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The effects of unaccounted-for elastic anisotropy in isotropic seismic tomographies

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The present-day structure of Earth's interior is commonly determined by means of seismic tomography techniques. Most of the tomographic models, however, assume that the mantle is isotropic, which produces a physical inconsistency in regions where significant mantle anisotropy is sampled by a heterogeneous seismic ray distribution. We investigate the possible effects of unaccounted-for anisotropy in seismic imaging of the upper mantle in a subduction setting by carrying out a synthetic test in three steps: (1) We build an anisotropic velocity model of a subduction zone. The model was built from self-consistent estimates of mantle velocity structure and strain-induced anisotropy that are derived from thermo-mechanical and microstructural modeling. (2) We generate P-wave travel-time delay data for this model using an event distribution that is representative of what is typically recorded by a temporary seismic array. The anisotropic travel times are calculated through the prescribed model using a graph-theory ray tracer. (3) We invert the anisotropic synthetic delays under the assumption of isotropy, as is common practice. The tomographic inversion of the synthetic data recovers the input velocity structure fairly well, but delays caused solely by anisotropy result in very significant additional isotropic velocity anomalies that are artificial. Some of these apparent seismic anomalies are nonetheless attractive targets for (mis)interpretation. For example, one of the most notable apparent seismic anomalies is a low velocity zone in the mantle wedge. Our results suggest that significant artifacts may be common in isotropic velocity models of subduction zones and stress the need for mantle imaging that properly handles anisotropy.