PyLith Modeling Tutorial
Using Gravity and Stresses

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June 18, 2016

Concepts Covered in this Session

- When are gravitational stresses necessary?
- Usage of gravitational body forces in 2D
- Usage of initial stresses and state variables
- Usage of small strain formulation in 2D
- Viscoelastic relaxation with a linear Maxwell model
- Spatial database with irregular distribution of points in 2D
- Turning off elastic prestep for a postseismic simulation

NOTE: Accuracy and convergence for gravitational problems will be much improved once PyLith includes higher-order elements.

# When Do We Need to Use Gravitational Stresses?

- Pressure/stress-dependent rheology
  - Pressure-dependent bulk rheology (e.g., plasticity)
  - Stress-dependent fault rheology (e.g., friction)
- Viscoelastic simulations where we care about vertical deformation
- Other simulations where we care about the absolute stress state

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Gravity Examples

- 2-D examples: `examples/2d/gravity`
  - Steps 1-3: Body forces, initial stresses, infinitesimal strain
    - Step 1: Body forces + infinitesimal strain
    - Step 2: Body forces + infinitesimal strain + initial stress
    - Step 3: Step 2 + local density variation
  - Steps 4-7: Body forces, initial stresses, finite/infinitesimal strain with postseismic relaxation
    - Step 4: Relaxation with infinitesimal strain and no gravity
    - Step 5: Relaxation with finite strain and no gravity
    - Step 6: Relaxation with infinitesimal strain and gravity
    - Step 7: Relaxation with finite strain and gravity
  - Step 8: Usage of initial state variables and density variation
- 3-D examples: `examples/3d/hex8/step15-17`

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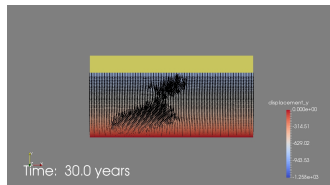INFRASTRUCTURE
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2D Gravity Simulations
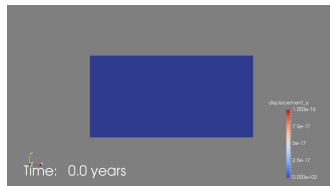Elastic layer over Maxwell viscoelastic layer
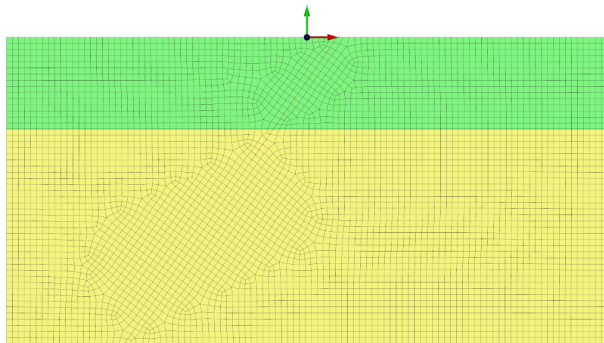
Steps 1-2 in Gravity Example
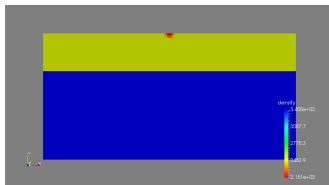Infinitesimal strain with and without initial stress

Step01: Infinitesimal strain
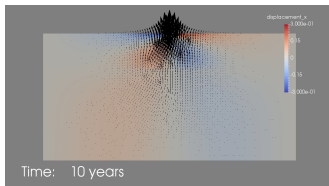

Step02: Infinitesimal strain + initial stress

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Step 3 in Gravity Example
Infinitesimal strain, initial stress, variable density

