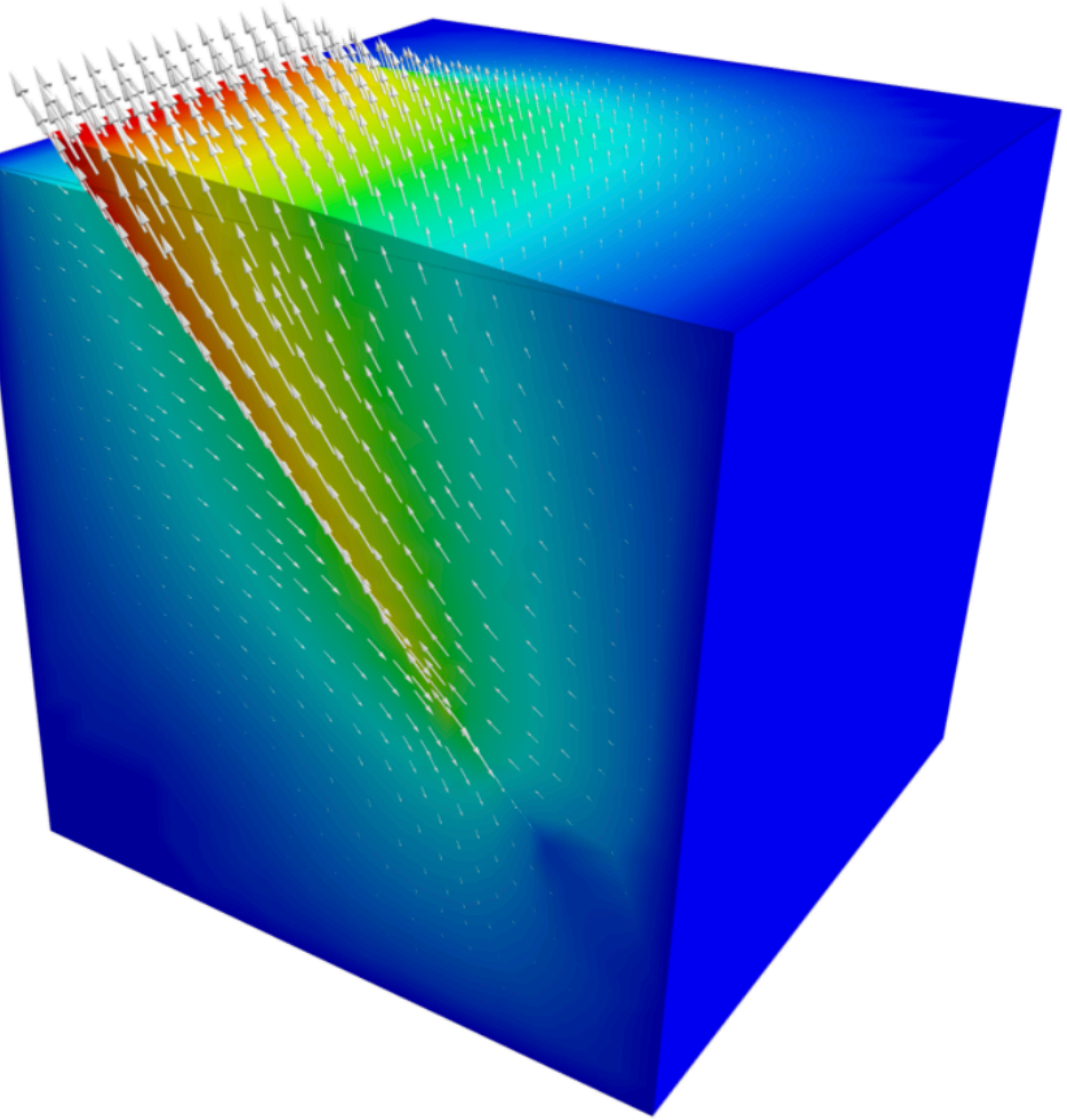
PyLith

PyLith Community Analysis

Ren Stengel, Fall 2021 CSCI 5636



Background

- **PyLith is a finite-element code for dynamic and quasistatic simulations of crustal deformation, primarily earthquakes and volcanoes.**
- **Features:**
  - **Quasi-static (implicit) and dynamic (explicit) time-stepping**
  - Cell types include triangles, quadrilaterals, hexahedra, and tetrahedra
  - Linear elastic, linear and generalized Maxwell viscoelastic, power-law viscoelastic, and Drucker-Prager elastoplastic materials
  - **Infinitesimal and small strain elasticity formulations**
  - **Time-dependent Dirichlet (displacement/velocity) boundary conditions**
  - **Time-dependent Neumann (traction) boundary conditions**
  - Time-dependent point forces
  - Absorbing boundary conditions
  - Gravitational body force
  - VTK and HDF5/Xdmf output of solution, fault information, and state variables
  - **Templates** for adding your own bulk rheologies, fault constitutive models, and interfacing with a custom seismic velocity model.
  - User-friendly computation of static 3-D Green's functions

