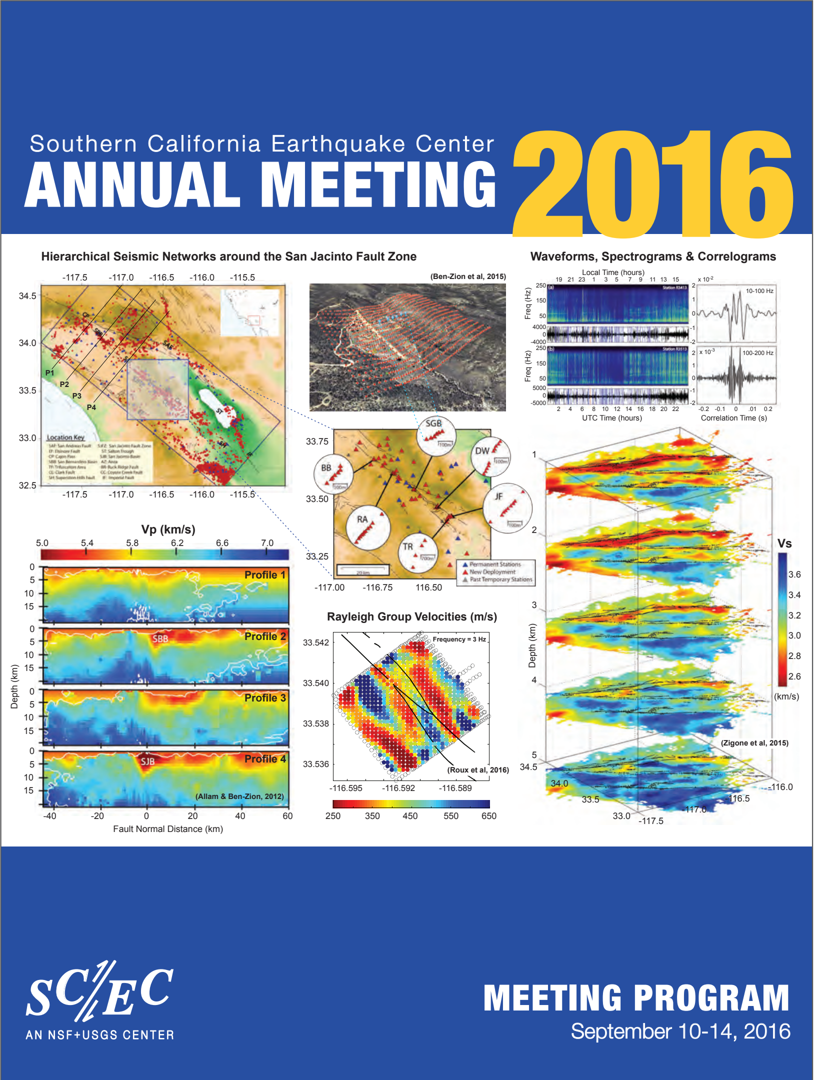
SCEC5 Science Planning; SCEC4 Science Accomplishments

Greg Beroza (Co-Director)

SC/EC
an NSF+USGS center



https://www.scec.org/meetings/2016/am

(draft Science Plan is available there)

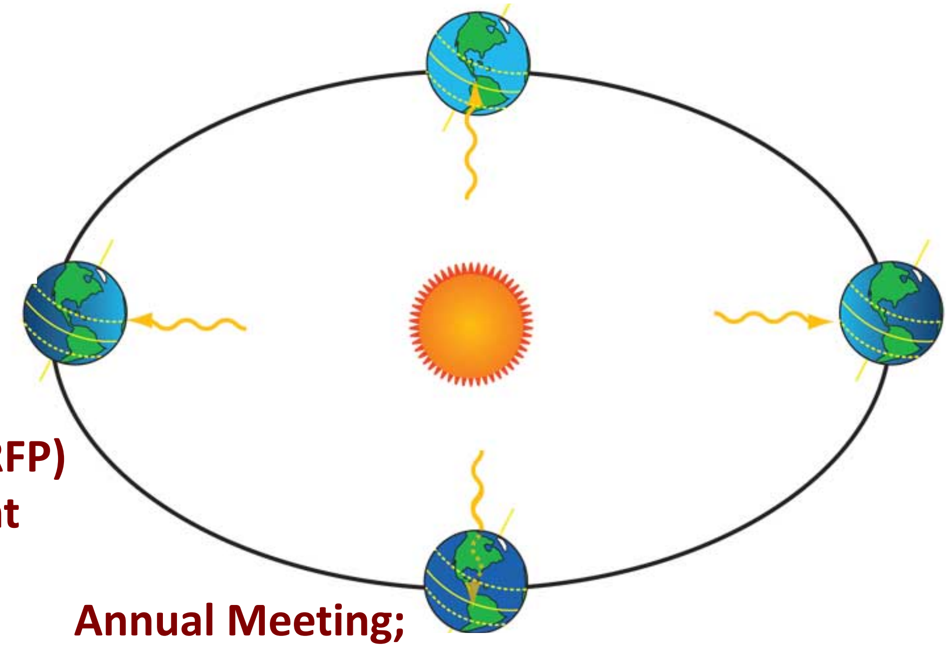
Goals of the meeting

- Wrap up SCEC4
- Get started on SCEC5
- Refine the Science Plan (RFP)

2-Hour Plenary Sessions
50/50 Talks/Discussion

Poster Sessions: dedicated time, up all meeting

The SCEC Planning Cycle



Leadership Retreat
(June)

Science Plan (RFP) Development
(Summer)

Annual Meeting; Science Plan Input
(September)

Modeling Fault Systems – Supercycles

(Moderators: Mike Oskin, Kate Scharer)

Tom F ... *ars of* ... *ult*

Moderators will both facilitate the discussion and capture salient points for potential improvements to the Science Plan

Dave Jackson *"The bridge from earthquake geology to earthquake seismology"* (30 minutes)

Open Discussion *What research do we undertake in SCEC5 to understand fault system behavior and its relationship to earthquake recurrence?* (60 minutes)

Modeling Fault Systems – Community Models

(Moderators: Brad Aagaard, Michele Cooke)

Liz Hearn *"How Sensitive are Inferred Stresses and Stressing Rates to Rheology? Clues from Southern California Deformation Models"*(30 minutes)

Karen Luttrell "*How stressed are we really? Harnessing community models to characterize the crustal stress field in Southern California*" (30 minutes)

Open Discussion *What research do we undertake in SCEC5 to advance our understanding of the state of stress?* (60 minutes)

Understanding Earthquake Processes

(Moderators: Nick Beeler, Nadia Lapusta)

Amanda Thomas *"Constraints on the Source Parameters of Low-Frequency Earthquakes in Parkfield and Cascadia"* (30 minutes)

Koji Okumura *"Kumamoto earthquake: a complex earthquake sequence with large strike-slip ruptures"* (30 minutes)

