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Towards Full-Waveform Ambient Noise Inversion

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Noise tomography usually works under the assumption that the inter-station ambient noise correlation is equal to a scaled version of the Green function between the two receivers. This assumption, however, is only met under specific conditions, e.g. wavefield diffusivity and equipartitioning, or the isotropic distribution of both mono- and dipolar uncorrelated noise sources. These assumptions are typically not satisfied in the Earth. This inconsistency inhibits the exploitation of the full waveform information contained in noise correlations in order to constrain Earth structure and noise generation. To overcome this limitation, we attempt to develop a method that consistently accounts for the distribution of noise sources, 3D heterogeneous Earth structure and the full seismic wave propagation physics. This is intended to improve the resolution of tomographic images, to refine noise source distribution, and thereby to contribute to a better understanding of both Earth structure and noise generation.

First, we develop an inversion strategy based on a 2D finite-difference code using adjoint techniques. To enable a joint inversion for noise sources and Earth structure, we investigate the following aspects: i) the capability of different misfit functionals to image wave speed anomalies and source distribution and ii) possible source-structure trade-offs, especially to what extent unresolvable structure can be mapped into the inverted noise source distribution and vice versa.

In anticipation of real-data applications, we present an extension of the open-source waveform modelling and inversion package Salvus (http://salvus.io). It allows us to compute correlation functions in 3D media with heterogeneous noise sources at the surface and the corresponding sensitivity kernels for the distribution of noise sources and Earth structure. By studying the effect of noise sources on correlation functions in 3D, we validate the aforementioned inversion strategy and prepare the workflow necessary for the first application of full waveform ambient noise inversion to a global dataset, for which a model for the distribution of noise sources is already available.