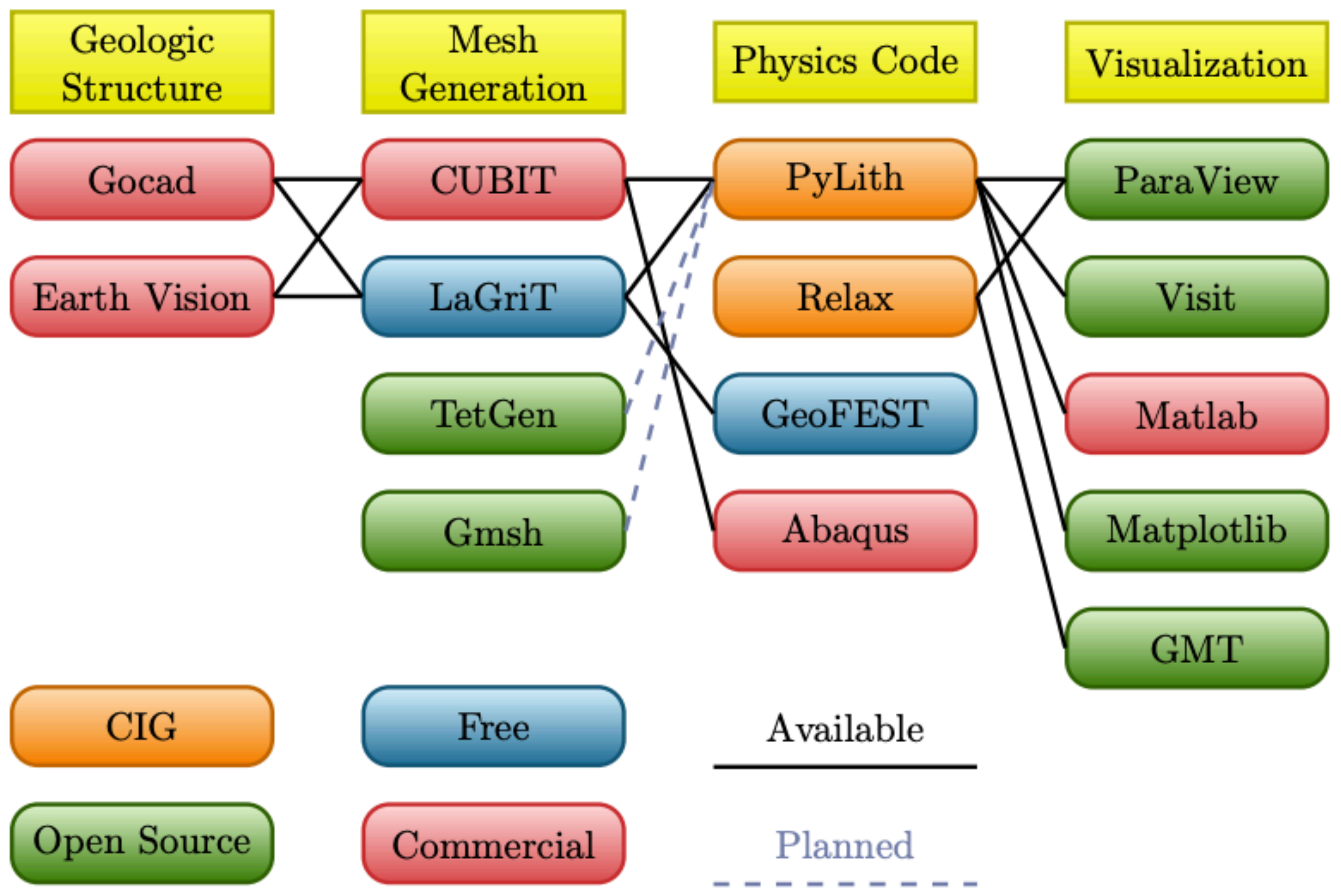


Figure 1.1: Workflow involved in going from geologic structure to problem analysis.

