2025-2026 Twinning Program Research Projects

PROJECT 1: Earthquake detection using machine learning tools in the Valles Caldera, New Mexico

Project Director:
Urbi Basu
New Mexico Tech (Socorro, NM)

Twin Mentor:
Akram Mostafanejad
EarthScope Consortium

Project Summary:
The Valles Caldera, located in northern New Mexico is a resurgent caldera with a central dome. The perceived lack of seismicity in the Valles Caldera has been attributed to elevated crustal temperatures inhibiting brittle failure (House & Roberts, 2020; Sanford et al., 1991), however sparse availability of seismic data in this region has made earthquake detection further difficult. Thus, in the absence of a seismic network, local and microseismic events within the caldera may remain undetected. Studying the microseismicity of the caldera is very important as it would help us accurately evaluate the seismic hazard risk of the region and its impact on the nearby cites and structures, it will provide key insights on the geometry (dip and shape) and extend of active faults in the study area and further understanding of the hydrothermal processes associated with the Valles Caldera. Recent temporary seismic installations of three channel 5Hz nodes and broadband stations during the Summer of Applied Geophysical (SAGE) summer campaigns of 2019 and 2022 have revealed microseismicity in this relatively aseismic volcanic region. We are looking for a keen undergraduate intern to use machine learning techniques to investigate microseismicity in the Valles Caldera using the six broadband stations installed for a period of around four months (June-mid October) in 2023 and 2024. The proposed project will utilize automated machine learning tools to detect any seismic activity in the Valles Caldera. The research will mainly consist of three steps: (1) seismic P and S wave phase detection using automated seismic phase EQTransformer (Mousavi et al., 2020); (2) phase association and initial event location using rapid earthquake association and location method (REAL; Zhang et al., 2019); and (3) initial 1D earthquake location using absolute location algorithm VELEST (Kissling et al., 1994). The initial analysis will be done with two months of data from the six broadband stations for year 2024 and then expand the processing with all data available from 2023-2024.

Role and probable activities for a student researcher in this project:

1. Will learn and test open-source Python based machine learning tools to detect earthquakes from broadband seismic dataset for the Valles Caldera
2. Will learn basic seismology software such as SAC (seismic analysis code) and GMT (generic mapping tool) to view seismogram data and plot earthquake maps
3. Hands on experience with broadband seismic station installation/servicing during summer 2026 in New Mexico. The student will have opportunities to help out in temporary broadband station installations in the Valles Caldera or help in the seismic station maintenance for the NMTSO permanent network in the Permian Basin or in the Socorro region.
4. Compose a short technical report for submission to CRESCENT and prepare presentation/ poster for conference.

Preferred Skills

1. Basic familiarity with python, shell scripting and basic terminal commands
2. Geophysics background is preferred, with interest in seismology and earthquake or geologic hazard studies
3. The student should have access to a Mac laptop or Mac computer, as most of the processing needs high computing power and the codes have been tested on mac systems.

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PROJECT 2: Quantifying infrastructure resilience to volcanic hazards in Cascadia

Project Director:
Einat Lev
Columbia University:
Lamont-Doherty Earth Observatory (Palisades, NY)

Twin Mentor:
Nathaniel Klema
Fort Lewis College (Durango, CO)

Project Summary:
This project will develop a formal educational collaboration between the Lamont-Doherty Earth Observatory (LDEO) and the Engineering/Applied Physics department at Fort Lewis College (FLC), which is an MSI identified as a Tribal Serving Institution. The work will leverage existing tephra dispersion models accessible through the VICTOR project by using model outputs for potential eruptions of high-threat volcanoes in the Cascades subduction zone as initial conditions for assessing structural stability and resilience of infrastructure in surrounding communities. A student with a background in structural/civil engineering or physics will learn to identify vulnerable structures and generate load maps for a range of eruption scenarios. Scenarios will be informed by the current understanding of potential eruption behaviors at South Sister, Mount Hood, Mount St Helens, Mount Adams, and Mount Rainier. In addition to providing access for an FLC student to the expertise and resources available at LDEO, this project would expose the student to interdisciplinary research that connects volcanology to civil/structural engineering, thus increasing the societal impact of open-source volcanology codes and the VICTOR platform.

