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Full-waveform modelling of 3-D seismic anisotropy at Pacific Lithosphere-asthenosphere depths

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Currently, the geometry and strength of radial anisotropy, $\xi = {V_{sh}}^2/{V_{sv}}^2$ beneath the oceans, notably in the Pacific, are far from being consistent across different global anisotropy models. Some models show a large region of strong positive ($V_{sh} > V_{sv}$) across most of the Pacific in the ~100-150 km depth range, with a flat pattern as lithospheric age increases (e.g., Burgos et al., 2014, Beghein et al., 2014, Auer et al., 2015). Other models (e.g., Kustowski et al., 2008, Chang et al., 2015) show strong ξ ~1.09 beneath the East Pacific Rise (EPR) at ~100 km depth, which decreases with age, as well as a separate anomaly with similar magnitude in regions with an age of ~ 90Ma. Here, we use full-waveform modelling to examine the robustness of upper mantle features and to help us understand deformation-induced anisotropy from ridge to subduction zones.

We use the spectral-element method (Komatitsch and Tromp, 1999) to compute full waveforms for over 2,600 paths for earthquakes around and in the Pacific with moment magnitudes Mw between 5-7 and focal depths <50km. We report fundamental-mode surface waveform comparisons with a special focus on the period range T ~60-100s, exhibiting a strong sensitivity to the 100-150km depth range. We consider several 3-D global Earth models such as S40RTS (Ritsema et al., 2011), S362WMANI (Ekström and Dziewoński, 2008), SAVANI (Auer et al., 2014) and SGLOBE-rani (Chang et al., 2015).

Our results show that anisotropic models overall better explain observations than models without lateral variations in radial anisotropy. We find that models such as SGLOBE- rani with a more defined depth-age anisotropic structure conform well to data, showing Rayleigh and Love wave phase misfits of $\pm$2s when the waveforms are filtered around T~60s. Contrarily, a model with a larger, flatter province of radial anisotropy at ~100 km depth shows on average Rayleigh wave delays of 7s, indicating too large values of ξ. We locate regions between the EPR and Hawaii where the Rayleigh waveforms predicted by this model are too slow, which indicates that ξ is too high. When considering models with no lateral variations in anisotropy, we identify predicted Love waves propagating between the EPR and Hawaii that are slower than observations by more than 9s. In contrast, 3-D radial anisotropy models such as SGLOBE-rani explain these waveforms well. Finally, we quantify for the various Earth models considered the adjustments in radial anisotropy needed to further improve the waveform fits in the Pacific and discuss their geodynamical implications.