# Crustal Deformation Modeling Tutorial

## PyLith: Modeling Afterslip with Friction

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# Kinematic Earthquake Rupture

## Slip time history is prescribed on fault surface

- Slip during seismic cycle
  - Coseismic slip from rupture model (scenario or inversion)
  - Postseismic slip (scenario or inversion)
  - Interseismic slip (locked or aseismic creep)
- May not be consistent with physical mechanisms driving slip

# Spontaneous Earthquake Rupture

## Fault constitutive model controls slip time history

- Slip during seismic cycle
  - Coseismic slip from spontaneous rupture
  - Postseismic slip due to stress perturbations
  - Interseismic slip associated with creep
- Consistent with physical mechanism driving slip but parameters may not be well constrained
- Highly nonlinear process– difficult to relate observations to parameters

# Earthquake Cycle Modeling

## Self-consistent simulation of multiple phases of the seismic cycle

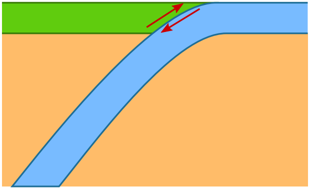
- Kinematic rupture models
  - Constrain sum of earthquake rupture, afterslip, and creep to match long-term slip rate
  - Usually impose repeated earthquake rupture based on recurrence interval
- Spontaneous rupture models
  - Drive system via far-field deformation or backslip
  - Earthquake rupture, afterslip, and creep evolve due to fault constitutive behavior
- Kinematic + Spontaneous rupture models
  - Prescribe slip for one phase of earthquake cycle (e.g., coseismic slip)
  - Slip evolves for rest of cycle based on fault constitutive model

# Step04: Stress Driven Afterslip

## Stress changes from coseismic slip in Step01 drive afterslip

Files are in src/pylith/examples/2d/subduction

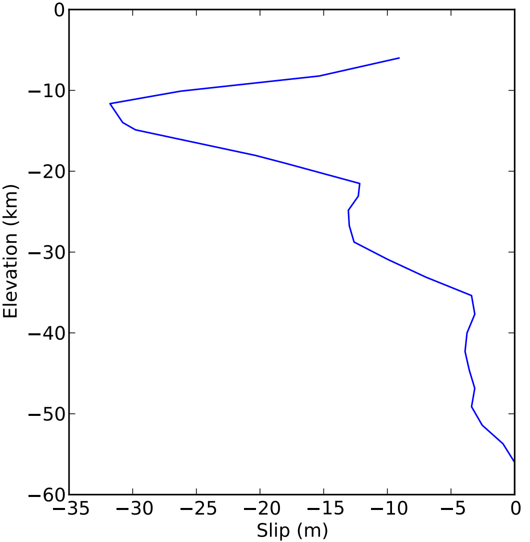
1. Step01: Compute stress changes from coseismic slip



2. Pre/Post-Processing
   - Generate background stress field
   - Add stress changes to background stress field
3. Step04: Compute afterslip using static friction based upon stress changes

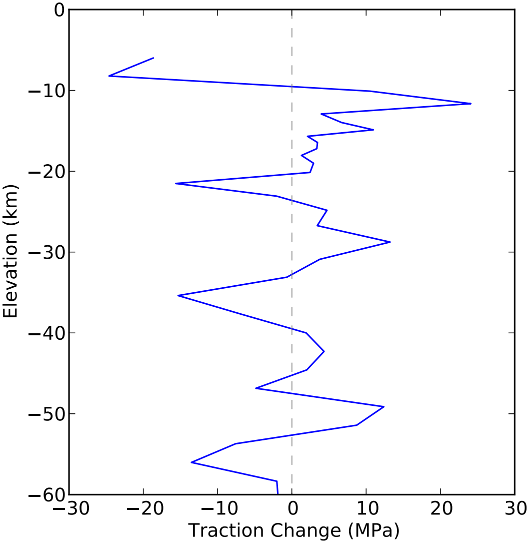
# Step01: Coseismic Slip

## Slip distribution based on inversion by Gavin Hayes (USGS), Reverse slip $< 0$



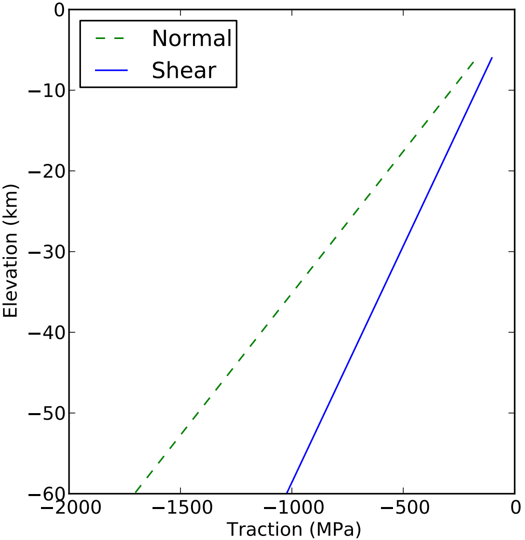
# Step01: Stress Changes

Output includes change in fault tractions associated with slip, Reverse slip $< 0$



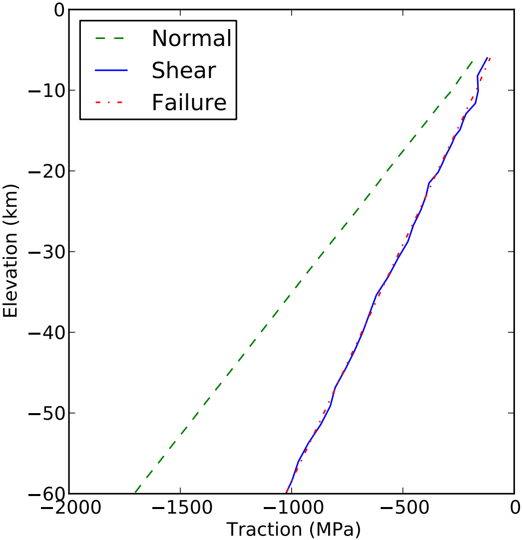
# Step04: Background Stress Field

Assume simple depth-dependent stress field, Reverse slip $< 0$



# Step04: Combined Stress Field

## Add stress perturbations from Step01 to background stress field, Reverse slip < 0



# Run Simulation: `Step04`

- Same mesh as in steps 1–3
- Parameter files
  - `pylithapp.cfg`
  - `step04.cfg`

    `pylith step04.cfg`
- Visualization with ParaView
- Extensions: Modify coseismic distribution to create more afterslip