Crustal Deformation Modeling Tutorial

Prescribed Fault Slip

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3-D Subduction Zone: Steps 1–4

Dirichlet boundary conditions and prescribed slip

Step 1 Axial compression (discussed in manual)

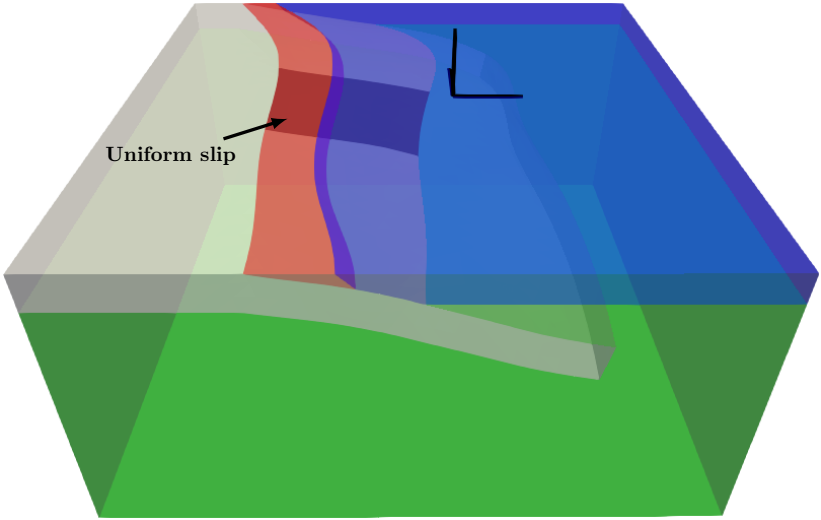
Step 2 Viscoelastic relaxation from coseismic slip on central fault patch

Step 3 Interseismic deformation with prescribed creep & viscoelastic materials

Step 4 Earthquake cycle with prescribed creep and earthquake ruptures

Step 2: Uniform Slip on Central Patch

Viscoelastic response to coseismic slip on subduction interface



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  - $\Rightarrow$ Five: east, west, north, south, bottom

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- **Which materials should we make viscoelastic?**
  - $\Rightarrow$ Linear Maxwell model w/depth dependent viscosity: mantle, slab
  - $\Rightarrow$ Elastic model: crust, wedge

Step 2: Prescribed Slip on Subduction Interface Patch

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  - $\Rightarrow$ Step slip-time function
  - $\Rightarrow$ Impose slip at 10 years

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  - $\Rightarrow$ 10 year (0.05–0.1 of the shortest Maxwell time)

Step 2: Tour of Input Files

Mesh is georeferenced, so georeference our parameters as well

`pylithapp.cfg` Parameters (mostly) common to Steps 1–8

`step02.cfg` Parameters specific to Step 2

`mat_viscoelastic.cfg` Material settings

`solver_fieldsplit.cfg` Solver settings

`spatialdb/mat_viscosity.spatialdb` Viscosity spatial database

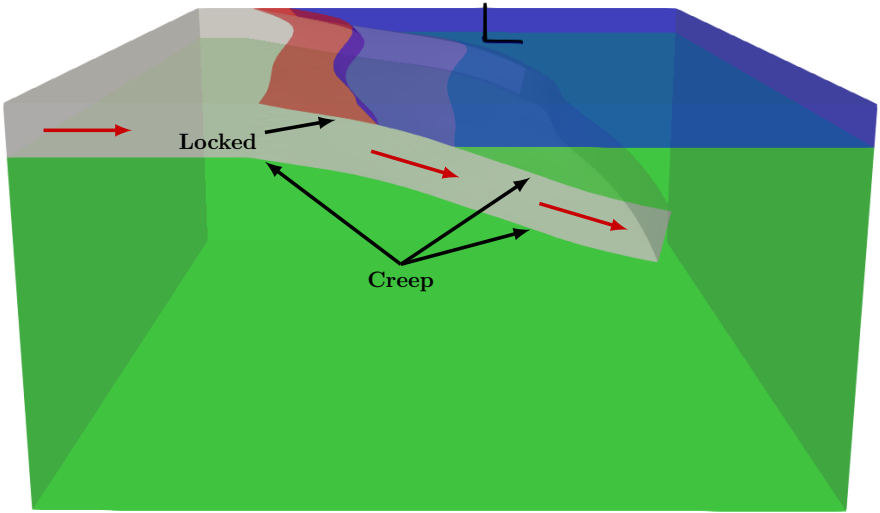
`spatialdb/fault_slabtop_coseismic.spatialdb` Fault slip spatial database

Note: See the `step02.cfg` file for a list of all `.cfg` files used in this simulation.

