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Empirical evidence of frequency-dependent directivity effects from small-to-moderate normal fault earthquakes in Central Italy

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Rupture source directivity and its potential frequency dependence remains an open question in seismology, especially for small-to-moderate earthquakes.

In this research, we first calibrate a non-ergodic empirical model of the acceleration Fourier Amplitude Spectra (FAS), and then we adapt our tool in Spectral Amplitude (SA). Thanks to the large amount of high-quality seismic recordings (consisting of more than 400 earthquakes from magnitude 3.4 to 6.5, 460 stations, thus involving more than 30'000 waveforms in the time frame 2008-2018), we provide a statistical overview based on empirical evidence of seismological observations in the Central Italy area, which represents a unique natural laboratory for earthquakes occurring on normal faults. The non-ergodicity enables to remove all the other components of variability (i.e. the event-, site- and path-related) in the ground motion model (GMM) and hence allowing to better isolate the effects connected to source-directivity, that are not unaccounted in the epistemic variability of the ground motion.

According to our criteria, about 36% of the analyzed events (162 out of 456) exhibits directivity. The distribution of the rupture directions is aligned, as expected, with the strikes of the major faults of the Central Apennines. We find that the directivity is a band-limited phenomenon, which spans from corner frequency (f_c) up to approximately 5 times the event's f_c; in case of not very pronounced directivity, this band tends to be narrow, suggesting that the complex rupture processes at high-frequency are mainly stochastic. Moreover, we observe directivity not only during seismic sequences, but also in background seismicity.

Preliminary results provide a useful hint regarding directivity's parameterization as a frequency-dependent band-limited phenomenon, to be implemented in future ground motion modeling and scenario's predictions.