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A probabilistic method for the estimation of earthquake source parameters from spectral inversion : application to the 2016-2017 Central Italy seismic sequence

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We develop a probabilistic framework based on the conjunction of states of information between data and model, to jointly retrieve earthquake source parameters and anelastic attenuation factor from inversion of displacement amplitude spectra. The evaluation of the joint probability density functions (PDFs) enables us to take into account between-parameter correlations in the final estimate of the parameters and related uncertainties. Following this approach, we first search for the maximum of the a-posteriori PDF through the basin hopping technique that couples a global exploration built on a Markov chain with a local deterministic maximization. Then we compute statistical indicators (mean, variance and correlation coefficients) on source parameters and anelastic attenuation through integration of the PDF in the vicinity of the maximum likelihood solution. Definition of quality criteria based on the signal to noise ratio and the similarity of the marginal PDFs with a Gaussian function enables us to the define the frequency domain for the inversion and to get rid of unconstrained solutions.

We perform synthetic tests to assess theoretical correlations as a function of the signal to noise ratio and to define the minimum bandwidth around the corner frequency for consistent parameter resolution.

As an application, we finally estimate the source parameters for the 2016-2017 Central Italy seismic sequence. We found that the classical scaling between the seismic moment and the corner frequency holds, with an average stress drop of 2.1 $\pm$ 0.3 MPa. However, the main events in the sequence exhibit a stress drop larger than the average value. Finally, the small seismic efficiency indicates a stress overshoot, possibly due to dynamic effects or large frictional efficiency.