Workshop

2. Christine Ruhl: **Is the workshop next week going to pick up where the 2011 one left off?**
* Brad Aagaard: Yes and no. There will be some overlap, but we hope to go deeper into various topics.

72. David Zuliani: **As I can understand every meeting session is recorded. Is there a way to get the recordings (.mov,.mpeg,...)?**
* Brad Aagaard: All sessions are being recorded (although we missed the first half of Schedule A, Session I). Links to the streaming versions are posted very soon after the completion of each session. After the workshop we will create QuickTime versions that break them up into smaller chunks. In each session there are also links to PDF versions of the slides for each session.

103. Da: **How long will you leave the material of the sessions available on the web?**
* Brad Aagaard: The tutorial website will be available for the foreseeable future (hopefully many years). The meeting room will be closed a few hours after the final session. We will extract all information from the meeting room (Q and A log and the streaming movies) and post downloadable versions on the workshop web page.

Meshing

9. achraf koulali: **Is there any converter from GMsh to CUBIT/Pylith format**
* Charles Williams: Not yet. We are still seeing what Gmsh can do. If you have any good examples that use Gmsh we would like to see them.

63. sanjay prajapati: **can we use Gmsh for mesh generation in place of CUBIT**
* Charles Williams: We do not yet have the option of using Gmsh for mesh generation. We are still evaluating its abilities. If you have an example of a mesh and boundary conditions generated by Gmsh we would like to see it.

21. Yang Zhang: **What are the main differences between CUBIT and LAGRIT in terms of serving as the mesh generator for Pylith?** Thanks!
* Brad Aagaard: LaGriT is command line only (no GUI) and is limited to tetrahedral cells. CUBIT has a nice GUI and can do quads and tris in 2-D and tets and hexes in 3D. LaGriT development is relatively limited.

73. David Zuliani: **I've downloaded Trelis for Windows but is there a version for the last Mac OSx (e.g. 10.8) version.**
* Brad Aagaard: I am not sure precisely what platforms are supported by Trelis. CUBIT from Sandia or csimsoft has been available in both 32-bit and 64-bit versions for Linux, 32-bit versions for Mac, and I believe 32-bit and 64-bit versions for Windows. The Mac version runs on most recent releases of OS X, including OS X 10.6, 10.7, and 10.8.

CUBIT/Trelis

1. Christine Ruhl: **In Trelis, how are the @A,@B etc assigned when splitting curves? Do you just have to check on the side what letters are assinged like numbers for the other objects?**
* Brad Aagaard: When a curve or surface is divided, the @A and @B are assigned arbitrarily so one has to use the GUI to identify which piece is @A and which one is @B.

11. achraf koulali: **Do you have an example similar to what you showed but specifying a dip to the fault plane in CUBIT instead of strike-slip ?**
* Charles Williams: We will have both 2D and 3D dipping fault examples. There is also a benchmark problem with a planar dipping fault.

12. achraf koulali: **suppose If I do a mistake connecting the surface, Is there any way to check the topology ?**
* Brad Aagaard: Usually any errors in constructing the surface will be obvious when the surface is displayed. If you use journal files (or Python files), you can go back and fix the vertex, curve, or surface ids or variable names and replay the file. If you just use the GUI, then you would have to redo all of the operations.

13. achraf koulali: **Is there an option to refine the mesh using coordinates file (eg. rectangle) in CUBIT ?**
* Brad Aagaard: Yes, the refine command can be given a volume or a bounding box. See the Savage and Prescott benchmark in the repository (see the manual chapter on benchmarks).

14. achraf koulali: **Is there a MAX number of elements in the mesh for the binaries**
* Charles Williams: Not really, although 32-bit versions will be more limited than other versions. Mesh sizes of a few million elements are OK. You can also use global uniform refinement within PyLith to generate higher resolution meshes. See examples/3d/tet4 step02 and step04.

