The 3rd SCEC CSM workshop

- Welcome on behalf of the organizers
  - Jeanne Hardebeck
  - Brad Aagaard
  - David Sandwell
  - Bruce Shaw
  - John Shaw
  - Thorsten Becker
- Thanks for playing!

SCEC
Community Stress Model (CSM)

Community Stress Model (CSM):

- New project starting in SCEC4.

- Long-term goal: a model or set of models of stress and stressing rate in the southern California lithosphere, 4D

- The CSM will probably not be a single model, but a (hopefully small) set of models.

- Any branches in the CSM will be based on clearly-defined differences in data or assumptions.

Main questions within SCEC framework

- How are faults loaded?
  - What is the pre-stress state?
  - What are the stressing rates?
    - for rupture propagation
    - for aftershocks
    - for earthquake prediction

General questions

- Degree of fault strain-localization
- Nature of the brittle ductile transition
- Time-evolution of plate boundary systems
- Role of mantle based tractions and those due to gravitational potential energy variations vs. seismic cycle timescale mechanics

Who are the users of the CSM and what do they need?

External users: Rupture dynamics, geodynamics, seismic hazard, stress triggering, others?
Needs: You tell us!
Provide: One or more reference stress and stressing rate models, accessible through an interface developed jointly with the user communities.

Internal users: Researchers working on problems directly related to stress.
Needs: Access to existing data and models, easier ways to integrate and compare models and observations.
Provide: A modeling environment with tools that will enable researchers to develop and test candidate models against suites of data and/or quantitatively compare their models with other models.

Progress on the SCEC CSM:

- *First workshop*, September 2011, at SCEC Meeting.
  - Large, wide-ranging group discussion.

- *Second workshop*, October 2012, USC.
  - compiled and compared existing stress and stressing rate models from the SCEC community.
  - All models in common format on pre-defined 3D grid.
  - Most models were submitted as full 6-component stress or stressing rate tensors.

- *Third* workshop: May 29-30 2013, Menlo Park.
  - Focus on reconciling stressing rate models
  - Validating models with data
  - More geological constraints
  - More geodynamic predictions

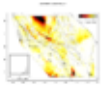
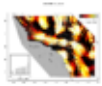
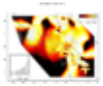
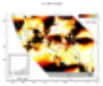
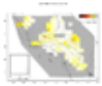
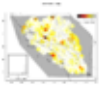
Community Stress Model

Stress Comparison

Constraining the amplitude of the deviatoric stress at seismogenic depths is a long.standing difficult problem, dating from at least the discovery of the .San Andreas heat.flow paradox.. Unsurprisingly, the submitted models did not agree on the magnitude of the deviatoric stress. There was both an order of magnitude disagreement in the magnitude of the deviatoric stress, and a disagreement as to whether the deviatoric stress increases significantly with depth over the seismogenic zone.

Metric:

[s | tdot | **vdot**]

	BirdSHELLS	BirdWSM	Ghosh	Luttrell	SmithKonter	Strader	HardebeckFM	HardebeckWSM	Yang
BirdSHELLS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BirdWSM		N/A	N/A						
Ghosh	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Luttrell	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Project Dashboard

Menu

- About
- Model Contributions
  - Formats
  - Current contributors
- Model Comparisons
  - Stress
  - Stressing Rate

Documents +

- Workshop Report for CSM 2012
- CSM format
- CSM grid

Contributed Models (see Jeanne's discussion):

Stress:

1) Inversions of focal mechanisms / Kostrov summations
2) Inversions of topography and fault loading for stress
3) Finite element, thin shell type models with faults
4) Global lithospheric stress models from mantle flow

