

Data analysis of recordings of slow earthquakes: Tectonic tremor, low-frequency earthquakes and slow slip events

Ariane Ducellier

University of Washington

General Exam - October 2019?

Introduction

Depth of the source of the tectonic tremor
A low-frequency earthquakes catalog for southern Cascadia
Detection of slow slip events in New Zealand
Time line

Slow slip

Tectonic tremor
Low-frequency earthquakes (LFEs)
Episodic Tremor and Slip (ETS)
Research questions

Slow earthquakes

Introduction

Depth of the source of the tectonic tremor
A low-frequency earthquakes catalog for southern Cascadia
Detection of slow slip events in New Zealand
Time line

Slow slip

Tectonic tremor
Low-frequency earthquakes (LFEs)
Episodic Tremor and Slip (ETS)
Research questions

Slow slip

Introduction

Depth of the source of the tectonic tremor
A low-frequency earthquakes catalog for southern Cascadia
Detection of slow slip events in New Zealand
Time line

Slow slip

Tectonic tremor
Low-frequency earthquakes (LFEs)
Episodic Tremor and Slip (ETS)
Research questions

Slow slip

Tectonic tremor

- Long (several seconds to many minutes)
- Low amplitude
- Emergent onsets
- Absence of clear impulsive phases

Introduction

Depth of the source of the tectonic tremor
A low-frequency earthquakes catalog for southern Cascadia
Detection of slow slip events in New Zealand
Time line

Slow slip

Tectonic tremor

Low-frequency earthquakes (LFEs)
Episodic Tremor and Slip (ETS)
Research questions

Tectonic tremor

Low-frequency earthquakes (LFEs)

- Small magnitude earthquakes ($M \sim 1$)
- Frequency content (1-10 Hz) lower than for ordinary earthquakes (up to 20 Hz)
- Source located on the plate boundary,
- Focal mechanism: Shear slip on a low-angle thrust fault dipping in the same direction as the plate interface

Low-frequency earthquakes (LFEs)

Episodic Tremor and Slip (ETS)

- Tectonic tremor observations spatially and temporally correlated with slow slip observations (Nankai, Cascadia)
- Only biggest tremor episode associated with slow slip
- No spatial or temporal correlation in other regions like New Zealand

Depth of the source of the tectonic tremor in the eastern Olympic Peninsula

- Lack of impulsive phases → Difficult to determine the depth of the source of the tremor
- Tectonic tremor is at least partly made of a swarm of LFEs
- LFEs are located on the plate boundary

→ Research question: Is the source of the tectonic tremor located on the plate boundary? What is the depth extent of the location of the source of the tremor?

A low-frequency earthquake catalog for Northern California

- LFEs grouped into families of events
- All the earthquakes of a given family originate from the same small patch on the plate interface
- LFEs recur more or less episodically in a bursty manner
- Wide range of recurrence behavior between seismic regions, and within the same seismic region

Introduction

Depth of the source of the tectonic tremor
A low-frequency earthquakes catalog for southern Cascadia
Detection of slow slip events in New Zealand
Time line

Slow slip

Tectonic tremor
Low-frequency earthquakes (LFEs)
Episodic Tremor and Slip (ETS)
Research questions

LFEs in Washington State

LFEs on the San Andreas Fault

A low-frequency earthquakes catalog for southern Cascadia

- LFE families in southern Cascadia:
 - 34 LFE families on the subduction zone
 - 3 LFE families on two strike-slip faults from the San Andreas Fault system
- Wide range of recurrence behavior between Washington State and the San Andreas Fault, and within the San Andreas Fault zone

→ Do low-frequency earthquakes families behave similarly or differently in southern Cascadia, compared to Washington State and the San Andreas Fault?

Detection of slow slip events in New Zealand

- Small ($M \sim 5$) or long (several months) slow slip events are harder to detect
- In Cascadia, Mexico, tremor used as a proxy to study slow slip events
- Different pattern in northern new Zealand:
 - Tremor source located downdip of the slow slip on the plate boundary
 - Tremor activity does not seem to increase during slow slip events

→ Can we detect smaller and / or longer slow slip events in the absence of spatially and temporally correlated tectonic tremor?

Current catalog

Current catalog

- Subduction zone families
 - 34 families
 - Period covered: April 2008
 - One burst of LFEs lasting a few days and propagating from south to north
- Strike-slip fault families
 - 3 families
 - Period covered: March and April 2008
 - Active all the time, several bursts of LFEs

Creating templates

Creating templates

Finding new LFEs

Finding new LFEs

Comparison with existing catalog

Extension of the catalog

Extension of the catalog

Detection of LFEs with permanent networks

Comparison FAME - permanent networks

Comparison FAME - permanent networks

Future work

- Two-year-long catalog for all LFE families
- Computation of new templates for the permanent networks
- Whenever possible, extension of the LFE catalog to 2009-2019

Effect of nearby earthquakes

Effect of nearby earthquakes

Effect of nearby earthquakes

Future work:

- Event rate before the earthquake
- Event rate after the earthquake
- Comparison between two event rates: Computation of likelihood ratio

Questions?