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
Step 04: 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

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**Graph Details**
- **Axes:**
  - **Traction (MPa):** -2000 to 0
  - **Elevation (km):** -60 to 0

**Lines:***
- Green dashed line: Normal
- Blue line: Shear
- Red dotted line: Failure

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**Example Simulations**
Setup
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