Assessment of seismic ambient noise parameter estimation and wavefield decomposition in WaveDec

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Knowledge about seismic ambient noise wavefield through decomposition into different participant waves is of special importance in geophysical studies. In this study, WaveDec technique (Maranò et al., 2012) as an array statistical signal processing technique was used to decompose seismic ambient noise wavefield and to estimate wavefield parameters. In this method, the measurements from all components of stations and parameters of interest are modeled jointly which leads to significant improvement in extracting characteristics of surface waves. Considering the contribution of both Love and Rayleigh waves in the wavefield, the method estimates the desired parameters including amplitude, phase, azimuth, wave number and the ellipticity angle (for the Rayleigh wave only) based on the Maximum Likelihood Estimation method. One of the main characteristic of WaveDec is estimating the ellipticity angle of Rayleigh waves. This is very beneficial in determining retrograde and prograde particle motion and also in mode distinction.

In the WaveDec algorithm, the Truncated Newton method is used to optimize likelihood functions with respect to wavefield parameters. Furthermore, Bayesian Information Criterion (BIC) is used to select the best model and wave type determination (Rayleigh, Love, body wave or noise). Regarding a group of generated models for different wave types, the one with the smallest BIC is chosen.

We examined consistency of WaveDec algorithm by applying different numerical optimization methods; Truncated Newton, L-BFGS-B quasi-Newton and simplex-based Nelder-Mead methods. Furthermore, different model selection criteria; BIC, Akaike Information Criterion (AIC) and Hannan–Quinn Information Criterion (HQC) were examined to study the quality of generated models. They possess different penalty terms to avoid overfitting the models on data. All possible pairs of optimization methods and model selection criteria were utilized and replaced in WaveDec algorithm. In order to compare the resultant dispersion curves of surface waves and ellipticity angle curves of Rayleigh waves, SESAME model M2.1 synthetic data and some seismic ambient noise measurements in Colfiorito basin in Italy (Array B) were analyzed.