Agreement between seismicity based stress models

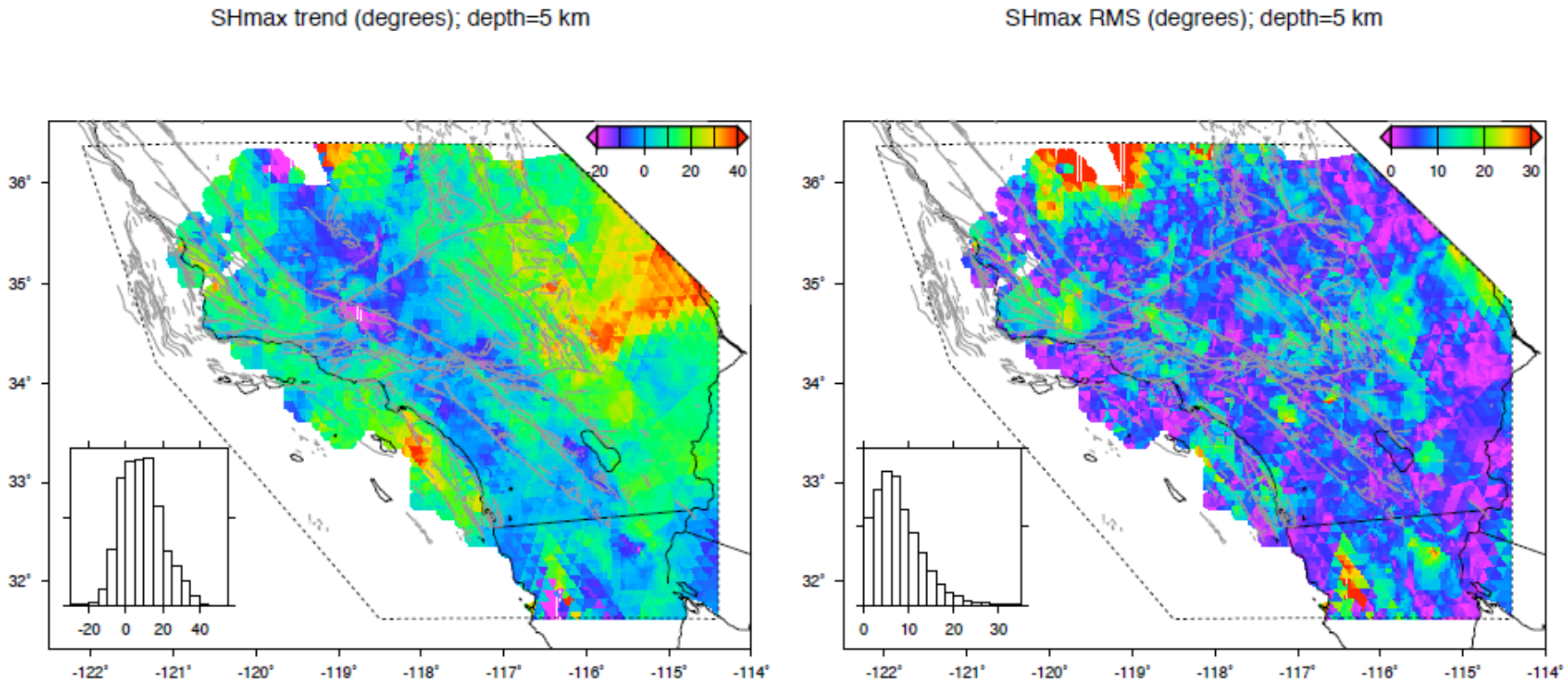


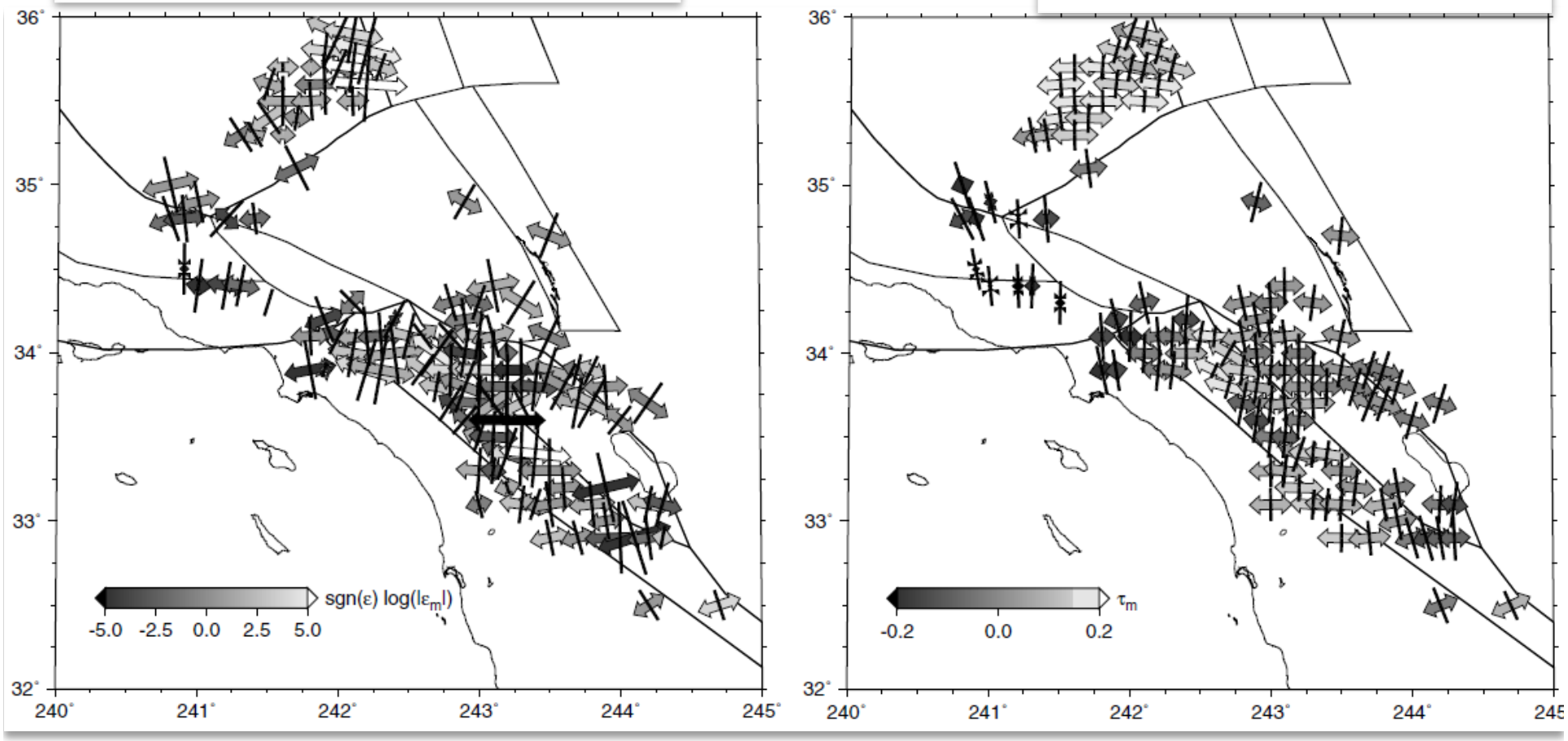
Figure 1. Left: *Maximum horizontal compressive stress axis (SHmax) for an average stress model generated by averaging the normalized stress tensors of the models of Bird; Luttrell, Smith-Konter and Sandwell; and Yang and Hauksson.* ***Right:*** *the RMS difference of the SHmax orientation of the three models relative to the mean.*

From 2nd SCEC CSM Workshop report

Some issues:
How to interpret seismic data?

