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Short-scale variations of shear-wave splitting at the Central Andean trench: discriminating between crustal and mantle anisotropy using waveform modeling

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In subduction zones anisotropy is often found to be dominated by fast axes oriented sub-parallel to the trench. Interpreting the fast-polarization directions in terms of mantle deformation has led to the hypothesis of trench-parallel mantle flow due to pressure gradients induced by slab geometry or trench migration. However, the relation between seismic anisotropy and the mantle-flow field in subduction zones remains poorly understood. Here, we compare splitting measurements from real and synthetic waveform data to constrain the seismic anisotropy at the Central Andean trench. We have studied shear-wave splitting along two EW-oriented profiles in the Central Andes at 21°S and 25.5°S in order to infer variations of fast-axes directions and delay times from the Pacific coast to the western margin of the Interandean Zone. Using both, recordings from teleseismic SKS and local S phases, we aim to discriminate between the effects of anisotropy within the lithosphere of the overriding South-American plate and anisotropy induced by mantle flow beneath the subducting slab. The analysis of SKS-splitting along the profiles from West to East reveals fast polarizations that vary abruptly from E-W (closer to the trench) to NW-SE. The corresponding delay times are relatively small and vary between 0.6 and 0.9 seconds. The splitting analysis from local events (within the slab) reveals similar delay times. However, the corresponding fast axes deviate from the SKS results and are predominantly oriented NE-SW beneath the Altiplano plateau. We compare our observations with splitting measurements from synthetic waveforms generated by finite-difference modeling. The waveforms are calculated for a range of models with elastic anisotropy confined to different regions within the crust and mantle of the subduction zone. We test for influences of crustal shear zones, changes in mantle-flow direction, and changes of olivine alignment due to its dependence on water content, respectively. The results indicate that crustal anisotropy contributes significantly to the observed variation of fast polarizations. Precaution must be taken when interpreting short-scale lateral variations of shear-wave splitting in terms of changes in the mantle flow field.