EarthScope Synthesis Workshop Report:
Towards a 3D Model of the Cascadia Subduction Zone

Oregon State University
Corvallis, OR 97331
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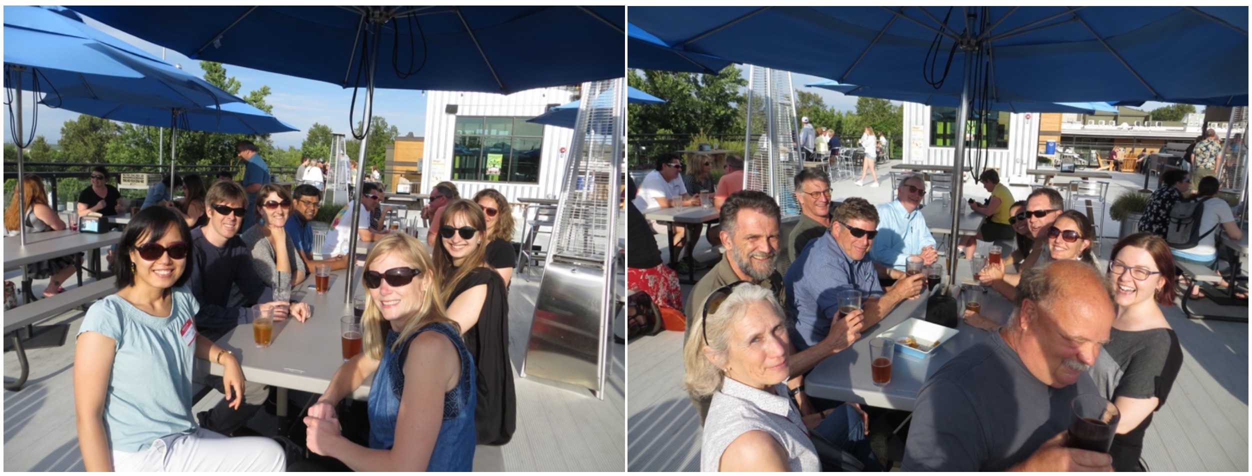
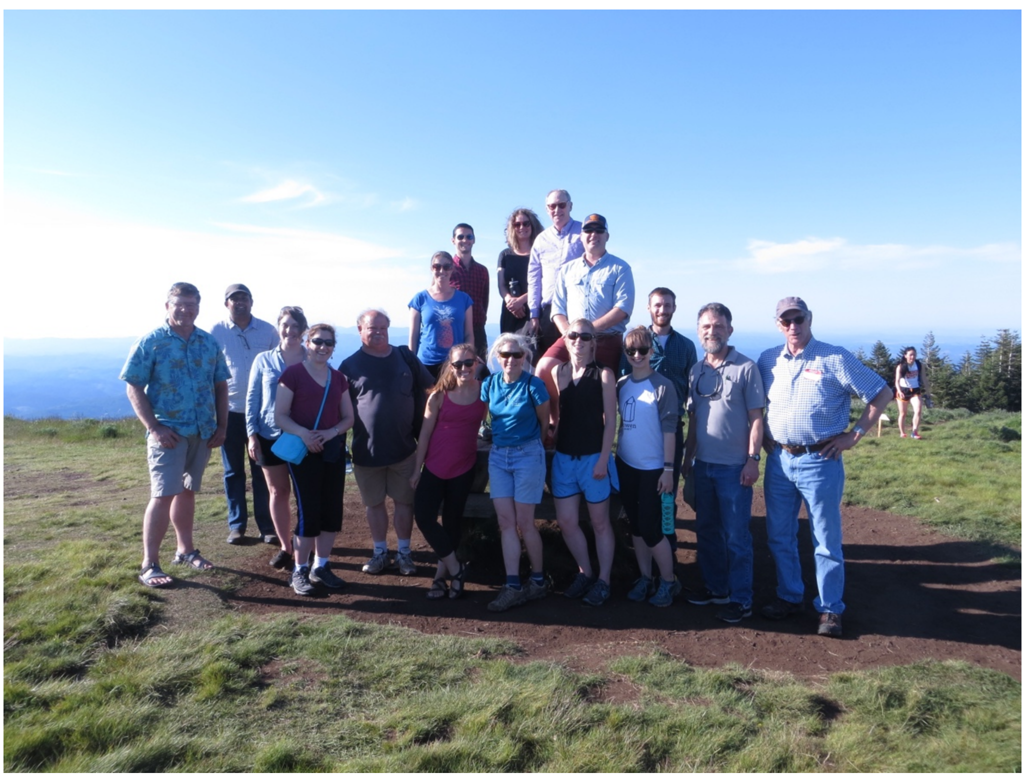


Workshop participants relaxing at the Sky High Brewery after a long day of discussions on day 1



and getting a view of the entire forearc from the summit of Marys Peak on day 2.

