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Visco-elastic controlled-source full waveform inversion without surface waves

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We developed a frequency-domain visco-elastic full waveform inversion for onshore seismic experiments with topography. The forward modeling is based on a finite-difference time-domain algorithm by Robertsson that uses the image-method to ensure a stress-free condition at the surface. The time-domain data is Fourier-transformed at every point in the model space during the forward modeling for a given set of frequencies. The motivation for this approach is the reduced amount of memory when computing kernels, and the straightforward implementation of the multiscale approach. For the inversion, we calculate the Frechet derivative matrix explicitly, and we implement a Levenberg-Marquardt scheme that allows for computing the resolution matrix. To reduce the size of the Frechet derivative matrix, and to stabilize the inversion, an adapted inverse mesh is used. The node spacing is controlled by the velocity distribution and the chosen frequencies.
To focus the inversion on body waves (P, P-coda, and S) we mute the surface waves from the data. Consistent spatiotemporal weighting factors are applied to the wavefields during the Fourier transform to obtain the corresponding kernels.
We test our code with a synthetic study using the Marmousi model with arbitrary topography. This study also demonstrates the importance of topography and muting surface waves in controlled-source full waveform inversion.