Understanding Earthquakes in the Shallow Regions of Subduction Zones

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The shallow regions of subduction zones are areas where a rich and complex variety of behaviors occur, including: tsunami earthquakes, slow slip events, the extension of coseismic slip to the trench, and steady creep. In an effort to better understand these behaviors and their associated seismic hazards, we conducted simulations and numerical experiments that examine the basic frictional stability properties of shallow thrust faults. The length of a fault influences its ability to generate an earthquake. Below some critical length, faults cannot generate an earthquake. We ran simulations of earthquake behavior to examine how the dip angle and shear modulus of shallow faults controls the critical fault length. For each value of dip angle and shear modulus, the critical fault length is defined by an abrupt change in the sliding behavior from aseismic to seismic. As the dip angle increases, the critical fault length also increases. This was more prevalent in simulations with a higher shear modulus. In general, the simulations show that shallow faults generate earthquakes on significantly shorter fault lengths compared to deep faults. This finding is important because results on deep fault stability are frequently applied to shallow faults, which our results show could lead to underestimating a shallow fault's potential for generating an earthquake.