15. achraf koulali: **Is there an upcomming part for how to set BC for this type of mesh ?achraf koulali: yes, defining nodes for BC**
* Brad Aagaard: One of the nice things about CUBIT is that creating nodesets for complex geometry is the same as creating nodesets for simple geometry. Create a group for the relevant curves or surfaces and then once you have the groups, then you can create a nodeset.

16. achraf koulali: **after the computation we reproject back to geographic coordinates ?**
* Brad Aagaard: PyLith understands geographic projections (using Proj.4) so you can do the meshing and PyLith simulations in a geographic projection. I usually pick a projection and work without throughout the whole process. Sometimes, I do visualize the data in a different projection (for example, with satellite imagery draped on the ground surface).

17. achraf koulali: **how the meshing size can affect the results in the case of problems for inversion of geodetic data for example ?**
* Brad Aagaard: A good approach is to start with a coarse mesh and then increase the resolution and see how your displacements vary.

Once they show convergence, there is no need to refine the mesh further for your forward problem. Another issue is how fine to discretize the fault in setting up the inversion. A resolution test would help you define what resolution would be appropriate. See examples/2d/greensfns for an example that you can try changing the resolution to see how it affects the results of the inversion.

28. Eric Lindsey: **it's strange that the script comands are commented out -- is this the syntax always?**
* Brad Aagaard: Yes the script commands begin with a comment character.

30. Yang Zhang: **Lines like "#{idPtMohoW=Id("vertex")}" in the jou file are regular comments or some sort of commands?**
* Brad Aagaard: Yes, APREPRO commands begin with the comment character.

29. Eric Lindsey: **the syntax is "nodeset ## name" -- is the number chosen arbitrarily as an id, or read from somewhere?**
* Brad Aagaard: The ## given to a nodeset is chosen by the user. We often start BC node sets at 10 and fault node sets at 20 just for convenience.

31. aNTHONY: **it's a bit disturbing to see the curves defining the slab offset from the slab domain. Is this really a bug with cubit?**
* Brad Aagaard: Yes, CUBIT uses a coarse representation of the geometry. This is a feature of CUBIT. Note that the mesh does follow the original geometry.

32. Yang Zhang: **Can you briefly talk about How to expand this 2d model to 3d?**
* Brad Aagaard: Generating the 3-D mesh for a subduction zone is covered in the 3-D part of this session.

33. Erin Todd: **What did you click on to set the working directory?**
* Brad Aagaard: File -> Set Directory.

34. Eric Lindsey: i**s this example included in the pylith distribution we have? I can't find it**
* Brad Aagaard: The 3-D meshing subduction zone example is in src/pylith/examples/meshing/surface_nurbs/subduction.

35. aNTHONY: **Getting following error msg with interface_netsurf.jou. Any idea?**
* Brad Aagaard: Make sure you play the entire journal file, because the curve ids are hardwired in the journal file. Further exploration seems to suggest there could be issues related to Trelis 14. We can play these files fine in CUBIT 14 and the Trelis documentation doesn't indicate any incompatibilities with CUBIT for creating splines or net surfaces. When we have time we will try to investigate running these journal files on our computers using Trelis.
40. aNTHONY: Quentin sent me his working interface_netsurf.jou. It's identical to mine and also crashes in Trelis 14. but he is on mac and I am on linux. Very strange because Trelis gives a different output to a simple list of "create curve spline" commands....
* Brad Aagaard: I don't see any difference in the Trelis syntax from CUBIT for creating splines or net surfaces. Does the 2-D subduction examples in examples/2d/subduction run okay?
44. aNTHONY: 2d/subduction runs okay. But examples/meshing/cubit_meshing/geometry.jou gives me a result with very thin viscoelastic layer compared to the elastic blocks. there is something wrong with my Trelis:-(
* Brad Aagaard: This may be an APREPRO issue (are you running the entire journal file or maybe Trelis change some APREPRO features) or Trelis 14 could have some bugs.