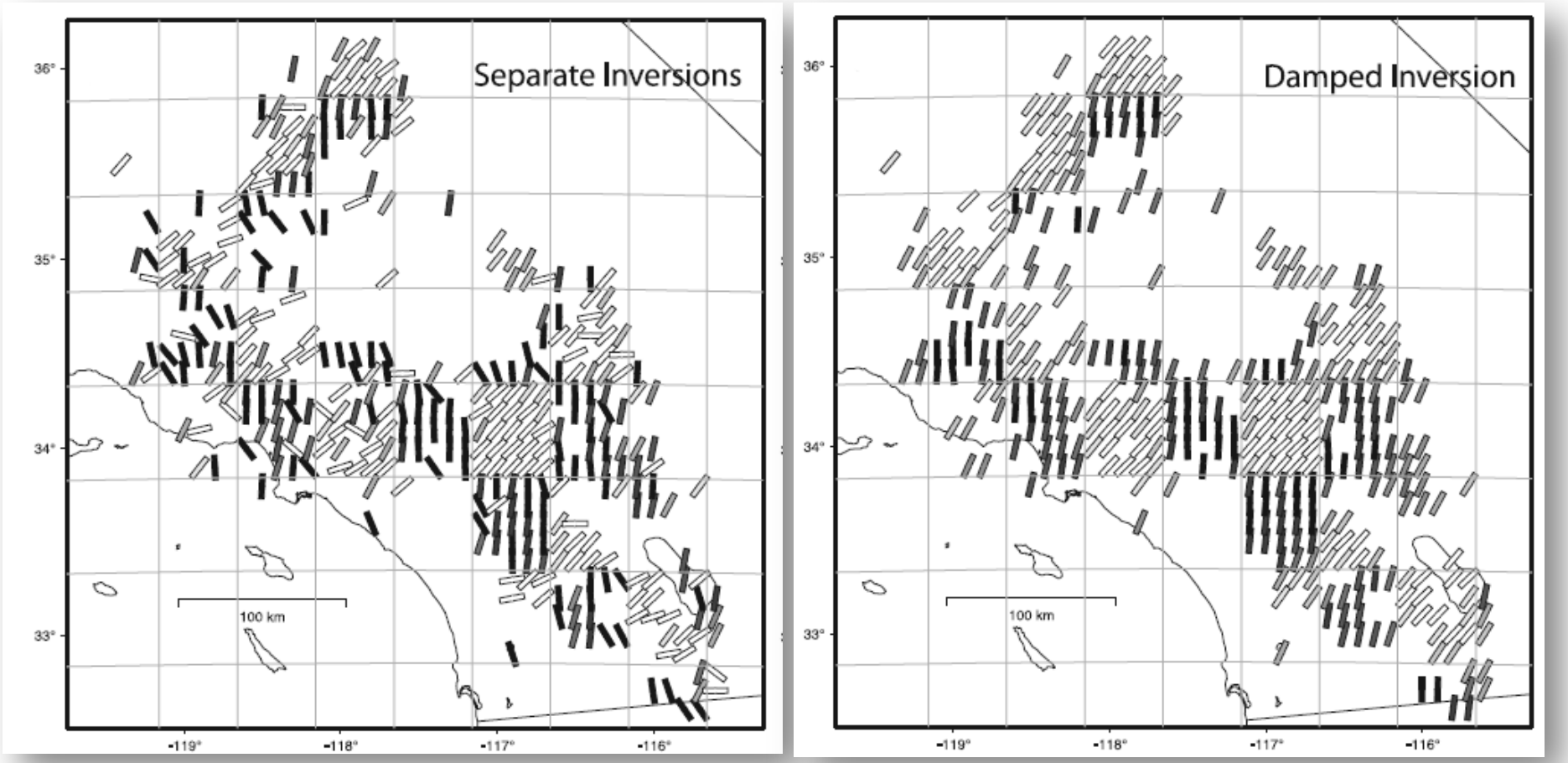
Kostrov summation

Damped stress inversion



Becker et al. (2005)

Inversion in the presence of noise and *a priori* assumptions



Hardebeck & Michaels (2006)

Contributed Models (see Liz' and David's discussion):

Stressing Rate:

1) Block models fitting geodetic data.
2) Fault loading models from geodesy and geology
3) Fault dislocation models plus static stress change from earthquakes
4) Local boundary element models

