Investigating the effects of 3-D anelasticity (Q) structure in global surface-wave propagation using the Spectral Element Method (SEM)

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In the past decades, lateral heterogeneities in S-wave velocity in the upper mantle haven been progressively mapped out in global surface-wave tomographic studies. It is known that S-wave speed anomalies canhave either a thermal or compositional origin, or both. The earth's anelasticity (Q) structure has strong sensitivity to temperature and weak sensitivity to compositional variations, and therefore can be applied as additional constraints to distinguish between thermal and compositional variations in the mantle. Compared to S-wave velocity tomography, studies of the global anelasticity (Q) structure have advanced only slowly in the past decades. In fact, the effects of 3-D Q variations in surface-wave propagation have not been well understood.

In Ruan and Zhou [2009], we quantify the effects of 3-D anelasticity (Q) on surface wave phase delays by simulating wave propagation in 3-D anelastic earth models using the Spectral Element Method (SEM). We compare measured phase delays caused by 3-D anelasticity structure to those caused by 3-D velocity structure. The 3-D Q model and 3-D velocity model are both constructed from a 3-D temperature model, and the strength (rms) of the 3-D models are comparable to current tomographic models. Our measurements based upon synthetic SEM seismograms show that (1) roughly 20-30% of the observed phase delays (travel times) are due to 3-D anelasticity (Q) structure; this implies that neglecting 3-D anelastic dispersion effects can lead to biased velocity perturbations in seismic tomography; (2) the significance of 3-D anelastic dispersion is frequency dependent, it's stronger in long period surface waves as their sensitivity in the low-Q asthenosphere is maximized; (3) the 3-D anelastic dispersion effects are stronger in regions of "slow" anomalies where the temperature is higher than the background model and (4) focusing and defocusing effects due to 3-D velocity structure account for a major portion of observed amplitude perturbatons in long-period surface waves.

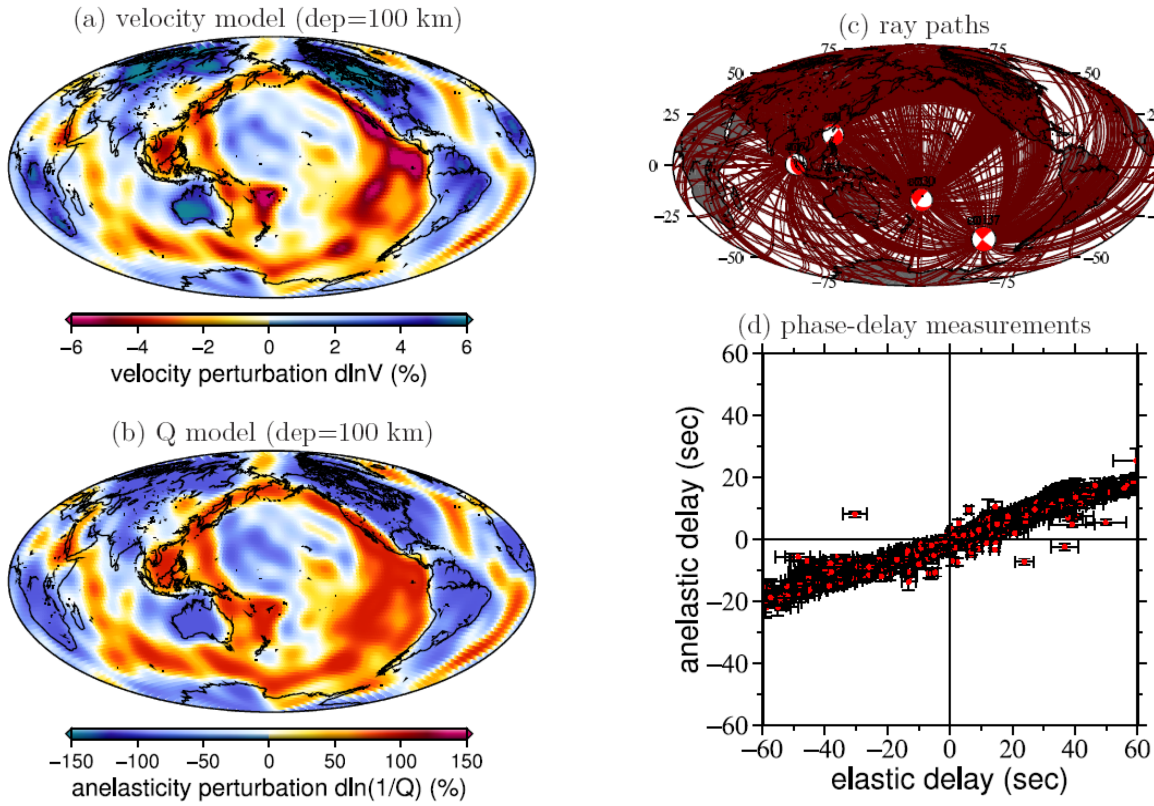

Figure 1: Examples of 100-s Rayleigh-wave phase delays caused by 3-D velocity structure and 3-D Q structure based upon global SEM wave propagation simulations in earth models.

References:

Ruan, Y. and Zhou, Y. (2009). "The effects of 3-D anelasticity (Q) structure on surface-wave phase delays", in preparation for *Geophysical Journal International*.

Ruan, Y. and Zhou, Y. (2008). "The effects of 3-D Q structure on surface-wave phase delays", Abstract AGU, San Francisco, CA.