Workshop objectives:

The Cascadia subduction zone offers a unique opportunity to address fundamental questions about a subduction zone that is nearly aseismic yet has a well documented paleoseismic history of large (up to ~M9) plate boundary earthquakes. Another unique feature of Cascadia is that the entire incoming Juan de Fuca plate has been instrumented with ocean bottom seismometers and traversed by modern multichannel seismic reflection data so that the crustal and upper mantle structure of this young plate at the time of subduction is relatively well known. Much of the southern Cascadia margin has also been instrumented with the largest amphibious 3-D magnetotelluric array ever deployed, providing independent information on margin segmentation and fluid distribution of relevance to studies of ETS and plate locking mechanisms.

Through EarthScope, GeoPRISMS and the Cascadia Initiative, a wealth of new data has been acquired to image the electrical resistivity and seismic reflectivity, velocity and attenuation structure of the Cascadia subduction zone. The new images provide information on the heterogeneity and buoyancy of the asthenosphere beneath the subducting plate, structural and compositional variations within the subducting plate and overlying sediments, the physical properties of the plate boundary and adjacent rocks, mechanical heterogeneity within the upper plate, and the connection between subducted material and the output of the volcanoes. This work builds on an earlier network of onshore/offshore controlled source and natural source seismic and electromagnetic profiles funded by NSF and USGS over the past 3 decades.

The objective of this workshop was to gather scientists working in this region to:

(1) evaluate differences between models based on similar data sets;
(2) integrate models derived for the same region from data sets with different imaging resolutions with potential field data in order to extrapolate from regions with high resolution data sets to tectonically or morphologically similar regions with less data;
(3) develop geological models that satisfy the multiple constraints provided by the different geophysical data sets from the region; and
(4) identify gaps in understanding and discuss the data needed to fill those gaps.

Although Cascadia encompasses the entire system from incoming plate to backarc, because of the research interests of the attendees (see appendix 1) most of the detailed discussion during the workshop focused on earthquake hazards and on the spatial heterogeneity in the incoming plate and forearc. An overarching theme was to evaluate what spatial heterogeneity in material physical properties derived from geophysical and geological studies extending from the asthenosphere to the surface tell us about subduction processes and geologic hazards.

Consensus statement:

A consensus emerged that a community model would provide a useful reference and that such a model must extend from the Juan de Fuca/Gorda/Explorer ridges into the backarc (approximately the border between Washington/Oregon and Idaho), from the northern San Andreas fault to the southern Queen Charlotte fault, and from the surface to 700 km depth.

Workshop format:

The workshop was held on the campus of Oregon State University in the CEOAS conference room (Burt 193) and began with a talk by Ray Wells on the tectonic history of Cascadia. This was followed by “lightening” talks (5 minutes with 2-3 slides). All participants were invited to present a brief summary of their research interests and recent results. Participants also had the opportunity to elaborate on recent results in posters, which were displayed in the lobby outside the conference room for the duration of the meeting. Informal discussions also were held during an informal gathering at a local brew pub on Monday evening and during a short hike to the top of Marys Peak, the highest point in the Oregon coast range. Unfortunately visibility was not very good at the summit, where on a clear day the view extends from the ocean to the volcanic arc.

We then summarized the main science drivers, highlighting recent results (many of which had been presented by workshop participants in the their “lightening” talks) and outstanding questions. We then discussed whether a community model would be useful, who would use it, how it would be used, and outlined a path to achieve it. Although the original plan called for discussions in smaller breakout groups, participants decided to remain as a single group for the duration of the workshop.

Workshop notes were typed on the screen and collectively edited, forming the initial draft of this workshop report. This draft was then made available through google docs for editing and comment by the workshop attendees.