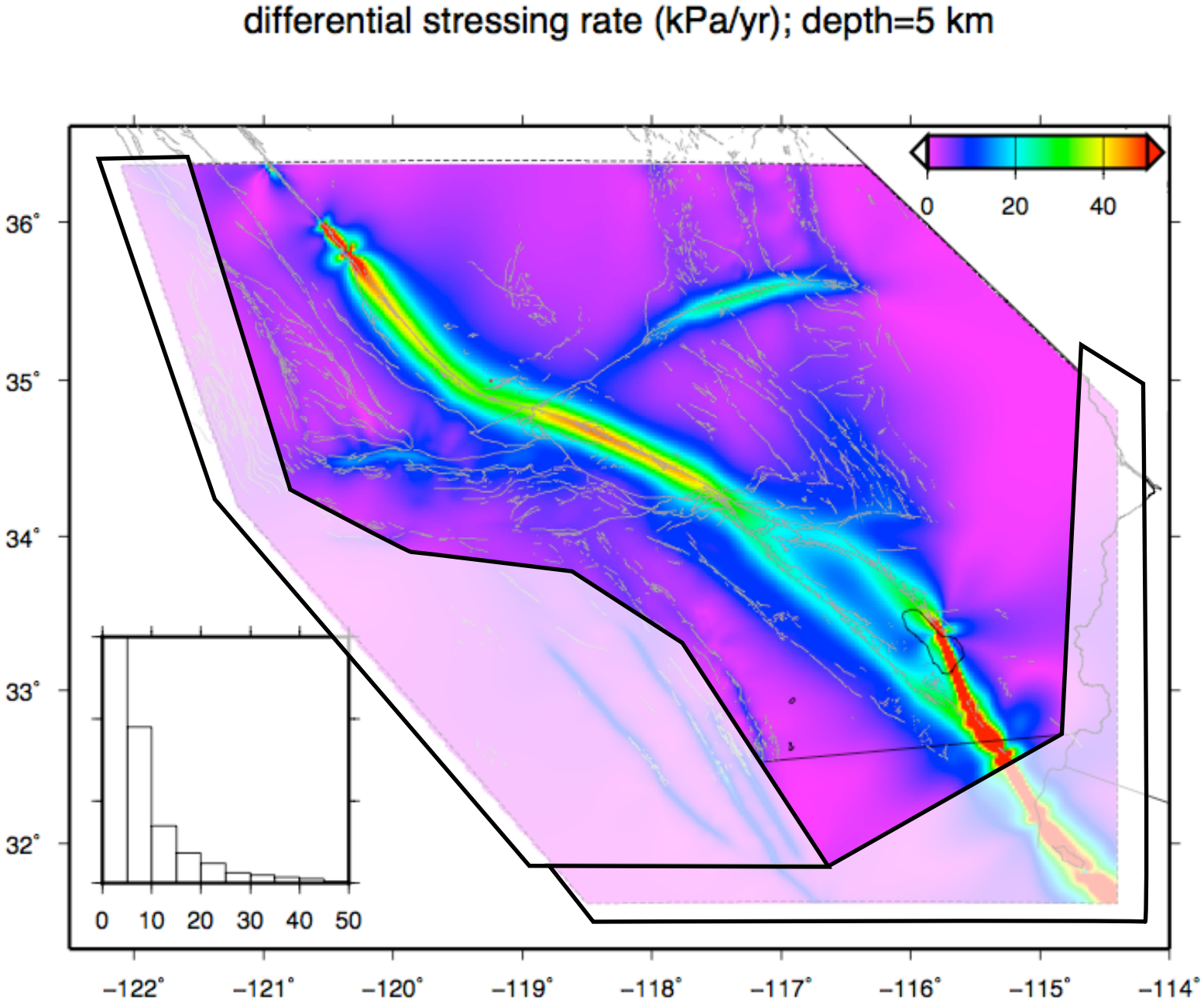
UCERF3 deformation models

- NeoKinema (Peter Bird)
- Average block model (Kaj Johnson)
- Buried dislocation model (Yuehua Zeng)

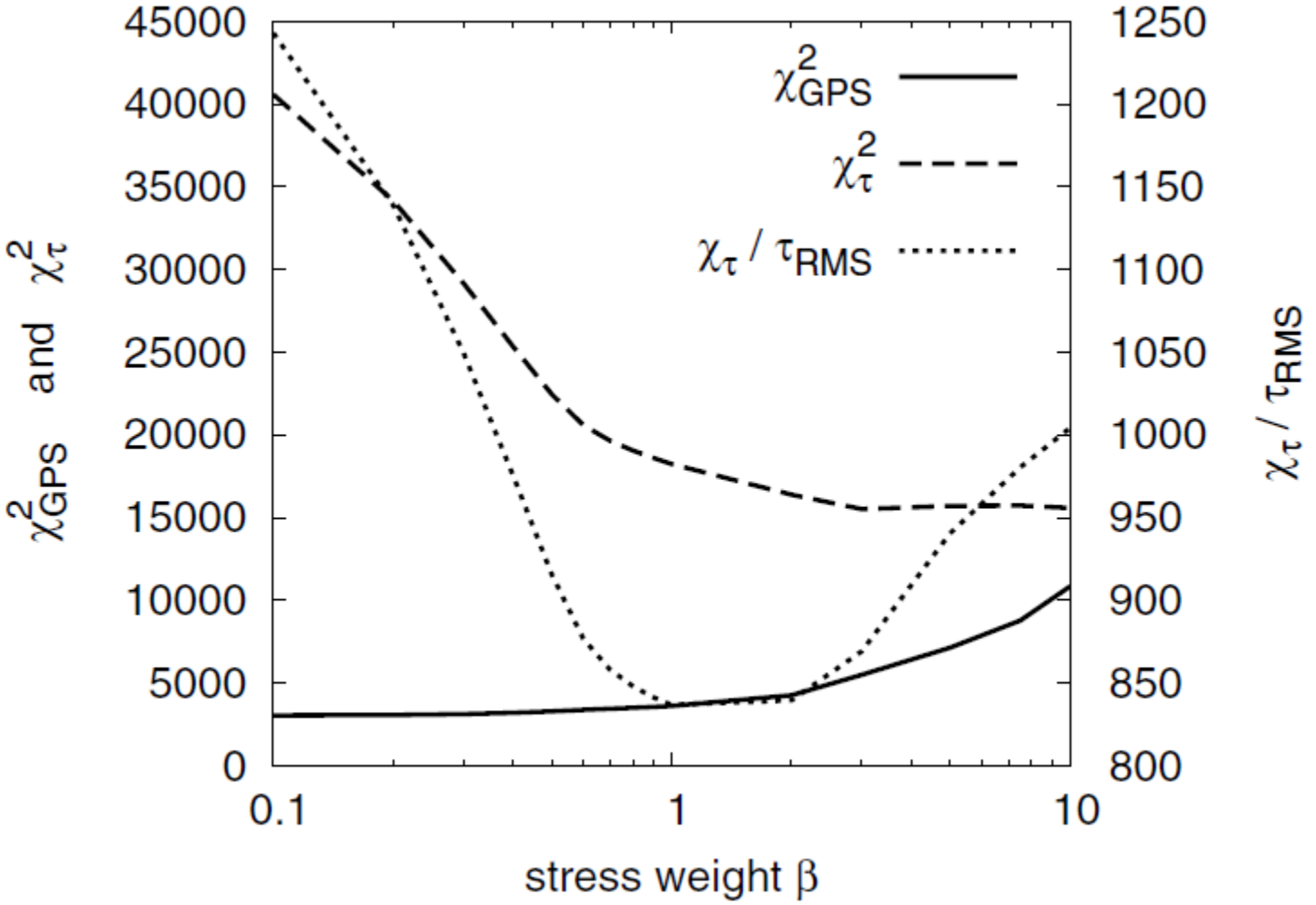
All models use the same fault geometry, slip rate bounds and GPS velocity data.

Differences arise from different methods and assumptions.

