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A new receiver-based passive-seismology technique to image sedimentary basins

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In sedimentary basins (SB), due to the sharp contrast of elastic properties across their basement, strong reverberations are generated and traditional receiver functions become inadequate for imaging Earth structure. Our study investigates the efficiency of a new auto-correlation technique to extract P-wave reverberations and image the crust characterised by SBs. This new method involves spectral whitening followed by cross-correlation and auto-correlation, and applies stacking in time or depth domain [1, 2]. We further demonstrate that spectrally-whitened auto-correlations are more efficient than classical receiver function methods to recover atypical structures beneath seismic stations. Firstly, we apply our approach to teleseismic earthquake data recorded by a receiver sitting on a normal crust, HRV (code IU), in the US. We find textbook examples of radial and vertical responses, best explained by a Moho at 30 km depth and 2 crustal layers. Secondly, we process data from 7 stations (CN WALA, CI SBC, US MCWV, TA 448A, IU HKT, US KVTX and TA 646A) located in North America, sampling SBs with variable thickness ranging from $\sim$4 to 13 km. Classical radial receiver functions are hardly interpretable due to the effect of reverberations. By identifying pulses of reflected P-waves on the vertical auto-correlograms, we, however, describe a fine crustal layering beneath these stations, including the internal stratification of the SBs. Finally, we reconstruct a long-range seismic profile of P-wave reflectivity from the Atlantic coastal plains to the Appalachian Highlands using 51 stations from the dense Transportable Array in the eastern US. This profile samples the large-scale and up to $\sim$10 km-thick sedimentary deposits of the Mississippi alluvial plain and Appalachian regions of thickened ($\sim$50 km) crust. For a comparison, we build a section from synthetic auto-correlograms using the low-resolution seismic model Crust 1.0. If we can take Crust 1.0 as a good first-order approximation for the crustal and SB structure in the US, our data analysis suggest additional complexity related to smaller-scale layering and 3D structure. This new methodology will be valuable in constraining the fine-scale architecture of the crust in interesting geological settings such as an ice layer or thick sedimentary basins over a bedrock. There is also a potential to filter out the effect of a water-layer in the increasing number of studies that use OBS data.

References:

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