Open Discussion *What research do we undertake in SCEC5 to improve our understanding the full range of earthquake processes?* (60 minutes)

New Observations

(Moderators: Yehuda Ben-Zion, Gareth Funning)

Bill Hammond *“The Ups and Downs of Southern California: Mountain Building, Sea Level Rise, and Earthquake Potential from Geodetic Imaging of Vertical Crustal Motion”* (30 minutes)

Monica Kohler *“Offshore Pacific-North America lithospheric structure and Tohoku tsunami observations from a southern California ocean bottom seismometer experiment”* (30 minutes)

Open Discussion *What are key new observations, or observational capabilities to pursue in SCEC5?* (60 minutes)

Characterizing Earthquake Hazard - OEF
(Moderators: Ned Field, Max Werner)

Nick van der Elst *"Induced earthquake magnitudes are as large as (statistically) expected"* (30 minutes)

Matt Gerstenberger *"Blurring the boundary between earthquake forecasting and earthquake hazard"* (30 minutes)

Open Discussion *How do move forward in quantifying time-dependent earthquake probabilities in SCEC5?* (60 minutes)

Reducing Seismic Risk

(Moderators: Jack Baker, Christine Goulet)

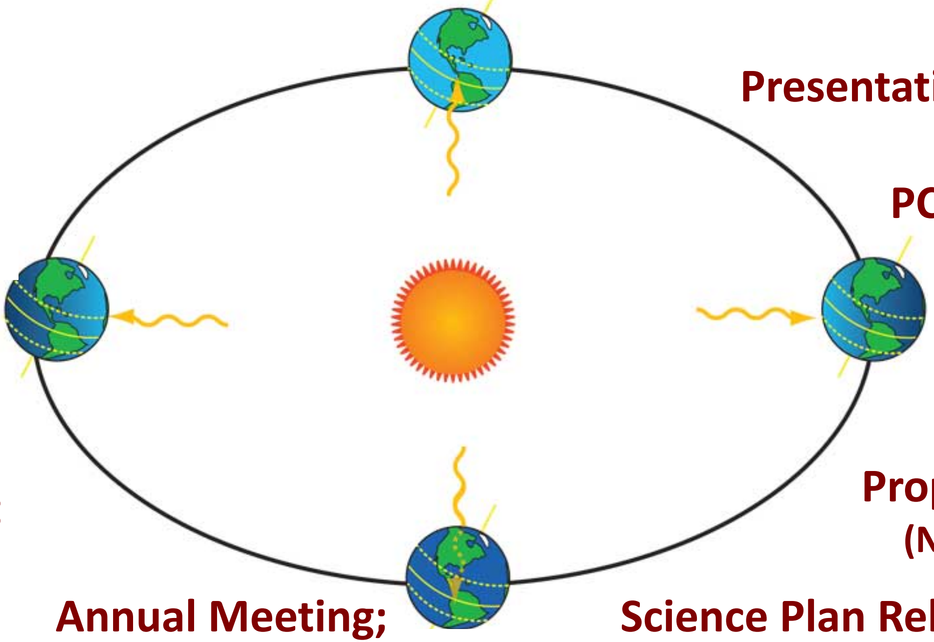
Greg ... *ear*

We will take a comprehensive last look at input into the Science Plan in a Wednesday morning plenary discussion.

C.B. C ... *tion Simulation (UGMS) Committee* (30 minutes)

Open Discussion *How can research during SCEC5 make a greater contribution to efforts to reduce seismic risk?* (60 minutes)

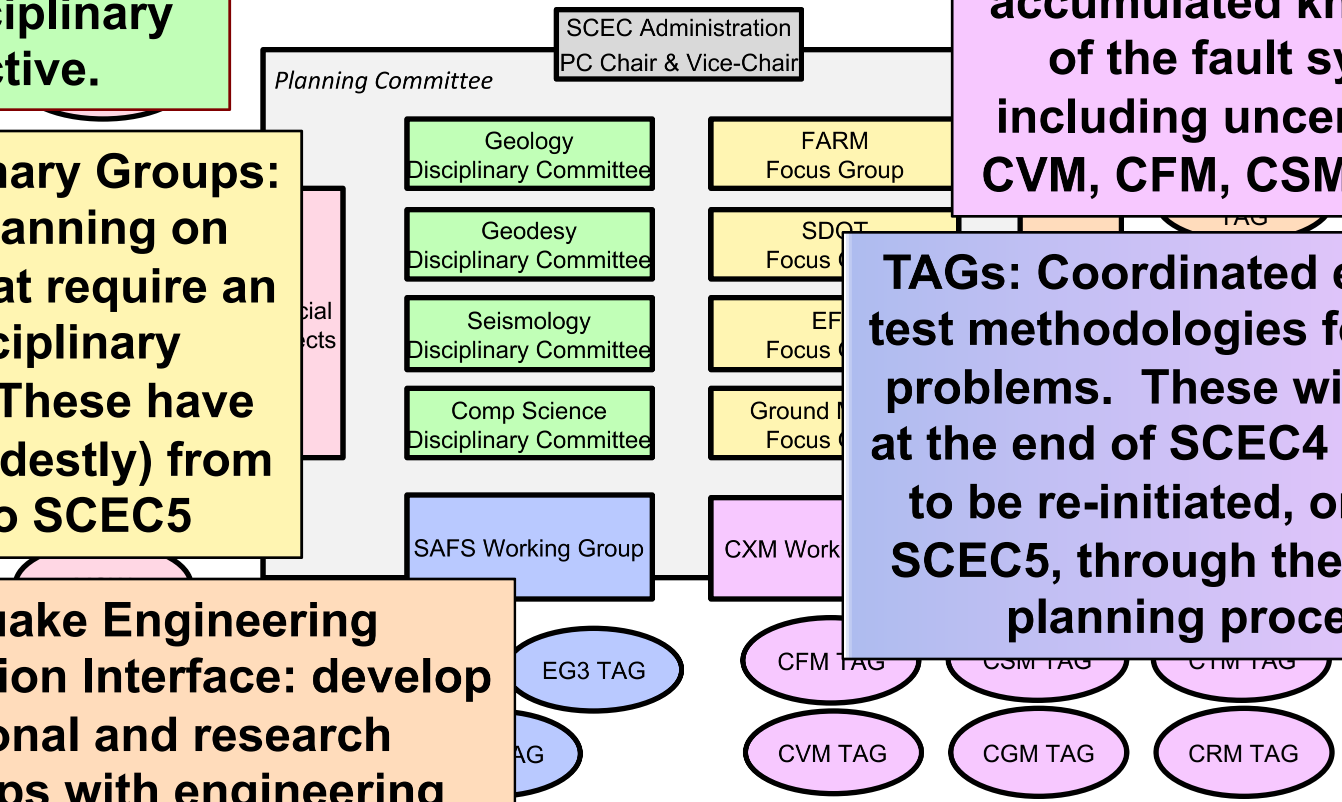
The SCEC Planning Cycle



SCEC5 Science Planning Organi

Disciplinary Groups: Science planning from a disciplinary perspective.

