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Effects of listricity on near field ground motions: the kinematic case

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Listric faults are defined as curved faults in which the dip decreases with depth, resulting in a concave upwards shape. Previous works show that breaking the symmetry of faults affects rupture dynamics and near field ground motions (e.g. Oglesby et al., 1998; Nielsen, 1998; Oglesby et al., 2000b; O'Connell et al. 2007). In recent years listric faults have been associated with devastating events, such as the 2008 Mw 7.9 Wenchuan earthquake that caused almost $150 billion of damage, and the 1999 Mw 7.6 Chi- Chi earthquake that caused $10 billion worth of damage, each of them responsible also for tens of thousands of injured and dead.

We focus on quantifying near field ground motions as a function of initial dip, style (normal or reverse) and a listricity. To construct a listric profile for the simulations we use an exponential function (Wang et al., 2009) that approximates the dip angle for a certain depth as a function of the depth itself, the initial dip angle and a listricity factor. We then generate an ensemble of source models, with initial dip ranging from 10 to 90 degrees and a listricity factor from 5 to 20. Finally, heterogeneous slip distributions are created for a magnitude Mw 6.8 earthquake. Choosing different hypocenter locations and rupture velocities, we construct a range of kinematic source models that are resolved on both the listric and planar-fault geometry. We then compute the near-source seismic wavefield within a uniform isotropic medium using a generalized 3D finite-difference method. The listric and planar simulations are then compared, and their differences quantified.

Initial results show a secondary directivity effect once the listricity factor exceeds 10 for the larger initial dip faults, thus inducing a change in the azimuthal angle with respect of the epicenter where peak ground motions are experienced. At the same time, overall PGV values are decreased, more so for geometries with higher listricity factors.

With the knowledge acquired, a ground motion reduction factor can be applied to ground motion prediction equations when the fault is considered to be listric and hazard maps should re-adjusted to cater for the relocation of peak ground motions due to directivity effects.