IMPERIAL

Megathrust Earthquake Hazards and Coastal Erosion of the Cascadia Subduction Zone (Pacific Northwest, USA)

Supervisors: Dr. Dylan Rood (d.rood@imperial.ac.uk); Dr. Martin Hurst (University of Glasgow); Dr. Devin McPhillips (U.S. Geological Survey); Dr. Anna Rood (Global Earthquake Model - GEM - Foundation)

Department: Department of Earth Science and Engineering

Earthquakes and coastal erosion are two of the most dangerous natural hazards – they can be profoundly destructive to societal infrastructure, human life, and the environment. It is well known that subduction zones generate the largest earthquakes on the planet, yet important questions remain about past and future shaking during M9 megathrust earthquakes of the Cascadia Subduction Zone (CSZ) in the Pacific Northwest, USA (i.e., states of California, Oregon, and Washington). Furthermore, it is clear that sea levels have and will continue to rise as a function of climate change and global warming; however, how this sea-level rise will impact future coastal erosion remains unclear.

This PhD project will fill these knowledge gaps by applying geomorphology, geochemistry, and numerical modelling to the assessment of earthquake hazards and coastal erosion in the CSZ. The primary goal of this PhD project is to combine geologic and geomorphic data, cosmogenic isotope exposure ages, and numerical modelling to quantify coastal erosion rates for the past and future, date ancient fragile geologic features, and place limits on the magnitude of past earthquake ruptures and shaking.

The PhD student will:

1) Construct geologic and geomorphic maps using lidar data, remote sensing, and GIS, including mapping of coastal landforms along the CSZ (e.g., rock coast shore platforms and sea stacks);

2) Determine the coastal erosion rates and ages of fragile geologic features along the CSZ utilising topographic/bathymetric surveys (e.g., drone photogrammetry and lidar) and cosmogenic isotope measurements coupled with numerical models;

3) Combine surface exposure age results and fragility analyses to quantify how long sea-stacks have been preserved and the upper limit of ground motion during the period of preservation;

4) Develop probabilistic seismic hazard analysis models using OpenQuake;

5) Validate and reduce uncertainties in the earthquake hazard models using the age and fragility data for coastal landforms;

6) Use numerical models, calibrated with optimised coastal erosion rate results, to make forecasts of coastal erosion for the next century for different fossil fuel emissions scenarios and associated sea-level rise trajectories.

Developing such datasets will directly contribute to and reduce uncertainties in earthquake and coastal erosion hazards assessments for the American Pacific Northwest where significant human population and critical infrastructure (e.g., the cities of Portland and Seattle) exist.

A passion for science that matters to society is critical. This is a multidisciplinary project, with significant training in field, laboratory, analytical, and numerical methods. The student will collaborate with international project partners in academia, government, and industry, and establish skills and networking connections important for further career opportunities in any of these scientific realms.

Key References

Rood, A. H., Rood, D. H., Stirling, M. W., Madugo, C. M., Abrahamson, N. A., Wilcken, K. M., . . . Stafford, P. J. (2020). Earthquake hazard uncertainties improved using precariously balanced rocks. AGU Advances, 1(4), 1-24. doi:10.1029/2020av000182

Shadrick, J. R., Rood, D. H., Hurst, M. D., Piggott, M. D., Hebditch, B. G., Seal, A. J., & Wilcken, K. M. (2022). Sea-level rise will likely accelerate rock coast cliff retreat rates. NATURE COMMUNICATIONS, 13(1), 12 pages. doi:10.1038/s41467-022-34386-3