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Wave mode isolation using spatial wavefield gradients

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Land seismic data recorded at the Earth's free surface typically consists of the superposition of the up-going wavefield and the down-going pure mode and mode-converted reflections. For example, a P-wave arrival at the free surface will be recorded as the overlap of the up-going P-wave, the down-going reflected P-wave and the mode-converted P-to-S-wave, whereby the composite particle motion significantly differs from that of the incident wave. Extracting the up-/down-going and/or P-/S-wave constituents from the recorded wavefield is crucial for near-surface and reservoir characterization purposes, although it remains one of the main challenges in multicomponent seismic data processing to date.

We propose a technique to separate recorded land surface seismic data into their main constituents of interest: (1) up-/down-going, (2) P/S and (3) up-going P/S wavefields. Our method makes use of local spatial wavefield gradient measurements as an additional variable in multicomponent data acquisition. The newly derived filters include the horizontal gradients of the recorded wavefield components, scaled by the local P- and S-wave velocities, and allow extracting the desired wavefields also for overlapping arrivals and heterogeneous media. Synthetic and field-data examples demonstrate that the filters perform well for incidence angles up to 25 degrees, which makes our method applicable to data from most near-surface land exploration settings.