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Coseismic slip on shallow décollement megathrusts

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Many regions of plate convergence are underlain by décollement megathrusts, which form the base of both accretionary wedges and fold-and-thrust belts. These faults may extend laterally for hundreds or thousands of kilometers, and downdip for tens to hundreds of kilometers. Traditionally, estimates of seismic hazard have assumed that these faults slip aseismically, without releasing significant seismic energy, under the belief that they are too weak to build accumulate large stresses. However, in several recent cases, these faults have been shown to slip in large, discrete events, resulting in hazardous groundshaking and/or tsunamis (e.g., 2011 Tohoku-Oki earthquake, Japan; 2010 Mentawai earthquake, Indonesia; 1999 Chi-Chi earthquake, Taiwan).

We present a series of fifteen examples, both on-land and offshore, demonstrating that many shallow décollements are capable of producing large, coseismic slip events that rupture to the toes of the systems. Some of these events are associated with ruptures that initiate down-dip, while others are limited to the frontal, shallow portion of the wedge, illustrating that the frontal portion can initiate rupture as well as participate in ruptures that initiated elsewhere.

We suggest that this behavior is not limited to the examples described here, but rather is common to many (perhaps most) accretionary wedges and fold-and-thrust belts. Although many earthquakes in subduction zones have been interpreted to have no slip at the tip of the accretionary prism, this interpretation is typically driven by model assumptions, rather than the data. We suggest that in addition to the examples provided here, there may be many other examples of similar earthquakes, where existing data cannot constrain slip at the toe. We do not characterize the regions and events described here as unusual, as they encompass a wide range of settings. This study indicates that there is an urgent need to reevaluate seismic and tsunami hazard in fold-and-thrust belts and subduction zones around the world, allowing for the possibility of shallow décollement rupture.