PyLith v2.2.2 User Manual

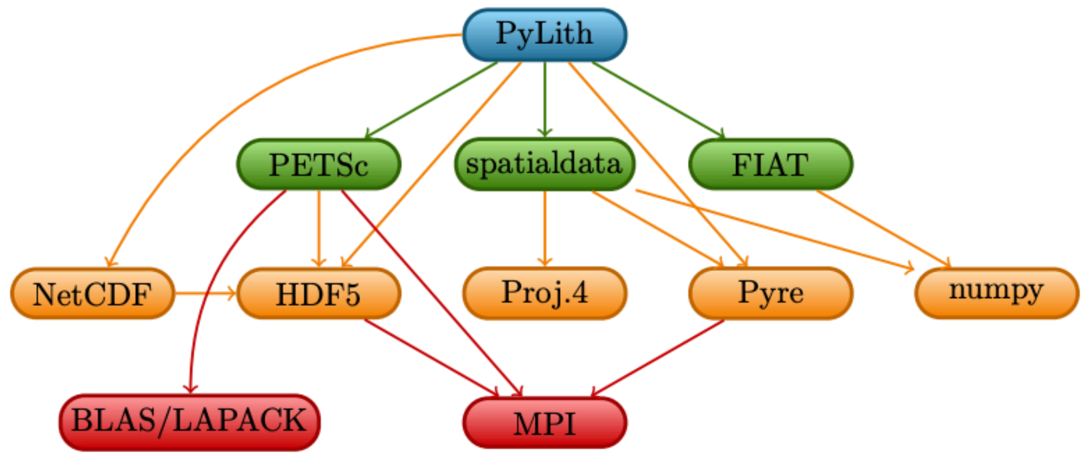
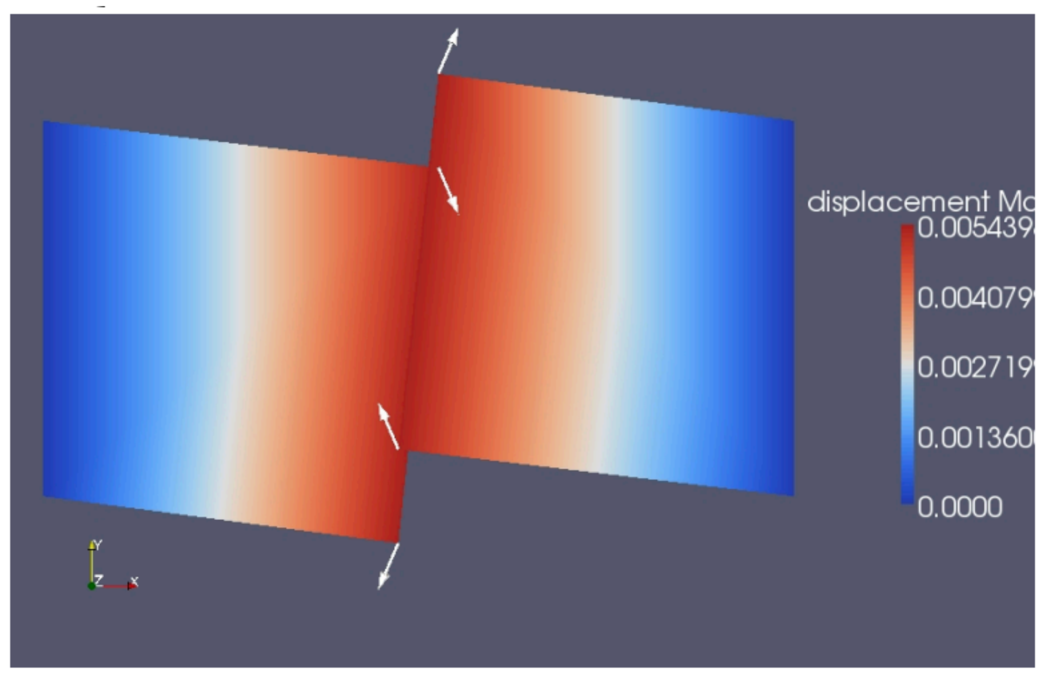
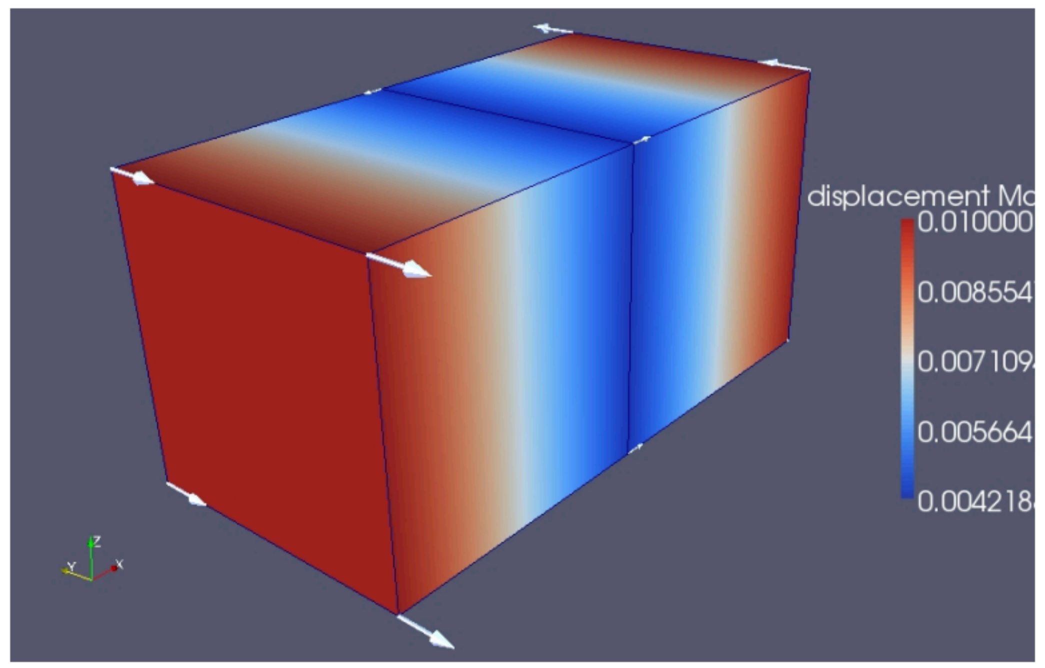


Figure 1.2: PyLith dependencies. PyLith makes direct use of several other packages, some of which have their own dependencies.



