Linear array ambient noise adjoint tomography with phases and amplitude ratios for high-resolution crustal structures: Methodology and application

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Ambient noise tomography using surface wave dispersion and Rayleigh wave amplitude ratios based on ray theory has been widely used in imaging crust and upper mantle structures at various length scales. However, this approach does not account for complexities in wave propagation in complex media and may lead to inaccurate tomographic results. 3-D adjoint tomography using earthquake or ambient noise cross-correlation waveforms has been utilized to improve the accuracy of tomographic models, however, with a tremendous computational cost. Nowadays more and more dense linear arrays have been deployed in the world, which facilitate high-resolution imaging of the 2-D structure beneath the linear array. Here we propose a new approach for linear array ambient noise adjoint tomography with phase and amplitude ratio information for high-resolution crustal tomography. We first convert the observed data for 3D media, i.e., surface-wave empirical Green's functions (EGFs) to the reconstructed EGFs (REGFs) for 2D media using a 3D/2D transformation scheme. Then for a 2D initial model, we compute 2D sensitivity kernels of frequency-dependent Rayleigh wave phases and Z/H amplitude ratios using the adjoint method. The velocity model and the kernels are iteratively updated in the adjoint inversion until the final convergence. We applied this new approach to a linear dense array in North China. With high-quality ambient noise cross-correlation data of this array, we show detailed crustal structures including pronounced low velocity anomalies in the lower crust and a gradual crust-mantle transition zone beneath the northern Trans-North China Orogen, which suggest possible intense thermo-chemical interactions between mantle-derived upwelling melts and the lower crust, probably associated with magmatic underplating during the Mesozoic to Cenozoic evolution of the region. Compared with the intensive computational cost and storage requirement of 3D adjoint tomography, this method offers a computationally efficient and inexpensive alternative to imaging fine-scale crustal structures beneath linear arrays.

References

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