PROJECT TITLE: Earthquake Ruptures in Complex Fault Networks: Short-Term Physics-Based Earthquake Forecasting

Project Science Theme: Earth Science and Hazards
Project keywords: earthquakes, faults, modelling, seismology, geology

Lead Institution: University Bristol
Lead Supervisor: Dr Max Werner, Bristol, Earth Sciences
Co-Supervisor: Ake Fagereng, Cardiff University, School of Earth & Environmental Sciences
Co-Supervisor: Matt Gerstenberger, Earth Science New Zealand
Co-Supervisor: Kevin Milner, US Geological Survey
Co-Supervisor: Dr Luke Wedmore, MS Amlin

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Project aims and methods:

Earthquakes threaten people, infrastructure and economies worldwide. Advanced physics-based computer models can now predict many features of earthquake ruptures, even in complex fault networks. This project exploits those models to move short-term forecasting beyond today's one-size-fits-all statistical aftershock forecasts, toward physics-based rupture forecasts constrained by geological and geophysical data. Such forecasts could eventually replace agency aftershock systems and give better risk guidance to disaster responders, the re/insurance sector, governments and the public.

The project uses rupture simulations on fault networks alongside statistical evaluation techniques to test predictive power against real data. This requires calibrating and running physics-based and semi-empirical models on well-constrained fault networks, including California and New Zealand, to generate million-year catalogues, plus methods for conditional short-term probabilistic forecasts of earthquake triggering. Specifically, deterministic simulations will be grouped by factors influencing a nearby fault section's "triggerability", producing forecasts that express uncertainty about its proximity to failure. Statistical methods then compare observable rupture parameters against forecasts for evaluation and benchmarking against current empirical models.

The project offers training in physics-based modelling (including HPC), earthquake mechanics, statistical model evaluation, seismic hazard/risk assessment, and catastrophe modelling, across a complementary team of long-term collaborators. According to interest, background and career plans, the candidate may steer research toward fundamental model development, model evaluation, or cat-modelling applications for re/insurance. Lead advisor Dr Werner (Bristol) brings forecasting and model evaluation expertise, including open-science practices. Co-advisor Prof Fagereng (Cardiff) trains the student in earthquake geology and mechanics; their previous students also received extensive training in scientific writing and research methodology.

Collaborator Kevin Milner (USGS) covers HPC modelling of rupture simulators, and Matt Gerstenberger (Earth Sciences New Zealand) covers seismic hazard applications. Both facilitate access to Californian and New Zealand datasets to assess tectonic setting and will host extended research stays. Partners in re/insurance will provide industry perspectives.

This project also offers a paid 3-month internship with MS Amlin, a global insurance and reinsurance provider.

Collaborative Partner:

Earth Science New Zealand will provide In-kind time contributions to the project as collaborative partner (approx 1 hour per week), including for 1) project co-supervision, 2) facilitating access to New Zealand datasets and existing benchmark models, 3) guiding the project regarding the use of rupture simulator output for national seismic hazard models for building codes and other applications, and 4) hosting the student for an extended research internship.

Useful recruitment links:

For information relating to the research project please contact the lead Supervisor via: max.werner@bristol.ac.uk

Bristol NERC GW4+ DTP Prospectus:
https://www.bristol.ac.uk/study/postgraduate/research/great-western-four-doctoral-training-partnership-nerc/

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/

The application deadline is Thursday 7 January 2027 at 2359 GMT