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Inverting long-period noise cross-correlations for noise sources

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Ambient noise tomography and passive monitoring of Earth's crust promise a wealth of information and practical applications in many fields. However there is increasing awareness that in particular for observations of fundamental-mode surface waves in correlations, non-stationary and heterogeneously distributed ambient noise sources should be taken into account to avoid artifacts. This is especially true if waveform information of the ambient noise correlations is to be exploited.

We have developed a method to invert for ambient noise sources that takes 3-D Earth structure into account. Our approach enables us to model cross-correlation functions for arbitrary noise source distributions in a heterogeneous medium and to efficiently calculate noise source sensitivity kernels. Using pre-computed wave fields representing the impulse response of the Earth between receiver locations and a dense source grid at the Earth's surface, we can iteratively update a noise source distribution model with little computational effort.

We apply this inversion method to the long-period background signal of the Earth or 'hum' to validate the method in comparison to plane-wave or normal mode-based approaches, and we explore possible time-dependent applications on regional scale.

While it is not possible to update Earth structure during the inversion, the method also contributes to waveform inversion of ambient noise correlations by providing a (starting) model for the space- and frequency dependent noise source distribution.