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The September 19th, 2017 (M7.1), intermediate-depth Mexican earthquake: An energetically inefficient deadly shock.

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On September 19th 2017, a magnitude 7.1 earthquake occurred between the states of Morelos and Puebla, Mexico. It was one of the closest subduction-related earthquakes to Mexico City in the recent history, with a hypocentral distance of 127 km. Mexico City, with more than 20 million citizens, is highly vulnerable to seismic activity due to the large amplification of seismic waves produced by the lake-bed sediments where most of the city extends. 228 people died and 43 building collapsed in the city due to the strong shaking induced by the earthquake that, at hard-rock next to the sediments, produced peak ground accelerations ($\sim$60 gal) twice as large of those observed during the devastating 1985 (M8.0) Michoacan earthquake that killed more than 10 thousand people.

The event was a normal-faulting intraplate (i.e. within the subducted Cocos plate) earthquake with a focal depth of 57 km. Although intermediate depth earthquakes (IDE) of this kind are relatively frequent across the globe, the physics of their source process is still not well understood. Due to the high confining pressure and temperature at depths below 50 km, rocks ought to deform by ductile flow rather than the brittle failure governing most of shallow, interplate earthquakes. We performed a dynamic source inversion of the M7.1 event using six strong motion records with epicentral distances smaller than 110 km to elucidate some properties of the rupture process. We implemented a new Particle Swarm Optimization algorithm for this purpose that takes advantage of parallel computing and allows a statistical analysis of the solution.

Consistently with similar Mexican earthquakes (Díaz-Mojica et al., 2014), the inversion of the M7.1 event revealed that the rupture speed (Vr/Vs $\sim$ 0.3-0.5) and radiation efficiency (0.02-0.28) are low. Besides, as expected for intraslab earthquakes, the stress drop ($\sim$20 MPa) is high. Similar results where recently found using an independent method for an IDE below the Wyoming Craton in US (Prieto et al., 2017) suggesting that slow, inefficient source processes may characterize earthquake ruptures below the brittle-ductile transition of the lithosphere. Although such rupture properties are typical of tsunami earthquakes, the M7.1 shock produced Fourier accelerations about two times larger than those observed between 1 and 2 s for earthquakes with similar magnitude reduced to the same hypocentral distance (Singh et al., 2018). This means that the source produced remarkably high radiation of short period waves, which is inconsistent with tsunami earthquakes that are characterized by large Ms-Mw disparity. It is possible that rupture directivity contributed to this observation. Our results also show that $\sim$72% of the total energy change produced by the event was not radiated. This means that the specific fracture energy was close to 2×107 J/m^2 in average, which is about 10 times larger than expected for shallow crust earthquakes. Recent studies suggest that thermal shear runaway is the leading rupture mechanism of IDEs (Prieto et. al., 2013). This mechanism produces a highly localized ductile deformation in the fault zone inhibiting brittle fracture but allowing large particle accelerations.