Science drivers:

In this section, the science questions driving research in Cascadia discussed during the workshop are classified into several groups. First, overarching science questions are listed, followed by bulleted lists of some important new results addressing these questions and specific questions raised by these results. We emphasize that these lists are not comprehensive and were influenced by the research interests of workshop attendees. However, we hope that they can none-the-less provide guidance to workshop participants and other scientists working in in this region or these problems in planning future research efforts.

Incoming plate: What is the physical state of the crystalline crust, overlying sediments and underlying mantle of the plate prior to subduction and how does it vary spatially due to both ridge and intraplate processes? These processes include ridge migration, faulting on and off the ridge axis, hydration of the oceanic crust and uppermost mantle, and spatially variable sediment thickness and composition.

New results (from, for example, the Ridge-to-Trench experiment and the Cascadia Initiative ocean bottom seismometer deployment)**:**

- New results on the physical state of crust and sediments resulting from better velocity analysis and deeper imaging enabled by the long hydrophone streamer and large tuned airgun array of the R/V Marcus Langseth and complementary data acquired by ocean bottom and onshore seismometers (limited spatial coverage). (e.g. Han et al., 2016, 2017, 2018; Horning et al., 2016; Canales et al., 2017).
- New results on the electrical conductivity of the incoming crust showing along-strike variations in the accretion of incoming sediments (limited spatial coverage, primarily of the Siletz terrane).
- New results on the distribution of seismicity within the subducting plate obtained by inclusion of CI data (limited temporal coverage) (e.g. Stone et al., 2018).
- New results on the spatial variability of upper mantle velocity structure from CI/onshore data providing resolution of mantle structure similar to that available for the western US and revealing a similar amount of spatial heterogeneity (e.g. Bell et al., 2016; Byrnes et al., 2017; Janiszewski et al., in review)
- New results on plate-scale anisotropic and isotropic lithospheric structure from Pn data (VanderBeek and Toomey, in review)

New questions:

- Why do the sediment physical properties vary substantially along strike? Is this due to hydration, composition or heat flow?
- Why does the uppermost mantle of the Gorda plate appear to be dry (based on seismic velocity) in spite of extensive faulting and internal deformation, which should provide pathways for infiltration of seawater, as has been documented elsewhere?
- What controls along-strike variability in the extent of bending-related faulting?
- Is the degree of heterogeneity seen within and beneath the Juan de Fuca/Gorda plate typical of oceanic mantle?

Forearc: Many questions related to plate coupling and earthquake potential in the Cascadia forearc were discussed. Why is the megathrust so quiet? What is the nature of the plate interface along and across strike? What is the impact of upper and lower plate structure and sub-slab mantle on the nature of the plate interface and vice versa? How do upper plate microplate dynamics influence the behavior of the subduction zone? Are there clues to tsunamigenic potential in the spatial variability of accretionary wedge structures? Why is there so much variability along strike in lower and upper plate seismicity? What is the role of metamorphic and flux melting derived fluids on the slip mechanics of the boundary between the slab and the mantle wedge? What is the relationship between locking on the plate boundary and episodic tremor and slip farther down-dip?

New results (from, for example, Ridge-to-Trench, Cascadia Initiative, EarthScope TA, EarthScope MT TA, EarthScope and GeoPRISMS MOCHA and iMUSH MT projects)**:**

