The University of Oxford Department of Earth Sciences

EARTHSCIENCES

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How do earthquakes start?

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Overview

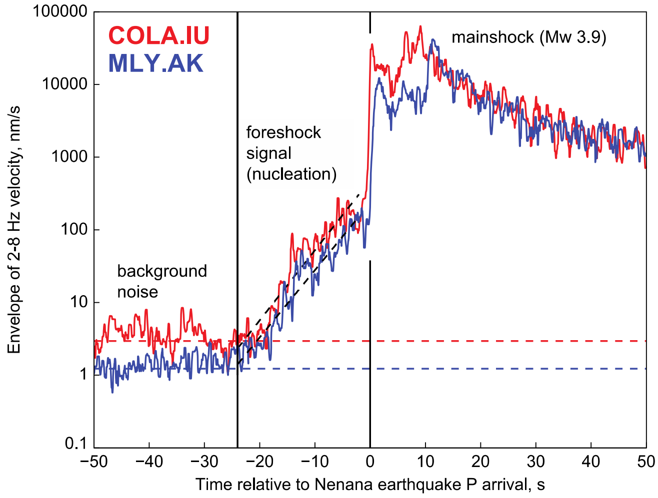
Most earthquakes start abruptly. Their faults accelerate from 10^{-9} m/s to 1 m/s in just a fraction of a second. But observations in the past few years have revealed that some faults accelerate more slowly, over seconds to days. The gradually accelerating slip triggers numerous tiny earthquakes that occur in the lead-up to the main large rupture.

These observations of accelerating aseismic slip could be crucial to our understanding of earthquake nucleation, as they may tell us whether the slip rate increases linearly, exponentially, or as a power law. And by observing the small seismic events, we can estimate the locations of the accelerating slip and examine whether the slip accelerates in place or whether it occurs in bursts at a range of locations.

Observations of preseismic earthquake bursts are rare---they occur after fewer than one in a few thousand earthquakes. But more than 100,000 M>3 earthquakes occur each year. So in this project, you will use new seismic techniques to automate a search for preseismic earthquake bursts in California, Greece, and Turkey.

Then you will examine the bursts you identified. You will assess how quickly slip accelerates and whether it occurs in smaller clusters. And you will examine where the bursts occur: on strike-slip faults, near the brittle-ductile transition, or closer to the surface?

Finally, you will couple your observations with models of frictional sliding to test proposed models of earthquake nucleation. You will use numerical models of fault slip along with your physical understanding to test models of earthquake nucleation, and will focus on distinguishing between models with lab-derived friction laws, viscsous rheologies, and interacting earthquake cascades. You will consider the implications of each of these models for short-timescale earthquake forecasting.



Seismic amplitude observed before and during a M3.9 earthquake in Alaska, on a log scale. The seismic amplitude gradually increases in the 25 sec before the mainshock, as numerous small earthquakes occur during the mainshock nucleation. From Tape et al., 2013.

Methodology

To search for bursts of earthquakes, you will use recently developed seismic techniques based on template matching. You will also use amplitude-based techniques and statistical analysis in the search, and you will use earthquake statistics to investigate what your findings imply for earthquake forecasting.

To simulate earthquake nucleation, 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.

Timeline

Year 1: Training, exploration of some identified earthquake bursts, automate large-scale search

Year 2: Complete large-scale search for nucleation signals, analyse their spatial and temporal growth

Years 3: Develop models of earthquake nucleation, test with your observations

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

Training & Skills

You will be trained in seismology and numerical modelling and will develop a strong understanding of earthquake physics by identifying features to test with the data. You will also become familiar with a range of other fault mechanics tools, including earthquake geology, geodesy, and statistics, 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

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Further Information

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