ESS 502: The Solid Earth: Cascadia Subduction and Hazards

1. The set of geophysical tools (same as first half)
   a. Seismology
   b. Geodesy
   c. Heat Flow
   d. Gravity (acceleration/potential field)
   e. Magnetics
   f. (plus a little basic geochemistry)

2. Fundamental observables and inferred models

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<th>Observe</th>
<th>Infer</th>
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<tr>
<td>Seismic travel times</td>
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<td>Seismic amplitudes</td>
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<td>Electric and Magnetic Fields</td>
<td>3-D electric conductivity models</td>
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<td>Areogravity</td>
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<td>Lidar</td>
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<td>GPS</td>
<td>crustal block rotations/deformation</td>
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<td>Seismic tremor</td>
<td>ETS (episodic tremor and slip)</td>
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<td>GPS/strain/tilt</td>
<td>silent earthquakes/episodic slip</td>
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<td>Gravity</td>
<td>3-D density model</td>
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<td>Heatflow</td>
<td>3-D temperature structure</td>
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See Web page for Schedule: subject to change

Reading List for Cascadia Subduction and Hazards

Overview of Cascadia tectonic setting
Read the paper Wells et al., 1998 and answer these questions (turn in your answers):
1) Summarize the main points of the tectonic model that they propose.
2) What are the key observations?
3) What do you not understand?
We will discuss this paper as a class. Be prepared to come up to the board and explain
the key points.

Wells, R. E., Weaver, C. S., and Blakely, R. J., 1998, Fore arc migration in Cascadia and
its neotectonic significance; Geology, v. 26, p. 759-762.

Model for Intermediate depth intraslab earthquakes:
Read one of the following three papers and identify 1) the most important point(s), 2) the
key observations that back this up, 3) whether you believe these results and 4) why they
are important. Before class you should meet with the other people in your group to
discuss these four issues. In class you will explain your answers to these 4 questions to
other members of your class, and learn about the other 2 papers from other members of
the class as described in the "Active Learning Model" on the web page.

Peacock and Wang, Seismic consequences of warm versus cold subduction
metamorphism: Examples from southwest and northeast Japan, Science, 286, 937-


intermediate-depth earthquakes in subducting slabs linked to metamorphic
2003.

Serpentine Mantle Wedge:

The three papers by Bostock, 2002; Blakely, 2005 and Audet, 2009 should be read in
groups and presented to each other in class, following the same procedure and answering
the same questions as for the intermediate-focus earthquakes.

This is the first paper to present compelling evidence for the existence of a strongly
serpentinized mantle wedge.
Bostock, M.G., R.D. Hyndman, S. Rondenay, and S.M. Peacock, An inverted continental

This paper discusses magnetic and gravity anomalies to infer the geographic location of
the serpentinized mantle wedge and its implications.
Blakely, R.J., T.M. Brocher, and R.E. Wells, Subduction-zone magnetic anomalies and

This paper discusses evidence for a serpentinized mantle wedge with a sharp boundary
directly under Mount St Helens and its implications.
Hansen, S.M., B. Schmandt, A. Levander, E. Kiser, J. E. Vidale, G.A. Abers, K. C.
Creager, Seismic evidence for a cold serpentinized mantle wedge beneath Mount St

This paper reports seismic evidence for water at high pore pressure in the upper crust of
the subducting Juan de Fuca Plate.
Audet, P. M. G. Bostock, N. I. Christensen, and S. M. Peacock, Seismic evidence for
overpressured subducted oceanic crust and megathrust fault sealing, Nature, 457| 1
Episodic Tremor and Slip:

You should all read the first paper (only 2 pages) and one of the following 3 papers for discussion in class:


You can choose which of these three papers you want to read for discussion in small groups.

This is an excellent paper that discusses the scaling laws of earthquakes. In a nutshell, for normal earthquakes the seismic moment scales as a characteristic duration cubed. This is because earthquakes generally propagate at near the shear wave speed, so the fault length is proportional to the duration, fault area is the square of the length (for an equidimensional fault) and empirically, the amount of slip is roughly proportional to the fault length (strain scales as slip/fault length, stress drop, which is proportional to strain, is observed to be roughly independent of earthquake size). So, the seismic moment (shear modulus * fault area * amount of slip) is proportional to duration cubed. Slow slip/ETS/Low-Frequency Earthquakes, Very Low-Frequency Earthquakes, etc all have duration approximately proportional to seismic moment.


Paper on how slip transitions with depth from stable sliding at depth to episodic slip characterized by frequent small events to infrequent large slip events and ultimately to stick-slip megathrust earthquakes at shallow depths.


Paper on sensitivity of tremor to tides and implications for fault friction:


Excellent review paper:


More ETS papers...

The focus of this paper is on a comparison of the spatial distribution of tremor and of geodetic inferred slip for four Episodic Tremor and slip events in Cascadia.


This paper uses low-frequency earthquakes to get S-P times to get the source depth of tremor and demonstrates that tremor is on the plate interface, lies above the intraplate
earthquakes and that the crust has especially high Vp/Vs ratios consistent with the presence of fluids.


This paper presents evidence for a strong correlation between tides and the strength of tremor during ETS events. This implies that tremor is sensitive to stresses that are \(10^5\) times smaller than lithostatic stress.


Some Review Papers:


Mostly Tremor papers:


Other recommended reading:

Crustal Structure of Puget Lowlands:


These are background reading if you are interested in pursuing ETS further:


Expanding on Wells et al. 1998


Update on crustal deformation in Washington and Oregon


Papers on seismic imaging of low-velocity wave-guides at the tops of slabs interpreted as basalt and gabro (7 km/s) surrounded by mantle peridotite (8 km/s).


Glacio-seismology


Northwest Structure studies