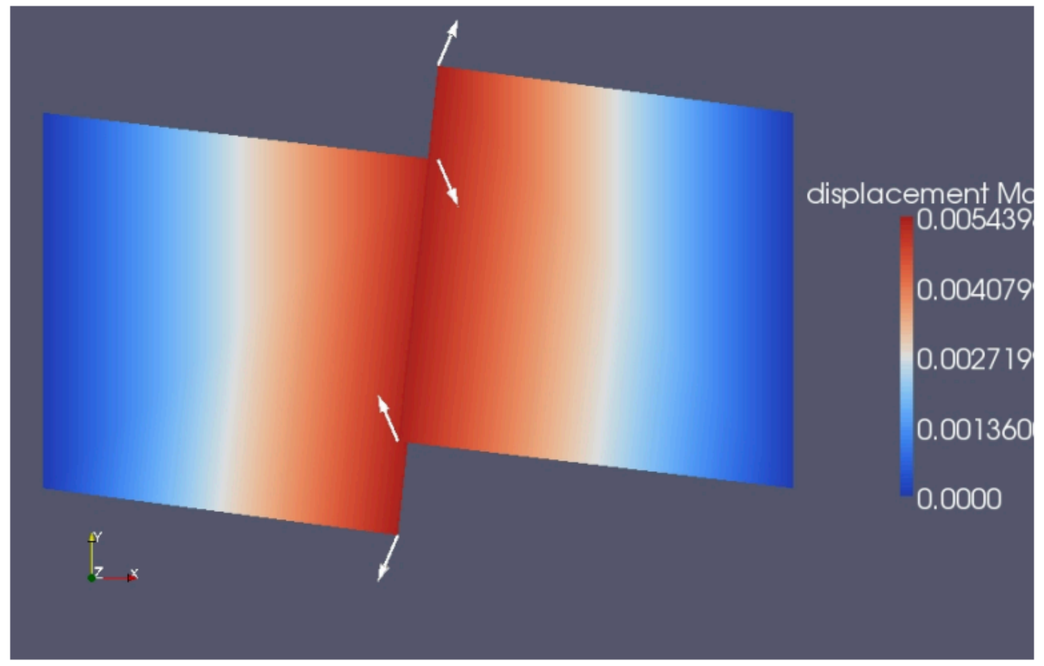
Kinematic Fault Example



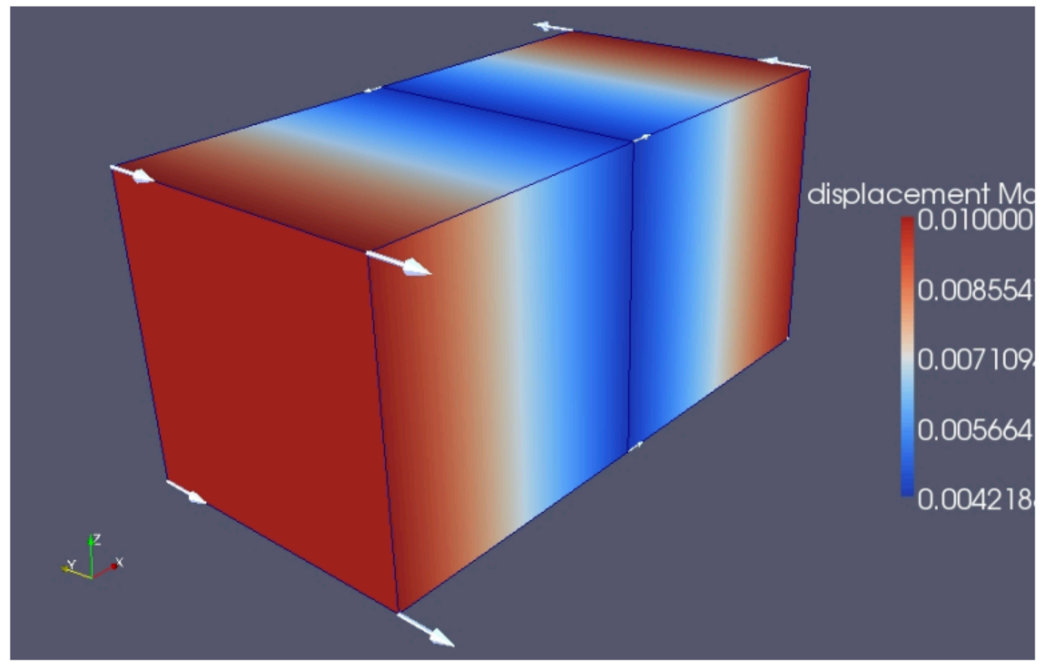
Shear displacement example

Applications

- **Fault interfaces using cohesive cells**
  - Prescribed slip with multiple, potentially overlapping earthquake ruptures and aseismic creep
  - Spontaneous slip with slip-weakening friction and Dieterich rate-and state-friction fault constitutive models
- Various seismic related problems such as subduction zones