Buried dislocation model stressing rate (Liz's discussion)

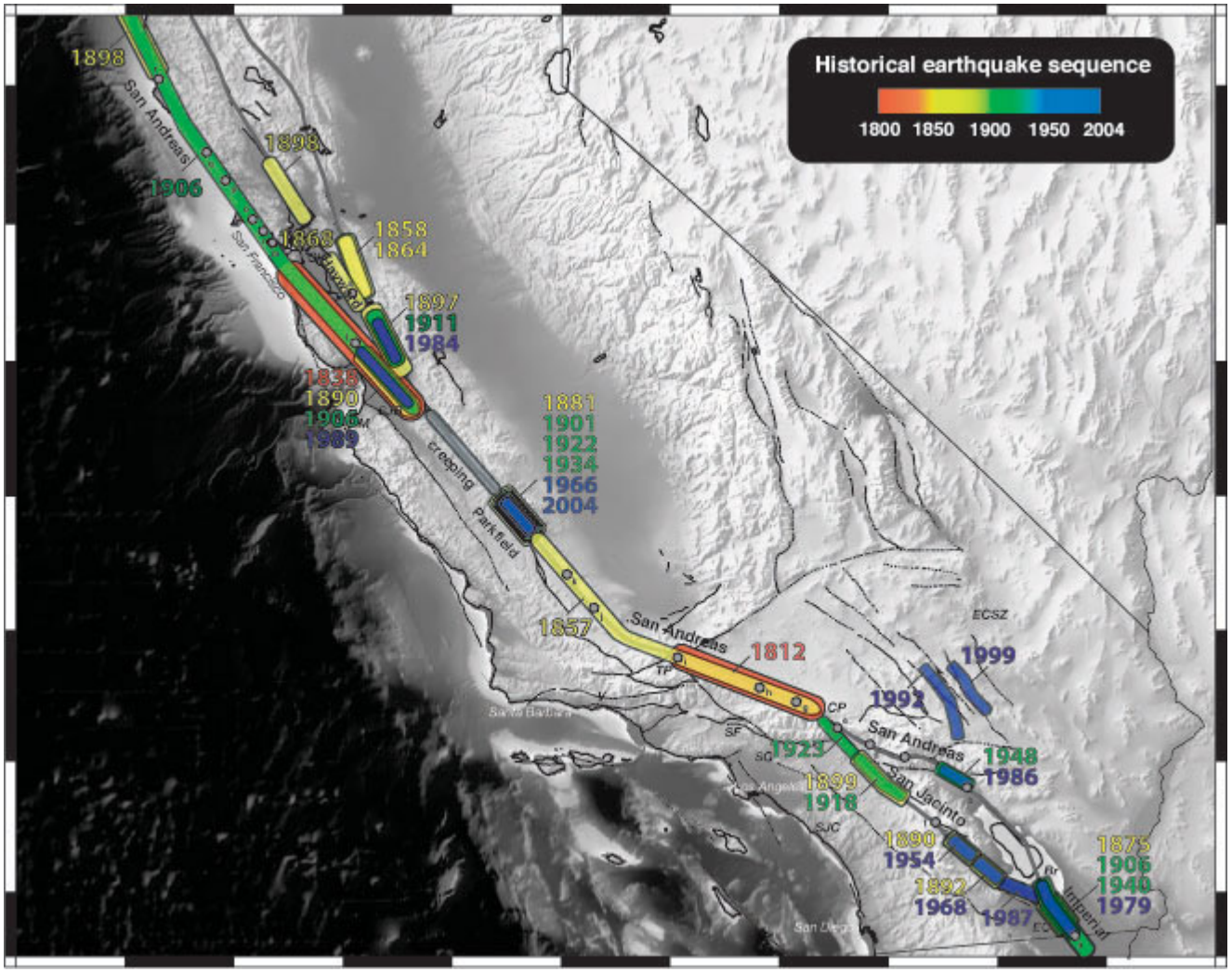


Some issues: Stress or stressing-rate? Joint inversions? Weighting?

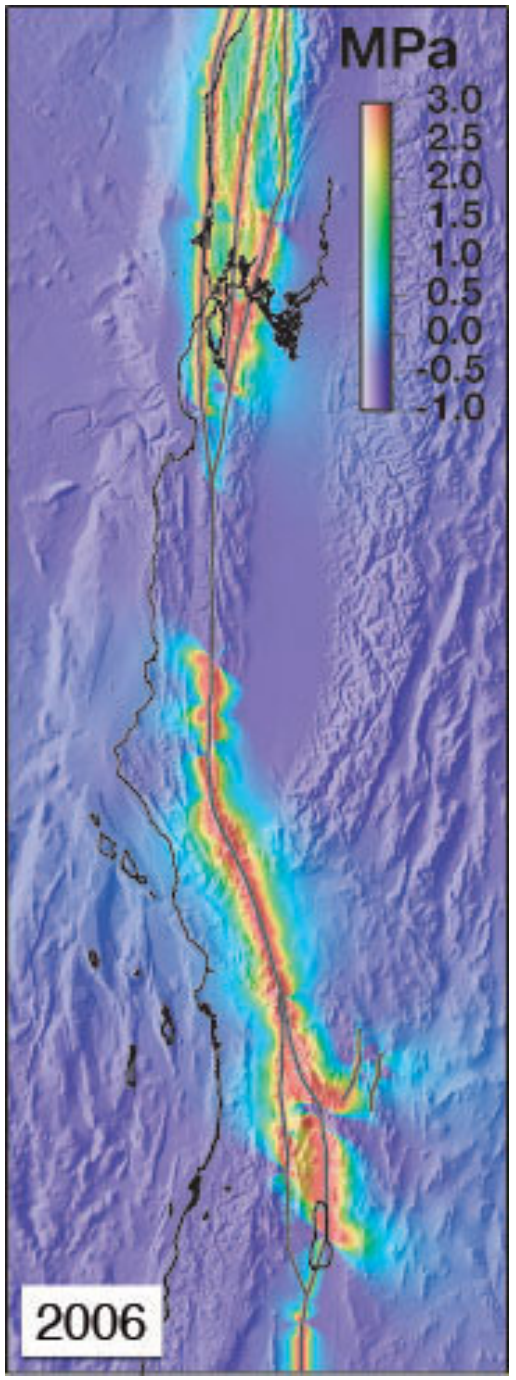


Becker et al. (2005)

