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Passive dispersion analysis on a sea dike using cross-correlations and beamforming

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In order to passively infer the velocities of surface waves beneath a receiver array, we propose to apply beamforming on cross-correlated noise records. We test the method with synthetic signals generated for a variety of array geometries and noise distributions. We show that the use of cross-correlations cleans the dispersion diagram that would be obtained from a phase-shift analysis alone, by resolving ambiguities between the location of noise sources and the wave velocities. In particular, when nearby noise sources are present, accurate dispersion curves can be inferred from arrays possessing poor azimuthal coverages. This passive method is therefore appropriate for the monitoring of stiffness at the civil-engineering scale, where multiple isolated noise sources may be present and where the field geometry does not always allow to deploy circular arrays.

We apply the method to field data obtained from a linear array installed on top of a sea dike. The seismic noise, recorded at high tide during 8 minutes, is essentially generated by impacts of sea waves. In contrast to a phase-shift analysis performed on the noise itself, we show that the use of cross-correlations allow to infer a dispersion curve consistent with an active hammer-shot measurement, in a larger frequency band, ranging from 5 to 55 Hz. This result opens the possibility of following passively the mechanical evolution of embankments on a daily basis.