California Lithosphere Model (SCEC_CLM)
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1. Introduction

Key to building a LAD model is how the 3D tectonics and geology evolved, so that current and starting conditions for geodynamical modeling are consistent with what we know about the margin. We keep seeing more and more examples of how the past is the key to the present: The 3D distribution of rock types, the drip under the San Gabriels and southern Sierras due to transpression, the formation of major basins though transtension, and volcanism from the slab window. Knowing rock type each side of a fault is important for problems of directivity and damage. Anisotropy can tell about finite strains from mantle flow, what has flowed in the past and is flowing now. The relationship between mantle temperatures, depth of seismogenic zone, rock type, and its rheology may be traced to tectonic inheritance. Much of the information we have on these properties is heterogeneous, based on localized refraction and tomographic surveys. A 3D lithospheric architecture model is needed in a format that can handle the heterogeneity, be readily modified as new data are added, and serve as kinematic boundary conditions for geodynamical modeling. Most information comes from Southern California, which is where the model will be most detailed. However we propose to make the model California-wide (CLM) since this dimension spans the full transform margin and Southern California evolved from structures seen in Central California which can serve as a reference.

2. Progress in 2007

(2.1) Anisotropy

Anisotropy in southern California has been puzzle in that the predominant fast direction of SKS splitting has been oriented EW (even ENE) and not in the WNW direction expected from transpression of the San Andreas system. Further, in contrast to the SKS results, azimuthal anisotropy of phase velocities of surface waves do exhibit the WNW direction but both inferred splitting time (0.4 s) and orientation do not explain SKS values (over 1s). Last year Tanimoto (Tanimoto and Davis Annmual Report) used surface wave eigenfunction analysis to separate the anisotropy into upper and lower crustal, mantle lithosphere and asthenospheric layers, and found that the main contribution to SKS splitting comes from the mantle lithosphere (33-100 km). Figure 1 compares the splitting from surface waves with values from SKS, where it can be seen the SKS values are over a factor of 2 too large, and in the wrong direction to be explained by the mantle lithosphere.

For the first time, we have good evidence of two mantle flow regimes orienting olivines: transpression in the mantle lithosphere; and a deeper flow, presumably related to global mantle circulation (e.g. as in the Becker model). In addition the largest mantle lithosphere effects concentrate in the big bend-Transverse Ranges region where transpressive strains are greatest. So if we can separate out mantle lithosphere anisotropy from effects of deeper flow, we can use it to examine the 3D finite strain associated with transpression of the margin, and compare it with that predicted from geodynamic modeling.

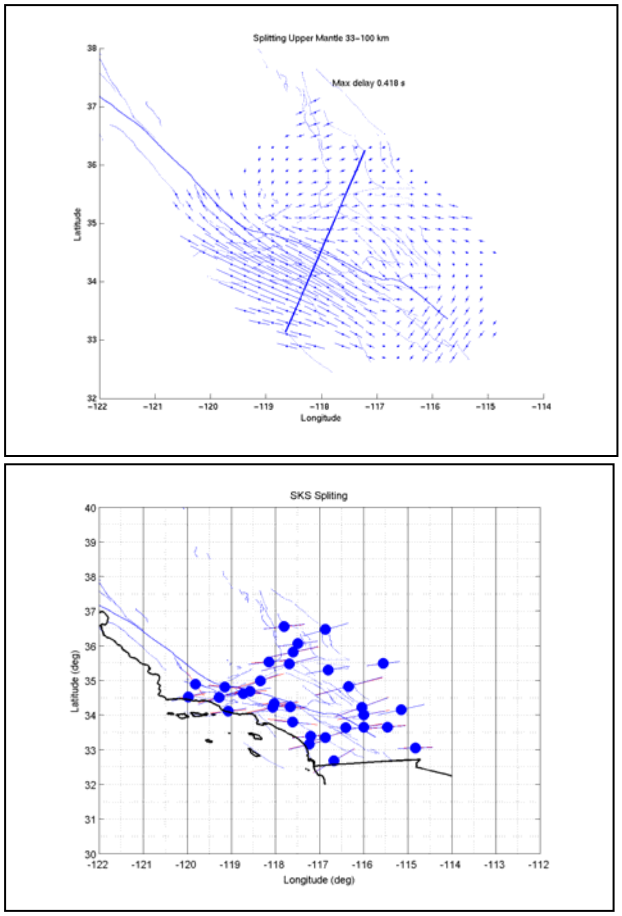

Figure 1. (a) Inferred splitting from surface wave analysis (thin blue lines) compared with (b) New SKS splitting estimates (red lines and blue lines after correcting for upper layer). Note the surface waves have depth resolution that places the azimuthal anisotropy in the upper 33-100 km depth range, or mantle lithosphere, and it concentrates in the Transverse Ranges where transpression has been greatest. The splitting which has larger amplitude and different orientation, and is hardly affected by the uppermost mantle layer, presumably comes from deeper in the mantle

(2.2) Developing the CLM

To build the present day models we are drawing on the results of a number of studies such as:

- Harvard Southern California model (SCEC_CVM) Seuss and Shaw (2003).
- The SCEC 3d model (Magistrale et al, 2000)
- Hauksson's tomographic model for S. California (1999)
- Thurber's tomographic model for N. California (Per. Comm.,2007)
- The N. California Velocity Model (Brocher,, 2005)
- Baja Model from Di Luccio and Clayton (2006)
- S-wave North American model of Van der Lee (2005).
- Moho depth in S. California from Yan and Clayton (2007)
- Transects from 5 large-scale refraction surveys in California
- Humphrey's 3D tomographic model (SCEC Proposal)
- Tanimoto's S wave Model (SCEC Proposal)
- Tanimoto and Davis mantle anisotropy model (SCEC Proposal)

Each of the studies presents the information in their own format. The regions they represent are often overlapping and the values to some degree conflict. To facilitate the building of an integrated model, we have adopted a simple common format and have converted the above studies into that format, but this will likely need to be done in a more rigorous manner to preserve the full resolution of each model.

The format we are using is based on sampling each of the datasets in vertical columns. The various parameters of interest are represented as layers with vertical gradients. The values of parameters at a particular (x,y,z)-point are obtained by a restricted weighted average of the values in a set of neighboring columns. This representation makes it easy to add new elements to the model (or remove elements) and to check component parts separately. The consistency of the model can also be checked by examining the variance of the estimates. The column representation also allows particular velocity model to me imbedded in others simply be selecting the appropriate columns from each.

To date we have developed a code to parse the models and dynamically create a database. Initially we thought we would use a relational database such as mySQL to hold the database, but we found that the simple hierarchical structure of the model columns-layers-values lends itself well to a network database which is simple enough to write in a few hundred lines of code, which we have done. This makes the package much more portable, in that the user we not have to install a separate piece of database software.

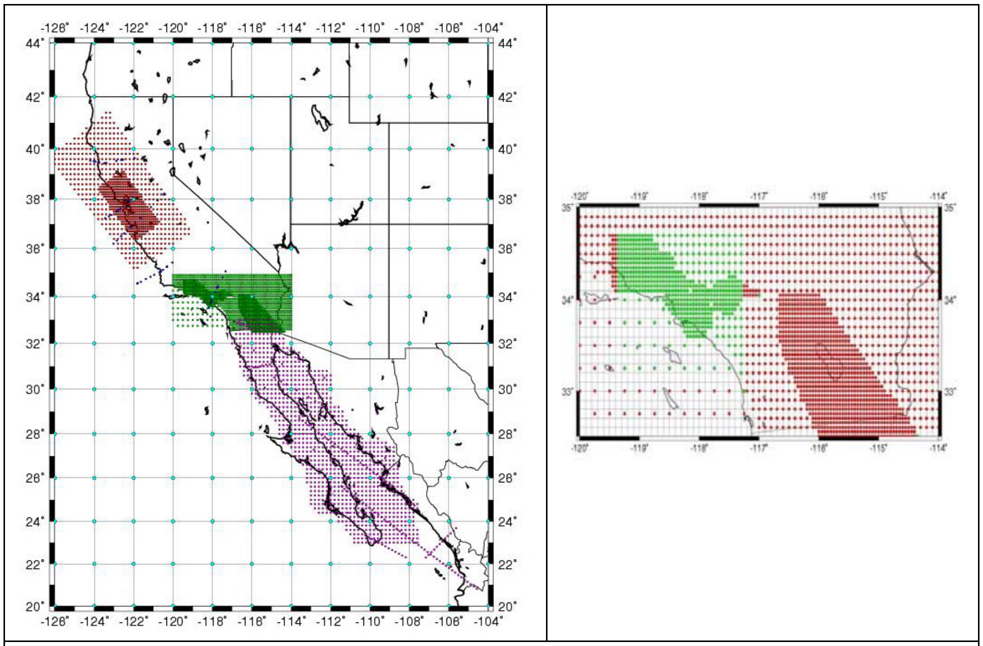

Figure 2. Map view of some columns in the model. The left model shows the large scale model and the right panels shows the detail in S. California with the red columns from the Magistrale et al model and the green columns from the Harvard model

Regarding the LAD effort and the CVM-H (which henceforth we refer to as the CVM) we have discussed how the LAD effort will feed into the CVM and vice versa.

We regard the LAD velocity model (LAD VM) as a time-dependent working model with the goal that through kinematic and dynamic modeling it will converge to and explain the CVM. We recognize that the CVM is to be the consensus model for use by groups such as Ground Motions, Seismology, Crustal Deformation. The LAD itself presently uses the CVM for t=0 in the regions covered by the CVM. Recognizing that eventually waveform tomography will require mantle paths where Moho depth and mantle anisotropy will be important, as well as modeling regional propagation, LAD will take on the responsibility of providing this information to the CVM in these areas.

In terms of technical practicalities the new LAD post-doc Minoo Kosarian with contact Andreas Plesch (Harvard CVM) so that LAD is active in updating and using the CVM. Representative/s of the Harvard CVM will attend the LAD workshop March 6/7 at UCLA.