36. Roby Douilly: **what is the command to import exodus file instead?**
* Brad Aagaard: In the 3-D meshing example, we import an ACIS file using the import command. import Acis "topobath_surf.sat"

37. Eric Lindsey: **when you made the surfaces, was it a requirement that they extend beyond the volume? or could they go right to the edge**
* Brad Aagaard: They need to go to the edge within the internal tolerances used by CUBIT, so we almost always extend the surfaces at least a little bit beyond the edges of the domain. Many times you may end up extending your domain a few km in some direction and extending the surface several km beyond the edges means you don't have to recreate your surface.

38. Eric Lindsey: **is the syntax for looping with aprepro included in an example?**
* Brad Aagaard: Yes, the meshing cell size example in cubtit_cellsize/mesh_size_spatialdb.jou.

39. Erin Todd: **In the .jou file you were just in, there was a command that sayd playback bc.jou. Does that play the entire file rather than line by line as has been done here?**
* Brad Aagaard: There are three ways to run commands in a journal file. (1) You can select commands with the left mouse button and then right-click and select "Play selected". (2) You can click on the big green right pointing triangle "Play" icon in the menu bar to play all commands in a journal file. (3) You can run commands in another journal file using the playback command.

We usually put all geometry commands in a geometry.jou file and our meshing commands in a mesh.jou file. This makes it easy to recreate the geometry.

41. Eric Lindsey: **for a simple case like this, would it be easier to use the 'bias' command instead of the material properties to size the mesh?**
* Brad Aagaard: The sizing function from a field is useful when the sizing information is independent of the geometry. It is also useful when the discretization size is not uniform or follow a bias. Using a spatial database for the sizing function is very powerful.

74. Eric Lindsey: **when setting up the bias factor, how do you decide on the amount of bias? is there a good criterion, or just experience?**
* Brad Aagaard: The value for the bias factor comes mostly from experience. A good rigorous test is to reduce it (and your finest discretization size) until you find the simulations give consistent results (solution with respect to discretization size has converged).

For dynamic spontaneous rupture problems in homogeneous half spaces, I have found that a bias of 1.02 is about the maximum that gives good accuracy.

For quasi-static problems, it all depends on the boundary conditions and geometric features. For example, in the 2-D subduction meshing example the quality became marginal near the boundary in the crust due to the discretization size exceeding the thickness of the crust. So you want to avoid the discretization size exceeding the length scale of the geometric entity. A value of around 1.05 for a bias factor used to coarsen away from the fault seems to work reasonably well. We have not done rigorous tests with various bias values, as it is problem dependent.

PyLith

Installation/running

3. Eric Lindsey: **When I run "pylith -- help", I get this error:**
* Brad Aagaard: When you run PyLith without any input files present, the validation of the input fails when no input mesh is specified. We can improve the error message, but the validation step is a feature of Pyre. We will add a short section on how to verify the installation.

4. Eric Lindsey: **the manual seemed to imply that I could run pylith --help without any arguments**
* Brad Aagaard: You can run pylith --help as long as the parameters satisfy the validation step, which occurs before "--help" is processed. No parameters at all doesn't pass the validation step.

5. Eric Lindsey: **I'd prefer if the default behavior wasn't an error, so when I install on different architectures I can verify easily it's working**
* Brad Aagaard: The easiest way to see if PyLith is installed correctly is to run one of the examples. We usually go to examples/3d/hex8 and run step01.cfg and some of the others.

Building PyLith from source

6. Eric Lindsey: **ifort: error #10236: File not found: 'libhdf5_fortran.so.7'**
* Brad Aagaard: See the INSTALL file in the pylith_installer with troubleshooting info for HDF5 and Intel compilers.

* Brad Aagaard: libtool shipped with the HDF5 distribution is bugger for the Intel compiler and requires manually changing some of the settings in order to properly build the HDF5 Fortran library as a shared library.

7. Eric Lindsey: **I wondered if the intel compilers would make things faster**
* Brad Aagaard: Using a better compiler may make things run faster. You can control the level of optimzation if you build from source on your machine.

