-Seismic Event Recognition using Dilated Recurrent Neural Networks

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Continuous monitoring of volcano-seismic signals is often carried out using systems trained on limited or incomplete datasets. From a machine learning standpoint, these systems typically learn from seismic records that contain not only information about volcanic dynamics but also intricate details about the inner structure of the volcanic edifice. This duality in the information content presents a challenge when it comes to modeling temporal events. In this study, we demonstrate that while existing monitoring systems based on Recurrent Neural Networks can recognize nearly 90% of the events cataloged in seismic databases, they struggle to capture long-range temporal dependencies effectively. Our research reveals that Dilated Recurrent Neural Networks, incorporating multi-resolution dilated recurrent skip connections between layers, possess a remarkable ability to both enhance model efficiency, reducing training time, and improve overall model performance compared to traditional Recurrent Neural Networks in tasks related to the modeling of extended seismic records. These findings hold the promise of enhancing the reliability of monitoring tools, even in the face of variations in the geophysical characteristics of seismic events within a volcano during eruptive periods.

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Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: poster

Modelling disruption to infrastructure from volcanic hazards

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Infrastructure systems can be disrupted by volcanic eruptions through a variety of mechanisms. For example, direct damage can cause service outages, outages from other systems may cascade and flow through to networks reliant on that system, or decision-makers may take pre-emptive actions to shut systems down to prevent long-term damage. Disruption to networks such as electrical systems, road networks, or water supply can have severe impacts to the functioning of socio-economic activities, and hamper response and recovery efforts. In highly volcanic regions, it can be critical to identify areas where disruption may occur and have severe consequences. Here, we work to develop methods that can identify disruption hotspots through consideration of the overlap between likely impact of volcanic hazards on exposed infrastructure and the importance of the infrastructure to network functionality. Highlighting disruption hotspots in this way allows attention and resources to be efficiently allocated in advance of or during an event.

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Preferred Type of Presentation: poster

Multi-component exposure and characteristics of densely populated neighbourhoods facing persistent volcanic threats: the Semeru volcano case, Indonesia

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We conducted a study in Semeru, East Java, Indonesia, with the aim of assessing the level of risk that the local population faces due to the volcano's ongoing and frequent eruptions. These eruptions pose a significant threat to >50,000 of the 950,000 residents living in areas on the East, South, and South-East slopes and surrounding plain of the volcano. Our research involved a combination of surveys, mapping, and statistical analysis to evaluate the exposure to volcanic hazards and to understand how 15 rural villages and small towns respond to these eruptions.

Our analytical approach encompassed key steps: 1) univariate and bivariate analyses: establish relationships between 11 variables, 2) Polytomous Logistic Regression (PLR) models: identified six key exposure variables, 3) multivariate analyses and Hierarchical Agglomerative Clustering (HAC): categorized the blocks into four distinct groups based on various attributes related to the exposure index. Additionally, we applied a distance/time criterion to assess accessibility to evacuation routes and response facilities, particularly for blocks that might be in imminent danger during an eruption.

This study highlights that logistic regression can be a useful tool for predicting the exposure index in areas beyond our survey zone, potentially on any active volcano. This method also provides insights at a local scale into which neighborhoods require enhanced disaster risk mitigation measures, aiding in prioritization of areas for disaster risk reduction efforts.

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Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: poster

Using empirical damage data to develop lava flow fragility functions for the built environment

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For risk assessment, lava flow impacts on the built environment have often been considered binary, whereby structures are either destroyed in contact with the flow or remain intact away from the flow margin. This framework, and lack of empirical data, limit our ability to assess vulnerability to lava flows and forecast future impacts. Impact datasets require international collaboration to develop and expand. In this work, we use post-eruption field missions and imagery from the lava flows of 2014-2015 Fogo, Cape Verde, 2018 lower East Rift Zone, Kīlauea, Hawai'i, and 2021 Cumbre Vieja, La Palma, Spain, to compile a building-level dataset of over 6,000 structures that includes building typology and damage severity, to show that lava flow impacts are, in fact, non-binary. Our dataset contains three main building types - masonry, timber, and metal – categorised into six damage states. We find that, on the lava flow periphery, structures exhibited a range of damage related to building typology. We identify lava flow thickness as the most appropriate hazard intensity metric and find a positive relationship between damage state and lava thickness, whereby increasing thicknesses correlate with increasing damage. There is almost total destruction of all building types impacted by lava flows >6 m thickness. We find circular and/or masonry structures relatively more resistant to thinner flows. Using our dataset, we develop the first non-linear empirically derived fragility functions for lava flows relating hazard intensity with probability of damage. These new fragility functions can be used in risk assessments to forecast potential lava flow damage.