Run the simulation:

```
pylith step02.cfg mat_viscoelastic.cfg solver_fieldsplit.cfg
```

Step 3: Interseismic Deformation



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Same as Step 2.

- Linear Maxwell model w/depth dependent viscosity: mantle, slab
- Elastic model: crust, wedge

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  - $\Rightarrow$ Constant slip rate slip-time function

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- **What sense of slip do we impose on the faults?**

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- **What sense of slip do we impose on the faults?**
  - $\Rightarrow$ Subduction interface: reverse w/right-lateral

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  - $\Rightarrow$ Two: Top and bottom of the slab
- **What type of slip time function should we use?**
  - $\Rightarrow$ Constant slip rate slip-time function
- **What sense of slip do we impose on the faults?**
  - $\Rightarrow$ Subduction interface: reverse w/right-lateral
  - $\Rightarrow$ Subduction interface: normal w/left-lateral

Step 3: Tour of Input Files

`step03.cfg` Parameters specific to Step 3

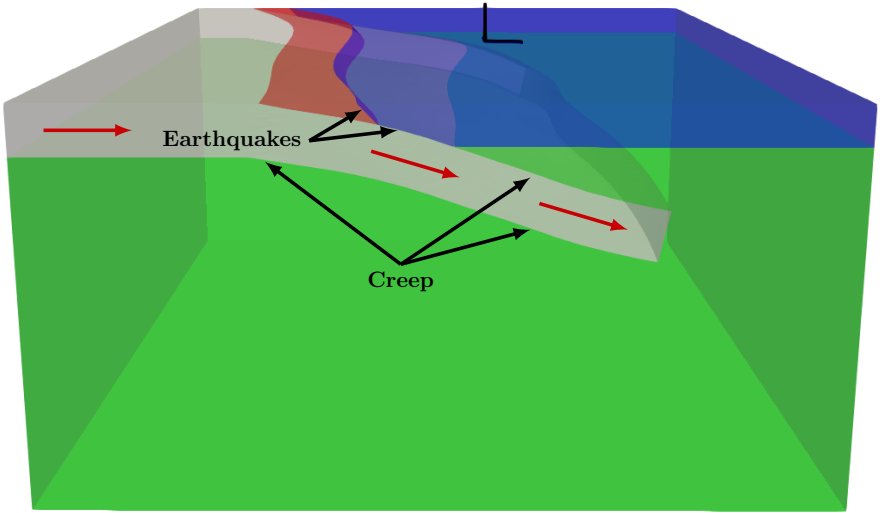
`spatialdb/fault_slabtop_creep.cfg` Fault slip spatial database

Note: See the `step03.cfg` file for a list of all `.cfg` files used in this simulation.

Run the simulation:

```
pylith step03.cfg mat_viscoelastic.cfg solver_fieldsplit.cfg
```

Step 4: Earthquake Cycle w/Prescribed Earthquakes



Step 4: Boundary Conditions and Materials

Same as Step 3.

Step 4: Earthquake Cycle

- Creep on deep portion of subduction interface
- Creep on bottom of slab
- Earthquake at 100 years and 200 years on subduction interface
- Earthquake at 150 years on splay fault

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- **How many faults do we need?**
  - $\Rightarrow$ Three: Top and bottom of the slab plus splay fault
- **How many earthquake sources do we need?**

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  - Splay fault? $\Rightarrow$ 1
  - Bottom of slab? $\Rightarrow$ 1
  - Top of slab?

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  - $\Rightarrow$ Three: Top and bottom of the slab plus splay fault
- **How many earthquake sources do we need?**
  - Splay fault? $\Rightarrow$ 1
  - Bottom of slab? $\Rightarrow$ 1
  - Top of slab? $\Rightarrow$ 3

Step 4: Tour of Input Files

`step04.cfg` Parameters specific to Step 4

`spatialdb/fault_slabtop_creep.cfg` Fault slip spatial database

Note: See the `step04.cfg` file for a list of all `.cfg` files used in this simulation.

Run the simulation:

```
pylith step04.cfg mat_viscoelastic.cfg solver_fieldsplit.cfg
```

Group Exercise

Work in groups of 3–4 to complete some of the exercises listed in the manual.

- Easy
  - Adjust values for material properties and faults
  - Change the slip in Step 2 to the splay fault
- Intermediate
  - Step 2: Create simultaneous rupture on the subduction interface rupture patch and the splay fault rupture patch.
  - Prescribe coseismic slip on the central patch for splay fault and the subduction interface below the intersection with the splay fault.
  - Add additional earthquakes with different amplitudes and depth variations in slip, keeping the total equal to the overall slip rate.
- Advanced
  - Make the splay fault and the deeper portion of the subduction interface form the through-going fault and the upper portion of the subduction interface is the secondary fault.