Kinematic Fault Example



Shear displacement example

PyLith v2.2.2 User Manual

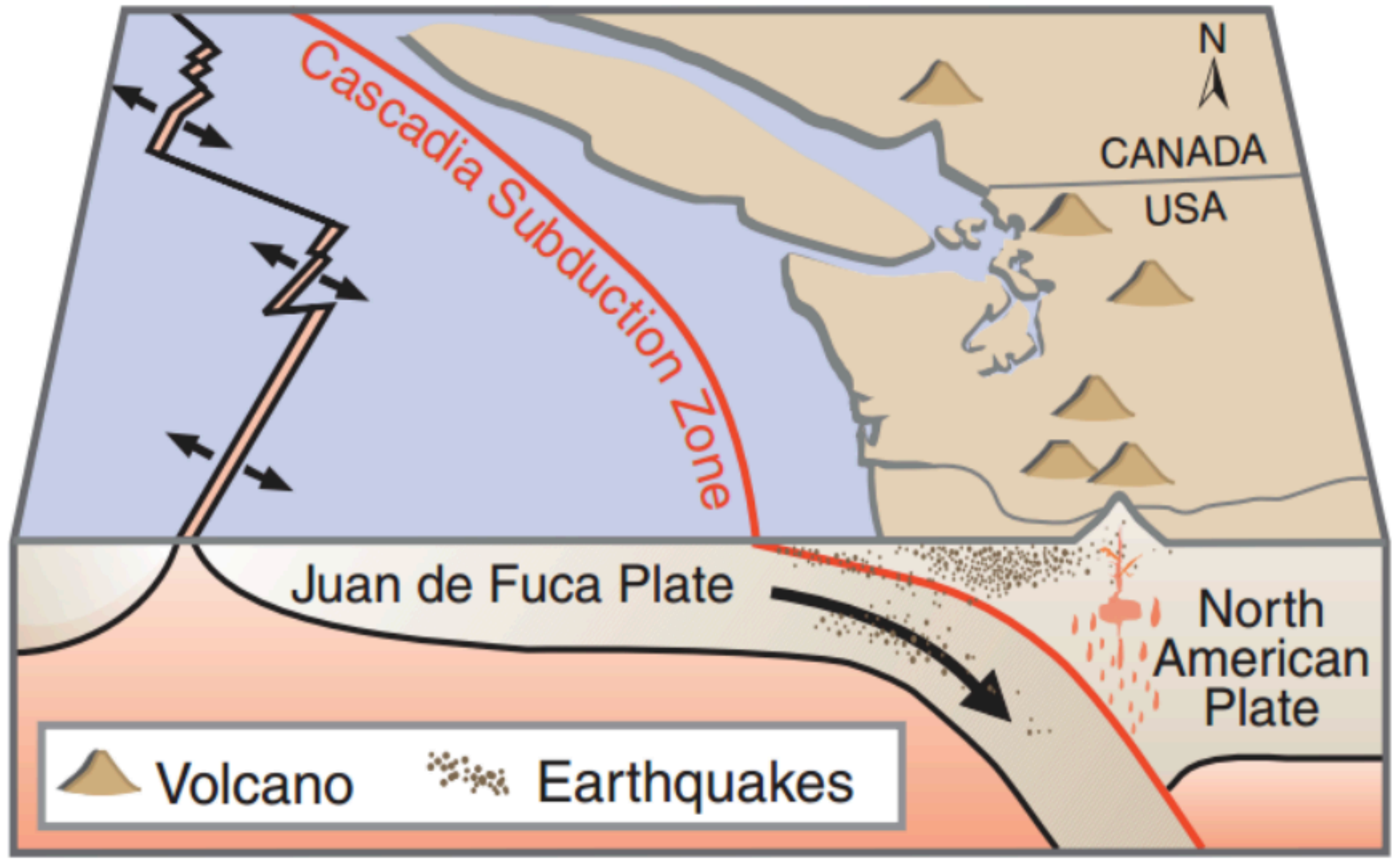


Figure 7.77: Cartoon of the Cascadia Subduction Zone showing the subduction of the Juan de Fuca Plate under the North American Plate. Source: U.S. Geological Survey Fact Sheet 060-00

