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Rapid Global Finite-Frequency Ambient Noise Source Inversion

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Common assumptions in ambient noise seismology such as Green's function retrieval and equipartitioned wavefields are often not met in the Earth. Full waveform ambient noise tomography methods are free of such assumptions, as they implement knowledge of the time- and space-dependent ambient noise source distribution, whilst also taking finite-frequency effects into account. Such methods would greatly simplify near real-time monitoring of the sub-surface. Additionally, the distribution of the secondary microseisms could act as a new observable of the ocean state since its mechanism is well understood (e.g. Ardhuin et al., 2011).

To efficiently forward-model global noise cross-correlations we implement (1) pre-computed high-frequency wavefields obtained using, for example, AxiSEM (Nissen-Meyer et al., 2014), and (2) spatially variable grids, both of which greatly reduce the computational cost. Global cross-correlations for any source distribution can be computed within a few seconds in the microseismic frequency range (up to 0.2 Hz). Similarly, we can compute the finite-frequency sensitivity kernels which are then used to perform a gradient-based iterative inversion of the power-spectral density of the noise source distribution. We take a windowed logarithmic energy ratio of the causal and acausal branches of the cross-correlations as measurement, which is largely insensitive to unknown 3D Earth structures.

Due to its parallelisation on a cluster, our inversion tool is able to rapidly invert for the global microseismic noise source distribution with minimal required user interaction. Synthetic and real data inversions show promising results for noise sources in the North Atlantic with the structure and spatial distribution resolved at scales of a few hundred kilometres. Finally, daily noise sources maps could be computed by combining our inversion tool with a daily data download and processing toolkit.