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Mapping the North American continent with inter-station phase and amplitude data of surface waves

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The investigation of a three-dimensional upper mantle structure using seismic surface waves has been generally based on the measurements of phase delay. The lateral heterogeneity in the Earth, however, not only affects the phase of surface waves, but also modulates their amplitude through focusing/defocusing effects. Such amplitude anomalies caused by elastic focusing are dependent on the second derivative of phase velocity across the ray path, and thus they are sensitive to short-wavelength structure than the conventional phase data, which should be useful for improving the lateral resolution of phase velocity models. In this study, we collect a large-number of inter-station phase velocity and amplitude ratio data working with a non-linear waveform fitting technique using USArray seismograms. Phase velocity maps of North America are then constructed using both phase and amplitude data of both Rayleigh and Love waves to check the validity and utility of inter-station amplitude measurements for enhancing the quality of the phase velocity models.

The phase velocity maps derived only from phase data reflect large-scale tectonic features well; e.g., slow anomalies in the tectonically active western U.S. and fast anomalies in the eastern cratonic region. To the contrary, phase speed models derived from amplitude data tends to emphasize smaller-scale structures characterized by strong lateral velocity gradients; e.g., significant slow anomalies in Snake River Plain and Rio Grande Rift, where the local amplification due to elastic focusing has been observed at USArray stations. Our results indicate that inter-station amplitude-ratio data reflect the effects of the second derivatives of phase velocity distribution well, and are extremely useful for reconstructing shorter-wavelength elastic structures. Thus, the measurements of inter-station amplitude ratios across a dense seismic array can be used to enhance the horizontal resolution of phase velocity models of surface waves.

Keywords: surface wave, phase velocity, amplitude, tomography, North America