- Shore-crossing body wave and surface wave tomography enabled by EarthScope and CI reveals intriguing correlations between seismic, geodetic and topographic segmentation on multiple scales, although not all models agree (e.g. Bodmer et al., 2018; Byrnes et al., 2017; Hawley et al., 2016; Janiszewski et al., in review).
- Shore-crossing MT results reveal similar spatial correlations (e.g. Egbert et al.,2017).
- Along strike variations in the long-term stress field as indicated by mapping of near-surface deformation (geologic mapping, high-resolution seismic, geomorphology), also reveals similar spatial correlations (e.g. .
- High resolution onshore/offshore controlled source imaging reveals strong local heterogeneity in upper plate structure (e.g. Kenyon, 2016).
- Continuing clustered earthquake activity on or near the plate boundary in central Cascadia indicates inter- and/or intra-plate slip in the nominally locked zone on the central Cascadia margin (e.g. Tréhu et al., 2015, 2018; Morton and Bilek, 2015; Morton et al., in review).
- Onshore/offshore imaging of the plate interface using wide-angle reflections and receiver functions reveals heterogeneous structure with low velocity zones extending into the locked region, although resolution of such features may depend on the imaging technique (e.g. Janiszewski and Aberts, 2015; Audet and Schaeffer, 2018).
- Along strike variations in ETS recurrence and locking may be related variations in incoming slab buoyancy (Bodmer et al., 2018) and/or slab permeability (Delph et al., in review) and/or underplated sediment (Wells et al., 2017).
- Initial results from a high-resolution dense onshore nodal deployment shows that the plate interface in central Cascadia looks different form the plate interface to the north (Ward et al., in review).
- Along-strike variations in electrical resistivity immediately above the downgoing slab-mantle wedge boundary likely linked to down-slab metamorphic and flux melting fluid release, suggesting relationship between plate locking and electrically resistive (dry) zones along the boundary (e.g. Egbert et al., 2017).

New questions:

- What are the causal relationships between these correlated observations? For example, are variations in ETS recurrence interval or intensity related to variations in subducted sediment, slab dehydration, sub-slab buoyancy or upper plate structure?
- What new data and new methodologies are needed to understand cause and effect?
- What are the fluid budgets, pathways and residence times for fluids transported to depth via the downgoing slab and how well are these constrained by the new results?
- How can the new observations of the long-term stress field be linked to earthquake process models?

- How do we link observations at different scales? For example, how can high resolution surface geologic observations provide insights into causative processes generating anomalies in the crust and upper mantle that can only be imaged with lower resolution methods?

Volcanic arc: What governs the distribution of melt in the wedge and its volcanic expression at the surface? Structural controls? Upper and lower plate crustal composition?

New results (from, for example, iMUSH; Café seismic and MT; MOCHA; Newberry)

- High-resolution electrical resistivity imaging of the southern Washington arc (St Helens, Adams, Rainier) reveals why St Helens and Mt Adams are where they are by revealing the presence of batholith that has disrupted the path magma takes to the surface.
- Seismic imaging reveals short wavelength variation in the depth and reflectivity of the North American Moho beneath St Helens (Hansen and Schmandt, 2017).
- Electrical resistivity imaging from MOCHA reveals along-strike variations in flux melting.
- Café data reveal a “cold nose” in the upper plate mantle wedge (Abers et al., 2017)
- Newberry data and modeling highlight the difficulty of imaging small melt bodies, the transitory signature of melt, and suggest new imaging approaches (Heath et al., 2015; 2018).
- Correlation between phase velocity periods that are sensitive to mid-crustal and upper mantle depths and quaternary magmatism and heat flow downplay the role of upper crustal structure in controlling magmatic variability along strike (Till et al., in review).

New questions:

- How can joint interpretation of seismic, electromagnetic and petrologic data constrain processes of melt segregation and magmatic differentiation?
- Can we detect different stages of melt replenishment and migration from geophysical data?

System-scale geodynamics: What drives plate tectonics? What is the pattern of flow in the mantle, and how does this affect the stress field at the surface? What defines the boundary that separates the lithosphere from the asthenosphere, and how does that boundary evolve? Cascadia is an important element of a laboratory for global scale geodynamics by providing a unique opportunity to develop a high-resolution data-constrained model for the entire life cycle of a plate (with the caveat that it represents a hot, young, quiet end-member to subduction and thus needs to be compared to other subduction zones) (see Zhou et al., Nature Geo. paper on Western US volcanism, 2017)

Towards a community model:

Once a consensus was achieved that community models along the lines of those developed by SCEC are an effective tool for focusing community research energy and providing the results of the research to “downstream” users, considerable discussion was focused on what parameters should be included, what resources are available for compiling data, and what initial steps can be taking in the near future that will lead towards achieving the goal.

Overview of potential users (2-letter codes are keyed to potential uses, listed below):
Academic science community (AS)
Community planners focusing on geohazards (CP)
Engineers (SE)
K-16 educators (ED).