8. Eric Lindsey: **is that done in the installer? or would I have to set my own optimization flags**
* Brad Aagaard: Add flags to the configure of the installer: CFLAGS="-O3 -NDEBUG" CXXFLAGS="-O3 -NDEBUG" FFLAGS="-O3 -NDEBUG"

PyLith features

19. Estelle: **Are there any cooling/heat transfer laws included in the current pylith or everything will come with v2.2?**
* Brad Aagaard: Currently PyLith only solves the elasticity equation. Additional governing equations will be added in future versions.

20. Carene Larmat: **Do you recommend some textbooks to improve our "physics" intuition?**
* Brad Aagaard: I would start with the PyLith manual. Some other references would be finite-element texts by Hughes (The Finite Element Method) and Zienkiewicz and others. Starting with problems that have simple geometries for which you know the analytical solution is also helpful to build up your intuition.

24. Yang Zhang: **Is there a comprehensive list and/or detailed document of all the user controlled parameters and options in Pylith .cfg file?**
* Brad Aagaard: An appendix in the manual includes a complete list of available components and each section of the manual lists all of the properties and sub-components for each object.

92. Erin Todd: **Where can we find an exhaustive list of the flags and arguements for running .cfg files?**
* Brad Aagaard: You can find a list of all the available components in an appendix of the PyLith manual. The parameters for each of the components are listed and discussed in the other chapters of the manual. You can always see all of the parameters for the current PyLith suite of parameters specified via .cfg files using the pylithinfo script. It dumps all parameters to a file that you can view in a text editor. pylithinfo is discussed in the manual.

42. Yang Zhang: **what is the "spatialdata" package in the python script?**
* Brad Aagaard: Spatial data is a Python and C++ package for specifying variations of parameters for BC, material properties, and fault parameters. It also includes wrappers around the Proj.4 library and nondimensionalization.

43. Yang Zhang: **How to set up a spherical earth model?**
* Brad Aagaard: CUBIT and PyLith use Cartesian or geographic projections, so it does not support spherical coordinates. You must transform into from spherical geometry to Cartesian using several different geographic projections or an Earth-Centered Earth-Fixed coordinate system (see the Proj.4 documentation).
45. Charles Williams: Yang Zhang: the gps stations capture the displacement of 2011 tohoku earthquake 2 thousands away from the epicenter
* Charles Williams: You would probably need to do a spherical earth calculation to see how much deviation in coordinates there is for that distance.

55. achraf koulali: **can we specify a transient ? like this**

* Brad Aagaard: There are a number of different slip time functions available, including a step function, constant slip rate, several analytical functions for earthquake rupture simulations, and a user-specified time history. For slow-slip events, you probably want to use the user-specified time history. The manual discusses each of the slip time histories.

71. Shaoyang LI: **Is it available to make user specified material, for example, Burgers viscoelastic material?**
* Brad Aagaard: We have templates for adding your own custom bulk constitutive models and fault constitutive models. The spatial database package includes a template for adding your own spatial databases, such as an optimized interface to a seismic velocity model. In most cases the SimpleGridDB (which supports efficient access to gridded data in ASCII files) works well for many tomographic models. They are in the templates directory. If you are using the binary, you would need to use the compilers and Python we used when generating the binary. It is easier to build from source to insure you can build extension modules that can be loaded by PyLith.

For Burgers body viscoelastic models, you can choose the parameters of the Generalized Maxwell model (3 linear Maxwell models in parallel with a linear elastic model) to create a Burgers body viscoelastic model.

83. Carene Larmat: **I have a general question. I am not sure what are the best boundary conditions to impose when considering the change of strain induced by a rupture. How to make a decision between fixed and roller?**
* Charles Williams: If you only care about deformation from the rupture, roller BC are OK (constrain direction normal to boundary). If you have far-field BC (e.g., velocities), you will need to constrain additional degrees of freedom.