Community Models: systematically encode accumulated knowledge of the fault system, including uncertainties: CVM, CFM, CSM, CGM,…



Interdisciplinary Groups: Science planning on problems that require an interdisciplinary approach. These have evolved (modestly) from SCEC4 to SCEC5

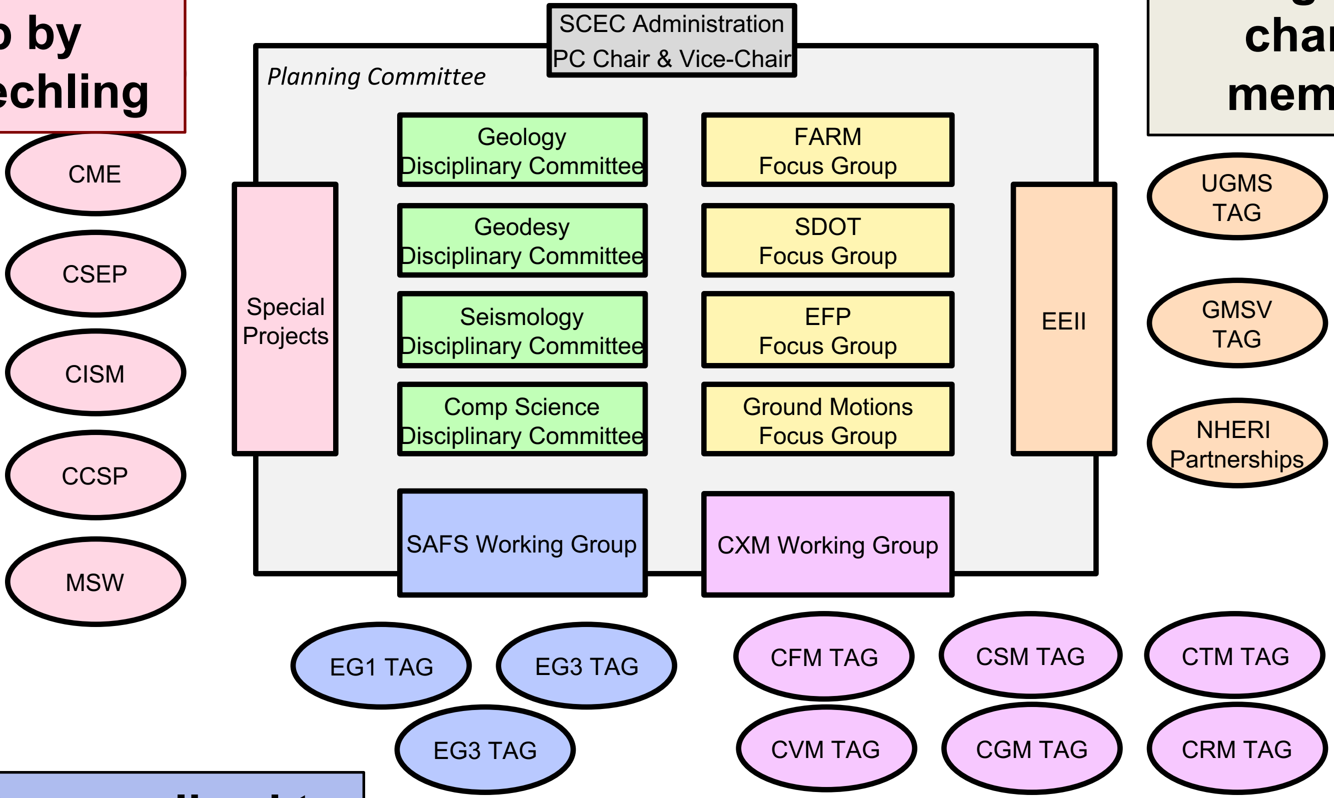
TAGs: Coordinated efforts to test methodologies for critical problems. These will sunset at the end of SCEC4 and need to be re-initiated, or not, in SCEC5, through the science planning process.

Earthquake Engineering Implementation Interface: develop educational and research partnerships with engineering community and beyond.

Special Projects no longer represented individually, rather as a group by Goulet & Maechling

SCEC5 Science Planning Organization

Net Result: smaller PC with significant changes in membership



SoSAFE/GMP generalized to SAFS/Ground Motions

USR re-envisioned to include all models under CXM

SCEC5 Planning Committee Membership

Geology Disciplinary Committee	Mike Oskin; Whitney Behr	FARM Focus Group	Nadia Lapusta*; Nick Beeler*
Geodesy Disciplinary Committee	David Sandwell; Gareth Funning	SDOT Focus Group	Kaj Johnson; Bridget Smith-Kontor*
Seismology Disciplinary Committee	Yehuda Ben-Zion*; Jamie Steidl*	EFP Focus Group	Max Werner; Ned Field
Comp Science Disciplinary Committee	Eric Dunham; Ricardo Taborda*	Ground Motions Focus Group	Eric Dunham; Ricardo Taborda*
CXM Working Group	Liz Hearn; Brad Aagaard	SAFS Working Group	Kate Scharer; Michele Cooke*
Special Projects	Christine Goulet; Phil Maechling	EEII	Jack Baker, Jonathan Stewart*

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Jacobo Bie
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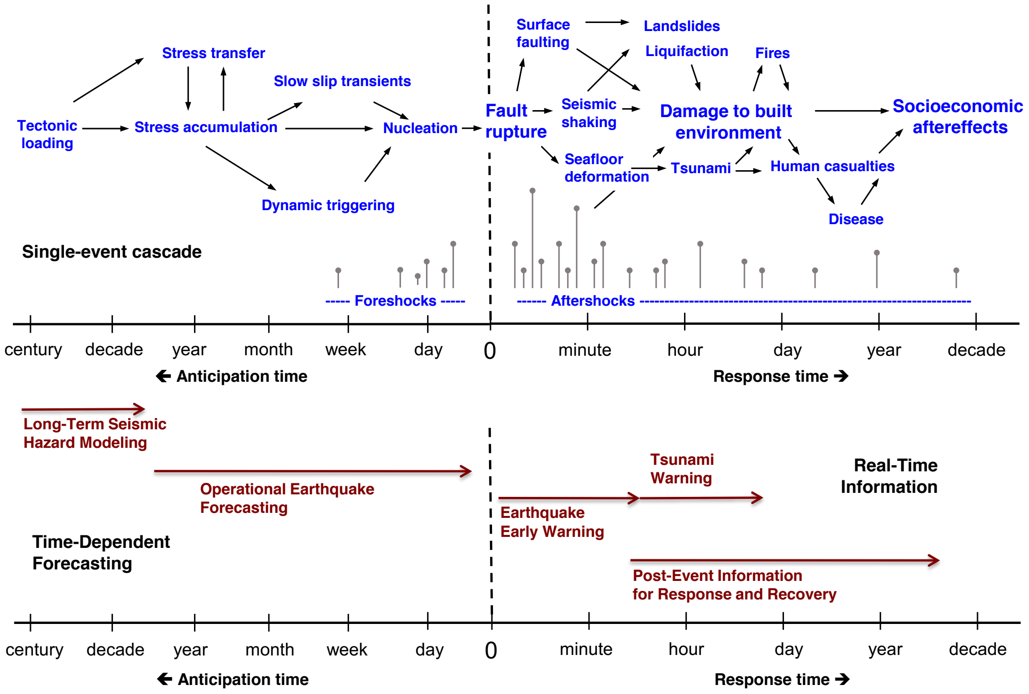
Tracking Earthquake Cascades

