Using Surface-Wave Amplitudes to Constrain Velocity, Density and Attenuation Structure Across USArray

Victor C. Tsai and Fan-Chi Lin
Seismological Laboratory, Division of Geological and Planetary Sciences, California Institute of Technology

The deployment of USArray across the continental U.S. has prompted developments within surface-wave tomography to exploit this unprecedented data set. Here, we present two methods of using surface-wave amplitudes to obtain new constraints on crustal structure. The first method builds on its phase velocity counterpart known as Helmholtz tomography, and uses phase travel-time and amplitude maps across the array for each period and earthquake. Spatial differential operators are applied to the maps to determine amplitude variations, including the effects of focusing/defocusing. Based on the 2D damped wave equation, the corrected amplitudes are then linked directly to local amplification and intrinsic attenuation, which can be separated by examining waves that propagate in opposite directions (Lin et al., JGR, 2012). Local amplification is governed by local velocity and density structure through conservation of energy flux. Applied to teleseismic Rayleigh waves across USArray, this new method provides improved velocity measurements, reliable large-scale attenuation estimates, and also sensitivity to density structure. Efforts are ongoing to apply the method to ambient noise data, at shorter periods than are possible with teleseismic earthquakes, and hence with improved spatial resolution. In the second method, we consider horizontal-to-vertical (H/V) amplitude ratios, also known as Rayleigh-wave ellipticity. H/V ratios are known to be particularly sensitive to shallow earth structure. We demonstrate that joint inversions of Rayleigh-wave H/V ratio and phase velocity provide better constraints on shallow (e.g. <3 km) crustal (Vs) velocity structure than phase velocities alone. Moreover, the joint inversions also provide robust constraints on shallow density and Vp/Vs structure (Lin et al., GRL, 2012). New images of shallow crustal structure are in excellent agreement with known surface features. These results demonstrate the consistency of broadband H/V ratio and phase velocity measurements as well as their complementary sensitivities that can potentially resolve density and Vp/Vs variations.