Some problems: time

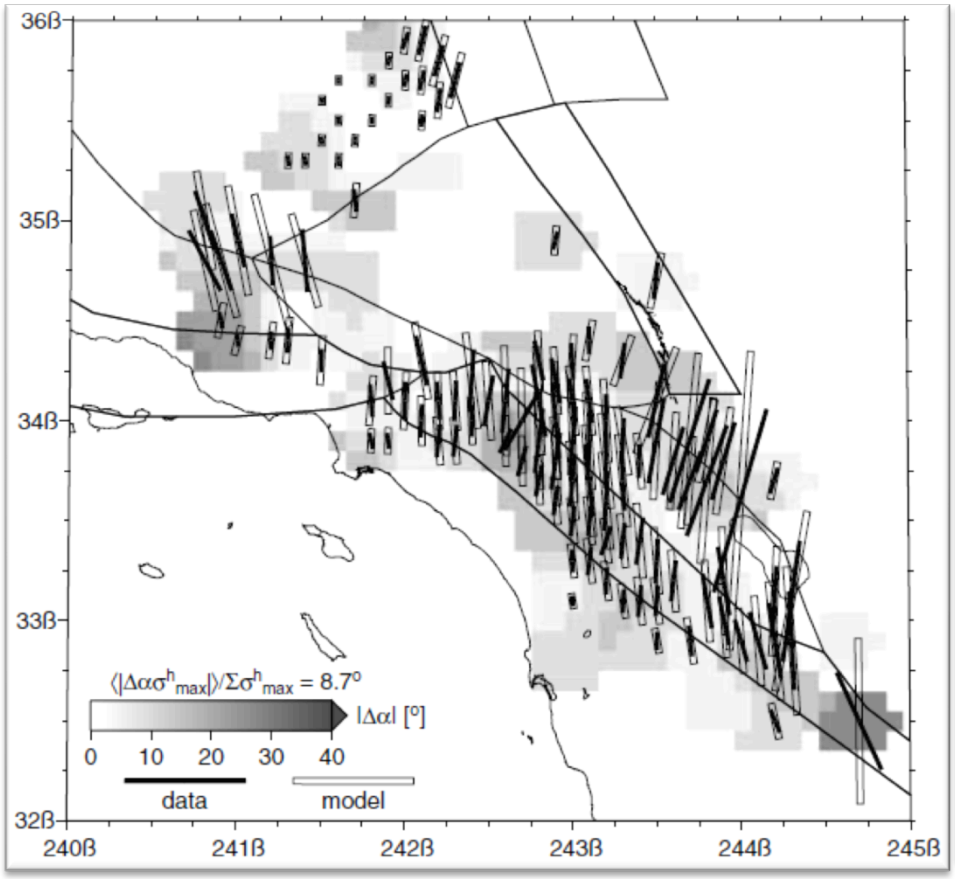


Smith-Konter and Sandwell (2009)

