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Sensitivity of Ambient Noise Autocorrelations to Noise Sources

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Ambient noise auto-correlations have been successfully used in a small number of recent studies in order to image crustal reflectors. This idea, which goes back to Claerbout, holds great potential for passive imaging: the naturally occurring ambient noise penetrates to large depths and can be measured continuously even in seismically quiet regions, and at low expense. Reflection profiles obtained from auto-correlations could supplement the sharp boundaries to the generally smooth images obtained with ambient noise tomography.

However, the interpretation of the auto-correlation traces in terms of crustal reflectors often appears far from straightforward. Some studies have relied on additional information such as well logs or active seismic profiles in order to delineate reflectors.

We suggest to utilize additional information about the source distribution of the ambient seismic noise in order to interpret noise auto-correlations. To do so, we investigate the influence of the source distribution on auto-correlations by means of a synthetic sensitivity study. We make use of our recently developed method to model auto-correlations for various Earth models – from layered to fully 3-D – and for various distributions of sources with spatially varying spectra. This also allows us to quantify the sensitivity of the auto-correlations to noise sources, as well as to variations in subsurface structure.

We firstly show and discuss the sensitivity of auto-correlation envelopes to proximal and distant ambient seismic sources. Cross-terms between signals arriving directly at the seismic sensor and signals reflected in between sources and the receiver give rise to signals in the auto-correlation, but not necessarily those one would expect by assuming subvertically incident ambient noise body waves. The auto-correlation sensitivity to sources provides an overview of these signals and could therefore be used to facilitate interpretation.
In this context, it is necessary to account for the role of processing applied to the continuous seismic data in order to retrieve auto-correlations, since it has been shown that the successful recovery of reflectors depends on it.

We then investigate the sensitivity of auto-correlation envelopes to Earth structure. It depends on the given ambient source distribution. Thus, we compare structural sensitivities for different scenarios of ambient source distributions to complement the first part of the sensitivity study, and to add to the understanding of this new passive imaging tool.