Notes from SIV workshop – SCEC 2009

There was a consensus that Problem 2 (first simple inversion) should be a dynamic rupture. This model can be a very simple crack-like rupture that is set up so that there will be little change in rupture velocity or rise time across the fault. Some suggested that the model should have one asperity. Yoshihiro Kaneko, who made the dynamic models that Ozgun Kunca inverted in his source inversion testing, agreed to make a model for us. His code, which uses rate and state friction (it's the code Nadia Lapusta, his advisor, uses also, I believe) has been validated in the dynamic code validation testing. Ruth Harris also expressed interest in helping us with dynamic models – I think she meant that their group already has lots of fully validated synthetics generated (but it should be blind…).

Some told me later, and I agree, that the modelers shouldn't know whether or not they are getting a model that was created from a dynamic model or not. However, what we could do for Problem 2 is give modelers several problems, that each use the same station geometry and fault geometry. One could be a dynamic model (they wouldn't know this) and one could be a kinematic model like the one in the Spice Test (with a simpler slip distribution?). It wouldn't be that much work for the modelers to do several, since they would be in the same format, and the main work is setting up the code to read in the format and to run with the correct geometry.

There was also much excitement at the workshop about using dynamic models, because it was thought that the SIV enterprise, in addition to testing the validity of inversion methods, could be used to answer pressing problems in earthquake physics that other groups in SCEC are wrestling with. For example, Ned Field, who runs the UCERF endeavor, really wants to know how deep slip penetrates in large events – that is, can the rupture extend below the seismogenic layer? This is a question of first importance in the development of magnitude-area relationships, which are really important for the big events, and therefore, for PSHA results. And we have dynamic models now, by several groups, where ruptures nucleate in the seismogenic zone but extend below it, and the slip that is deep is slower (longer rise times) and at lower frequencies. It is thus not clear if inversion models would be able to image this slip, even if it does occur, because the slip is less impulsive and resolution is worse at depth. We could probe this question with a realistic dynamic model – both to see if the parameterization of the inversion methods and the inverse problem properties themselves allow this slip to be imaged.

There are other physical questions we could image with SIV "experiments" as well – like whether or not inversions can resolve the difference between a crack-like rupture and a pulse-like one. Such potential adds to the "sellability" of SIV, which can help us get funding with other agencies and also within SCEC. Interfacing with other groups in SCEC would be good.

Modelers want to know the metrics they will be evaluated on before they prepare their inversions. There was some discussion (which we also had at the last SCEC workshop) that the point should not be to make one model; and even a model that

does well according to goodness-of-fit metrics is not necessarily better than one that does worse because of the underdetermined nature of the problem. I tried to follow this line of reasoning, several times, by asking if people would prefer to submit multiple models (so that from the ensemble a sense of model error could be established) or to submit model parameter error bars/pdfs. But this seemed a dead end; people didn't like that idea even though some thought that one model was not particularly meaningful. My feeling is that the methods modelers often use to assess the model uncertainty are necessarily insufficient (they cannot assess, just for one example, to what extent model error is introduced from the parameterization itself), and we will be determining a large portion of this nonuniqueness just from the inter-model variability (and corresponding waveform fits).

People seemed fine with Danijel's idea to eventually move to a CSEP-style testing center, even though this would mean giving the testing center their codes. Certainly such a testing center would allow us to test many, many more models than we can do otherwise. The modelers would set up their codes to run for a specific geometry using a (problem-dependent) subset of stations. We could set up the stations on a fine grid, and then run experiments using subsets of the stations. This would allow us to test different station configurations, without having to set up the code differently each time. Each code would use the same input and output files, and the testing center (assuming we have money for a developer!) would be tasked with making Python wrappers for each code, and validating that they produce the expected answer for a simple test problem.

Modelers wanted to see a variety of metrics used – so that they would not be penalized if, for example, their slip model was off but their rupture velocities were perfect. I think this won't be hard – we can have different metrics for each source parameter, as well as metrics that rely on multiple source parameters (like a 3d correlation on the slip velocity field in time). Daniel Lavalee is presenting a poster at SCEC on a different kind of slip correlation test – it is similar to what was used in SPICE test, except that is analyzes each spatial frequency independently, and also shows if the model matches if it is just shifted spatially.

It was agreed that modelers should submit source models and synthetics (for stations they have the data for and for additional stations they will predict) in a standard format. It was also decided that the formats must be extremely flexible – so that they can handle different grid spacings that may be used by the modelers, or arbitrarily complex source-time functions (some codes, for example, allow points to slip multiple times, so that "rise time" does not even have much meaning). This can be done by having all the modelers submit their models on a very fine grid spacing – say, 250 m. That way everyone can grid the problem as they like, then interpolate their results onto a fine grid (them, not us), and we will still receive model files in directly comparable formats. (Even irregular grids wouldn't be a problem.) This also has the advantage that we will not give away any grid spacing that is used in the forward model.

It was suggested that at some point we could do a test using real earthquakes – small M4 events as empirical Green's functions. By superposing a bunch of EGFs (Parkfield has a lot) we could generate a larger earthquake for people to invert the data from – and the seismograms would be realistic.

One modeler wondered if they would be allowed to correct their models after submitting if they realized they had made a mistake. I think we can allow people to submit more than one model – we'll just need some sort of versioning system.

Errors! The first few tests will be simple & noise-free, but eventually we will want to add noise. We are in a unique position to test something that isn't normally done – Green's function errors. We can actually do this right – leave Gaussian perturbations behind and change the locations of velocity layers. This is a better approximation to what real errors might be like.

We agreed on a rough time line: Nov. 15 deadline for Problem 1a. Problem 1b description and Problem 2 description done by Nov. 15 (this was before it was decided this should be, a least in part, a dynamic model, but hopefully we can still pull this off). Problem 1b due Jan. 15. When Problem 2 should be due, I think, depends on how the Green's function testing goes. If it goes well we should try to get Problem 2 done before the March workshop; otherwise we may need to use the spring workshop working out Green's function problems.

There were about 30 attendees in the room at a given time – although they weren't always the same people. The dynamic weakening workshop was going on at the same time, so many people were going back and forth. Speaking of which, many of the ~80 attendees to our workshop also registered for another workshop on the same day. We should make sure we are splitting their lunch costs with the other workshops!

Between 1/3-1/2 of the workshop attendees (there were about 30 in the room at the time) will be attending SSA. No one was attending EGU for sure.

People were interested in a KAUST workshop, although there was some concern that those with Israeli passports might have trouble entering the country. I don't really have any idea if this is likely or not; or even if there are any Israeli seismologists involved in SIV. Another concern (for me) is the USGS foreign travel restrictions. As a federal employee I have to get permission well in advance (it might be 6 months+, I'll have to ask) for any foreign travel. So any foreign workshops should be organized well in advance!

The UCSB contingent (Ralph, Chen Ji et al.) committed to participating (although they said there may only be one model between them).

Major to-dos for the website:

Get names of people who registered for the workshop form Tran, add to e-mail list

The website should have a way to get on the e-mail list

Read-only FTP site (drop box) for models

Add timeline with deadlines to website

Pressing action items:

Decide amongst ourselves Problem 2 attributes

Meet with Yoshi – dynamic model generation

Proposals!