Overview of potential uses:
Facilitate comparison of results at the same scale (AS)
Provide common platform for joint inversion/interpretation of multiple observables (AS)
Serve as input to new modeling efforts, including as constraints on geodynamic models (AS)
Identify knowledge gaps (AS, CP, SE)
Improve earthquake location (AS, CP, SE, ED)
Input to strong ground motion modeling (AS, CP, SE, ED)
Provide input for real-time response (AS, CP)
Seismic velocity and seismicity as indicators of volcanic hazard (all)
Seismic velocity and seismicity to prospect for and monitor geothermal energy generation (all)

Geographic scope and spatial resolution of the model:

- Expand geographic boundaries of existing Stephenson et al. (2017) model to extend from the Juan de Fuca/Gorda/Explorer ridges into the backarc (approximately the border between Washington/Oregon and Idaho) and from the northern San Andreas fault to the southern Queen Charlotte fault.
- Extend depth extent of the model to 700 km.
- Allow for variable spatial scale (as done for the SCEC and Bay Area CVMs). Resolution should be dictated by the resolution of the input data.

Resources for constructing a community model (with current archive, if available):

- Body wave tomography (e.g., Brocher et al., 2001; Ramachandran et al., 2006) - IRIS EMC
- Surface wave tomography (derived from earthquakes and background noise) – IRIS EMC
- Well logs, cores, and cuttings (onshore and offshore) – IODP data bank, State data archives (Brocher and Ruebel, 1998; Brocher and Horta, 1998; Brocher, 2008)
- Models derived from large-aperture seismic controlled source (2D and 3D) – data are archived at IRIS but there is no current standard for archiving models
- Surfaces defined from multichannel seismic reflection and velocity information - data are archived but there is no current standard for archiving models

- Thermal models (e.g. Syracuse et al., 2010, van Keken et al., 2011) – data are archived but there is no archive for models
- 2D and 3D MT - IRIS EMC
- Seismic anisotropy – IRIS EMC
- Surfaces derived from gravity (Gravity data freely available globally at http://bgi.omp.obs-mip.fr/ but no current archive for models)
- Laboratory measurements on sedimentary and crystalline rocks at in situ P/T (Brocher and Christensen, 2001)
- Empirical relationships derived from measurements (e.g., Brocher, 2005)
- Geologic maps (e.g. State geological surveys; global macrostrat from EarthCUBE at macrostrat.org).
- Surfaces derived from scattered wave images (no current archive)
- Surfaces projected into the subsurface from geological mapping, water wells, and boreholes (such as base of the Quaternary and Cenozoic sedimentary rocks).
- Compliance measurements offshore (no current archive for models)
- DEMs (can download various resolution DEMs from GeoMapApp)

Parameters to be included in a community model:

- Volumetric: Vp, Vs, density, attenuation (Qp, Qs), anisotropy, electrical resistivity, electrical anisotropy, magnetic susceptibility, temperature
- Surfaces: Topography/bathymetry, Geologic contacts, faults, depth to basement, Moho, plate interface, LAB
- Derived data products: porosity, permeability
- Related data products: Gravity, magnetics, earthquake/tremor catalogs

(All data sets to be aggregated into community repositories: e.g. IRIS EMC (IRIS DMC, 2011) is suitable for a variety of models. The EMC is currently soliciting feedback to enhance the capabilities of this Earth model repository.

Major challenges to achieving an operational plan:

- Quantifying spatial resolution and uncertainty. To what degree should parameters be extrapolated, or should they be left undefined when filling the model volume? How are poorly resolved parameters flagged, and what is the threshold for flagging?
- Defining model provenance – How much detail is needed? Is a peer-reviewed publication required for inclusion? If not, what other quality checks are acceptable?
- Incorporating alternative models for the same volume – Should different models be averaged or should the user given a choice of models?
- Achieving consensus on parameters and models.
- Identifying infrastructure and personnel to build and maintain the model.
- Ensuring that any assumed relationships are well documented and can be undone.
- Identifying any constraining rules used to limit model parameters.
- Convincing the community to buy into open data repositories.

- Validating and testing models – e.g., must a density model derived from seismic data satisfy gravity data; are predicted synthetic waveforms consistent with independent seismic data; is predicted anisotropy consistent with observed shear wave splitting.