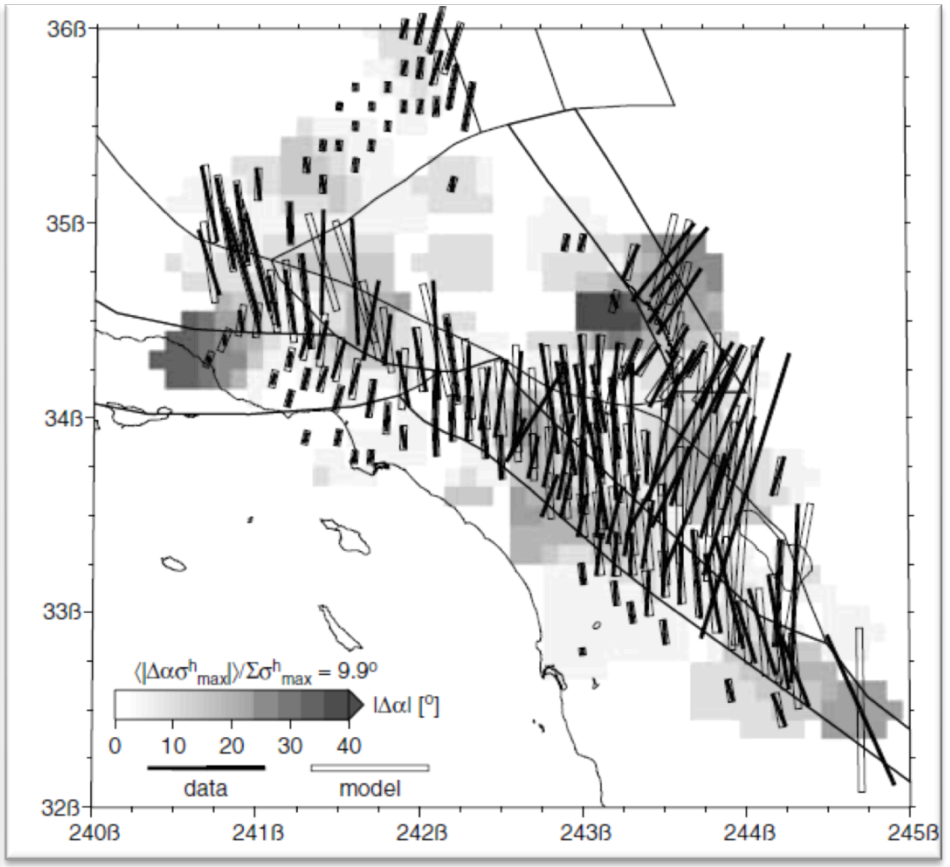


Some problems: time

Before Landers



After Landers

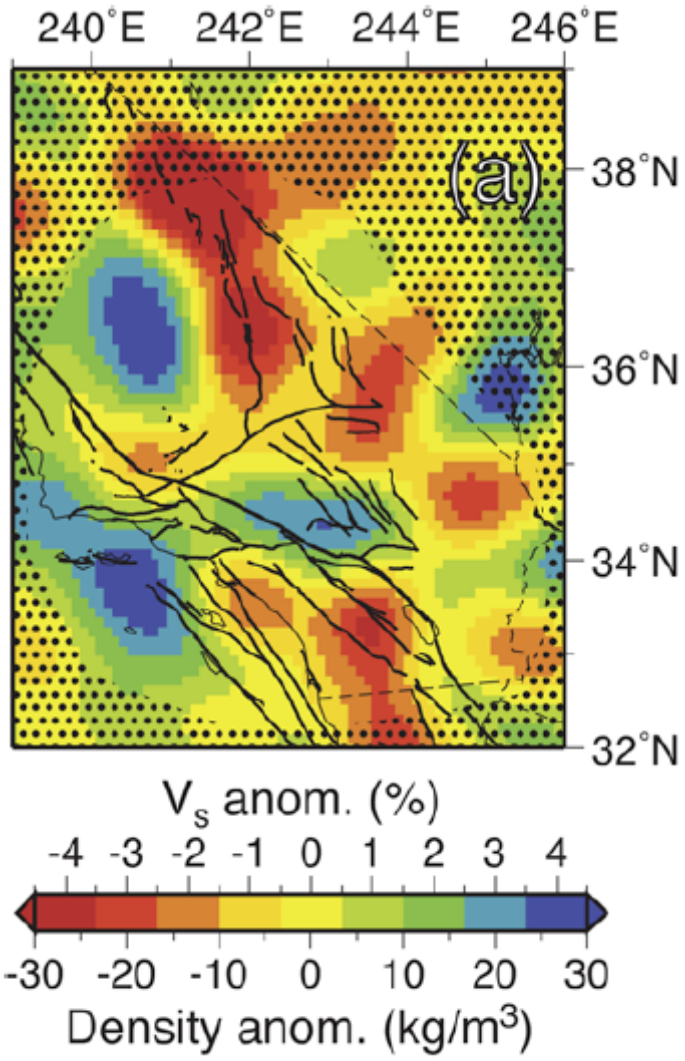


Comparison of focal mechanism based stress (boxes) and stressing-rate from block model (sticks) from joint inversion

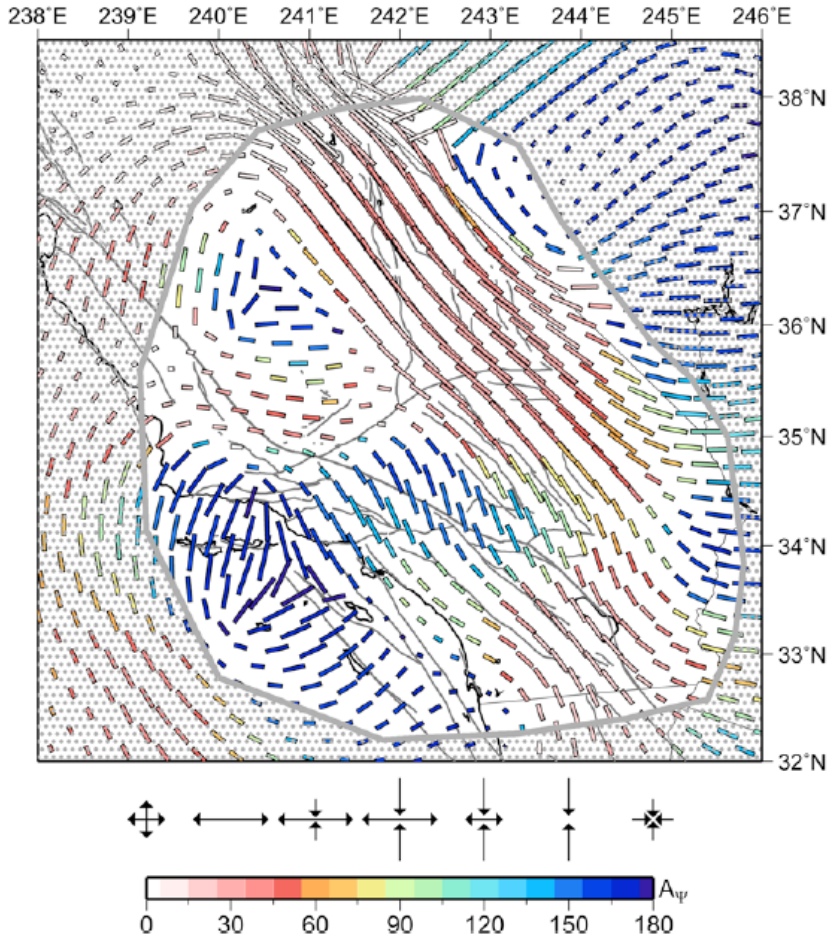
Becker et al. (2005)

Some problems: upper mantle flow?

