The University of Oxford Department of Earth Sciences

EARTHSCIENCES

UNIVERSITY OF OXFORD

Tracking and modelling complex earthquake ruptures

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Key Words	**Geophysics, Earthquakes, Modelling, Seismology**

Overview

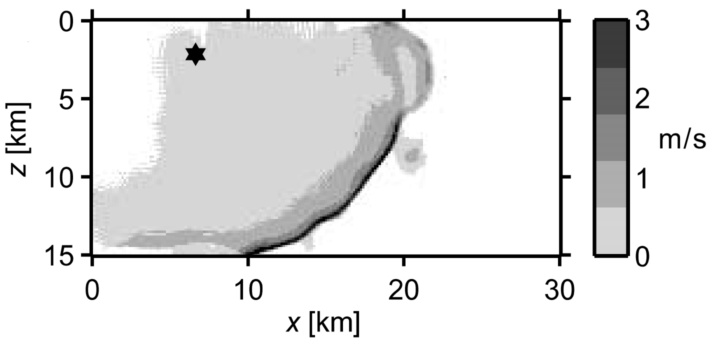
Earthquakes often display complex propagation patterns. They rupture in fits and starts and contain numerous bursts of slip. The bursts of slip likely result from ruptures of parts of the faults with particular properties: with especially large stress build-up, especially low fault strength, or especially favourable fault geometries. But currently we do not know which fault properties have the largest influence on earthquake ruptures, and that ignorance makes it hard to infer fault properties from earthquake observations and to forecast potential earthquake sizes from physical understanding.

So in this project, you will use fault slip modelling and seismic and geodetic observations to determine which fault properties are most plausible given the earthquake data.

First, you will develop models of fault slip that include various types of heterogeneity, including spatial variations in stress, rock type, and geometry. You will use numerical simulations and analytical understanding to predict how ruptures will evolve in each scenario. You may examine, for instance,

- Whether earthquakes should start abruptly and slow down gradually, or start gradually and stop abruptly
- How the average stress released by earthquakes varies with earthquake size
- Whether the area where the earthquake begins is also the area with largest slip

You will compare your model predictions with a range of existing observations, such as the slip and slip rate histories estimated for a range of earthquakes. And you will make some of your own observations of earthquakes in California, Italy, or Turkey. You may, for instance, further develop a back-projection technique to precisely track the migrating location of slip in large earthquakes, or you may use the seismograms of small earthquakes to examine their complexity.



A snapshot of slip rate taken during simulated earthquake rupture. The earthquake begins at the star and propagates down and to the right. Slip rates are highest near the rupture edge, as indicated by the darker colour. From Ripperger et al, 2007.

Methodology

To simulate earthquake ruptures, you will use a suite of existing numerical codes, to be modified as needed. You will interpret the model behaviour with a combination of mathematical tools and physical intuition.

To examine real earthquakes' heterogeneity in detail, you will use and further develop template-based seismic techniques, in which we compare the seismograms created by adjacent earthquakes or slipping locations in order to precisely locate the slip and estimate its magnitude.

Timeline

Year 1: training, exploration of earthquake literature, simulations of earthquakes with heterogeneous stresses.

Year 2: simulation and examination of earthquakes with heterogeneous fault properties, development of model predictions

Year 3: Comparison with existing data, seismology-based analysis of new earthquakes.

Year 4: Further comparisons with data, synthesis of models and observations

Training & Skills

You will be trained in numerical simulation, seismology, and physical interpretation of fault slip. By working on both models and observations, you will develop a strong understanding of earthquake mechanics. You will interact with researchers working on lab experiments, modelling, and geological and geophysical observations and will attend conferences and workshops in the UK, Europe, and the US. You will also receive training in scientific writing and presenting.

References & Further Reading

Mai, P. Martin, and Gregory C. Beroza. "A Spatial Random Field Model to Characterize Complexity in Earthquake Slip." *Journal of Geophysical Research,* 107 (2002) 2308. https://doi.org/10.1029/2001JB000588.

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Further Information

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This project would be suited to a student interested in a physical understanding of earthquake mechanics, with a background in geology, physics, engineering, or computer science.