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Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

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Preferred Type of Presentation: poster

Topographic data collection needs for forecasting lava flows

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Lava flows are one of the primary hazards associated with volcanic activity. To accurately forecast their routing and potential impacts, models simulate flow over topographic data using digital elevation models (DEMs). However, it is unknown what DEM sources, including satellite and airborne topographic mapping methods, spatial and temporal resolution, and accuracy, are needed to provide accurate and timely forecasts. In this work, we perform a sensitivity study to understand how the spatiotemporal sampling of different topography data sets affects errors in the derived DEMs, and how these, in turn, propagate into the accuracy and uncertainty of lava flow forecasts. To achieve this, we use an isothermal numerical model built on the shallow water approximation for lava flows over topography which allows for the simulation of a wide range of flow scenarios. Using this method, we show how changes in vertical accuracy and spatial resolution of a pre-eruption DEM impact the lava flow forecast, and how the acquisition of syn-eruptive DEMs is able to improve forecast accuracy. Our results highlight the necessary trade-off between noise levels and resolution in elevation data, which will guide future missions to measure topography for the purposes of volcanic hazard monitoring and mitigation, such as NASA's Surface Topography and Vegetation missions.

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Preferred Type of Presentation: poster

Using recent activity to reconstruct eruptive history and develop hazard scenarios at Sangay volcano, Ecuador

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Eruption history is essential for assessing volcanic hazards. Unfortunately, many active volcanoes are located in areas that are difficult to access, preventing in-depth tephrochronological studies. Sangay is a large stratovolcano located in the sub-Andean zone of Ecuador. It is surrounded by high paramos to the north, west and south, and impenetrable cloud forest to the east. As a result, Sangay's historical activity is poorly characterized. In recent years, its eruptive activity has caused serious local and regional impacts. Ashfalls have affected agriculture to the west of the volcano, as have repeated closures of Guayaquil's international airport. In this work, we use satellite monitoring data, field reports and ash sampling results to quantify the Volcanic Explosivity Index (VEI) of recent eruptions. Over the past 20 years, Sangay volcano has been almost constantly active, with numerous small explosions and lava flows (VEI = 0) occasionally interrupted by ash venting events and more intense explosive phases (VEI = 1). From 2020 to 2021, it also presented several short-lived paroxysms with high eruptive columns reaching VEI = 2-3. These results are compared with historical chronicles and newspaper articles to estimate the size of historical events. We found that at least sixteen VEI 2-3 events have occurred over the past 400 years, but these events are generally clustered together in 1-3 year periods, and the intervals between clusters vary from 10 to 60 years. This work is the first step towards fine-tuning the eruptive scenarios and reassessing the volcanic hazard at Sangay volcano.

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Surface deformation in the Alfredo Mainieri Protti Geothermal Field, Guanacaste, Costa Rica

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The Alfredo Mainieri Protti Geothermal Field, situated between the Miravalles and Rincon De La Vieja (RDLV) volcanoes, is home to the Costa Rican Institute of Electricity (ICE) Power Plant, responsible for extracting geothermal energy from naturally-occurring reservoirs of hot fluids, fed by the Miravalles volcano. The power plant's impact on the surfaces around its extraction and injection wells has not been extensively researched, providing space for more studies to be conducted. In this study, we use synthetic aperture radar interferometry (InSAR) to detect ground surface deformation by using images from the Sentinel-1 satellite between March 2021 to March 2022. We implemented StaMPS software, applying the multi-temporal small baseline method to create multiple displacement time series. The resulting time series indicated cycles of uplift and subsidence in the area surrounding the power plant, with total displacement values of 3.9 cm in one year of data. These cycles are associated with the activities of extraction and injection of water into the ground by the geothermal plant. Within the same time period, the southern flank and peak of RDLV showed a significant uplift of 9.3 cm, attributed to volcanic activity at RDLV, and the area around Betania, a displacement of 12 cm was obtained, which may indicate the presence of an active tectonic fault. The results reflect how these geothermal activities directly impact the ground surface, and highlight the importance of satellite methodologies as a tool for constant monitoring in geologically dynamic areas for risk and hazard management.