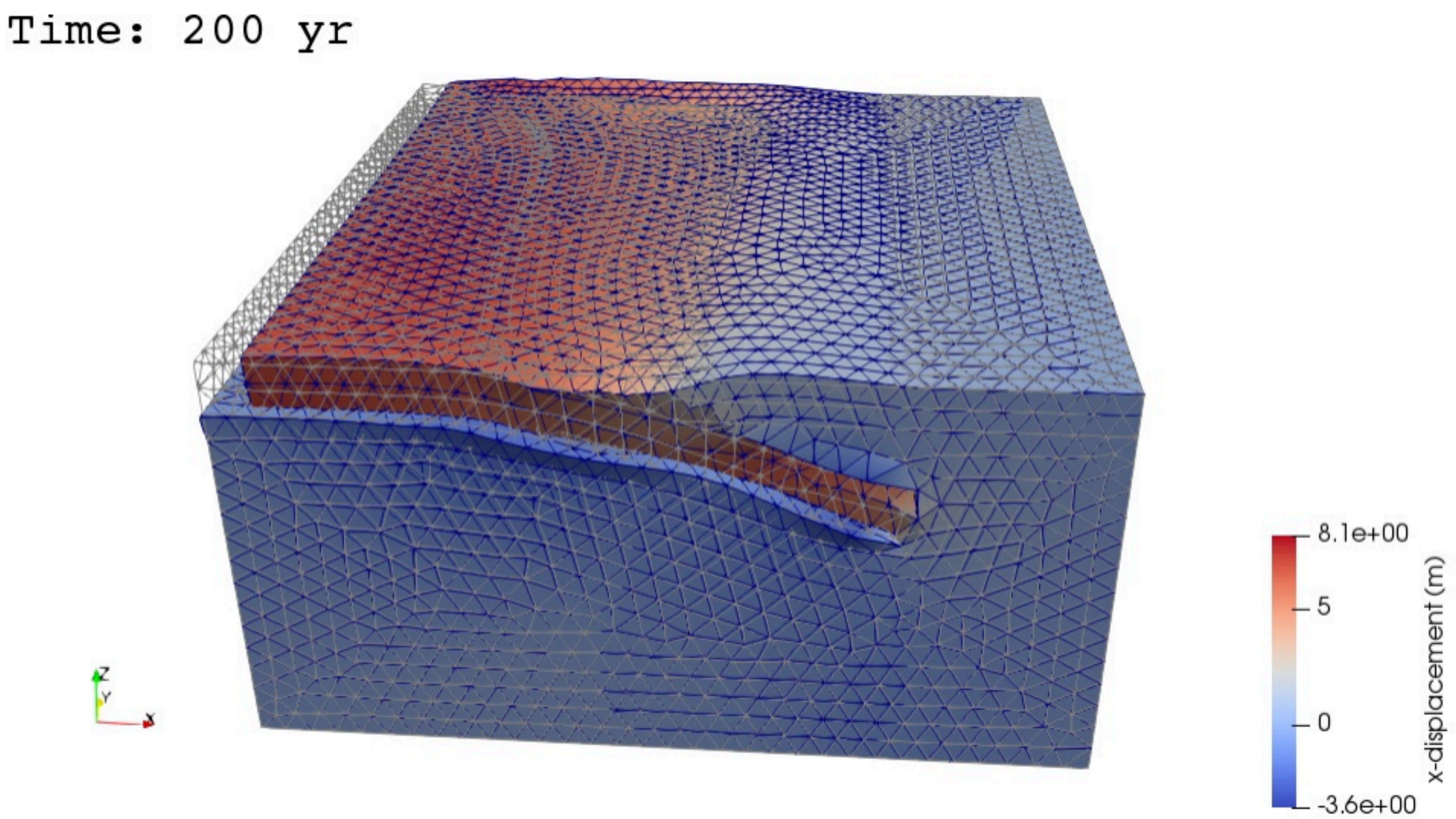


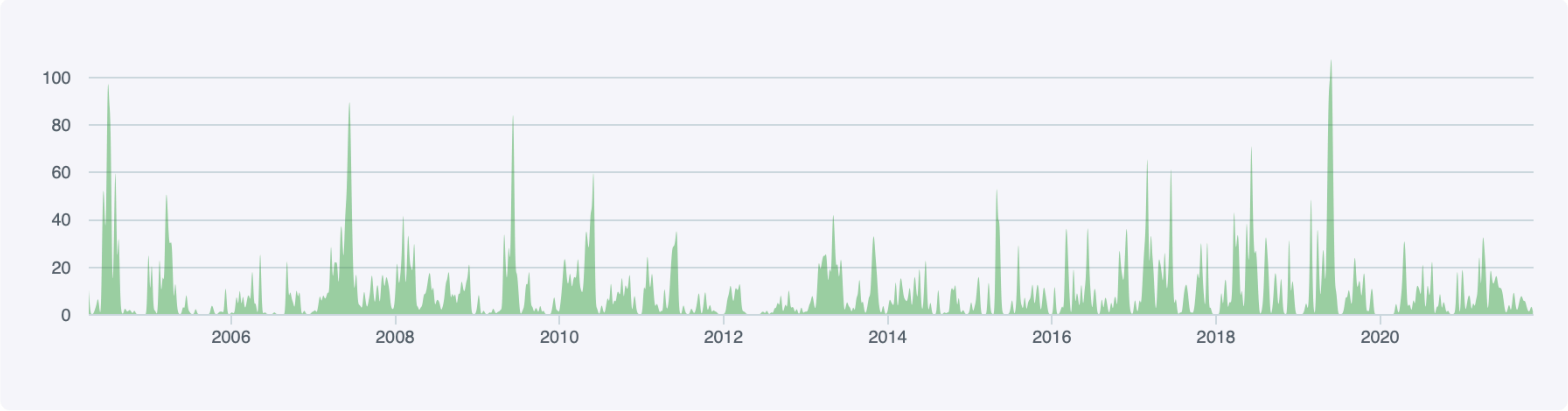
Figure 7.85: Solution over the domain for Step 2 at $t = 200$yr. The colors indicate the x-displacement and we have exaggerated the deformation by a factor of 5,000.

