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Efficient cross-correlation modelling for noise source inversion

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Knowing the ocean-generated noise source distribution is of fundamental importance for new methods in ambient seismic noise tomography. Furthermore, noise correlations could be a new seismic observable related to wave heights in the present and past ocean. Our study aims to make routine modeling of cross-correlations at the periods of oceanic microseisms (down to 5 s and shorter) feasible and thereby enable ambient source inversion at these periods on a global scale.

The noise source distribution, i.e. the PSD of the force densities, can be estimated from station-pair cross-correlations, for example by evaluating their asymmetry. However, modelling the cross-correlations for periods less than 20 s on a global scale is computationally challenging. We propose a solution to this problem, thereby making the first step towards a global-scale finite-frequency inversion of noise sources at short periods.

To forward model cross-correlations, we take advantage of pre-computed wavefields between potential noise sources and seismic receivers using Axisem, a spectral-element solver for spherically symmetric global wave propagation. The noise sources are parametrized on a geographical grid that can be adapted to the PSD distribution in order to achieve high computational efficiency. For example, the grid can be particularly dense in regions of high PSD, and sparser in regions where PSD is low. To correctly scale the source strengths, the Voronoi cell areas of the grid are computed and used as weights for every grid point.

As an illustrative application, we use the ocean floor pressure maps inferred based on wave height observations by Ardhuin et al. (2011) to compute cross-correlations resulting from a realistic noise source distribution. With our approach, cross-correlations for these noise source distributions can be computed more efficiently compared to a homogeneous grid. At 20,000 gridpoints the spatially variable grid is already converged to the minimum misfit whereas a homogeneous grid would need at least 40,000 to converge. In the future, the tool can be used to do ambient seismic noise source inversions for the ocean microseism frequency band on a global scale.

References

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