Signature of rupture dynamics in off-fault damage

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Résumé

Natural fault zones are complex structures. While there are strong variations from one outcrop to another, they all share a common characteristic: a non-planar fault core, where extensive shearing is observed, surrounded by pervasively fractured rocks that lack significant displacement. Recent observations have highlighted that this overall structure, from the properties of the fault core to the rheology of the damage zone, influences the modes of deformation (seismic and aseismic) and the total amount of slip.
Using a micromechanics-based constitutive model that accounts for off-fault damage at high strain rates, we show that the off-fault damage structure carries information about the rupture dynamics itself. This discovery opens new avenues to revisit past earthquakes. We consider 2D in-plane ruptures on rough faults with root mean square (rms) height fluctuations of the order of 10^-3 to 10^-2 times the profile length. We explore the dynamic effects of fault roughness on off-fault damage structure and earthquake rupture dynamics. Our findings demonstrate that the co-seismic damage zone structure embeds details of the fault rupture dynamics, which in turn affects strong ground motion. This opens up a novel approach to infer or invert rupture velocity variation from natural observations of co-seismic damage, whether from historical earthquakes or more recent ones with high-resolution co-seismic damage measurements.

Mots-Clés: earthquake, damage, modelling

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