Development Community

Apr 11, 2004 – Nov 17, 2021

Contributions: Commits ▾

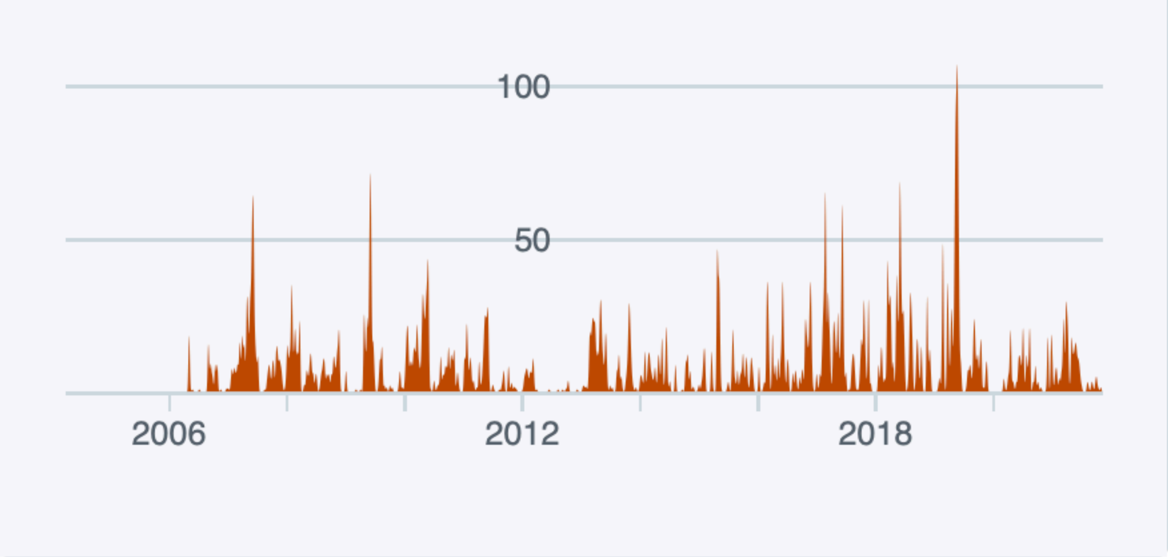
Contributions to main, excluding merge commits and bot accounts



Languages

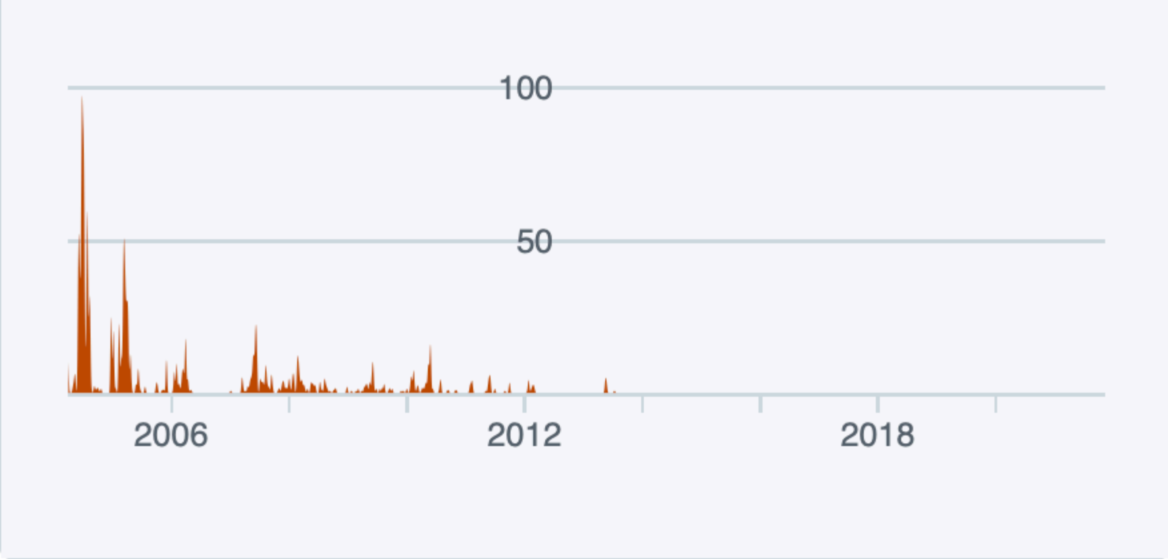
- C++ 80.1%
- Python 16.4%
- C 1.8%
- Makefile 1.1%
- TeX 0.4%
- M4 0.1%
- Other 0.1%

