Reflection Profiles Extracted From Ambient-Noise Using Seismic Interferometry

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Seismic Interferometry (SI) is the process of generating seismic traces from the crosscorrelation of existing traces. One application of SI is the retrieval of surface-wave arrivals between two passive stations at the Earth's surface from the crosscorrelation of ambient noise. Another application is the retrieval of body-wave reflections from the crosscorrelation of ambient noise recorded at the Earth's surface. Retrieved reflections would afford the construction of subsurface velocity models and subsurface reflection images with higher resolution than provided by surface-wave tomography. So far the extraction of body-wave reflections has proven to be more challenging. Several factors contribute to this difficulty: e.g., the difference in geometrical spreading between body and surface waves and the reliance on a random distribution of noise sources in the subsurface, as opposed to the ubiquitous and well-studied surface noise.

We apply SI to ambient noise and further process the retrieved records to bring out reflections. Approximately 11 hours of noise were recorded in a desert in North Africa on 8 parallel lines with 50 m station spacing and 500 m spacing between the lines. Strong surface-wave energy, concentrated mainly below 6 Hz, was caused by traffic along a road bisecting the survey in the Northern section of the survey. We therefore first applied a low-cut frequency filter, followed by a frequency-wavenumber filter to remove remaining surface-wave noise. The corner frequency on the high end was 24 Hz. Next, the traces were energy normalized and then crosscorrelated.

Despite the relatively short recording period, we retrieve coherent events. A comparison of virtual common-shot gathers (a response from one virtual shot recorded by all receivers on a line) with common-shot gathers from an active survey along the same line, shows that the retrieved events coincide with reflections in the active data. We further process virtual common-shot gathers using routines commonly applied in exploration seismics to enhance reflections. The results are stacked sections, outlining subsurface structure along several lines. The Southern part of these stacked sections show several coherent events. In the Northern part these events are not traceable, probably due to remnant surface-wave energy. Comparing stacked sections retrieved using SI with the stacked sections from the active survey, we observe that two relatively shallow marker events in particular have been adequately reconstructed from the noise.