COMBINING FREQUENCY-DEPENDENT TRAVELTIME TOMOGRAPHY AND FREQUENCY-DOMAIN WAVEFORM TOMOGRAPHY FOR NEAR-SURFACE SEISMIC REFRACTION DATA

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Abstract: Seismic refraction surveys and tomographic methods are commonly used to characterize the near-surface. The advantage of traveltime tomography is its robustness because it uses only traveltimes. Its disadvantage is that it provides relatively low spatial resolution velocity models. The advantage of waveform tomography is its ability to provide high-resolution models. The disadvantage of waveform tomography is its strong dependence on an accurate starting model since it is a very nonlinear inverse problem. The spatial resolution of traveltimes data is related to the Fresnel zone, which can be very wide, whereas for waveform data it is related to the seismic wavelength, typically a smaller length scale by comparison. A new integrated strategy for deriving velocity models from near-surface seismic refraction data using two complementary tomographic methods is presented. For near-surface studies there is a strong potential for ray theory to be invalid given typical seismic wavelengths and the length scales of shallow heterogeneities. A new form of traveltime tomography that takes the finite frequency of the data into account in both the forward and inverse modeling yields improved spatial resolution and more accurate estimation of velocity. Frequency-dependent traveltime tomography (FDTT) calculates frequency-dependent traveltimes, wave paths, and sensitivity kernels. Given the width of the sensitivity kernels, it is possible to perform stable traveltime tomography with little or no smoothing regularization and thereby allow the data alone to determine the model structure. Two-dimensional, frequency-domain waveform tomography is used. Although it requires a fairly accurate starting model, here provided by FDTT, its robustness is greatly enhanced by its ability to invert the waveforms in a bootstrap fashion proceeding from low to high frequency. In addition, the relatively low frequency of typical near-surface seismic data is ideal for waveform tomography. Applications to realistic synthetic data, and real P- and SH-wave data are presented.

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