baagaard-usgs #1
6,859 commits 2,702,607 ++ 3,484,377 --



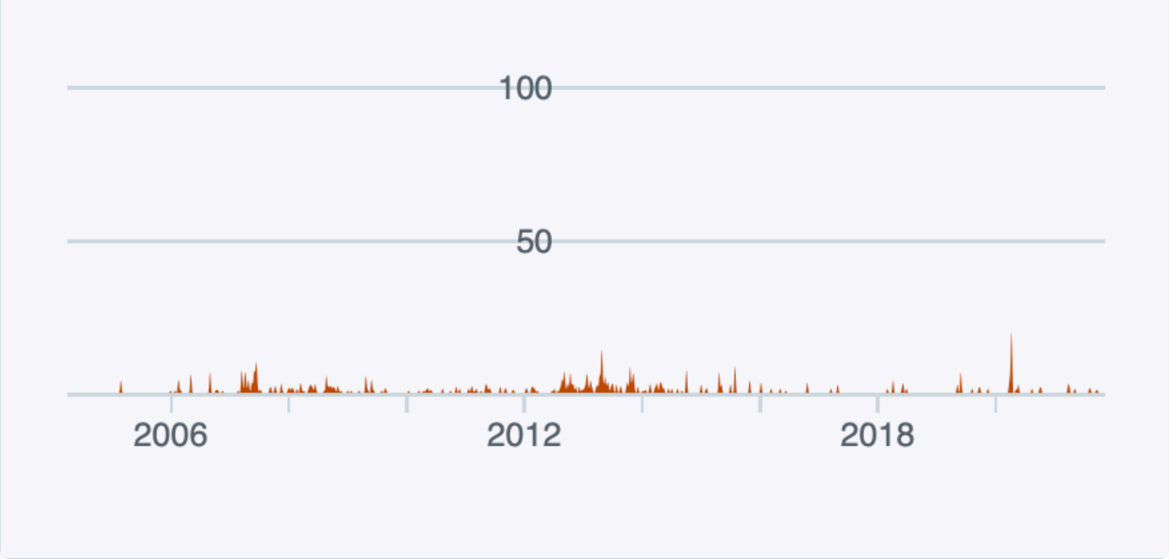
Brad Aagaard @ USGS

willic3 #2
1,583 commits 1,867,916 ++ 704,584 --



Charles Williams @ GNS Science

knepley #3
670 commits 49,009 ++ 37,237 --



Matthew Knepley @ University at Buffalo

+ 5 others

Barriers to community development

PyLith can be challenging to install and develop in

- PyLith users can install via source, binary, Docker, or by the PyLith Installer package
- Installing the development version can be more intensive (especially on Mac)
  - Development can be difficult due to intermingling of languages in the code and addressing bugs
- Varying sets of instructions depending between the forum, user manual, and readthedocs pages

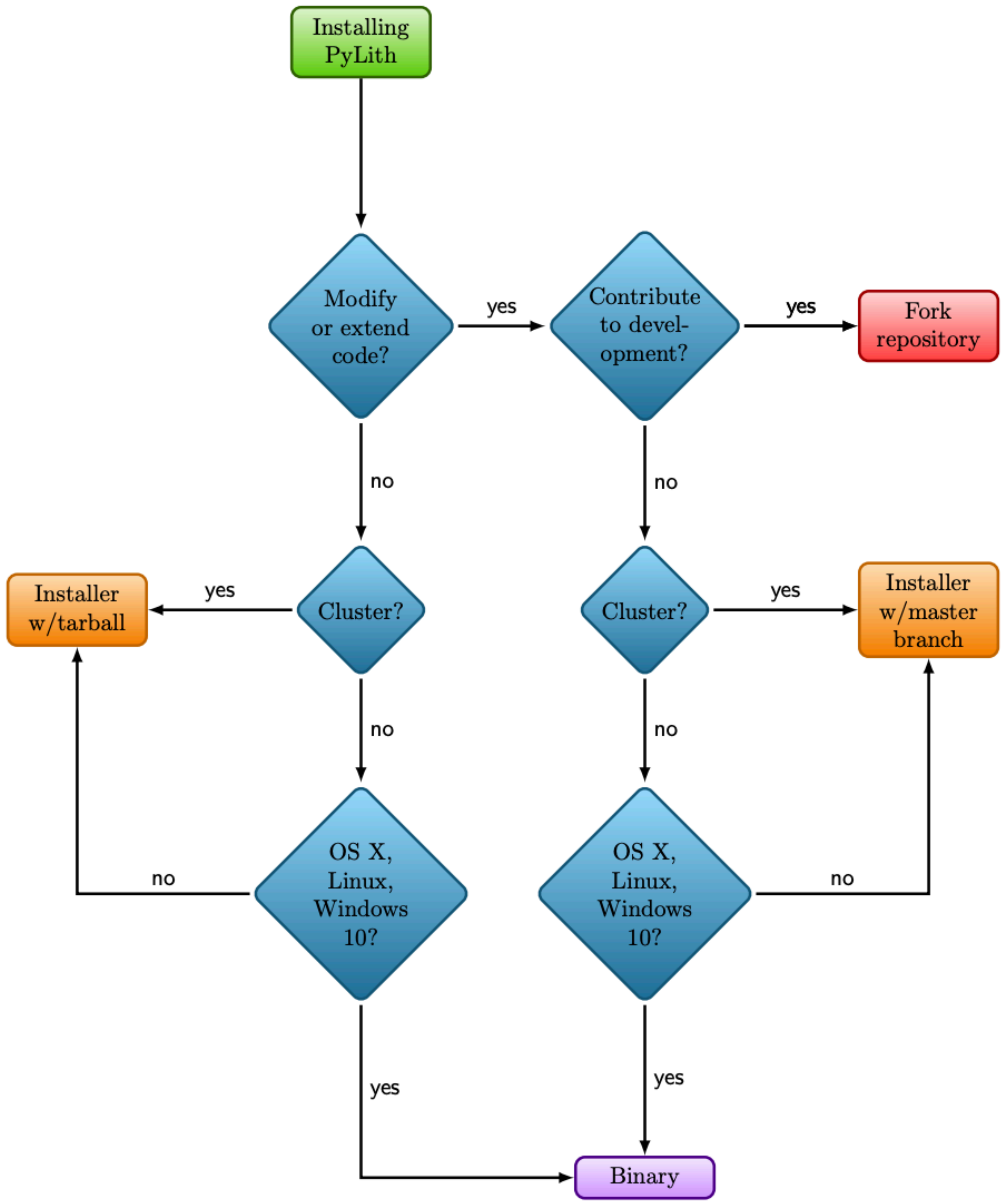


Figure 3.1: Guide for selecting the appropriate installation choice based on a hardware and intended use. The installation options are discussed in more detail in the following sections.

Relevant links and references

- https://community.geodynamics.org/
- https://wiki.geodynamics.org/software:pylith:start
- https://geodynamics.org/cig/software/pylith/
- Aagaard, B., Knepley, M., Williams C., (2017) PyLith v2.2.1, Computational Infrastructure for Geodynamics, doi: 10.5281/zenodo.886600, url: https://geodynamics.org.cig/software/pylith
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