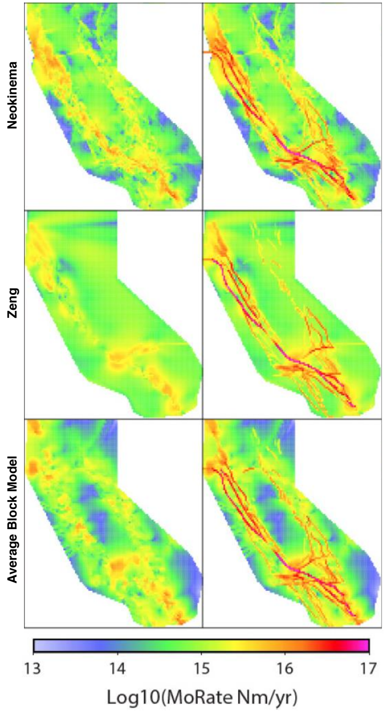


Box 2.1. Fundamental Problems of Earthquake Science

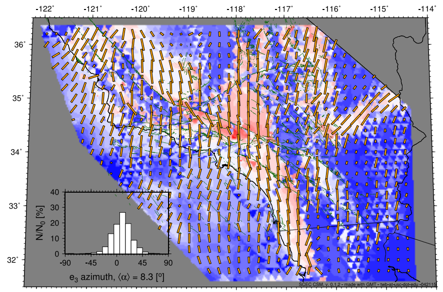
1. Stress transfer from plate motion to crustal faults: long-term fault slip rates
2. Stress-modulated fault interactions and earthquake clustering: evaluation of mechanisms
3. Evolution of fault resistance during seismic slip: scale-appropriate laws for rupture modeling
4. Structure and evolution of fault zones and systems: relation to earthquake physics
5. Causes and effects of transient deformations: slow slip events and tectonic tremor
6. Seismic wave generation and scattering: prediction of strong ground motion

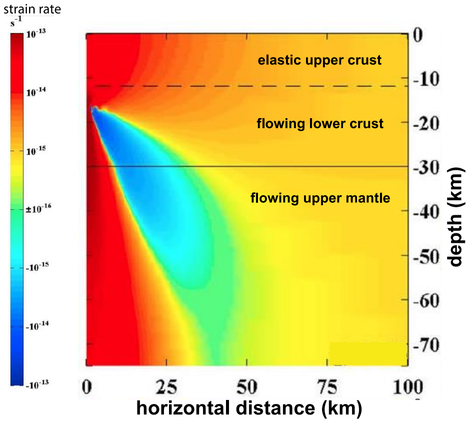
1. Stress Transfer from Plate Motion to Crustal Faults

UCERF3 Deformation Models: off fault vs. total (*Field et al.*)



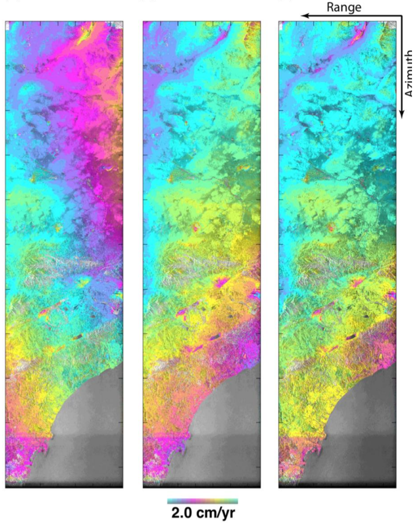
Shells Stress Model (*Bird*)





