Synthetic Surface Wave Interactions with an Upwelling Northern Appalachian Anomaly

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The Northern Appalachian Anomaly (NAA), a low-velocity zone beneath the northeastern United States, has been consistently imaged by surface wave studies. Shear wave splitting analysis identified a cluster of null measurements coincident with the NAA within an otherwise consistent pattern of horizontal mantle flow, suggesting localized mantle upwelling. However, continental-scale surface wave inversions for radial anisotropy only recover the regional horizontal flow fabric and fail to image a complementary radial anisotropic signal reflecting potential upwelling. We seek to understand these results by using SPECFEM 3D Globe to examine the propagation of Rayleigh and Love waves through a simulated thermal and upwelling heterogeneity within a 3-dimensional crust and mantle structure. We perturb the s362ani Earth model with multiple Gaussian heterogeneities to simulate a thermal and upwelling anomaly whose depth, depth extent, lateral extent, and amplitude are allowed to vary. While the Rayleigh wave phase velocities effectively recover the shape of the upwelling anomaly, the broader lateral sensitivity of the Love wave phase velocity produces an artificially enlarged anisotropic signal that will present challenges for imaging radial anisotropy. We also present an upwelling model with a deep (centered at 300 km), weakly upwelling (anisotropy parameter of 0.96) anomaly which fits observed Rayleigh wave phase velocities. Models with stronger anisotropic perturbations overprint the well-observed thermal signature of the NAA. These results suggest that if the NAA may reflect an active mantle upwelling, the associated anisotropic signal must be relatively weak.