# PyLith Modeling Tutorial

## Using Gravity and Initial Stresses

Charles Williams
Brad Aagaard
Matthew Knepley


June 18, 2016

# Concepts Covered in this Session

- When are gravitational stresses necessary?
- Usage of gravitational body forces in 3D
- Usage of initial stresses
- Usage of small strain formulation in 3D
- Viscoelastic relaxation with a linear Maxwell model
- Spatial database with irregular distribution of points in 3D

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

# Other 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`

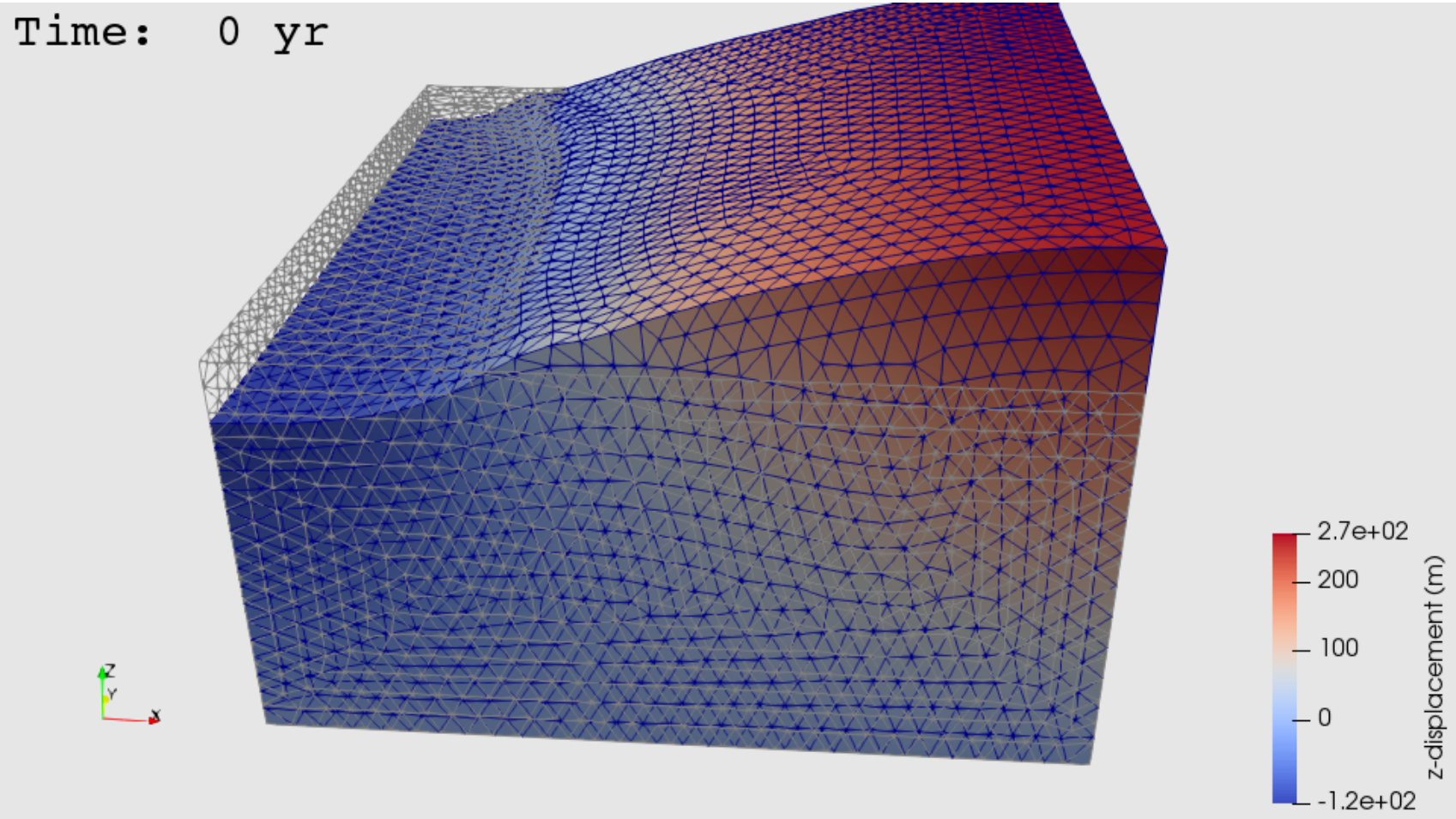
# Cascadia Gravity Simulations

Files are in `examples/3d/subduction` None of these problems involve faulting.

