The CRESCENT Dynamic Rupture, Earthquake Cycle, and Tsunamis Working Group (DET)

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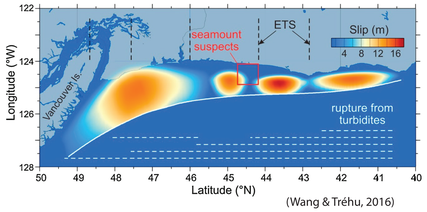
Model to answer science questions and inform seismic and tsunami hazard assessments

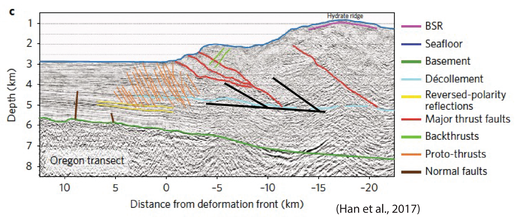
Science questions:

Controls on rupture extent and segmentation



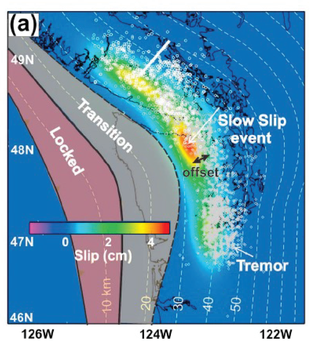
(Wang & Tréhu, 2016)

Shallow rupture behavior and tsunami generation



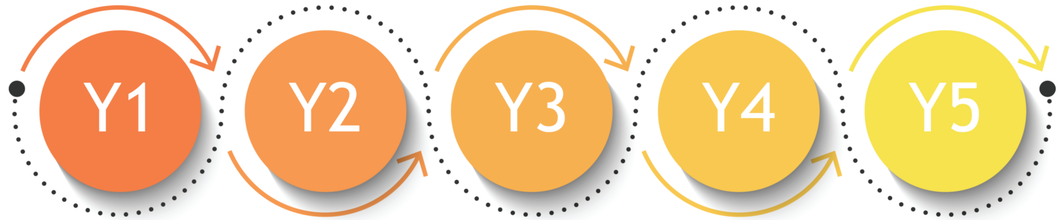
(Han et al., 2017)

Relation between earthquakes, slow slip events, and tremor



(Hyndman et al., 2015)

DET Timeline



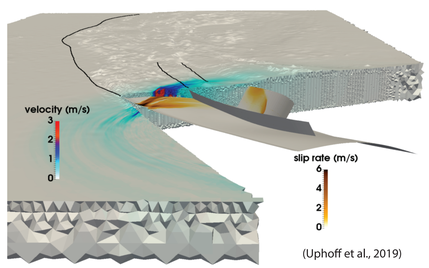
YEAR 1
- Dynamic rupture simulations of megathrust earthquakes with tsunami generation
- Earthquake cycle simulations accounting for fluid production and transport, slow slip events, and megathrust earthquakes
- Website for community code verification activties
- Dynamic rupture benchmark problems (2D and 3D megathrust earthquakes)

YEAR 2
- Extension of dynamic rupture simulations to account for splay faults and off-fault yielding, using preliminary CFM and CVM
- Continued development of earthquake cycle simulations, focusing on slow slip events (fast boundary element code for elastic half-space)
- Earthquake cycle benchmark problems (2D and 3D, elastic)

YEAR 3
- Development of 3D earthquake cycle code using finite elements to handle heterogeneous elastic properties and material nonlinearity
- Tsunami modeling from dynamic rupture simulations and validation against paleoseismic data
- Earthquake cycle benchmark problems (2D and 3D, focusing on slow slip events)

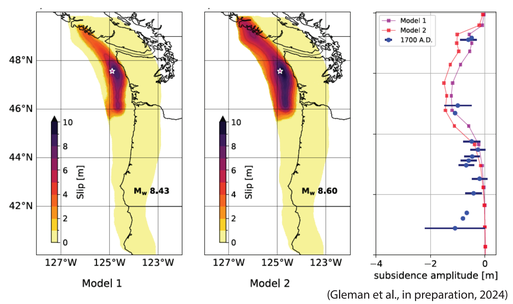
YEAR 4
- Extension of 3D earthquake cycle code to account for viscoelasticity, integrating CFM and CVM
- Framework for self-consistent earthquake and tsunami hazard modeling
- Earthquake cycle benchmark problems (2D and 3D, adding viscoelasticity and/or fluid transport)

YEAR 5
- Extension of 3D earthquake cycle code to account for fluid transport, fully integrating CFM and CVM
- Hazard assessment using self-consistent earthquake and tsunami models
- Earthquake cycle benchmark problems (2D and 3D, adding viscoelasticity and/or fluid transport)



(Uphoff et al., 2019)

Dynamic rupture simulation of a subduction zone megathrust rupture, including activation of seaward and landward verging splay faults. Colors show slip rate on the faults and particle velocity (shaking) in the solid.



(Gleman et al., in preparation, 2024)

Dynamic rupture simulations for Cascadia, exploring different scenarios and comparing with coastal subsidence measurements from the 1700 event (right).

The software and workflows that are used to produce these models are freely available for use by the community. In addition, DET organizes community code verification efforts by designing benchmark problems for dynamic rupture and earthquake cycle models, supported by a new web visualization platform to facilitate comparison of different modeling results.

DET Community Products

Dynamic rupture models of megathrust earthquakes that couple solid Earth deformation to the ocean to generate tsunamis in a self-consistent manner. The models incorporate structural constraints from the CVM and CFM; they are validated and calibrated using paleoseismic observations from CPAL and coupling constraints from C3S. These models are primarily focused on determining the rupture process, low frequency (<1 Hz) ground motion, and tsunami generation. The extension to tsunami propagation and inundation requires coupling with nonlinear tsunami models. The Ground Motion SIG has a complementary focus on higher frequency ground motion through kinematic source modeling. Tsunami propagation and inundation modeling, as well as high frequency ground motion modeling, are of interest but require additional funding beyond the core CRESCENT grant from NSF.

Earthquake cycle models that encompass thousands of years of earthquakes, aseismic slip, slow slip events, and distributed ductile deformation at depth that occur naturally in response to slow tectonic loading. The models also account for fluid production by metamorphic dehydration reactions and the ascent of those fluids, which determines the pore fluid pressure, fault frictional strength, and fault slip dynamics. These models provide constraints on stress conditions that affect single-event rupture dynamics and ensure self-consistency with a broader set of observables that includes slow slip.

Topical and training workshops: fluids and faulting (YR2), shallow rupture (YR3), slow slip (YR4), model validation with paleoseismic data (YR5), and training for DET modeling software (YR5)

Contact us:

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