Combine GPS & InSAR in a Community Geodetic Model

Liu and Shen



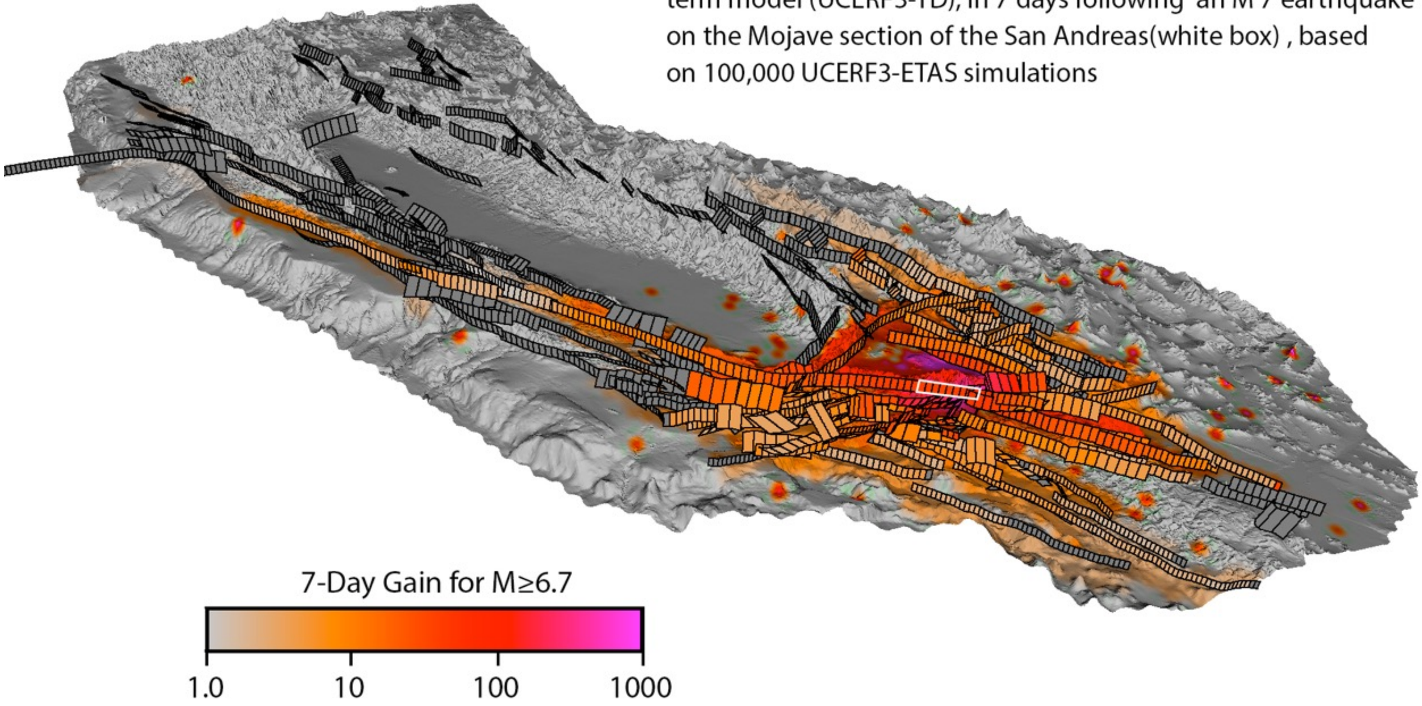
Earthquake Cycle Deformation Model

Takeuchi and Fialko

poster 298

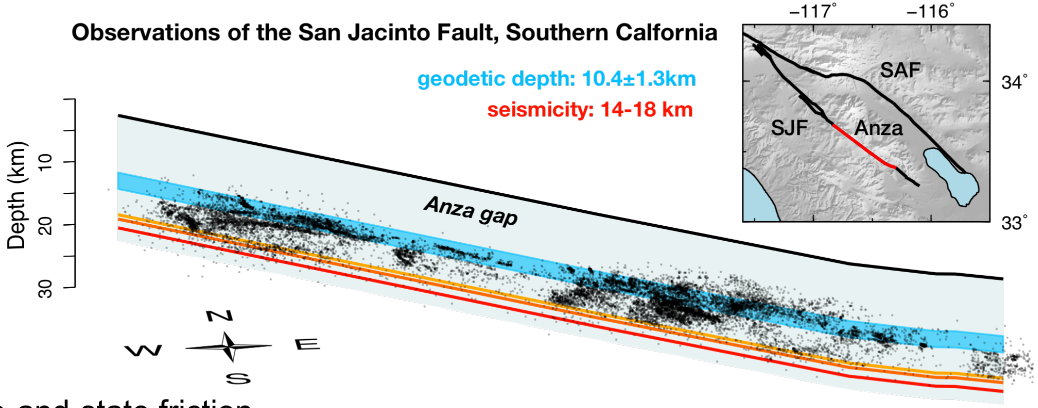
UCERF3-ETAS

Increased M≥6.7 earthquake likelihoods (gain), relative to long-term model (UCERF3-TD), in 7 days following an M 7 earthquake on the Mojave section of the San Andreas(white box) , based on 100,000 UCERF3-ETAS simulations

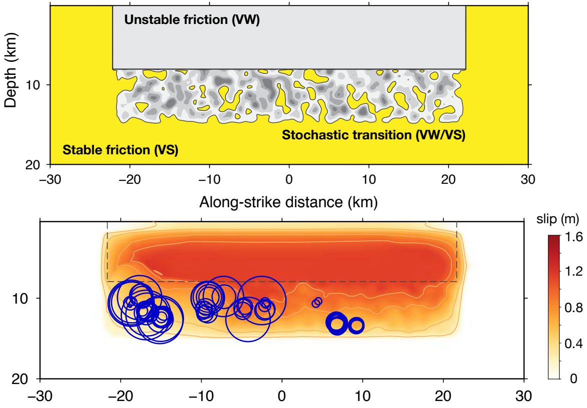


Reconciling seismicity and geodetic locking depths on the Anza segment of the San Jacinto Fault

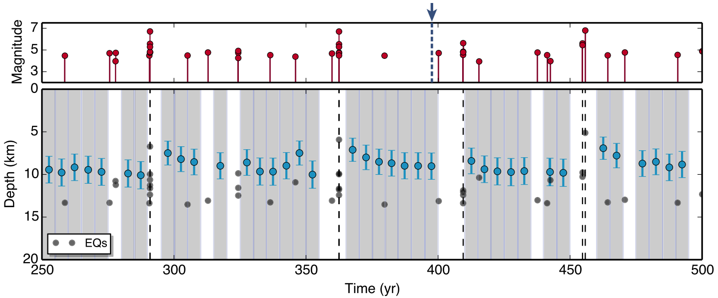
Jiang and Fialko (submitted)
Poster 066



- Models of faults obeying rate-and-state friction
- Stochastic heterogeneity in frictional properties

