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Blind deconvolution of the seismic source time function based on higher order statistics of regional coda waves

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Recovering the source time function (STF) of a seismic event provides essential information on the nature and physical mechanisms of the source. Nevertheless, the broad-band estimation of STF is often a difficult task particularly at regional distance where the unknown high heterogeneity of the crustal limits wave inversion to the low frequency content of the source. On the other hand, the widely used empirical Green's function (EGF) suffers from certain limitations towards the selection of valuable empirical green function, especially for small events. Several studies have proved the usefulness of the S coda wave for source parameter estimation such as its moment or its power spectrum. Unfortunately, as these methods are based on second order statistics (power spectrum), the phase of the source spectrum is lost as well as the event STF.

In this study, we have developed an original method to recover STF based on the higher order statistic (HOS) blind deconvolution of the S wave coda excitation. Under the assumption that the coda excitation time series is a non-Gaussian independent and identically distributed random signal, this higher order spectral approach provides the amplitude and especially the phase of source spectrum, allowing thus the complete estimation of the seismic STF.

We propose a two step algorithm to recover the seismic STF: first, the diffuse coda wave field is whitened to remove the non-stationary attenuation effect; second the STF of the event is estimated from the HOS of the whitened coda excitation such as its bicorrelation and tricorrelation.

This algorithm has been tested on regional records of the Rambervillers, 22/02/2003, Ml=5.4 earthquake, located in North-east of France. As the convergence rate of the higher order statistic is slower than second order one, their estimation requires rather long time series and high signal to noise ratio. In order to improve the signal to noise ratio for HOS estimation, a multi-stations stacking procedure of the bicorrelation and tricorrelation has been implemented.

After a preliminary whitening of the coda excitation signal, the bicorrelation and tricorrelation have been estimated. In agreement with the a priori symmetric distribution property of the coda excitation random process, no bicorrelation has been detected. From the tricorrelation, we obtain a STF of the Rambervillers earthquake consistent with the STF estimated by empirical green function analysis. These first results show the ability of HOS blind deconvolution to extract STF from regional coda records, and provide interesting new insights of the potential non-Gaussian behaviour of the coda excitation time series.