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New Imaging Approach for Constraining the Azimuth and Dip of Seismic Anisotropy Using Teleseismic P-wave Delays and its Application to the Western United States

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Despite the well-established anisotropic nature of Earth's upper mantle, the influence of elastic anisotropy on teleseismic P-wave imaging remains largely ignored. Unmodeled anisotropic heterogeneity can lead to substantial isotropic velocity artefacts that may be misinterpreted as compositional and thermal heterogeneities. Here, we present a new parameterization for imaging arbitrarily oriented hexagonal anisotropy using teleseismic P-wave delays. We evaluate our tomography algorithm by reconstructing geodynamic simulations of subduction that include predictions for mantle mineral fabrics. Our synthetic tests demonstrate that accounting for both the dip and azimuth of anisotropy in the inversion is critical to the accurate recovery of both isotropic and anisotropic structure. We then perform anisotropic inversions using data collected across the western United States and offshore Cascadia. Our preliminary models show a clear circular pattern in the azimuth of anisotropy around the southern edge of the Juan de Fuca slab that is remarkably similar to the toroidal flow pattern inferred from SKS splits. We also image dipping anisotropic domains coincident with the descending Juan de Fuca slab. In contrast to prior isotropic tomographic results, the Juan de Fuca slab in our anisotropic model is characterized by more uniform P-wave speeds and is without an obvious slab hole below ~150 km depth. We also find a general decrease in the magnitude of mantle low-velocity zones throughout the model relative to prior studies. These results highlight the sensitivity of teleseismic P-waves to anisotropic structure and the importance of accounting for anisotropic heterogeneity in the imaging of subduction zones.