Understanding Seismic Anisotropy Observations in the Context of 3D Slab-induced Flow in Cascadia

UC DAVIS

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Introduction

Existing studies of the Cascadia Subduction Zone (CSZ) disagree on many aspects of the slab geometry, such as the presence and location of gaps as well as the depth extent

The CSZ has a relatively low rate of background seismicity, making it difficult to construct high resolution seismic tomographic imagery of the slab

Seismic anisotropy observations obtained from shear wave splitting (SWS) measurements can be used as a proxy for flow patterns in the upper mantle around the slab

Direct comparisons between predicted anisotropy and tomography from geodynamic models of varying slab geometry with observed SWS may provide new constraints on the slab shape

Objective: Use temperature (T), pressure (P), and flow velocity from the below 3D geodynamic models to predict seismic structure of the CSZ and compare to seismic observations

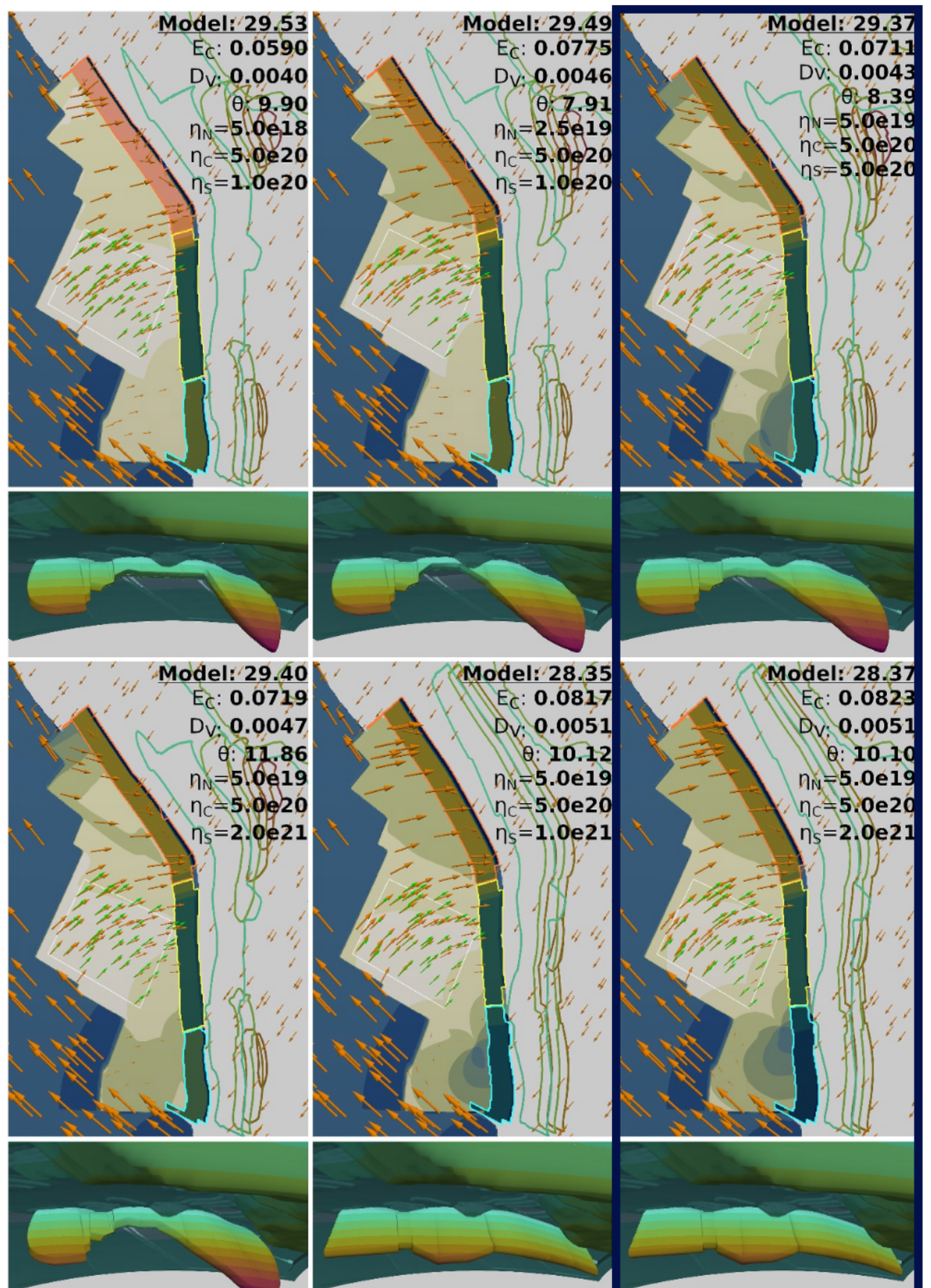


Figure 5, modified from Fraters et al., 2025.

Methods

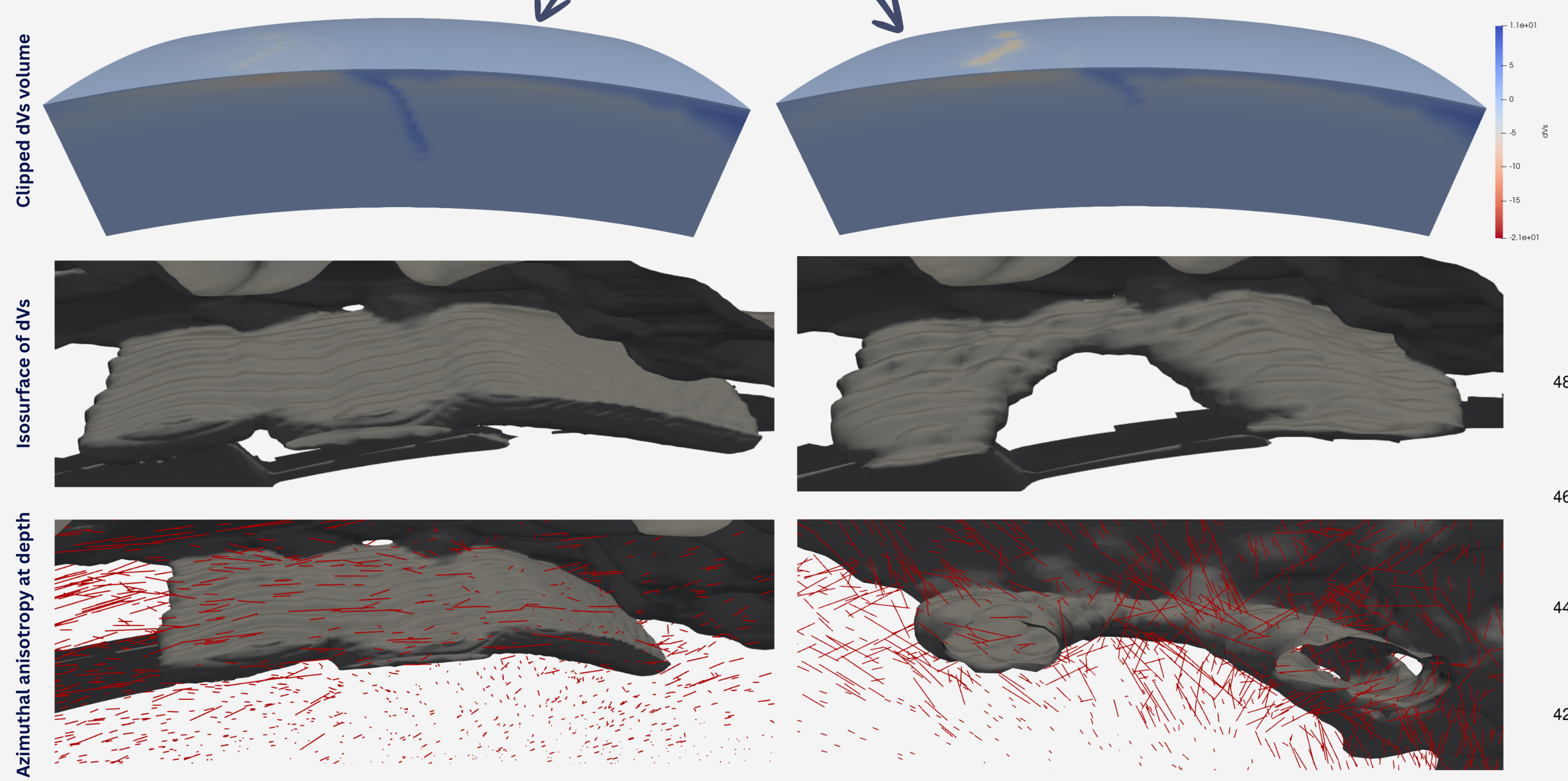
D-REX_M
Use mantle flow velocity data to generate seismic anisotropy (LPO)

