Physics-based generation of stochastic initial stresses
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Dynamic rupture models that stop by **abrupt strong barriers** produce ground motions dominated by radiation from the rupture ends (Madariaga, 1983)

A more realistic model should **generate ω^{-2} radiation sustained all along the rupture**

This can be obtained in two ways (Madariaga, 1983):

- Abrupt variations of fracture energy G_c
- Presence of **initial stress singularities** $r^{-1/2}$, typical of residual stresses at the edge of previous ruptures

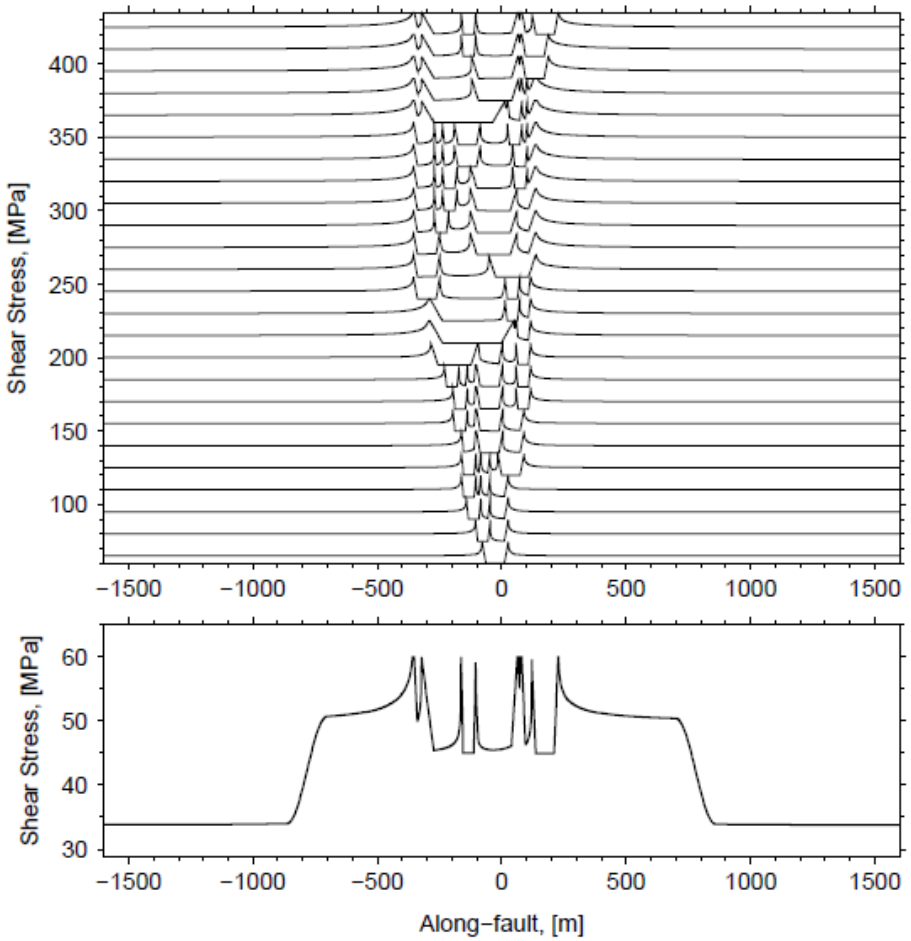
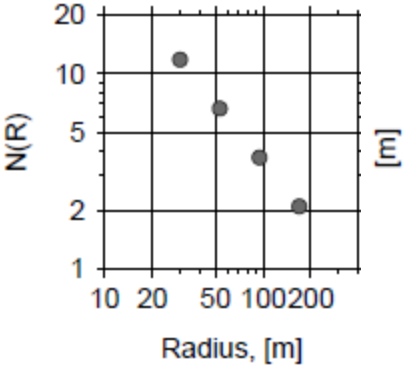
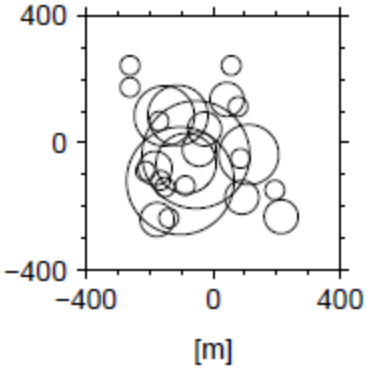


Figure 1: Procedure adopted to generate the heterogeneous initial stresses for dynamic simulations. The background seismicity in the fault zone follows a Gutenberg-Richter distribution (bottom left) with quasi-random hypocenter locations (bottom right). The stress on the fault plane (middle) is the sum of the residual stresses from the previous seismicity, and a low stress taper to stop rupture. The top figure shows the construction of the stress distribution: from bottom to top, each event contributes a stress concentration at each of its edges, and the next event is nucleated close to one of these.





