Cycles within cycles: Repetitive tremor of and between Cascadia 14-month ETS episodes

Creager, Wech, Vidale, Melbourne
Outline

ETS

• ETS events repeat every $14\pm2$ months
• Look at similarities/differences among last 4 ETS episodes
• Compare tremor and geodetic slip
• There is a slip deficit, even in the region with the most slip
  • Sharp up-dip boundary is 75 km from inferred locked zone!

InterETS

• InterETS tremor contributes about 45% of tremor
• Accounts for some of the slip deficit
• Down dip from ETS tremor
• Events with duration 1 - 200 hours follow b-value distribution; $b=0.9$
• Repeating events
Tremor Migration for four ETS events

Wech, Creager and Melbourne, JGR, submitted

July 2004 ETS

September 2005 ETS

January 2007 ETS

May 2008 ETS

2,774 epicenters, 173.7 hours

3,118 epicenters, 196.8 hours

3,061 epicenters, 199.8 hours

3,677 epicenters, 226.7 hours
Tremor vs Slip

Wech, Creager and Melbourne; JGR, submitted

Wech, Creager and Melbourne; JGR, submitted
Tremor from 2004, 2005, 2007 ETS

- Sharp western boundary to tremor
- Consistently 75 km from tremor to 40% locking
- Crustal earthquakes stop at eastern tremor boundary
- Tremor is most active over water
Tremors relative to Japan locked zone?

Tremor from Obara, 2002
Slip of 1944 and 1946 thrust events from Sagiya and Thatcher, 1999
ETS vs interETS tremor

Wech, Creager and Melbourne; JGR, submitted
ETS vs interETS Tremor
Power-Law Distribution of Tremor Swarms

\[ N = A \times \tau^{-0.6} \]

\[ \log_{10} N = a \times 10^{-bM_w} \]

- \( b = 0.9 \)
- if moment proportional to duration
Summary

ETS

• ETS events repeat every 14±2 months
• 2004 and 2005 ETS migrate updip, then bifurcate
• 2007 and 2008 migrate north along strike; late activity in south
• All four match geodetic slip pattern
• There is a slip deficit, even in the region with the most slip
• Sharp up-dip boundary is 75 km from inferred locked zone

InterETS

• InterETS tremor contributes about 45% of tremor
• This accounts for some of the slip deficit
• Locates down dip from ETS tremor
• Events with duration 1 - 200 hours follow b-value distribution; b=0.9
• Events of all sizes repeat
N = A * Duration^{-0.6}

Tremor swarms follow power-law distribution
If moment proportional to duration:

\[
\log_{10} N = a \ 10^{-bM_w}
\]

\( b = 0.9 \)
Four ETS and One Inter ETS

<table>
<thead>
<tr>
<th>Event</th>
<th>Number of Epicenters</th>
<th>Duration (hrs)</th>
<th>Migration (km/day)</th>
<th>Slip (cm)</th>
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<td>182</td>
<td>11</td>
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</table>
Two kinds of quakes?

Iide et al., Nature, 2007
Inter ETS Tremor
Feb 2007-April 2008