84. Yang Zhang: **I have a more general question: My advisor keeps warning me that FEM modeling is time consuming and takes a lot efforts, what would you say? With Pylith do we really can save a lot time? With other options available (for example, RELAX), is it worth to try Pylith?**
* Brad Aagaard: Finite-element, finite-volume, and finite-difference modeling can handle more complex BC and spatial variations of physical properties than semi-analytic methods and modeling software like Relax. If these are important for matching the constraints you have, then the additional effort required to setup models is justified. If not, then using codes like Relax are a better option. In quasi-static problems, there aren't many options besides PyLith for open-source, well-documented, parallel codes with similar features. This is why we developed PyLith. For dynamic problems, there are more codes available and they each have their strengths and weaknesses. Most finite-difference codes are limited to flat surfaces and can only use vertical, planar faults in spontaneous rupture. SPECFEM3D is great for regional and global wave propagation. I don't believe its spontaneous rupture capabilities are available in the released version yet.

90. achraf koulali: **do you have any reference for using green's functions from pylith for inversions using other codes ?**
* Brad Aagaard: Generating Green's functions in PyLith and using them in an inversion is a relatively new feature of PyLith. I know Charles has been using this feature and I will forward this question to him.

95. Erin Todd: **Could you elaborate on the quadrature.cell (or general quadrature) parameters in the .cfg files? What exactly does quadrature mean in this context, and what is this doing?**
* Brad Aagaard: Numerical quadrature is used to compute the finite-element integrations. FIATLagrange is for line, quad, and hex cells, whereas FIATSimplex is for line, tri, and tet cells. The quadrature order specifies the number of points to use in the integration. Nearly all introductory finite-element texts will include a section on numerical quadrature, which is often also called Gauss quadrature. The number and location of the points depends on the basis functions used and they are chosen to optimize the accuracy of the finite-element integrations.

96. achraf koulali: **In case if we run an interseismic simulation, Do we need to specify time history of rupture to put earthquakes ? I mean x seismic cycles**
* Brad Aagaard: If you want to seismic cycle calculations you can use faults with either prescribed slip (if you know the earthquake history and slip) or fault friction models (if you want to compute when the earthquakes occur given the loading).

101. Yang Zhang: **Can you talk a little bit about postseismic afterslip simulation controlled by friction law? (Do the examples we talked today cover that situation?)**
* Brad Aagaard: In this tutorial we didn't cover friction controlled afterslip, but this is discussed in examples/2d/subduction/step04. In that example, we impose the perturbation in the tractions from a coseismic slip calculation and compute afterslip with a static friction model.

102. Da: **I know there is a software called COMSOL multiphysics. Doyou know it? What do you think of it?**
* Brad Aagaard: COMSOL is good for developing simple geometric models and experimenting with interactions among different physical processes. It is not designed for geophysics problems, and I don't think it runs in parallel. It does not solvers as sophisticated as those available in PyLith via PETSc. I don't know what bulk and friction constitutive models, if any, are available, so you might have to implement all of those. PyLith contains a lot of physics and robust solvers, and will soon add multiphysics capabilities.

105. Yang Zhang: **Do you have a list of published papers that use PyLith?**
* Brad Aagaard: CIG maintains a list of papers published that use the various codes. See the PyLith User Resources page for a link http://www.geodynamics.org/cig/community/documents/reference#pylith

PyLith and CUBIT

10. **achraf koulali: the material id sould be the same as specified from CUBIT ?**
* Charles Williams: Yes. You can check the block number in the Cubit journal file.

Output

23. Roby Douilly: **Can we disable the output of the default state variables such as strain and stress?**
* Brad Aagaard: You can disable output by setting the output fields properties to an empty array [].

26. Shaoyang Li: **In Pylith, can I set user-specified time_step for output just like (or the same as) the user specified calculation**

time_step?
* Brad Aagaard: There are two options for controlling how often the various forms of output are written. You can select to write every Nth time step computed or you can select to write every X seconds or years, etc. See examples/3d/hex8/step07.

27. Erin Todd: **In the output files *.vtk, what does the double column represent where the specified parameters (i.e. displacement, strain, stress, etc.) are listed?**
* Brad Aagaard: The word "double" in the VTK file indicates a floating point value.

