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Finite-fault inversion of the Mw 5.9 2012 Emilia-Romagna earthquake (Northern Italy) using aftershocks as near-field Green's function approximations

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On May 29, 2012 occurred a Mw 5.9 earthquake in the Emilia-Romagna region (Po Plain) on a thrust fault system. This shock, as well as hundreds of aftershocks, were recorded by ~10 strong motion stations located less than 10 km away from the rupture plane, with 4 stations located within the surface rupture projection. The Po Plain is a very large EW trending syntectonic alluvial basin, delimited by the Alps and Apennines chains to the North and South. The Plio-Quaternary sedimentary sequence filling the Po Plain is characterized by an uneven thickness, ranging from several thousands of meters to a few tens of meters. This particular context results especially in a resonance basin below 1 Hz and strong surface waves, which makes it particularly difficult to model wave propagation and hence to obtain robust images of the rupture propagation.

This study proposes to take advantage of the large set of recorded aftershocks, considered as point sources, to model wave propagation. Due to the heterogeneous distribution of the aftershocks on the fault plane, an interpolation technique is proposed to compute an approximation of the Green's function between each fault point and each strong motion station in the frequency range [0.2-1Hz].

We then use a Bayesian inversion technique (Monte Carlo Markov Chain algorithm) to obtain images of the rupture propagation from the strong motion data. We propose to retrieve the slip distribution by inverting the final slip value at some control points, which are allowed to move on the fault plane, and by interpolating the slip value between these points. We show that the use of 5 control points to describe the slip, coupled with the hypothesis of spatially constant rupture velocity and rise-time (that is 18 free source parameters), results in a good level of fit with the data. This indicates that despite their complexity, the strong motion data can be properly modeled up to 1 Hz using a relatively simple rupture. The inversion results also reveal that the rupture propagated slowly, at a speed of about 45% of the shear wave velocity.