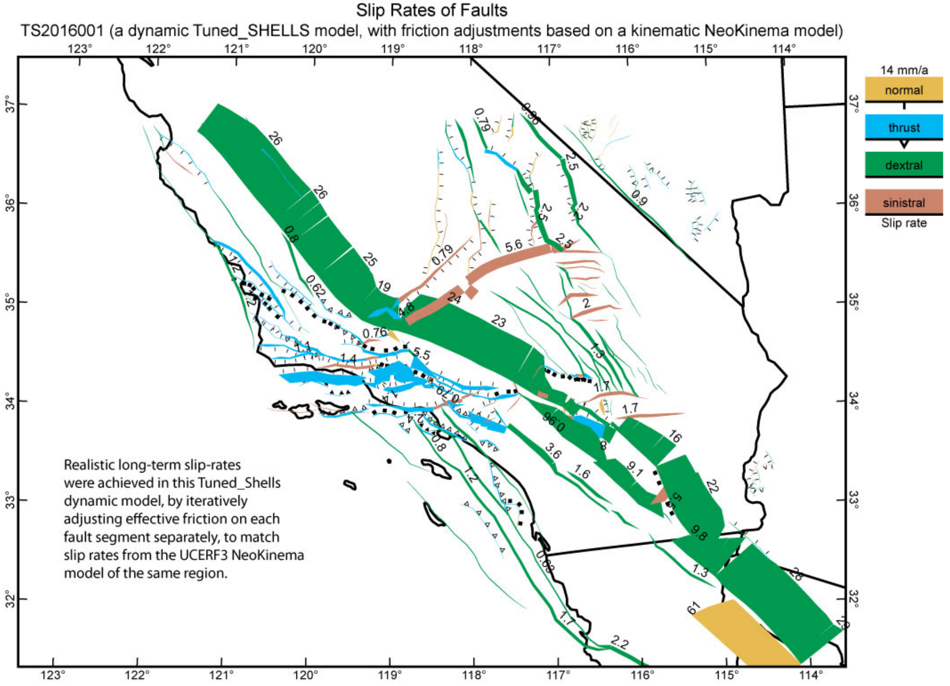


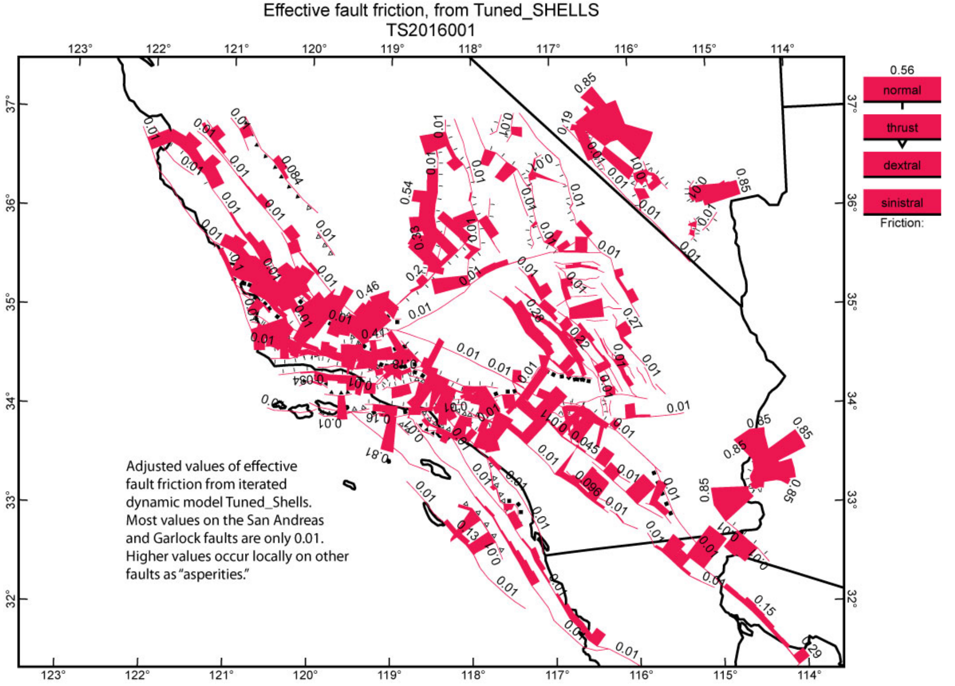
- Explanation for seismicity below the nominal locking depth – reconciles geodetic-seismic discrepancy.
- Consistent with relative scarcity of repeating events
- Implications for system-size ruptures and interseismic transients



Strength of Faults in Southern California

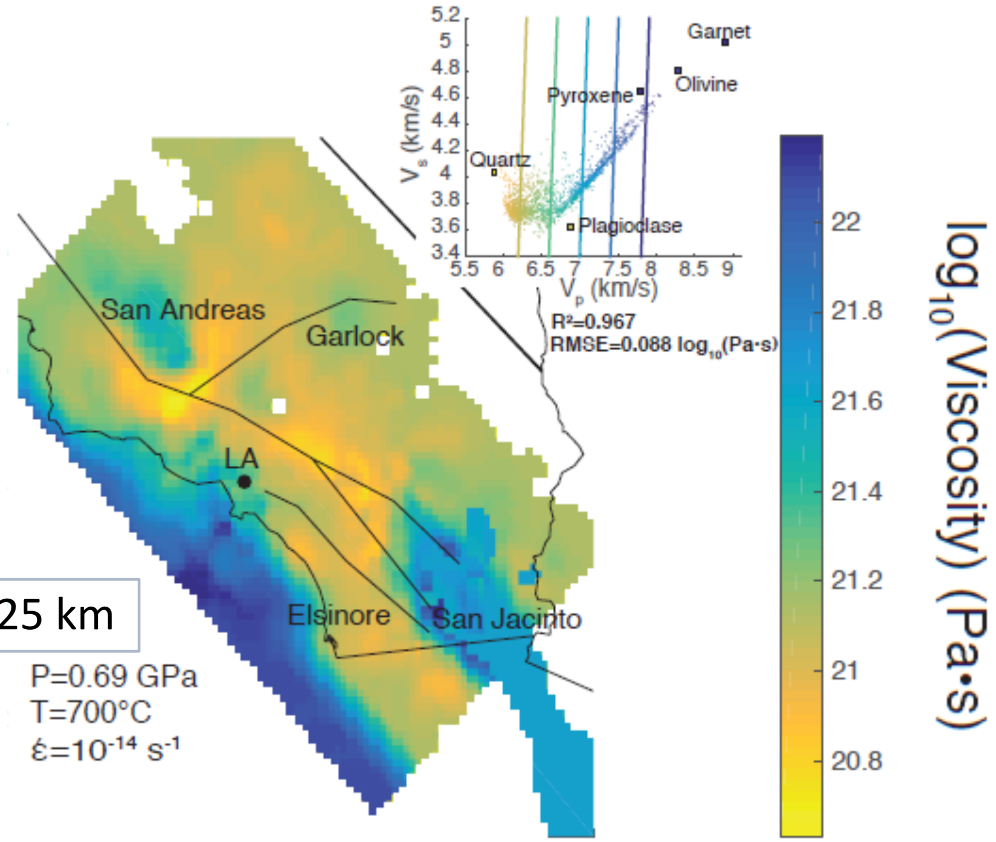
Chris Johnson and Roland Burgmann (UC Berkeley)





Adjusted effective friction incrementally from Shells model (Bird) on 1000 fault elements based on slip-rate error. Most elements move to very low friction. One interpretation is that most active fault surface experiences near-total stress-drop in large earthquakes.

Inferring Crustal Viscosity Structure from the CVM



Viscosity at 25 km

Equilibrium assemblages and seismic velocities for global compilation of lower crustal rocks (Hacker et al., 2015)

Use Huet et al. (2014) mixing model and single-phase flow laws to calculate bulk viscosity for predicted assemblages.

Estimate viscosity by fitting to CVM.

Shinevar, Behn, Hirth & Jagoutz
Poster 339

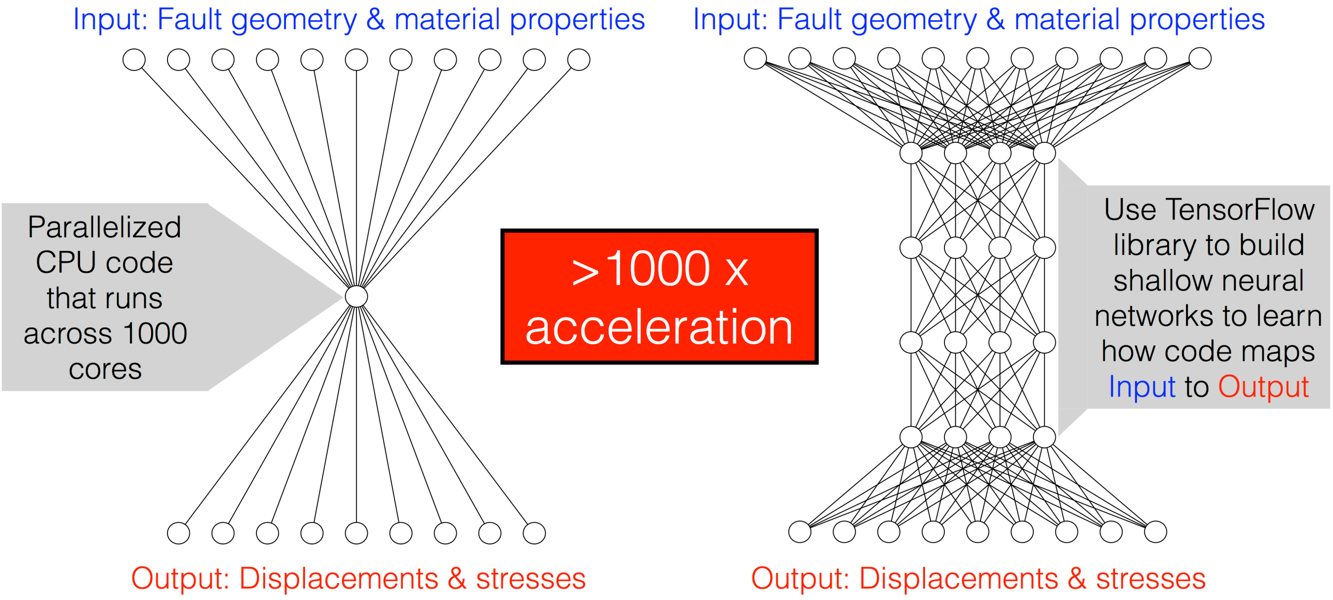
Approximating Physical Modeling using Machine Learning