49. Erin Todd: **I just have a more general question about the HDF5 files. Could you elaborate on what they are and how they are used?**
* Brad Aagaard: HDF5 files are a type of binary files that follow a specific scheme. Some of the advantages are that they are binary (so reading and writing is much faster then ASCII), they can be written in parallel, they are platform independent, and the values can be accessed in just a few lines of code from Matlab and Python.

93. Erin Todd: **When specifying output files, is it simply a matter of writing filename.vtk vs. filename.hdf5 in the .cfg file?**
* Brad Aagaard: In addition to updating the filename with the proper extension, you also need to change the data writer component. The default data writer component is DataWriterVTK. To use normal HDF5 output, change it to the DataWriterHDF5 component (see examples/3d/hex8/step06.cfg). See step03.cfg for a discussion of the VTK output parameters.

Examples

22. Francisco Delgado: **where are the files located???**
* Brad Aagaard: The examples are in src/pylith/examples with the 3d hex examples in src/pylith/examples/3d/hex8. If you are using the Windows binary and installed PyLith in the default location, the examples is at C:\Program Files (x86)\PyLith\src\pylith\examples. If you installed in a custom location, the prefix will be different but the PyLith\src\pylith\examples will be the same.

68. Cathina L Gunn de Rosas: **I was wondering where the example files you open in Cubit/Trelis are found ... are these something we are supposed to have or just something you're using to help us visualize?**
* Brad Aagaard: The files for all of the examples we have shown are in the examples directory. In the binary distributions they are in src/pylith/examples. The 2-D meshing example from Session II is in examples/2d/subduction and the 3-D meshing examples from Session III is in examples/meshing/surface_nurbs/subduction. The cell size example is in examples/meshing/cubit_cellsize.

54. achraf koulali: **In case if we want to add a viscoelastic block, do we need to change other params than the spatial database ?**
* Brad Aagaard: See examples/3d/hex8 step07.cfg. This uses a Maxwell viscoelastic model rather than an elastic isotropic model.

98. Carene Larmat: **Is there an example with non-uniform boundary conditions? And how to plot boundary conditions with ParaView?**
* Brad Aagaard: See examples/3d/hex8/step19 for a Neumann BC with spatial variation in the parameters for the tractions. Also our slip and creep distributions inexamples/3d/hex8/step06 use nonuniform slip and slip rate distributions. Other examples include the slip distributions in examples/2d/subduction.

ParaView

18. Shaoyang Li: **Is the output of a fault, 1d fault for instance, slip_x and slip_y mean fault left lateral slip and fault opening, respectively?**
* Brad Aagaard: ParaView shows the components of slip and traction as x and y. The components in 2-D are lateral and opening, and in 3-D are horizontal left-lateral, reverse, and opening.

25. Erin Todd: **How do you display displacement vectors (like the images from the two cell examples)?**
* Brad Aagaard: Use the Glyph tool to display displacement or velocity vectors.

52. Erin Todd: **Silly question: how did you rotate the slip scale by 90 degrees?**
* Brad Aagaard: In Paraview you can drag the colorbar against the edge of the window.

100. Roby Douilly: **On paraview, is there a way to insert coastlines?**
* Brad Aagaard: Anything you can put into VTK files, you can load into ParaView. I am not aware of any community tools for adding in things like coastlines and seismicity. We would certainly welcome contributions in this regard and post contributions on the CIG website. Charles and I do have some scripts that do this in certain cases, but the input data are not in standard formats.

Session III: Green's Functions

47. Erin Todd: **What is the superscript -g stand for?**
* Brad Aagaard: The -g in G^{-g} is a notation the identifies the generalized inverse. It provides the inverse in a least-squares sense in this case.

48. Erin Todd: **Is the purpose of the bias curves to create a finer mesh on a particular portion of the fault?**
* Brad Aagaard: Yes, we want greater resolution along the fault than the rest of the domain. We expect the solution to be smoother as we go further from the fault, so we can coarsen the mesh with distance from the fault and still capture the solution at the same accuracy.