VIZTOMO
Use LPO with T and P to predict seismic wave velocities and azimuthal anisotropy

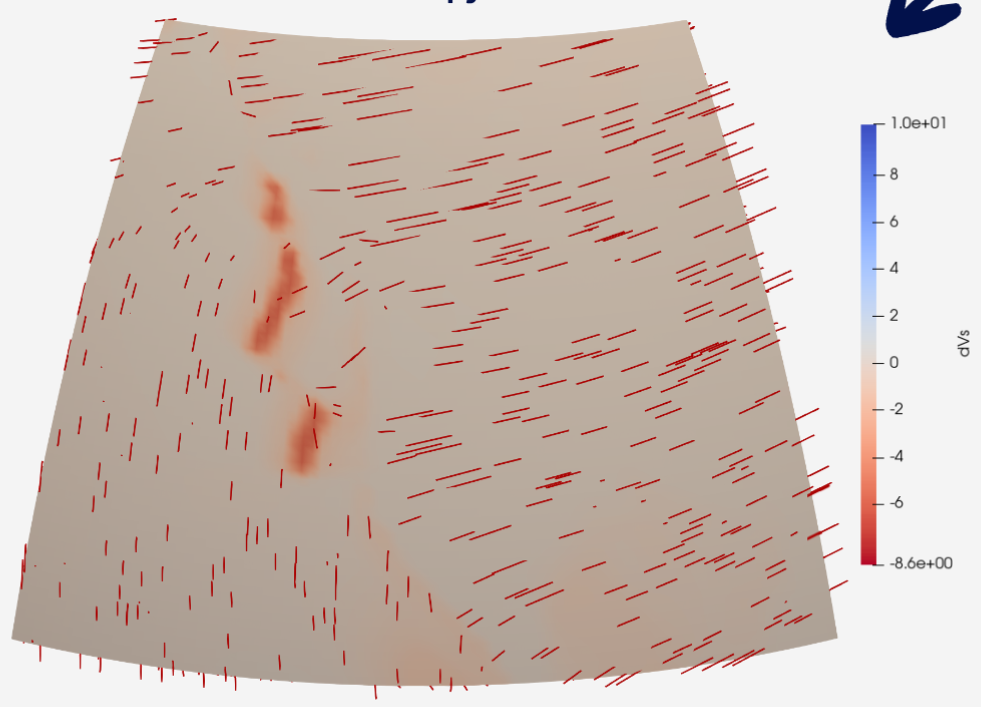
SKS-SPLIT
Use the seismic wave velocities to calculate SKS splitting times