Main assumption: fault stress heterogeneities result from the background seismicity

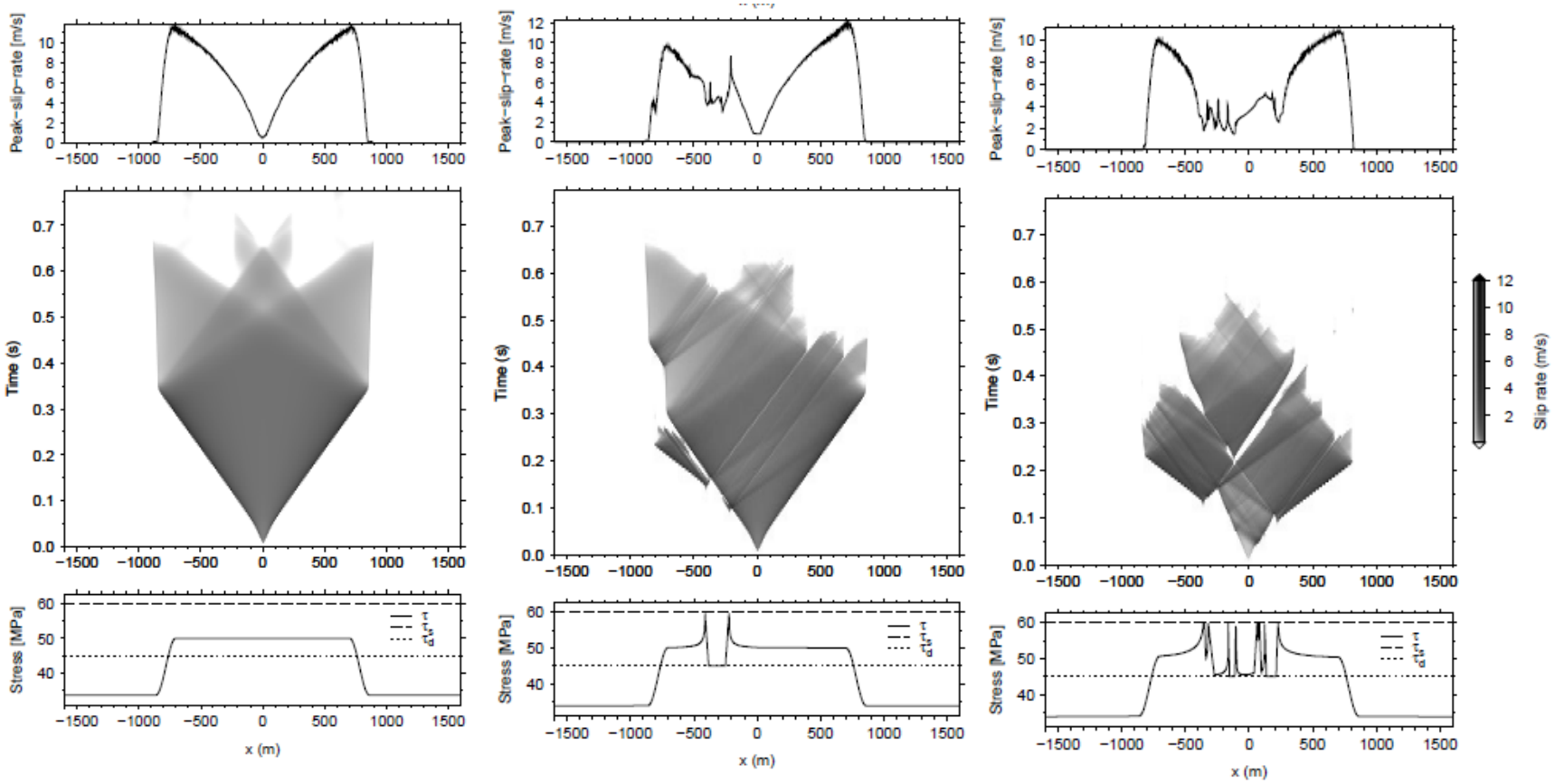
Implications:

