2026-2027 Twinning Program Projects

PROJECT: Characterizing Earthquake Swarms and Aftershock Sequences in Southern Cascadia

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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.