Notes from 2010 SIV Workshop

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The SIV Workshop in Palm Springs, CA, was held on September 11 and 12, 2010 in conjunction with the 20th SCEC Annual Meeting. There were upwards of 60 participants in the workshop including many students who were new to the SIV community. The goals of this workshop included review of test exercises conducted to date, presentation of research results on different aspects of the source inversion problem, and planning for the next round of blind tests.

The meeting began with a review of the point-source Green's function test and possible reasons for the discrepancies between groups with the objective of identifying ways to help the modelers bring these results into agreement. Reasons for discrepancies include unit problems, boundary reflections, failure to perform wavenumber summations to high-enough order or at sufficient discretization, and differences in interpretation of the problem (some may have done a single point-source, while others may have discretized the single square of slip with several point sources). Some stations have particularly bad discrepancies (for methods that match well otherwise) – these stations are likely nearly nodal and thus the waveforms are unstable to small differences in the setup. Participants were particularly surprised at the differences between people using the same method – but this reflects the many choices the modelers can make in setting up the codes. Indeed, some of the submissions from modelers using different codes match better than submissions with the same code – this could reflect choices, such as the number of point sources used, that have more impact on the waveforms than the exact code that is used.

To help modelers properly setup their codes, identify potential pitfalls associated with all/some of the methods, and bring the results into agreement, we decided to set up a general Green's function computation discussion page on the site wiki, as well as individual pages for each code. Eventually these discussions may become useful documentation for successful set-up and execution of each code. It was also suggested to contact the original code developers. They will have insight into how to properly set up the codes (for example, what frequencies to sum to) and could provide benchmark results for their codes. While the PowerPoint presentation with everyone's results is available on the website, we also need to provide downloads of the raw data files (perhaps in a protected version of the site?) and allow people to post revised versions online, with explanations as to what was changed/fixed in the resubmission (so others do not repeat the same mistakes). I will need to talk with John Yu about giving everyone more access on the website – currently once you sign up you cannot even edit pages without him changing the permissions.

The website developed by Michael Barall for the Dynamic Code Validation Exercise (http://scecdata.usc.edu/cvws) has a very nice benchmark comparison tool that dynamically makes browser-friendly plots and allows users to compare models easily. This would be a great thing to have on the SIV website as well, although of

course what we can do is limited by funding resources & the fact that we do not have a dedicated full-time programmer. But perhaps we can make small changes to the code already written on the Dynamic Code Validation Exercise Website to make it work to plot our data formats.

The workshop continued with a series of contributed talks and discussion on those contributions. These included:

Guanfu Shao & Chen Ji : What did the Exercise of SPICE Source Inversion Validation BlindTest I not Tell You?

Seok Goo Song: Does earthquake slip follow Gaussian statistics?

Daniel Lavallee, Ralph Archuleta & Jan Schmedes: Spectral analysis of slip spatial distributions

Bill Ellsworth: Source inversion with minimal assumptions

Sarah Minson: A Bayesian approach to finite-fault inversion

Lingsen Meng & Pablo Ampuero: Optimal network geometries for source inversion

At the end of the workshop, we had a plenary discussion of where we should go from here. We spent a lot of time going over the problem description for Stage 2 (the initial inversion exercise) carefully. It was felt that given the differences in Green's function computations that have already been discovered, there should be an independent check on the forward solution for this problem (by someone who would not be participating in the inversion). We want to also be sure that the computations are done on a fine-enough grid to compute waveforms to 3 Hz (we agreed that the modelers should not be given the grid spacing used, as long as the model is essentially a "continuum" model in this frequency band that does not show signs of discretization).

The hypocenter depth is currently slated to be given to the modelers (although it just says "XX km" in the description). It was decided that the modelers should be given the complete location (depth & distance along-strike) to further reduce the potential for any trivial errors by the modelers in this round.

With regards to the coordinate system, there is ambiguity about such things as azimuth, which appears to be E of N, not the angle measured from X towards Y (N of E). The caption of Figure 2 explains the coordinate system but if it is indeed right-handed, given that the y-axis direction is down on the page, then positive z (which should be above ground) would go into the page. This caused some confusion (as did, to a lesser extent, the fact that north is down!). Since the green and blue boxes are not used in this round (they are for a dipping fault), they should be removed from the problem description for the moment. It was also suggested that as in the SPICE test, modelers should be given the fault plane but not the exact boundaries.

There was quite a bit of discussion about the station configuration. Most importantly, it was decided that modelers should not be given all 168 synthetics, but each told to use the same stations (and to use all of this subset). We want to be sure that the differences between models is not caused by different sets of stations being used by different models. This will be an improvement on SPICE test because it will limit the reasons for differences between the models (and, after all, we want to test the inversion methods, not how good the modelers are at choosing the best stations to use). Everyone at the meeting said that there was no computational problem to invert 40 stations, and synthetics could be computed at an additional 10-20 stations. These stations can be randomly chosen from the existing stations (with care to avoid using stations on exactly the opposite location on the other side of the fault, since in the strike-slip case these station pairs are redundant). Some people suggested using a more uniform grid of stations, rather than the racetrack configuration, while others felt that the stations should be in the most optimal configuration possible. Unfortunately, as we learned from Lingsen Meng's talk, it's not completely clear what that the optimal configuration is – although the talk suggested the optimal configuration would have most stations close to the fault with a few farther away, and good azimuthal coverage – the racetrack configuration does satisfy these requirements.

We weren't sure if the predicted ground motion format is the same as the input data format, but they should be. A small change to this format that would make it more readable by different programs would be to use a space-delimited format (as opposed to requiring 15.6e).

We decided that static displacements should also be given to the modelers (at the same stations) and that these should be independently checked by a code designed for statics. It was felt that inclusion of geodetic modelers is important, so providing files specifically for them, and specifying an output format specifically for them (for the final static field – it would be the same format as we have now but with only 1 time step) & having it in the problem description will encourage their participation. We could also put a note on the website that the problem is open to geodetic modelers as well. Additionally, we should probably consult with someone in that community to decide if more points with displacements than the ~40 seismic stations should be provided to them, given what is appropriate these days in terms of the density of GPS measurements and satellite-derived displacement measurements. . If we simulated the latter, they might be LOS displacements to mimic InSAR or horizontal displacements to mimic pixel correlation data. Anyway, making a test that would be of interest to the geodeticists would be worth doing.

The rupture model output currently specifies a string for the elementary source-time function, but these could be quite variable. It was decided that it would be better to have each modeler, whether they are using a simple source-time function or allow for more flexibility, to specify completely the slip at each point on the fault for each time step. This will make the file sizes bigger, but it's nothing we can't handle, and it will require less complicated scripts to read in the models because the

format will be more similar from model to model. This change will also eliminate the single-time window version of the output format. To make the output even more simple (at the expense of file size), dt (the time step) and NumPoints (the number of points in time) would be same for each subfault. This would result in 0's for most of the file – and the results would look something like movie frames on the fault. Alternatively, we could use multiple files – one file for each subfault. Then we could reuse the seismogram file format for the slip-time history on each subfault.

It was decided that we should set the deadline for Problem 2 (first inversion) to the next meeting, in spring 2011. Not many of the participants will be at SSA. Since we have limited funding, we could consider having a conference-call type of meeting remotely. Setting a deadline for the inversion test will help put pressure on the modelers to bring the Green's function results into alignment, since that is a necessary prerequisite to the inversion test.

There was also discussion about redoing SPICE test as an SIV exercise once the Green's functions are fixed up. The link to the SPICE test on the SIV webpage is currently broken, but perhaps those data files could be migrated to the SIV webpage.