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Passive Reflection Seismic Imaging of the North Anatolian Fault at crustal-scale: A Matrix Framework for Aberrations Correction

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To understand fault systems, it is required to identify the structure of the crust and upper mantle. Seismic investigations have long been relying on active sources generating an incident wave-field from the Earth surface. The reflected wave-field is then recorded by sensors deployed at the surface. Nowadays, passive imaging has been adopted as an alternative of this source-receiver configuration by computing the correlations of ambient noise. This process allows to estimate the Green's function between two receivers. We here present a passive imaging technique applied to data recorded with the Dense Array of North Anatolia [1], which was deployed in western Turkey during 16 months. The array consists of 73 stations covering the two major fault branches of the North Anatolian Fault (NAF). Inspired by previous works in optics and acoustics, we introduce a matrix approach of seismic imaging based on seismic noise cross correlations. Our method applies focusing operations at emission and reception (Blondel et al., 2019) allowing to project the reflection matrix recorded at the surface to depth (redatuming). Although seismic noise is dominated by surface waves, focusing operations allow to extract the body wave components that carry information about the reflectivity of in-depth structures. However, complex velocity distribution of the Earth's crust results in phase distortions, referred to as aberrations in the imaging process. Phase distortions prevent the imaging of the true reflectivity of the subsurface leading to unphysical features and blurry images. To overcome these issues, we introduce a new operator: the so-called distortion matrix. It connects any virtual source induced by focusing at emission with the distorted part of the reflected wave-front in the spatial Fourier domain. A time-reversal analysis of the distortion matrix allows to correct for high-order aberrations. Crustal-scale 3D images of the fault structure of the North Anatolian Fault are revealed with optimal resolution and contrast.

(1) DANA. Dense array for north anatolia. International Federation of Digital Seismograph Networks doi:10.7914/SN/YH2012, 2012.