ID: 464

Preferred Session: 413: Nuevas metodologías para la evaluación de peligros y riesgos volcánicos

Preferred Language of Presentation: Español

Preferred Type of Presentation: póster

Evolution of the Shannon Entropy of 2021 Tajogaite eruption

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In a volcanic eruption they are an important exchange of energy from the interior of the Earth to the surface altering physical and chemical fields that affect the live around the volcano. One approach to forecasting of volcano eruptions is to analyze geophysical data in order to detect changes or pattern in the data to study what it happen inside of the volcano and use this information to detect precursor elements of a possible volcanic eruption.

Previous work has shown that the evolution of the Shannon Entropy (SE) of seismic signals is a useful indicator of proximity of one eruption. SE is a statistical quantifier introduced in the frame work of Information Theory and indicate the level of randomness in a system. The range of possible values of SE is between 0 and 1; SE is 0 if all the available data belong to the same class, in this case, it is possible to predict the class of a new data; the highest SE value is obtained when the probabilities of all the class is the same.

In this work we study the evolution of SE during 2 years of seismic records of the Cumbre Vieja volcano in La Palma (Canary Island) from January of 2021 to December 2022 including the period of the eruption. We study the evolution of this parameter and their behavior when the eruption occurs and we observe that ES is confirmed as a precursor parameter of an eruption.

ID: 574

Preferred Session: 413: New methodologies for volcanic hazard and risk assessments

Preferred Language of Presentation: English

Preferred Type of Presentation: poster

Distributed acoustic sensing for seismic events monitoring using machine learning. Luz García Martínez (1) (luzgm@ugr.es)

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Two distributed acoustic sensors (DAS) installed in the islands of Teide and La Palma (Canary Islands, Spain) provide continuous monitoring information about the volcano-seismic activity of the area. Under the umbrella of the Spanish enterprises and institutions consortium driving the project DIGIVOLCAN ('A digital infrastructure for eruption forecast in the Canary Islands'), this proposal presents the advances achieved in signal processing and machine learning strategies devoted to analyzing DAS data and extracting relevant information. The idiosyncrasy of DAS sensing data (continuous time monitoring with high spatial resolution and low SNR providing enormous amounts of data) offers a set of advantages and challenges attractive to apply state-of-the-art processing approximations. Signal SNR needs to be increased while discriminative information must be distinguished from redundant one to reduce the size of data and permit practical computation times in effective approaches. Being the final goal to implement an automatic volcano-seismic events detection system able to work in real time with DAS data, this work presents the steps followed up to now in the directions of exploratory data analysis, discriminative feature extraction, and automatic detection strategies. Complementary analysis of data obtained with classical seismic sensors together with manual earthquakes catalogues provided by INVOLCAN (Volcanology Institute of the Canary Islands) will help evaluate the potential of this relatively new DAS technology combined with automatic signal processing and machine learning for the sake of volcanic hazard and risk assessment.

ID: 578

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Preferred Type of Presentation: poster

Correlating Ground Displacement and Eruptive Activity at Rincón de la Vieja Volcano