Initial actions towards building this model:

- Stephenson et al. (2017) 3D model is a seed to build on – Currently the model is in EarthVision format. It needs to be reformatted to a more widely used format.
- Tom Brocher has contacted Bill Stephenson, USGS, Golden, to discuss his interest in a revision of his USGS 3D seismic velocity model for Cascadia
- Workshop participants should open this model, explore it, and evaluate how it can be exported and to what it should be exported.
- Identify all data sources available to construct the model (Note: this effort is ongoing as part of a recently funded USGS Powell center focused on Cascadia).
- Archive published models at the IRIS EMC.
- Encourage grass-roots efforts to compare different models that synthesize existing data on several topics.
- Encourage joint presentations in upcoming synthesis sessions at AGU and other meetings.
- Develop a website with links to needed data sets (Note: this activity is part of the current USGS Powell Center effort).
- Specify the metadata needed to use a model.
- Provide incentives to researchers to submit models for evaluation and incorporation into an eventual “final” 3D community model.
- Develop a procedure for release of interim model(s).
- Consider an EarthCube/RCN effort to complement USGS Powell Center.
- Decide what software framework is most appropriate for this effort.

Brainstorming to enhance Education and Outreach opportunities:

- Bay Area has visiting scientists in schools. Is there something similar in the Pacific Northwest.
- Lawrence Hall of Science at UC Berkeley showcases science related to regional geohazards. What can be done in the PNW in collaboration with museums/science centers such as OMSI, the PNW Science Center and the Burke Museum of Natural History?
- How can we take advantage of existing regional programs to enhance exposure?
    - “Rocking Out” program: college students do presentations at area schools
    - Burke Natural History Museum
    - PNW Seismic Center has visiting school groups—maybe do a display·
- Field trips and workshops for middle and high school teachers related to EarthScope data, such as those organized and presented by Bob Lillie (former EarthScope co-PI and E&O director, now retired) and Bob Butler (retired professor of geoscience education at the Un. of Portland).
- Provide teaching materials to the National Assoc. of Geoscience Teachers (NAGT).

- Propose a Cascadia session at SSA in Seattle in 2019.
- Develop simple jargon-free descriptions of the 3D model for use in E&O.

Leveraging upcoming efforts in Cascadia:

- 2020: R/V Marcus Langseth cruise planned for summer 2020 will improve the model and provides opportunities for piggyback and complementary experiments. Preliminary discussion of a proposal to deploy a dense nodal array onshore was initiated during the workshop, with plans to submit a proposal to NSF before the end of 2018. A proposal to deploy ocean bottom seismometers should also be encouraged.
- 2018 – 2022: USGS Coastal and Marine Geology Program has begun a 5-year effort focused on characterizing Quaternary deformation and interactions between upper plate structures and the megathrust. This effort will involve multiple marine geophysical cruises focused on imaging the shallow crustal structure (upper few hundred meters), which will help identify major active structures for inclusion in the 3D model.
- USGS Powell Center Project has been funded and provides funds for synthesis workshops and for a postdoc who will be compiling a comprehensive database of existing data. This effort could be complemented and enhanced by proposal to NSF for a regional coordination network (RCN).
- An IODP drilling pre-proposal has been submitted and others are under discussion, in response to a 2015 workshop (http://usoceandiscovery.org/past-workshops-old/investigating-cascadia-subduction-zone-geodynamics-through-scientific-ocean-drilling/). There is a symbiotic relationship between drilling and development of a community model in that a drilling proposal provides new motivation for additional site survey information and the results will contribute to new process-based knowledge that will contribute to interpretation of the features of the model.

Summary:

The workshop consensus was that development of a community model provides goalposts that the research community can use to organize and focus its efforts. Many interesting results from recent data collection efforts in Cascadia, acquired through various NSF initiatives such as GeoPRISMS, EarthScope and the Cascadia Initiative, were presented and are summarized in the sections on “new results.” These results lead to new questions, also listed above. Both the “new results” or “new questions” are surely influenced by the interests of workshop attendees and should be interpreted as examples rather than as a comprehensive list.

Much of day 2 of the workshop focused on the process of building a community model. Various aspects of this effort – definition of model scope and resolution; discussion of potential users, uses and available resources; and action items that can be taken in the near future that will advance the community towards the goal of a community model were the primary topics for discussion on day 2.

The third day of the workshop was spent reviewing and organizing the material discussed on the previous two.