Seismic tomography at
~100 km depth

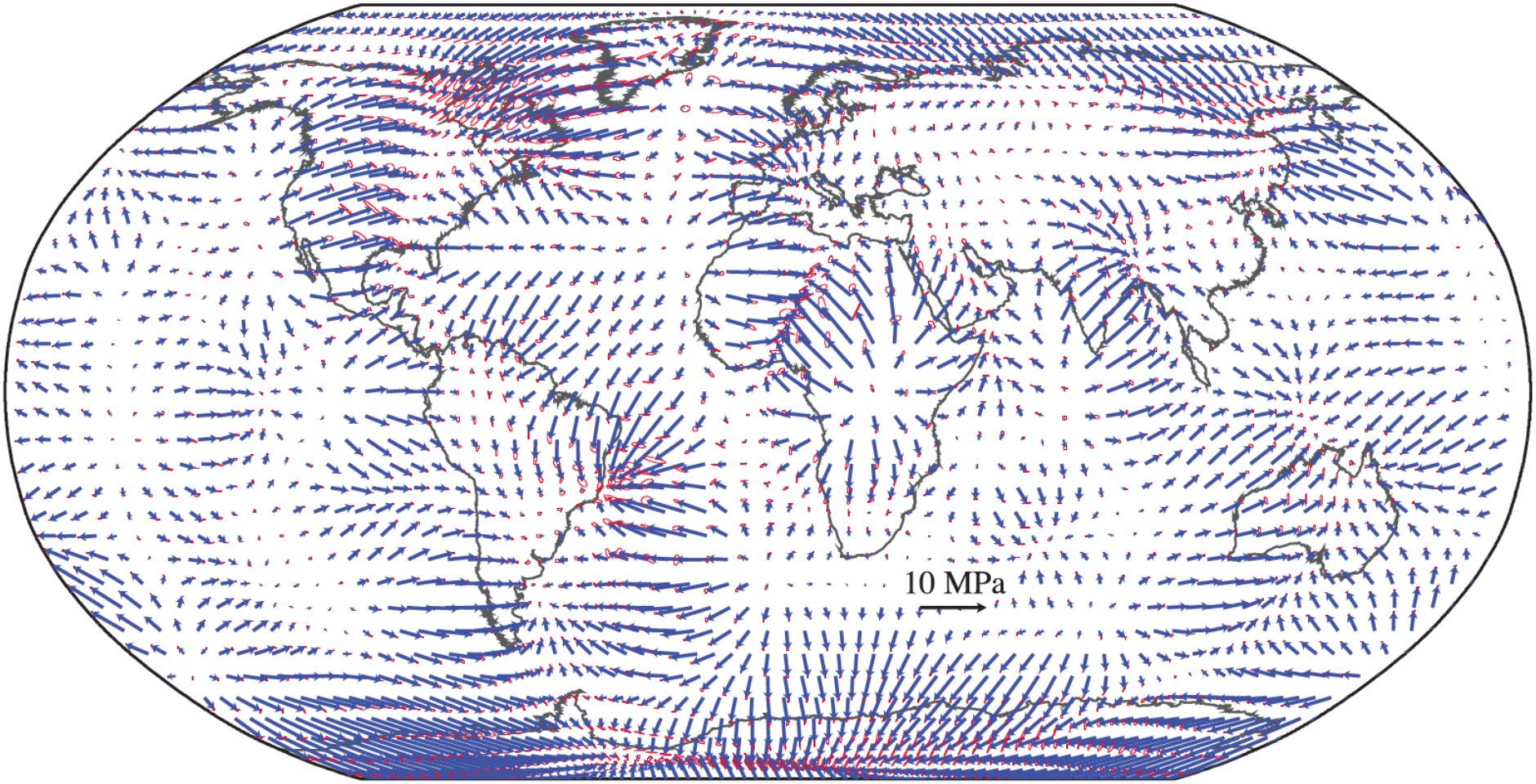


Predicted crustal stresses
(of order ~5 MPa)



Fay and Humphreys (2008)

Some issues: Global mantle flow
(see Bill's discussion)



Tractions at base of lithosphere imposed by mantle flow from *Ghosh and Holt* [2012]

Some broader problems:

- Physics-based stress and stressing rate models rely on assumptions about rheology, which is poorly known.

- Stress and stressing rate models are generally in good agreement in the upper crust where elastic and brittle deformation dominate.

- Models become more different near the base of the seismogenic zone. Much of this disagreement is due to differences in assumed fault locking depth – better understanding of the brittle-ductile transition and strain-localization is needed.

- Very poor agreement of models below seismogenic depths. Need better constraints from rheology and geodynamic modeling.

The journey is the goal

- Comparison of stress from stressing rate models as f(*z*) immediately leads to debate about strain localization
- Huge model differences in prediction of absolute stress level, fix with geology?
- In the end, debate more useful than a single "product"

Some of the next steps

- Expand the range of data for validation
- Base different stress models on same data and faults to get at method differences
- Provide uncertainties for models
- Allow/enhance multi-data inversions
- More geodynamic predictions
- Build a web site and modeling/testing environment

WEDNESDAY, May 29, 2013

08:00-09:00	*Breakfast*, served in Vallombrosa Dining Room	
09:00-09:15	Welcome and Introductions	Thorsten Becker
09:15-09:30	Overview of CSM Plans and Goals	Thorsten Becker
09:30-09:50	Review of Submitted CSM Models	Jeanne Hardebeck
09:50-10:10	Review of CSM Workshop 2 Model Comparisons	Jeanne Hardebeck
10:10-10:50	Discussion: Stressing Rate from UCERF3 Defomation Models	Liz Hearn, *moderator*
10:50-11:10	*Break*	
11:10-12:00	Discussion: Reconciling Deformation/Stressing Rate Models	David Sandwell, *moderator*
12:00-13:00	*Lunch*, served in Vallombrosa Dining Room	
13:00-13:50	Discussion: Bringing Geodynamic Models into CSM	Bill Holt, *moderator*
13:50-14:20	Discussion: Reconciling Stress Models	Jeanne Hardebeck, *moderator*
14:20-14:40	*Break*	
14:40-15:30	Discussion: Moving Forward - Models	Brad Aagaard, *moderator*
15:30-16:00	Plans for CSM Website	Thorsten Becker
16:00-18:00	*Free Time*	
18:00-19:00	*Dinner*, served in Vallombrosa Dining Room	

THURSDAY, May 30, 2013

08:00-09:00	*Breakfast*, served in Vallombrosa Dining Room	
09:30-10:45	Discussion: Existing Data and Data Needs	Egill Hauksson, *moderator*
09:50-10:40	Discussion: Validating CSM Models Against Data	Jeanne Hardebeck, *moderator*
10:40-11:00	*Break*	
11:00-11:50	Discussion: Moving Forward - Data and Validation	Brad Aagaard, *moderator*
11:50-12:00	Wrap-Up	