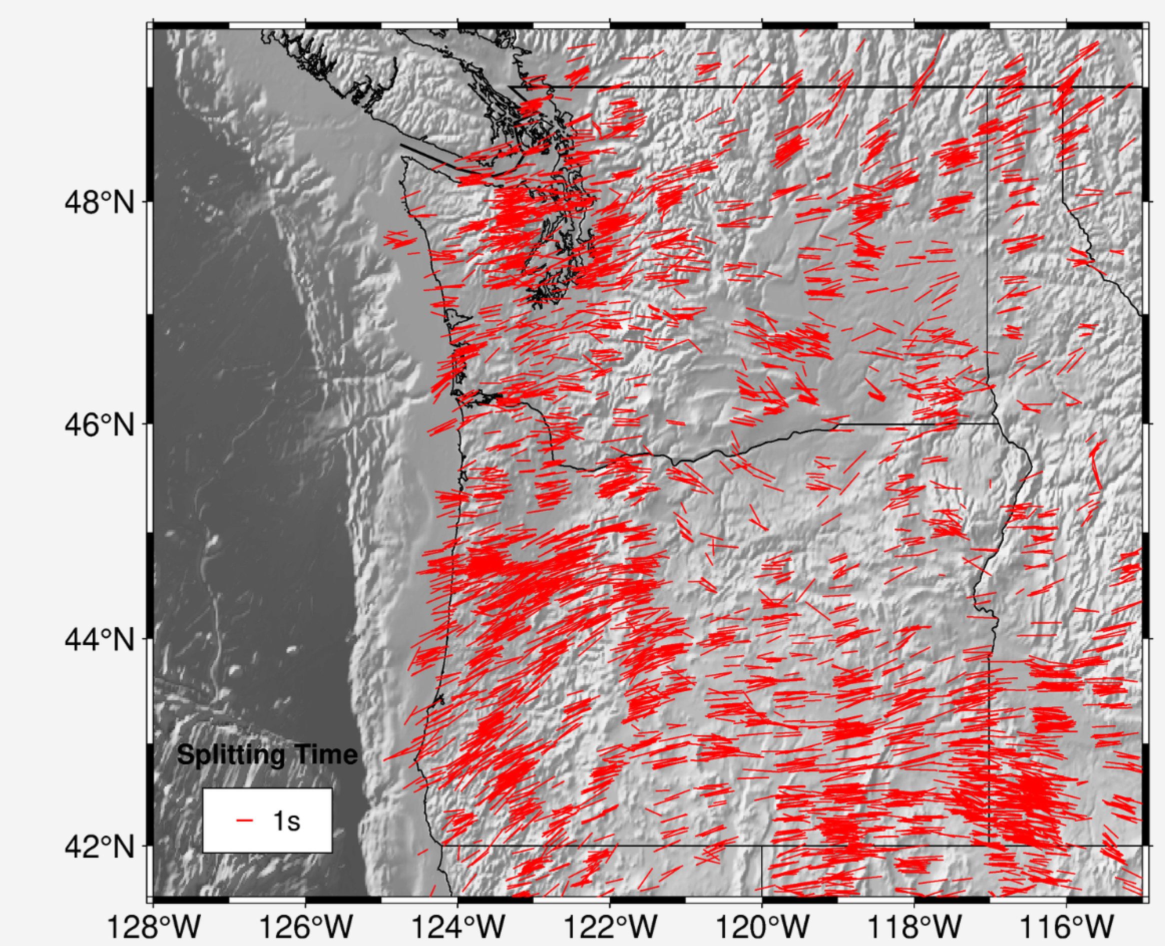
PSI_D
Generate synthetic body wave travel times (Vs, Vp), splitting intensity, and SWS parameters

Analysis
Compare to observed SKS splitting in Cascadia



Azimuthal anisotropy at the surface





SKS splitting measurements from Yang et al., 2016

Results

- Slab geometry is distinctly visible in predicted velocity/velocity anomalies for both models from VIZTOMO
- Azimuthal anisotropy at depth follows hypothesized flow patterns
  - Trench-parallel flow around slab for gapless model (28.37)
  - 3D toroidal flow around slab edges and through the slab gap (29.37)
- Azimuthal anisotropy patterns at the surface visually agree with observed SKS splitting measurements

Next Steps

- Run analysis with higher resampled resolution across all 6 models
- Predict SKS splitting at the surface and compare to observed SKS splitting from Yang et al., 2016
- Examine flow patterns at depth to determine where dominant components of anisotropy originate
- Use the ECOMAN/PSI_D package to perform ray-path integration of the data to compute synthetic seismic observables that can be directly compared to observations

References & More Info