50. Yang Zhang: **Does the type of boundaries conditions matter here in the inversion? For example, do the bcs have to be homogeneous?**

* Brad Aagaard: The boundary conditions in computing the Green's function will contribute to the solution. In most cases we are inverting just for fault slip, so we usually have homogeneous (zero displacement) BC at the edges of our domain far from the fault.

51. achraf koulali: **Can we tell pylith to calculate the ground displacements at all surface vertices instead of a set of defined points ?**
* Brad Aagaard: We output the solution over the ground surface in the other file. The points match up to the vertices in the mesh, so they wouldn't necessarily match the coordinates of the observations, like GPS or seismometer sites.

53. achraf koulali: **-1 because z is positive downdip ?**
* Brad Aagaard: For this vertical fault, we used two components of shear slip: left-lateral (positive) and reverse (positive). We setup the problem for lateral slip, so we use an impulse amplitude of -1 for right-lateral slip.

69. Roby Douilly: **If we have a dynamic simulation, can we generate the green functions between the source a receiver and convolve the green functions with a source time function to have the estimated seismogram at the site?**
* Brad Aagaard: The current version of PyLith only supports static Green's functions. We need to extend our output implementations to allow 4 dimensions (impulses, time steps, entity, component). This is a planned feature but implementing more physics has a higher priority.

70. Roby Douilly: **If there was a bias in the fault mesh, would it cause problem when calculating the area around a vertex?**
* Brad Aagaard: The area field in fault output is calculated based on the cells in the fault mesh, so it accounts for variations in discretization size and deviations from perfectly formed cells (e.g., equilateral triangles and squares). In 2-D problems with 1-D faults "area" is "length".

75. Eric Lindsey: **how would you do greens functions for two connected fault patches? do you need to generate them separately in pylith as two problems, then combine them in the inversion?**
* Brad Aagaard: To compute Green's functions on two patches of the same fault, you can use one Green's function simulation; you just need to use the impulse amplitude spatial database to control where you want the slip impulses.

To compute Green's functions on two different faults, you need two simulations, one for each fault. In your inversion code you would combine the responses and impulses to formulate the complete inversion.

Session IV: Solvers

80. Eric Lindsey: **can you provide some examples of these solver.cfg files for us to try out? or are they available somewhere?**
* Brad Aagaard: The solver.cfg file are posted with links from the agenda page. I back ported them to v1.9 so they are slightly different than what you saw (the fields don't have names, instead of displacement you will see "0" and instead of lagrange_multipliers you will see "1").

85. Erin Todd: **What are MegaFlops? I'm not familiar with that term.**
* Brad Aagaard: Megaflops are millions of floating point operations (add, subtract, multiple, divide) per second.

81. Yang Zhang: **It looks like that Pylith manual does not provide too much detailed info about how each solver works and how to choose between solvers. Can you give more references about these topics?**
* Brad Aagaard: See the PyLith JGR paper and the PETSc manual for references for the PETSc solvers. The solverXX.cfg files have been posted on the agenda page. We will be adding these to the distribution and include some discussion of them to the manual.

88. Erin Todd: **Most of this is very new to me. Could you recommend any texts for beginners that may help?**
* Charles Williams: Other than texts focussed on mathematics, best option at present is the PyLith paper.

89. Erin Todd: **Are there any qualitative descriptions for the solverXX.cfg files that could help users determine when an particular solver would be useful?**
* Brad Aagaard: Matt will add descriptions at the top of the files when they are included in the distribution. For now you can use his slides. In general, use solver03.cfg to get started (small problems) and then solver07.cfg for larger ones.

Session V: Fault Friction

56. Erin Todd: **When we go through the example, could you point out where the converged_reason=true tells/helps you realize that you have enough iterations?**
* Charles Williams: There are portions that show the convergence of both the linear and nonlinear solutions:
Linear solve converged due to ...
Nonlinear solve converged due to ...
One simple thing to do is grep the log file for the phrase DIVERG to see if divergence ever occurred.
Grep for the phrase Nonlinear to see what the SNES solution did.