- statistical self-similarity inherited from the Gutenberg-Richter distribution
- long tail probability distribution due to the spiky nature of the residual stress concentrations at the edges of previous ruptures

SCEC project by Ampuero, Ruiz and Mai (2008/2009)

2D dynamic ruptures with increasing level of complexity in initial stresses

Smooth | Single pre-existing crack | **Multiple previous cracks**



Interaction between the rupture front and the pre-existing stress concentrations radiate strong ω^{-2} phases, induce multiple-front coalescences, and produce healing fronts that encourage pulse-like rupture and heterogeneous final stresses

Radiated spectra: enhancement of high-frequency radiation

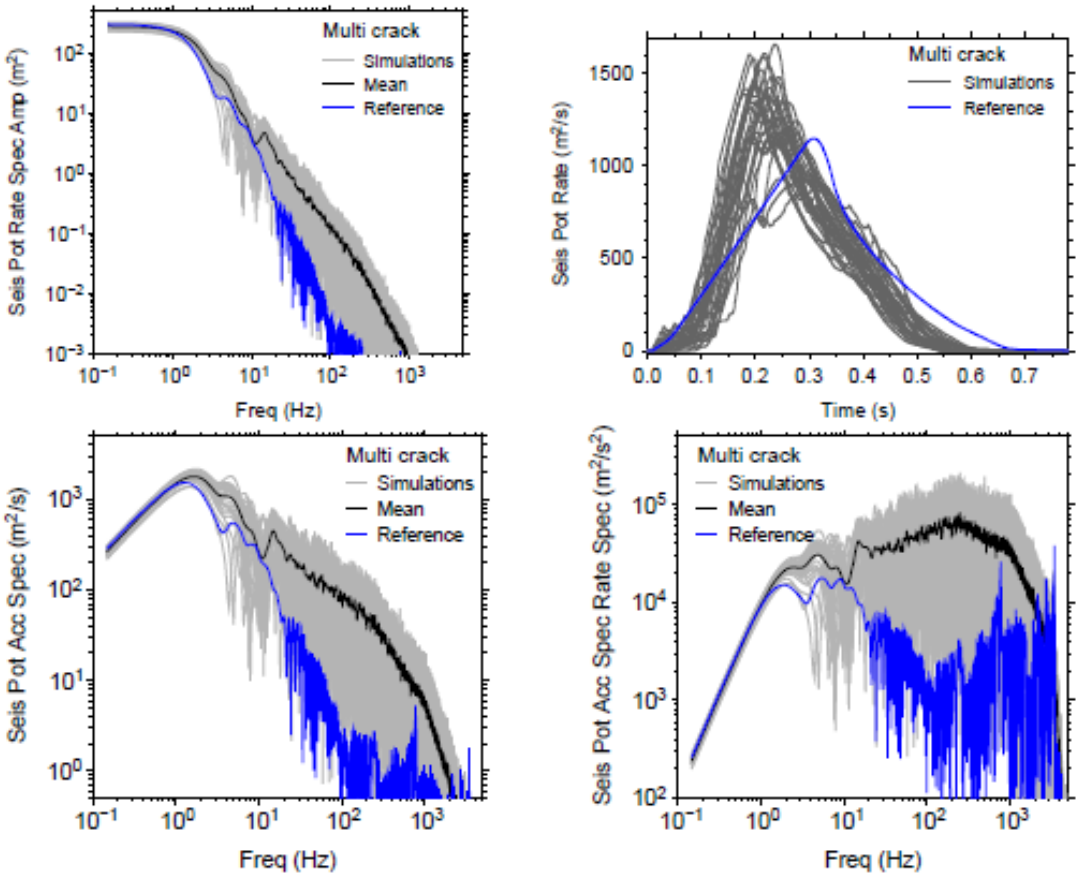


Figure 3: Spectra of far-field displacement (a), velocity (c) and acceleration (d) derived from the seismic potency rate (b) of 30 simulations with the multi-crack model. The reference model (blue) has uniform initial stress.