Poster #18

Accelerating Viscoelastic Models via Neural Networks

{phoeberobinson, tthompson, meade}@fas.harvard.edu

Code is written in terms of physics but simpler computational representations often exist and we use neural networks to learn compact forms



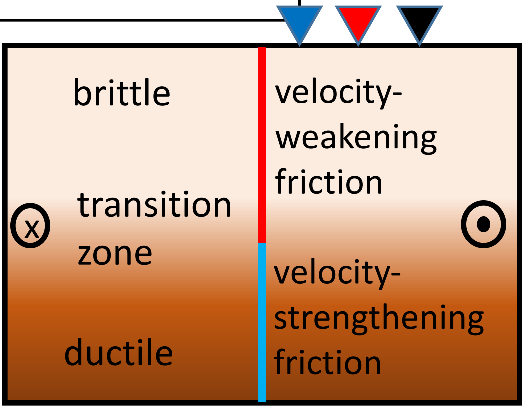
Earthquake cycle simulations with friction and viscoelasticity

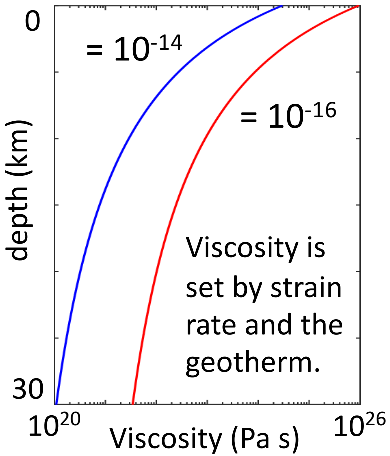
Poster #321

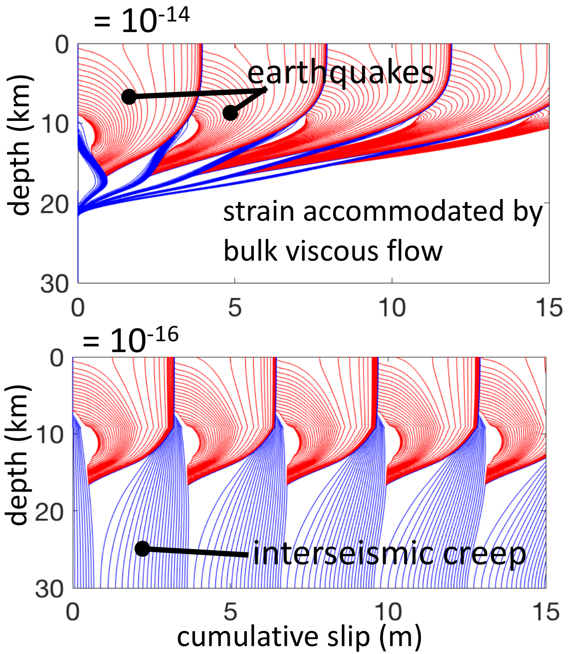
What determines the depth extent of ruptures?

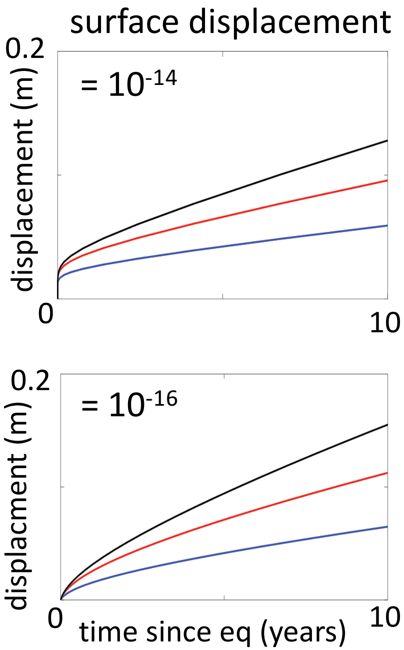
Kali Allison and Eric Dunham
Stanford University

We use earthquake cycle simulations in a viscoelastic medium to investigate the nature of the brittle-ductile transition and the interplay between distributed viscous flow and fault slip. Examples below are for linear Maxwell model, but our code handles power-law rheologies as well.







