EFFECTIVE STRESS AND FAULT STRENGTH VARIATIONS WITH DEPTH: INSIGHTS FROM SEISMO-THERMO-MECHANICAL SUBDUCTION MODELS AND DYNAMIC RUPTURE MODELS

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The near-fault stress regime and fault strength before and during fault sliding exert first-order control on mechanics and earthquake rupture dynamics, but remain difficult to constrain, especially in complex subduction zone settings. In addition to inferences from earthquake observations, drill holes and conceptual models, insights from geodynamic-seismic cycle modeling provide an additional avenue by which to constrain these parameters. These seismo-thermo-mechanical models suggest that both the effective stress field near a megathrust and the static and dynamic fault strength vary non-linearly with depth and are materially dependent. We contrast results from two dynamic earthquake rupture models resulting from (A) these heterogeneous initial conditions from geodynamic-seismic cycle models, and (B) simpler, depth-dependent initial conditions that are more commonly used to initiate earthquake rupture models. Although the maximum fault strength is similar in both scenarios, the heterogeneous initial conditions in (A) result in larger fault slip, but lower average dynamic stress drop and lower rupture velocity. In addition, we observe that seismic waves traveling through complex materials around the fault in (A), as opposed to the homogeneous material in (B), influence earthquake rupture style and shallow slip accumulation. These insights underscore the need to better understand initial earthquake conditions from a variety of sources, including integrative modeling, in order to advance understanding of earthquake initial conditions, fault strength, and earthquake behavior.

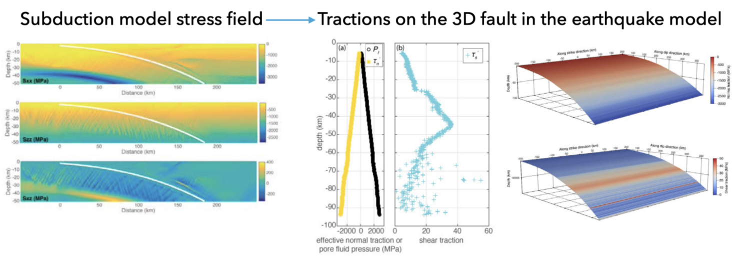

Figure: The conditions at the start of a 2-dimensional seismo-thermo-mechanical model slip event (left, middle) are ported to the 3-dimensional dynamic earthquake rupture model as initial conditions (right). The normal tractions increase with depth along the fault, while the shear tractions are below 15 MPa along the upper part of the fault, then increase more rapidly with depth from approximately 30 km depth to a maximum of ~38 MPa at 45 km depth, before decreasing again.