PROJECT: Comparative Analysis of Slab-edge Driven Upwelling in Cascadia and the Pacific Ring of Fire System

Project Director:
Margarete Jadamec
The State University of New York at Buffalo

Twin Mentor:
Maureen Long
Yale University

Project Summary:
With advances in computational resources, geodynamic models have been able to incorporate increasing levels of complexity into the model design, thus enabling a more realistic representation of subduction zones in numerical simulations. This is especially important as the three-dimensional slab geometry, including slab edges, gaps, and intersections, has been shown to have a first-order effect on the flow dynamics. The CRESCENT researcher will use an automated framework to compare the flow results from numerical simulations of the Cascadia subduction zone with the flow results from previously run simulations of other subduction zones in the Pacific Ring of Fire system. This comparison and contrast approach will allow for differing styles of slab-edge driven upwelling to be analyzed, specifically in terms of driving anomalous off-axis volcanism in subduction zones, with the goal of identifying processes unique to the north and south slab edges in Cascadia. In addition, the researcher will plot shear wave splitting results from Cascadia and the comparative subduction zones, using seismic anisotropy to further constrain the slab-edge driven flow dynamics. This will be a joint effort supervised by a geodynamicist and seismologist, with over 20 years experience working on the dynamics of subduction systems from both a geodynamic and seismic perspective. The undergraduate researcher will gain experience learning to program in MATLAB and python, with the programming skills easily transferable to future projects. In addition, the student will gain experience in the fundamentals of numerical modeling, seismology, and constraints from rock deformation experiments, as they relate to mechanisms of slab-edge driven volcanism and hazards in Cascadia.

Role and probable activities for a student researcher in this project:
The CRESCENT sponsored undergraduate researcher will use an automated framework to compare flow results from models of the Cascadia subduction zone with flow results from other subduction zones along the Pacific Ring of Fire previously run by PI Jadamec's team. In addition, the researcher will plot shear wave splitting observations from Cascadia and the comparative subduction zones in the Pacific Ring of Fire, building on a previously compiled database of splitting observations from Cascadia. The compilation of splitting will be led by PI Long. The researcher will gain experience in data synthesis, using scientific workflows, learning the software development method, and leveraging newly learned programming skills to analyze geodynamic and seismic data from subduction zones. The researcher will also learn how to process and parse scientific literature.

Preferred Skills
Desired intern qualifications and technical skills include (a) completed coursework in Geophysics, Structural Geology and/or Global Tectonics, and Physics I and II and (b) an interest in subduction dynamics and learning to program.

PROJECT: Evaluating the Real-World Impacts of Earthquake Early Warning in the US

Project Director:	**Twin Mentor:**
Gabriel Lotto	Samantha Stanley
University of Washington (Seattle, WA)	University of California, Berkeley
Pacific Northwest Seismic Network	

Project Summary:
This project will engage an undergraduate student in applied earthquake hazards science focused on the ShakeAlert, the Earthquake Early Warning system for the U.S West Coast. The student will work with practitioners at two institutions to explore how the public and technical engagement component of operational warning system translates into public benefit, and how that benefit can be measured, evaluated, and improved.

Rather than being hypothesis-driven, the project will utilize qualitative data collection and analysis methods to thematically explore engagement with ShakeAlert's technical partners. The student will gain experience working with survey datasets, evaluation metrics, stakeholder perspectives, and communication products - including fact sheets, scientific graphics, and social media products - that sit at the intersection of geophysics, social science, and public safety. The student will gain experience in speaking with technical and general audiences, and presenting complex scientific information clearly and precisely.

Role and probable activities for a student researcher in this project:
The student will be responsible for contributing to the development of data collection instruments, analyzing data about ShakeAlert impacts, and packaging that analysis in clear and meaningful ways for a variety of audiences. Depending on the interests and skills of the student, objectives may include:

1. Working with survey results and public data to quantitatively assess the total impact of ShakeAlert implementations.
2. Analyzing qualitative survey results to evaluate the needs of ShakeAlert technical partners.
3. Developing map-based visualizations to explore alert performance or usage patterns, relying on GIS tools or StoryMaps.
4. Assisting with the design or evaluation of outreach or engagement activities tied to ShakeAlert.
5. Contributing to internal or public-facing products (such as fact sheets, web pages, graphics, videos, social media, or other communication products).
6. Crafting and delivering public presentations to community groups or technical teams.
7. Conducting site visits with prospective technical partners to help them determine whether and how ShakeAlert technical partnership would work for them.