The workshop also provided an opportunity to initiate plans for collaboration to best take advantage of planned and developing efforts in this region that can contribute to development of a community model. It is noteworthy that over half of the workshop participants were early career scientists, highlighting the vigor of Cascadia research and the importance of the problems being addressed.

[Note: the following reference lists are not comprehensive. Development and maintenance of comprehensive reference lists should be undertaken in the context of development of a community model.]

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Appendix A: Workshop attendees

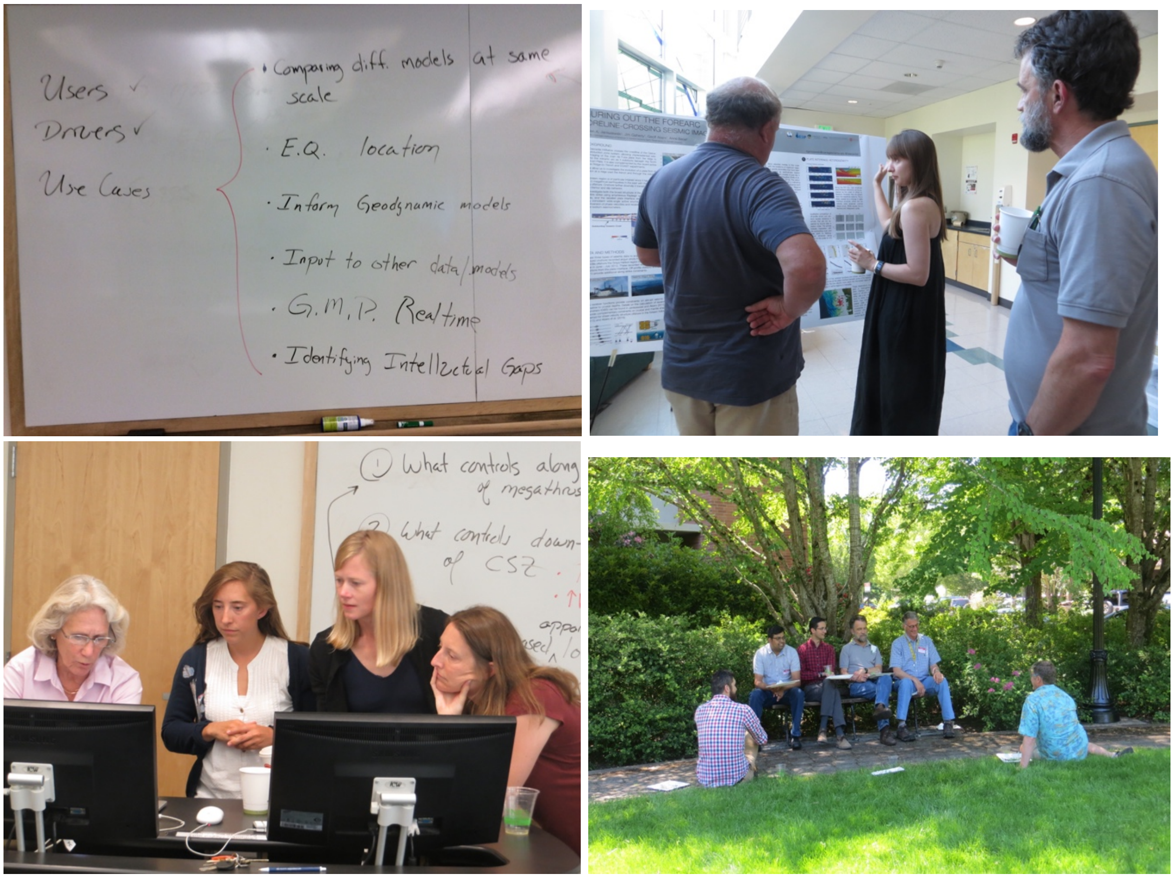
Name	Surname	Affiliation
Beth	Grassi	EarthScope National Office, Un. of Alaska
Shuoshuo	Han*	Un. of Texas Institute for Geophysics
Anna	Kelbert	U.S. Geological Survey
Doug	Wilson	Un. of California, Santa Barbara
J. Renate	Hartog	Un. of Washington (PNSN)
Chris	Goldfinger	Oregon State Un.
Sampath	Rathnayaka	Un. of Massachusetts
Gary	Egbert	Oregon State Un.
Kasey	Alderhold	IRIS
Adam	Schultz	Oregon State Un.
Eric	Kirby	Oregon State Un.
Emma	Myers	Un. of Washington
Emily	Roland	Un. of Washington
Janet	Watt	U.S. Geological Survey
William	Hawley	Un. California Berkeley
Scott	Bennett	U.S. Geological Survey
Kevin M.	Ward	Un. of Utah (now at South Dakota School of Mines)
Helen	Janiszewski	DTM Carnegie Institution for Science
Carl	Tape	EarthScope National Office, Un. of Alaska
Kathy	Davenport	Oregon State Un.
Anne	Tréhu*	Oregon State Un.
Thomas	Brocher	U.S. Geological Survey
Ray	Wells	U.S. Geological Survey (emeritus)
Douglas	Toomey*	Un. of Oregon
Miles	Bodmer	Un. of Oregon
Jonathan	Delph	Rice University
Pablo	Canales	Woods Hole Oceanographic Institution