Role and probable activities for a student researcher in this project:
The student researcher will first become familiar with the execution of ash and tephra dispersal codes available on the VICTOR platform, including tephra2 and ASH3D. They will then generate maps of spatial load distributions from tephra fallout encompassing a range of eruption scenarios for each volcano based on current knowledge of chemical compositions, potential eruption volumes, likely weather conditions, and tephra properties (grain size distributions, moisture content). The student will design and conduct a streamlined quantitative comparison between the predictions of the two tools and assess the sensitivity of model outputs to variation in input parameters. The student will also study common regional design trends and perform structural analyses to derive generalized failure criterion for essential infrastructure elements. These criteria will then be compared with the tephra fallout maps to assess vulnerability of northwestern communities to regional volcanic hazard and identify regions of likely infrastructure problems in the event of a volcanic eruption.

Preferred Skills
This project will require proficiency in programming (preferably in Python) and experience calculating dynamic loads on structural elements. A student participant will be required to have passed courses on basic python programming and engineering dynamics. An ideal candidate will also have completed courses on computational methods and the mechanics of materials. An interest in geoscience and geological hazards are a plus.

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PROJECT 3: Enhancing Pacific Tsunami Warning Center Operations Through Geospatial Data Analysis and Visualization

Project Director:
Jonathan Weiss
NOAA/NWS/Pacific Tsunami Warning Center (Honolulu, HI)

Twin Mentor:
Helen Janiszewski
University of Hawaii at Manoa (Honolulu, HI)

Project Summary:
This project involves working with scientists at the NOAA/NWS/Pacific Tsunami Warning Center (PTWC) and the University of Hawaii Department of Earth Sciences on enhancing visual representations of earthquake- and tsunami-related information that are used to guide decision making while issuing domestic and international tsunami message products. For example, one of many small projects the intern could work on involves modifying existing computer programs to create a new set of map products that show maximum tsunami computer model wave heights for coastal warning points in Cascadia. Another small project consists of creating maps and graphics illustrating time-varying seismicity around Hawaii and Puerto Rico.

Role and probable activities for a student researcher in this project:
The student will initially gain familiarity with computer terminal windows, the command line interface, and basic Linux and Python programming aimed at geophysical, earthquake, and water-level data manipulation. Subsequently, the student will learn the widely employed Generic Mapping Tools (GMT), which is an open source collection of tools for manipulating geospatial data sets and producing tailored maps, plots and 3D perspectives. After this initial training, the student will use their newly acquired computer-based skills to modify existing and create new map/data products for PTWC areas of responsibility including the Cascadia Subduction Zone in the Pacific Northwest, the Hawaiian Islands, and the Caribbean including Puerto Rico. The products convey information such as earthquake source parameters and tsunami wave model output (e.g., predicted maximum wave heights at coastal warning points).

Preferred Skills
Ideally the student/intern will already be comfortable working with computers and will have some basic computer programming skills. However, this is not necessary as long as the student/intern is motivated and willing to learn something new.

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PROJECT 4: Assessing and Sharing Risk with a Rapid Earthquake Damage Estimation Tool for the Cascadia Region of Western Canada

Project Director:
Mike Brudzinski
Miami University (Oxford, OH)

Twin Mentor:
Tiegan Hobbs
Geological Survey of Canada;
University of British Columbia
(Vancouver, BC Canada)