Much of this can be performed remotely, although public engagement at the host institutions or within the student's own community will add to the experience.

Preferred Skills
There are no specific technical skills required for this project. However, the student must be willing to work with and learn from a wide variety of stakeholders and represent a publicly funded and publicly facing warning system. The ideal candidate will be interested in the intersection of geophysical science and social science, and/or in science communication. Preferred skills and interests may include:

1. Strong writing and editing
2. GIS skills
3. Comfort with public speaking
4. Interests in social science, emergency management, and/or seismology

PROJECT: Characterizing Earthquake Swarms and Aftershock Sequences in Southern Cascadia

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

Twin Mentor:
Aditya Kar
Fort Valley State University
(Fort Valley, GA)

Project Summary:
Earthquake swarms have been increasingly recognized as important parts of the earthquake cycle. This is of particular interest in subduction zones where swarms can potentially be driven by aseismic slip, increased fluid pressure, or stress interactions across spatial and temporal scales. We propose to explore the prevalence of swarms in southern Cascadia where the seismicity rate is the highest throughout the subduction zone. CRESCENT is working on a unified machine-learning catalog for Cascadia seismicity that would be ideal for our project, but if it is not yet available, we plan to use the NCEDC double-difference catalog from 1984 to the present (Waldhauser, 2009) (https://www.ncedc.org/ncedc/catalog-search.html). We will utilize an approach recently developed in the Mexico subduction zone that is designed to assist with identifying swarm activity. This approach first identifies clusters of earthquakes in space and time using the nearest neighbor technique (Zaliapin and Ben Zion, 2013). These clusters of earthquakes are then evaluated on a spectrum of behavior from mainshock-aftershock to swarm-like based on five attribute calculations developed by Ventura-Valentin (in revision) (code: https://doi.org/10.5281/zenodo.14474411). The algorithm uses quantitative characteristics derived from Omori, Båth, and Gutenberg-Richter laws: magnitude difference relative to largest event, when the largest event occurs, seismicity rate over time, maximum magnitude over time, and ratio of the magnitude range to number of events. When applied in the Mexico subduction zone to clusters with at least 10 events, the approach identified twice as many swarms as aftershock sequences. Preliminary analysis as part of USGS EHP project indicates that seismicity in the Alaska subduction has the opposite, with twice as many mainshock-aftershock sequences as swarms. One possible explanation for the higher level of swarm activity in Mexico compared to Alaska is the warmer temperature of the subducting plate, potentially leading to higher fluid pressures that lower effective stress. If true, then we would expect the Cascadia subduction zone to also have prevalent swarm behavior. We propose to characterize the behavior of seismicity in southern Cascadia to investigate this potential relationship.

Role and probable activities for a student researcher in this project:
The student will be responsible for learning about the southern Cascadia seismo-tectonic environment, exploring the seismicity catalog, applying the algorithm to the southern Cascadia earthquake catalog, and then evaluating the results of the algorithm. This would include:

1. Reading papers about southern Cascadia, the Mendocino triple junction, nearest neighbor clustering, and swarm characterization
2. Generating plots that illustrate the spatial, temporal, and frequency-magnitude distribution
3. Calculating the nearest neighbor values and potential clustering of seismicity and evaluating the resulting patterns
4. Applying the automated swarm-vs-aftershock characterization to the detected seismicity clusters and determining whether the results are consistent with manual examination of the catalog and if the processing parameters should be adjusted
5. Evaluating the resulting patterns of swarms and aftershocks in the tectonic context of southern Cascadia and the Mendocino triple junction

Preferred Skills
The computational capabilities offered by the Seismology Skill Building Workshop (e.g., shell scripting, GMT, python) would be essential. Exposure to topics in earthquake seismology would be an asset.