Workshop co-convenor indicated by *. Suzanne Carbotte also assisted with workshop planning but was unable to attend.

Appendix B: Talks

Ray Wells' talk was a 20-minute overview of Cascadia geology and geodynamic history. Other talks were short "lightening" talks, meant to familiarize attendees with each participants recent or planned research in Cascadia. In some cases, titles and authorship lists were extracted from the talk slides; when no title was given in the slides, the general topic is summarized.

Title	Authors
Cascadia: How does it work?	Ray Wells (20 minute introductory overview)
Magnetic anomalies: observed and extrapolated	Doug Wilson
The Cascadia creeping section: structural evidence for heterogeneous plate coupling and linkages to geodesy and paleoseismology	Chris Goldfinger and Tim Kane
Western North America tectonics	Scott Bennett
3D MT imaging of the Cascadia subduction zone with an amphibious array	Gary Egbert, Bo Yang, Paul Bedrosian Anna Kelbert, Kerry Key, Dean Livelybrooks, Blake Paris, Adam Schultz
Mount St Helens iMUSH seismic comparison	Adam Schultz
Data inversion for electrical resistivity	Anna Kelbert
OBS and transportable array	Kasey Alderhold
P-wave teleseismic tomography: LAT in subduction zones?	William B. Hawley
Pn tomography of the Juan de Fuca plate and Gorda deformation zone: implications for mantle deformation and hydration in the oceanic lithosphere	Brandon VanderBeek & Doug Toomey
Crustal-scale seismic structure from trench to forearc in the Cascadia subduction zone; Quality analysis of high frequency air-gun shot seismic recording in the Juan de Fuca plate	Sampath Rathnayaka
Structure onshore and offshore from surface waves and receiver functions	Helen Janiszewski (with J. Gaherty, G. Abers, H. Gao, A. Becel, Z. Eilon)
Evidence for slab permeability-controlled tremor along the Cascadia margin	Jonathan Delph, Alan Levander, Fenglin Niu
Evolution and hydration of the Juan de Fuca crust and uppermost mantle: a plate-scale seismic investigation from Ridge to Trench	Pablo Canales (with S. Carbotte, H. Carton, A. Trehu, S. Han, B. Boulahanis, M. Nedimovic, G. Abers, G. Horning)
Faulting in the incoming Juan de Fuca plate; contrasting sediment consolidation states offshore WA and central OR	Shuoshuo Han
Plans for improving onshore/offshore velocity models	Emma Myers
First results from a transect of nodal seismometers across the central OR forearc	Kevin M. Ward
Overview of PNSN stations and velocity models used to locate earthquakes	Renate Hartog
Overview of USGS plans in Cascadia	Janet Watt
Overview of UW earthquake and tsunami early warning working group	Emily Roland



Some scenes from the workshop (clockwise from upper left): whiteboard notes for the report; Helen Janiszewski explaining her poster to Gary Egbert as Doug Wilson listens in; Anne Tréhu, Emma Myers, Emily Roland and Janet Watt talking science; informal discussion over lunch in the courtyard – Miles Bodmer, Sampath Rathnayaka, William Hawley, Doug Wilson, Ray Wells and Chris Goldfinger.