58. Erin Todd: **The tolerances are telling the solver how low the residuals need to get to converge, right?**
* Charles Williams: Yes.
Matt Knepley: The relative tolerance is the ratio of the initial residual to the final residual
Matt Knepley: The absolute tolerance is just the size of the final residual

61. Lujia: **How to determine an appropriate time step? Can we now vary time steps instead of using a constant time step? Thanks!**
* Charles Williams: The only controlling factor for this problem (step14) is rate-state friction. If we had finer scale spatial resolution we would want to decrease the time step size to see the details of slip nucleation.

62. achraf koulali: **the atol values depend on the dimension of the domain ? nature of the problem ?**

* Charles Williams: Not really because of nondimensionalization. Make sure things are nondimensionalized correctly.

64. Erin Todd: **Could you restate the difference between the implicit tie stepping and explicit time stepping?**
* Charles Williams: Explicit time stepping is for problems that include inertia (wave propagation). Implicit time stepping is for problems with no momentum (static or quasi-static).

65. **Lujia: Does quad-order = 2 mean there are more points to represent one cell? Thanks!**
* Charles Williams: The quad-order is the order of integration used. For a quadrilateral cell this means 2x2 Gaussian integration (the default for a quad4 cell).

66. achraf koulali: **Is there an option to add a rupture in the quasi-static simulation ?**
* Charles Williams: We can't include a dynamic rupture in a quasi-static simulation since seismic waves don't propagate in quasi-static problems.

97. Roby Douilly: **Is there an error in the slip weakening equation. The first term in the right hand side suppose to be the static friction but not the dynamic friction**
* Brad Aagaard: If you look at the slip weakening equation, for D = 0, the D/D0 term = 0, so the right factor is 1.0 and we end up with the static coefficient of friction. For D = D0, the right factor is 0.0, so we end up with the dynamic coefficient of friction.

99. vadacca luigi: **I didn't understand well how the force_healing function works in quasi-static simulations. What is the difference if i set friction.force_healing = False/true**
* Brad Aagaard: The force healing function is used to limit the weakening behavior with slip weakening to a single time step in a quasistatic simulation. With time steps of years in a quasistatic simulation we want the earthquake slip to be confined to a single time step. The D is accumulated slip in a single event, so we reset D to 0 to heal the fault and return the coefficient of friction to the static value, resulting in relocking of the fault.

In dynamic simulations, we want the weakening to occur over multiple time steps (for numerical stability of the cohesive zone). In order to accommodate both types of behavior we use this force_healing flag.

Session VI: Running in Parallel

91. Erin Todd: **Is this argument added when running a .cfg file? FOr example, would it be pylith step01.cfg --nodes=NUMCORES?**
* Brad Aagaard: Yes, running PyLith in parallel a desktop is that easy.

89. Lujia: **Is pylithapp.pbs a new feature? I used to use a separate shell script to run qsub.**
* Brad Aagaard: Specifying PBS parameters on the command line has been there from the very beginning of PyLith. It is part of Pyre. The info is in the installation/configuration chapter of the manual.

94. achraf koulali: **If I want to compile Pylith on our cluster, what the things I should take care of ?**
* Brad Aagaard: Carefully read the INSTALL file included in the PyLith installer utility, which can be downloaded from the PyLith webpage. It includes a discussion of the requirements and detailed instructions for using the installer on a variety of platforms.

104. vadacca luigi: **I tested the step.12 example on ingv cluster. I noted that when i used 1 core then the time of the simulation was 23.07 s; with 2 core the time was 23.91s; with 4 core 20.27s; with 8 core 23.21s and finally with 16 core the time was 33.10 s. Is it due to the bandwidth saturation?**
* Matt Knepley: In order to interpret this, we need to see the log_summary output. However, this is strong scaling and a small problem, so you would expect minimal speedup from the start.