Project Summary:
The goals of this project are twofold: (1) to understand the potential impact of earthquake scenarios in the Cascadia region of western Canada and (2) to further develop tools to share this information with users in a timely fashion. The first goal involves modelling the hazard and risk posed by seismic scenarios in western Canada, using the methodology of the First-Generation Seismic Risk Model. Per the second goal, the results will then be communicated to practitioners and the public using the RiskProfiler.ca website. More importantly, the student will help to code a script to generate static products for a Rapid Earthquake Damage Estimator (RED-E) tool, similar to the PAGER and TwoPAGER products produced by the USGS. This will include a text-only product and a pdf product with maps and charts. Wireframes of these products were already developed by Patchett (2024), based on consultation with a wide range of practitioners, but have not yet been prototyped. The end product will be a catalogue of scenario events and a script to translate scenario results into usable information products for first responders and emergency managers. This will mark a significant step forward in understanding risk from future earthquakes in western Canada, sharing that information, and operationalizing a tool that will help practitioners best direct limited resources in the first 24-72 hours after a major earthquake.

Patchett, M. (2024). Characterization of End-User Needs to Optimize the Development of the Rapid Earthquake Damage Estimation (RED-E) System in Canada (Doctoral dissertation, University of Victoria).

Role and probable activities for a student researcher in this project:
The student researcher will be running scenarios, using the OpenQuake Engine, and writing code to turn scenario outputs into static products for the RED-E tool. Specifically, they will:
- Perform background reading, at the discretion of advisors, to familiarize themselves with the OpenQuake Engine, seismic hazard, seismic risk analyses, risk communication, and western Canadian tectonics.
- Complete online training on the use of the OpenQuake Engine.
- Run a test scenario, to confirm they can generate reproducible results.
- Run a series of scenarios, as progress allows, to quantify the impact of hypothetical earthquakes in the Cascadia region of Western Canada.
- In discussion with advisors, create a mock-up of the static products: (1) text-only and (2) pdf. These will be based on wireframes developed by Patchett (2024), subject to revision in light of best science communication practice.
- Compare the prototype design to PAGER and TwoPAGER products from the USGS.
- Create one or more scripts to automatically generate the RED-E static products from OpenQuake outputs.
- If time and interest allows, create a containerized environment to run OpenQuake and produce the static products.
- Create a short report on the work.

Preferred Skills
Some experience with coding in Python is essential. Exposure to topics in geophysics, geoscience, civil or structural engineering are an asset. Beneficial to have experience working with Docker, Podman, or similar, but not required.

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PROJECT 5: Exploring linkages between larger-scale aseismic slow fault slip and accompanying smaller-scale fast seismic slip

Project Director:
Joan Gomberg
US Geological Survey, Earthquake Hazards Program (Seattle, WA)

Twin Mentor:
Kathryn Materna
University of Colorado Boulder

Project Summary:
This project focuses on understanding the various ways in which faults slip, particularly when at large-scale they slide so slowly that they are not considered 'regular' earthquakes and don't radiate destructive seismic waves. These 'slow slip events' do seem to be accompanied by a tiny amount of 'fast' slip that radiates seismic waves that are observed as tiny overlapping 'tremor' signals or as swarms of distinct but small earthquakes. This project explores the connection between tremor and swarms and the larger-scale slow slip that is hypothesized to initiate or 'trigger' clusters of smaller seismic events. We will analyze data from both seismic and geodetic (e.g. GPS) monitoring networks for this exploration.

Role and probable activities for a student researcher in this project:
The student researcher would be conducting a variety of analyses that combine both seismic and aseismic observations to test hypotheses about how the slow fault slip that manifests as geodetic signals might impact the characteristics of the seismic signals that radiate from concurrent relatively tiny, but readily observable fast earthquake-like events.

Preferred Skills of Student:
This project requires a basic understanding of Earth science, and some background in wave propagation and deformation (stress, strain) theory is desirable. Basic computer skills, particularly in running Python codes and ideally even writing some simple scripts, are needed. This project does not involve any field work, but a student spending several weeks or more in Seattle would be encouraged to assist with field projects in the area for short intervals.