PROJECT: Influence of megathrust geometry on Cascadia earthquake ruptures

Project Director:
Elizabeth Madden
San Jose State University (San Jose, CA)

Twin Mentor:
Megan Anderson, Ashley Streig
Washington Geological Survey

Project Summary:
Earthquakes pose a significant threat to lives and livelihoods in the Pacific Northwest of the United States. However, the last large earthquake along the Cascadia subduction zone occurred in 1700, before modern instrumentation. This project is focused on mitigating seismic hazard in the region by (1) comparing physics-based models of potential Cascadia rupture scenarios on faults with different three-dimensional geometries and (2) summer field work in Washington state using gravimetry to identify the three-dimensional geometries of faults.

Role and probable activities for a student researcher in this project:
During the academic year, the student researcher will join a team that is running dynamic rupture models of Cascadia earthquakes on a high-performance computing platform. The student will gain experience in all steps of the model workflow from building several structural models with different fault geometries, gathering information to set the initial model conditions, trouble-shooting the model runs and analyzing the output. During this process, the student will learn about earthquake physics and acquire command line interface and programming skills. Over the summer, the student will participate in fieldwork, gravimeter data processing, and map view interpretation of the gravity data to determine fault geometries with a team of scientists at the Washington Geological Survey. Together, these activities provide broad experience in geological and geophysical research focused on earthquakes and earthquake hazard.

Preferred Skills
This position requires interest in learning the programming skills that are part of executing the earthquake models, willingness to travel to the summer field sites and participate in data collection (including driving on forest roads and occasional light hiking), and the ability to work both independently on tasks as well as a part of a research team.

2026-2027 Twinning Program Projects

PROJECT: Subduction zones in the 21st century, from the field to the classroom

Project Director:
Carolyn Tewksbury-Christle
Fort Lewis College (Durango, CO)

Twin Mentor:
Eirini Poulaki
Louisiana State University (Baton Rouge, LA)

Project Summary:
Students learn best when they are able to get hands-on with real world data and problems. Subduction zones are an excellent sandbox to explore everything from structural geology and metamorphic petrology to igneous processes to geophysical data, but many classrooms do not have easy access to the rocks or data that can be collected from modern subduction zones or exhumed subduction-related rocks. Research into exhumed subduction complexes is producing cutting-edge structural, geochemical, geochronologic, geophysical, seismic, and rheologic data that we want to make accessible so that faculty can bring subduction zones into their classroom regardless of where they are located and the resources they have. Virtual Field Experiences (VFEs), including static imagery, videos, maps, drone imagery, 3D models of outcrops and rocks, and field data allow students to experience field research even when getting out in the field is not possible due to location, funding, or accessibility concerns. In addition to VFEs, published data for exhumed subduction complexes provides opportunities to explore and interpret genuine research data from a wide range of fields. Activities investigating subduction zones can be incorporated into many different courses to give students experience with different datasets. Active learning like this improves student retention of course materials and increases student success across a wide range of student backgrounds.

For this project, we plan to leverage published data collected by our research groups in exhumed subduction complexes around the world to create a Virtual Field Experience and a suite of associated activities that could be adapted and adopted into upper-level undergraduate or graduate-level courses at any institution. We will specifically focus on designing several different options (e.g., field-focused vs. lab-focused) and at several different levels (e.g., undergrad vs. grad) to make these as widely usable as possible. We will share these on the Teach the Earth website as a part of the Science Education Resource Center (SERC).

Role and probable activities for a student researcher in this project:
This project is a chance to learn how to teach effectively. Virtual field trips and hands-on project-based classroom activities are important themes in effective and equitable teaching, and this experience will be invaluable to a student who is interested in teaching students at any level in the future. To develop these activities, the student will draw on several decades of education research to learn about best practices and will learn about subduction processes and the data available from our research groups and beyond. Based on what we have available, the student will storyboard and design a virtual field experience and associated data analysis activities. During the spring, the student will revise the activity outlines and start to build out instructions and related materials. This project will also involve field work during the summer to collect imagery and structural data in an exhumed subduction complex that the student will use for the virtual field trip. The final activity for the student will be to post the VFE and data processing exercises to Teach the Earth so that they are publicly available and to share their resources at a national geoscience meeting like GSA or AGU.

Preferred Skills
Experience with ArcGIS and/or experience as a teaching assistant is preferred but not required. We will provide training through our regular meetings, online resources and classes in our institutions for students who do not have these backgrounds.