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Inverting seismic noise cross-correlations for noise source distribution: A step towards reducing source-induced bias in seismic noise interferometry

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We report on the ongoing development of a new inversion method for the space- and time-dependent power spectral density distribution of ambient seismic noise sources. The method, once complete, will mainly serve two purposes: First, it will allow us to construct more realistic forward models for noise cross-correlation waveforms, thereby opening new possibilities for waveform imaging by ambient noise tomography. Second, it may provide new insights about the properties of ambient noise sources, complementing studies based on beamforming or numerical modeling of noise based on oceanographic observations.

To invert for noise sources, we consider surface wave signal energy measurements on the 'causal' (station A to B) and on the 'acausal' (station B to A) correlation branch, and the ratio between them. These and similar measurements have proven useful for locating noise sources using cross-correlations in several past studies.
The inversion procedure is the following: We construct correlation forward models based on Green's functions from a spectral element wave propagation code. To construct these models efficiently, we use source-receiver reciprocity and assume spatial uncorrelation of noise sources. In such a setting, correlations can be calculated from a pre-computed set of Green's functions between the seismic receivers and sources located at the Earth's surface.
We then calculate spatial sensitivity kernels for the noise source distribution with respect to the correlation signal energy measurements. These in turn allow us to construct a misfit gradient and optimize the source distribution model to fit our observed cross-correlation signal energies or energy ratios.

We will present the workflow for calculation of the forward model and sensitivity kernels, as well as results for both forward modeling and kernels for an example data set of long-period noise or 'hum' at a global scale. We will also provide an outlook on the noise source inversion considering the particular characteristics of the noise source sensitivity kernels.