1. `step08a` Use gravitational body forces for an elastic problem and balance them with initial stresses computed for a constant mantle density.
   - Stresses are out of balance and there is significant deformation.
2. `step08b` Use gravitational body forces for an elastic problem and balance them with initial stresses from `step08a`.
   - Stresses are in balance and there is no deformation.
3. `step08c` Use gravitational body forces for a viscoelastic problem with finite strain and balance them with the same initial stresses as for `step08b`.
   - Stresses are in balance for the elastic solution but viscous flow in the time-dependent solution results in large deformations.

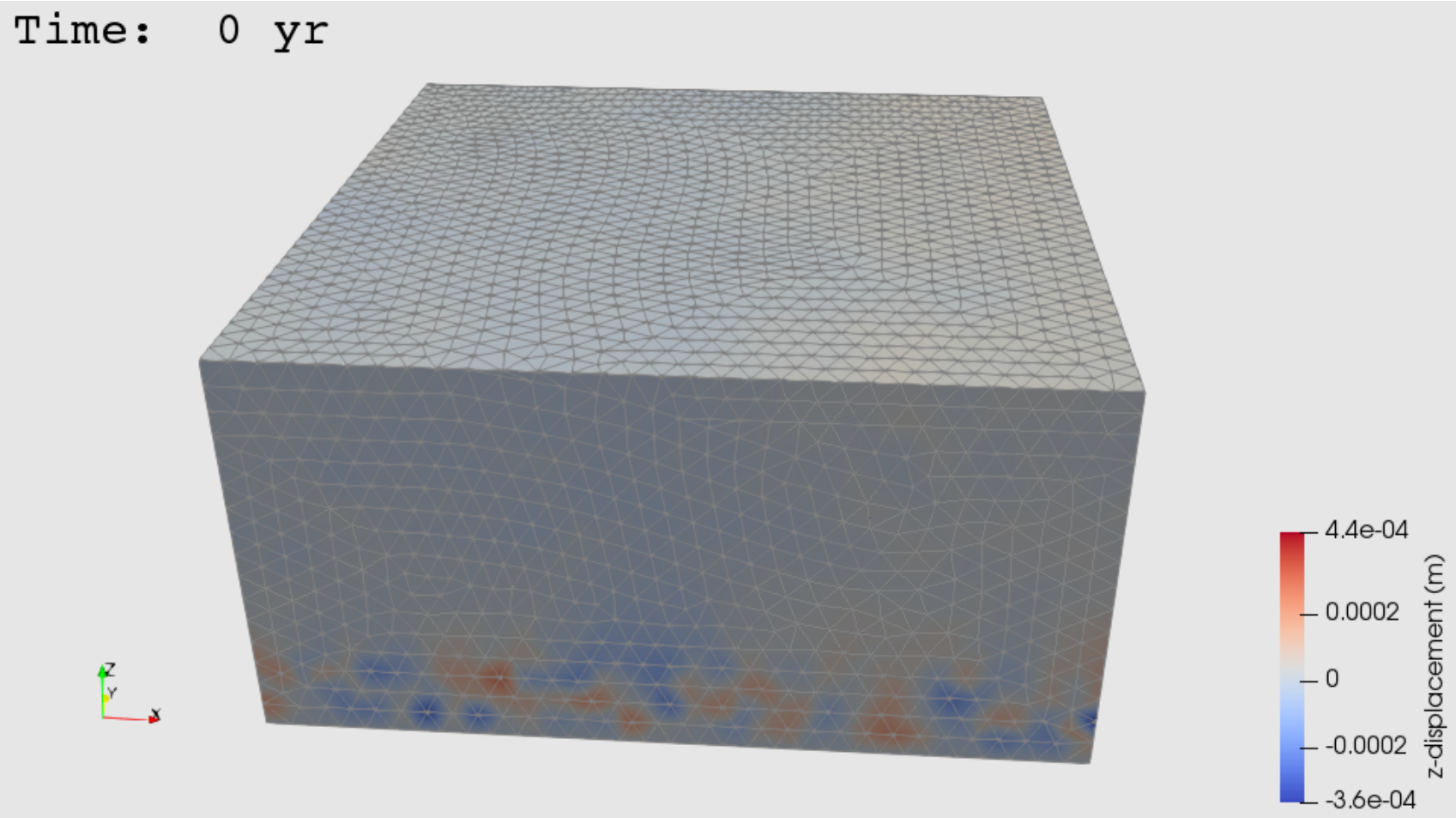
# Step 8a

## Elastic infinitesimal strain with initial stress from mantle density



# Step 8b

## Elastic infinitesimal strain with correct initial stress



# Step 8c

## Viscoelastic finite strain with correct initial elastic stress