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Full-field MDD for body-wave reflections from passive transient-sources under severely limited and irregular illumination conditions

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Seismic interferometry (SI) presents a set of inexpensive and noninvasive methods that can be applied to any array at the surface to retrieve virtual body-wave reflection responses from earthquake recordings. Conventional SI by cross-correlation requires recordings of wavefields in lossless media generated by a smooth continuous distribution of passive sources with isotropic source radiation patterns and similar power spectra. These conditions are unlikely to be met in the lithosphere: earthquakes are distributed sparsely and generated by complex mechanisms. The resulting anisotropy in the illumination of the receiver array causes the retrieved virtual-source radiation patterns to be irregular, leading to artifacts which can obscure the desired body-wave reflections.

SI by multidimensional deconvolution (MDD) can inherently correct for anisotropic illumination of the array and does not rely on the medium being lossless. We propose an alternative formulation of MDD for two-way wavefields: full-field MDD. Different from previous MDD methods for passive two-way wavefield recordings, full-field MDD uses multiples in the passive data to construct the reflection response without free-surface interaction. Therefore, this MDD method profits from additional wavenumbers provided by scattering to compensate for sparse earthquake distributions. Besides, this method does not require wavefield decomposition, which is sensitive to velocity variations at the receiver level.

We compare the reflection retrieval by full-field MDD and cross-correlation for a limited passive source distribution in a lithospheric model with a discontinuous Moho at a depth of 50 km. We simulate earthquakes generated by dipole sources along a listric fault-system with power spectra varying within bandwidth 0.2-2.6 Hz. The reflection response retrieved by full-field MDD shows a continuous high-resolution Moho reflection, while cross-correlation yields a very low resolution response obscured by artifacts.