Earthquake Hazard Investigations in the Pacific Northwest

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Investigations

This research focuses on earthquake hazards in the Pacific Northwest, including large scale plate interactions, through the study of regional structure and tectonics. Current investigations by our research group include determining the configuration of the subducting Juan de Fuca plate, kinematic modeling of the minimum strain-rate configuration of the plate, and determining source moments of local earthquakes.

Deep three-dimensional velocity structure of the Cascadia Subduction zone:

A recently completed doctoral dissertation investigated the large scale velocity structure of the upper mantle (VanDecar, 1991). The findings of this study include the identification of a seismically "fast" (3-4% velocity perturbation) planar feature that dips steeply to the east (at approximately 60°) with a thickness of 100 km or less. This is inferred to be the seismic manifestation of the thermal and compositional anomaly associated with the subducting Juan de Fuca oceanic plate. At shallow depths (less than about 80 km) this feature is consistent with the projections of models of shallow slab structure. The high velocity zone is located at a depth of 100-120 km beneath the Cascade volcanos, consistent with other subduction zones. Under central and northern Washington the high velocity feature extends to depths of 400 km or more, while beneath southern Washington and Oregon, it dies out at much shallower depths. This apparent lack of deep slab material in Oregon and southern Washington, when considered with the tectonic history of the region and other geophysical observations, is consistent with a deep slab that has torn away from the shallow portion of the slab.

Kinematic Modeling:

A recently completed doctoral dissertation on the geometrical configuration of the subducting slab flow-field that produces the minimum total strain-rate (Chaio, 1991), found that for Cascadia, the proposed arch structure revealed by seismic observations is a natural consequence of the subducted slab responding to the concave-oceanward bend of the trench. The arch also provides a plausible explanation for the origin of the Olympic Mountains accretionary prism in the context of the "critical taper" theory. The concentration of seismicity beneath the Puget Sound area may be the result of bending the already arched slab. The computed deformation rate is dominated by N-S compression in the Puget Sound area and the peak compressional strain-rate is around 2×10^{-16} sec^{-1}, which is comparable to the value estimated from the seismic moment release rate of the last century. In both the Alaska-Aleutian and NW-Pacific subduction zones, preliminary experiments performed also indicate that the predicted arch structures are the natural results of slabs subducting in a concave-oceanward trench geometry.

Source moment estimation and magnitude determination through use of S-coda amplitude:

Magnitude determinations using regional and local (mainly vertical component) short-period data remain problematical. The most common approach, using S-wave coda duration, is subject to noise level variations that compound the inherent difficulty of assigning duration times. Signal frequency variations also add considerable problems. We have found the machine algorithms to automatically assign coda durations are far from satisfactory.

To alleviate the limitations of the coda duration magnitude, we are developing a method to base magnitudes on coda amplitude rather than duration. Using standard coda amplitude models based on scattering theory (e.g. Aki and Chouet, 1975), we can relate the amplitudes back to the source spectrum and hence directly to moment. Magnitudes can then be derived directly from the moment estimates.

We are currently using a single scattering model to source-equalize the coda amplitude measurements from a number of stations for each event. We have found that using a large number of stations in a least squares estimation results in stable estimates of relative station gains and relative source factors. Source factors estimated in this way are linearly related to magnitudes estimated from coda durations. While we could empirically estimate magnitudes at this point, we are seeking an improved understanding of the source scaling that will allow us to make valid moment measurements using coda amplitudes.

Articles

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Abstracts

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Theses

Chiao, L.Y., 1991, Membrane deformation rate and geometry of subducting slabs, Doctoral dissertation, University of Washington Geophysics Program, Seattle WA

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