Density variation

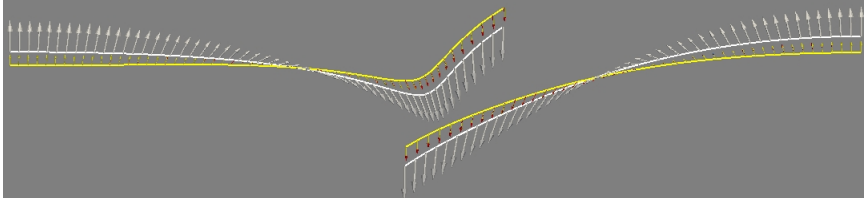Displacements

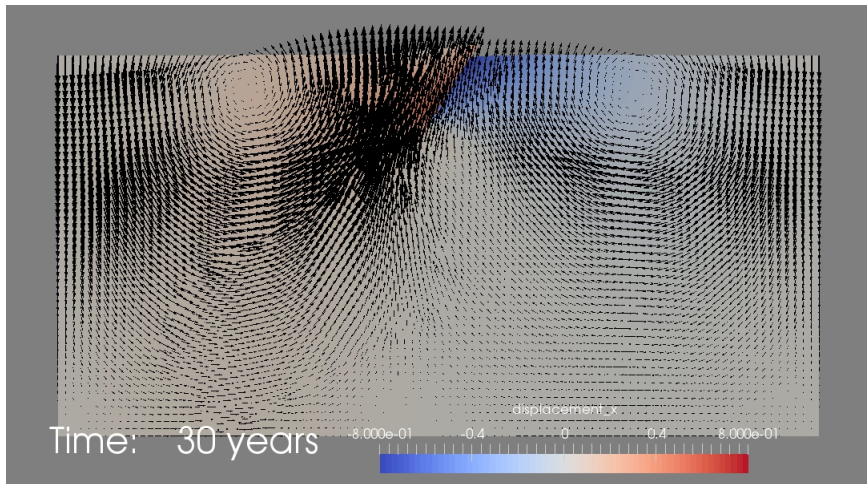# Postseismic Relaxation Problem Description

Thrust fault plus postseismic relaxation
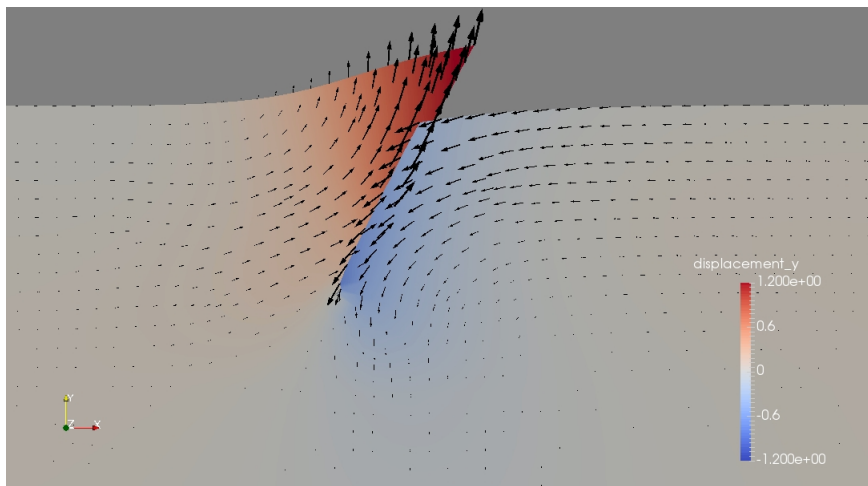
Finite strain with gravity
Finite strain without gravity
Infinitesimal strain with gravity
Infinitesimal strain without gravity

Time: 3990 years

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Time: 30 years

displacement_x

-8.000e-01   -0.4   0   0.4   8.000e-01

Spatial Databases

- `matprops_unidensity.spatialdb` Material properties for all simulations except step03 and step08
- `matprops_vardensity.spatialdb` Material properties for simulations step03 and step08
- `eqslip.spatialdb` Fault slip for all postseismic simulations (step04-step08)
- `gravity_isostatic.spatialdb` Isotropic stresses for all simulations using initial stresses (step02-step03, step06-step08)
- `grav_statevars-xx.spatialdb` State variables generated by Python script for step08

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Configuration Files
Settings shared between simulations

- pylithapp.cfg Base settings for all simulations
- postseismic.cfg Settings for all postseismic simulations (step04-step08)
- gravity_initstress.cfg Settings for all simulations using initial stresses (step02-step03, step06-step08)
- nogravity.cfg Settings for all simulations without gravity (step04-step05)

All other .cfg files are for a specific simulation

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