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The Guanacaste Volcanic Cordillera(GVC) in Costa Rica is a well-monitored range that provides opportunities to analyze eruption dynamics and volcanic hazards in an area with critical national infrastructure. Rincón de la Vieja is an andesitic composite volcano that has been active since 2011, with numerous phreatic events occurring every few months. Various communities and the state-owned Borinquen-Las Pailas geothermal plant are within a few kilometers from the active crater. Assessing the hazards posed by Rincón de la Vieja to these communities are essential. The seismic and volcanic activity at Rincón is well monitored and has ideal conditions for InSAR (Interferometric Synthetic Aperture Radar) studies as it is less vegetated than other surrounding volcanic centers. From January 2020 to May 2023, velocity time series analyses of 122 Sentinel-1 images reveal substantial fluctuations— as great as 25mm within a 12-day span— in the phase range within the line of sight. Comparisons with Real-Time Energy Measurements (RSEM) from the VRBA station at Rincón, reveal that the most energetic eruptive events coincide with periods of ground subsidence relative to the satellite, and are preceded by periods of significant uplift towards the satellite. This method of estimating ground deformation using InSAR, can provide new data as frequently as every 12 days, which can prove to be an invaluable method for monitoring and hazard mitigation.

ID: 648

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Preferred Language of Presentation: English

Preferred Type of Presentation: poster

Ecological vulnerability to volcanic hazards in the South Sandwich Islands evaluated using scenario-based probabilistic multi-hazard maps

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Remote volcanoes in hostile environments pose considerable challenges for hazard assessment, as both past and ongoing eruptive activity is often poorly known. Although isolated and consequently data-poor, the volcanoes of the South Sandwich Islands represent major ecological hotspots for terrestrial and marine fauna. We present a probabilistic volcanic multi-hazard assessment for Mt Michael (Saunders) and Mt Curry (Zavodovski). We simulate the spatial distribution of lava flow, gas emission and tephra fall hazards for a range of realistic eruptive scenarios using TephraProb, HYSPLIT and Q-LavHA, with input parameters drawn from in situ measurements and analogue volcanoes. We convert all model outputs to a common likelihood scaling and combine with ecological population census data to produce integrated multi-hazard maps of volcanic risk. Under explosive eruptions equivalent to VEI 3 and 4, major penguin nesting sites are likely (> 66%) to accumulate tephra thicknesses of 0.1-1 cm and 1-10 cm, respectively. Prevailing winds result in a disproportionate tephra hazard towards the east, but it is very unlikely (<33%) that tephra fall would impact neighbouring islands. Lava flows are unlikely to reach the ocean except for high effusion rates exceeding 100 m^3s^{-1}. Ecological vulnerability is strongly linked to population mobility and therefore risk is highly seasonal as well as species-dependent. Long-term ecological impacts are exacerbated by prolonged aeolian and fluvial remobilisation of tephra deposits; although high rates of erosion can also reduce the timescale for habitat re-exposure. Volcanic multi-hazard maps may inform terrestrial management plans to manage safe access and ensure long-term population sustainability.

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Integración de la geomática en el monitoreo de peligros volcánicos: Complejo de Domos del Volcán Santiaguito, Guatemala

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El volcán Santiaguito es un complejo de domos Dacíticos y es considerado uno de los volcanes más peligrosos de américa latina. Posee una altura de 2,500 msnm y se encuentra activo desde 1922.

A lo largo de su formación el volcán Santiaguito a tenido varios periodos de actividad fuerte, que modifican los vents sobre la cúpula y cambian de dirección las amenazas. Las principales amenazas son las explosiones, ceniza, avalanchas, PDCs, lahares, colapsos del domo Caliente, siendo este el que ha presentado mayor actividad en la actualidad.

El periodo actual de actividad inicio en diciembre de 2021 y ha incrementado durante estos años con la generación de PDCs. explosiones en rangos de 50 a 60 por hora, además de una constante extrusión de lava que va desde la cúpula del cráter, formando un flujo que alcanza 4,300 metros de longitud y se extiende en el flanco suroeste, dentro del canal del rio San Isidro.

A través de técnicas de monitoreo satelitales, sobrevuelos con dron y visitas de campo se realizaron diversos modelos de elevación digital y se definió una serie temporal de imágenes para observar la movilidad del flujo de lava. Tambien se determinaron aproximadamente las distancias máximas alcanzadas por el descenso de corrientes de densidad piroclástica.

Los resultados tiene la finalidad de establecer un marco general sobre el alcance y delimitación espacial de las zonas más afectadas y contribuye a la gestión del riesgo. Los productos tambien pueden ser utilizado para la actualización de mapas de peligros volcánicos.