Imaging the complexity of earthquake source

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In recent years the seismic observation has made a huge leap forward in terms of coverage and density of recording stations. This instrumental effort has fostered the development of new approaches to the study of the seismic rupture, which can support and complement the classical finite source kinematic modeling.

The availability of dense seismic arrays makes today possible to image the earthquake extended source through the coherent interferometry of the wave radiation emitted during the rupture propagation. One of the advantages of this approach is to deliver images of the source emissivity that do not need a-priori information on the rupture speed or on the fault geometry, while they can constrain these parameters for kinematic inversion. Moreover, coherent interferometry provides intrinsically high frequency images of the rupture, since it works at frequencies that are generally one or two order of magnitudes higher than those used for kinematic slip inversion.

The broadband study of the seismic rupture, through the integration of coherent imaging and slip inversion, can provide new elements for understanding the mechanisms that control the generation and the development of the earthquake rupture process.

We combined coherent rupture imaging by back projection and kinematic modeling for the study of the rupture process of the 2011, Mw 9.0 Tohoku earthquake. The joint analysis of the rupture images shows distinctive patterns in the space-time partition of high-frequency emissivity and low-frequency large slip.
We interpret these results in terms of the geometrical and mechanical properties of the subduction interface and in relation to rupture dynamics. Finally, we discuss their general implications for the understanding of the structural control of seismic activity and mega thrust rupture in subduction zones.