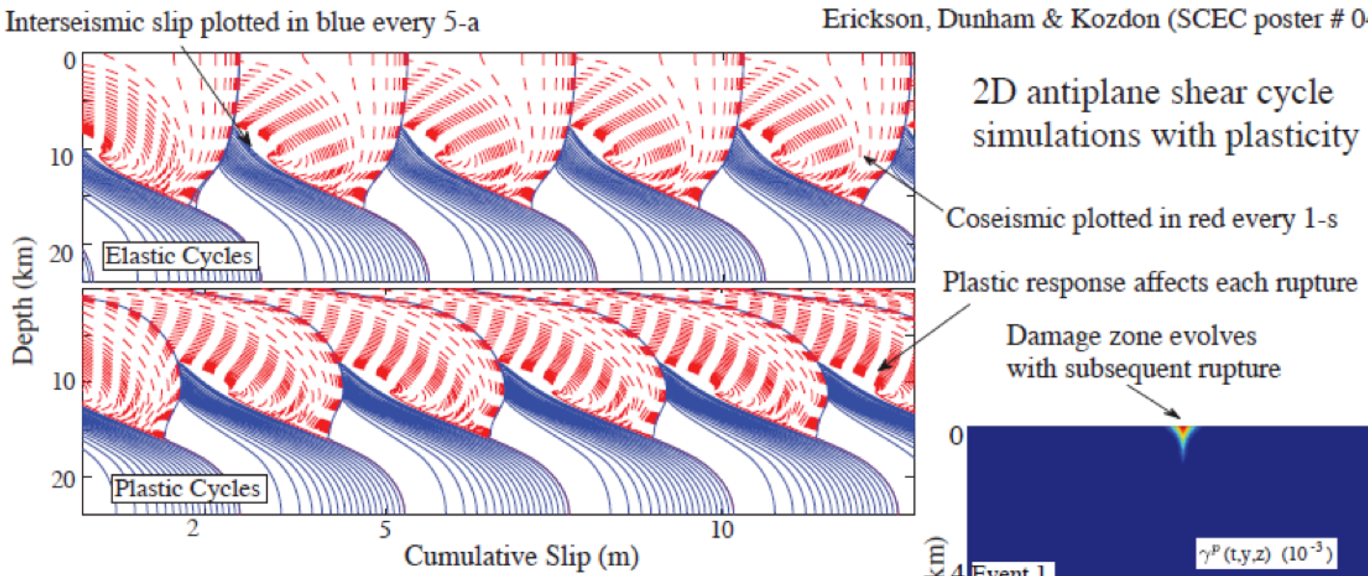


produced primarily by viscous flow

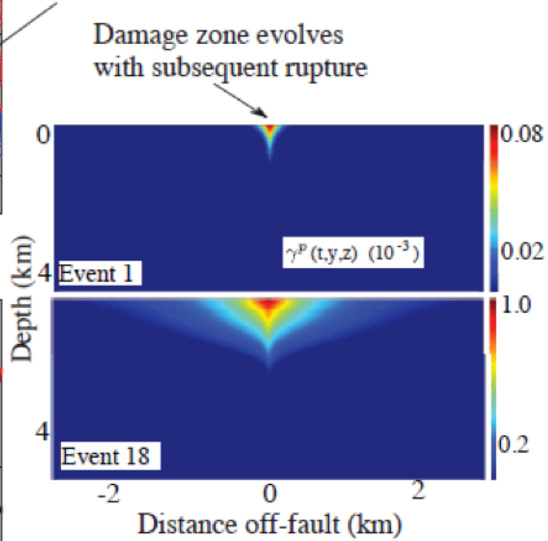
produced by afterslip

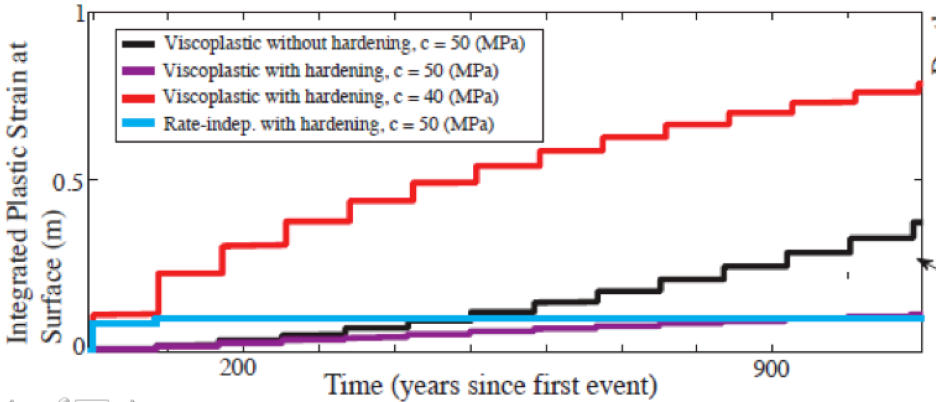
Plasticity Throughout the Earthquake Cycle

Erickson, Dunham & Kozdon (SCEC poster # 045)



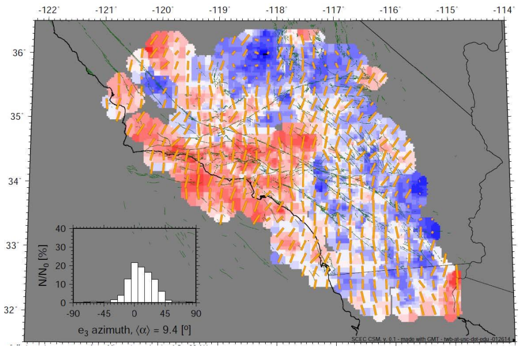
2D antiplane shear cycle simulations with plasticity



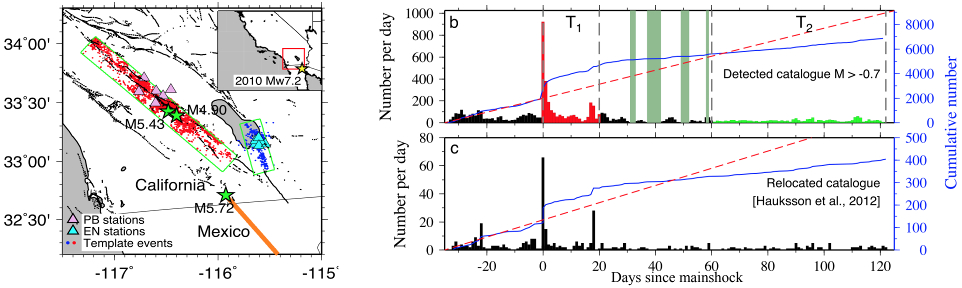


2. Stress-Mediated Fault Interactions

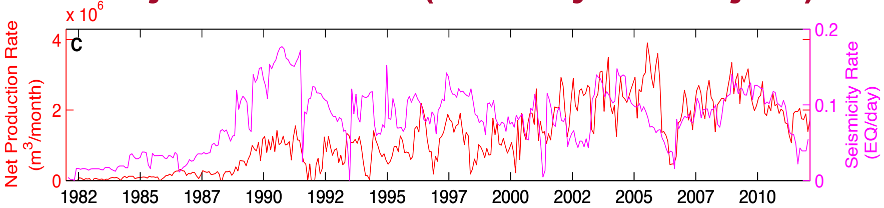
Community Stress Model (*Yang and Hauksson*)



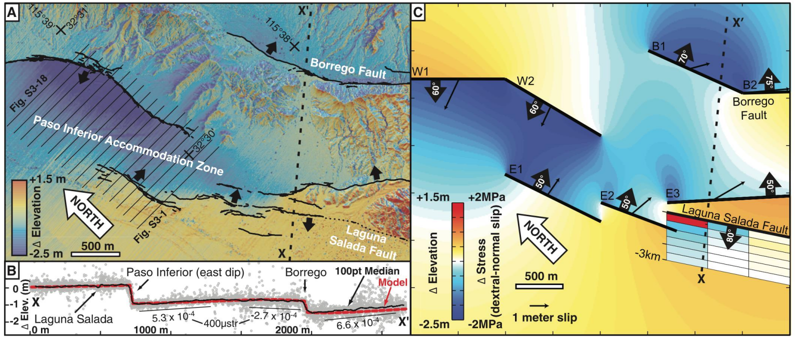
Static and Dynamic Triggering (*Meng and Peng*)



Net Injection and IS (*Brodsky and Lajoie*)



Differential LiDAR and Stress (*Oskin et al.*)



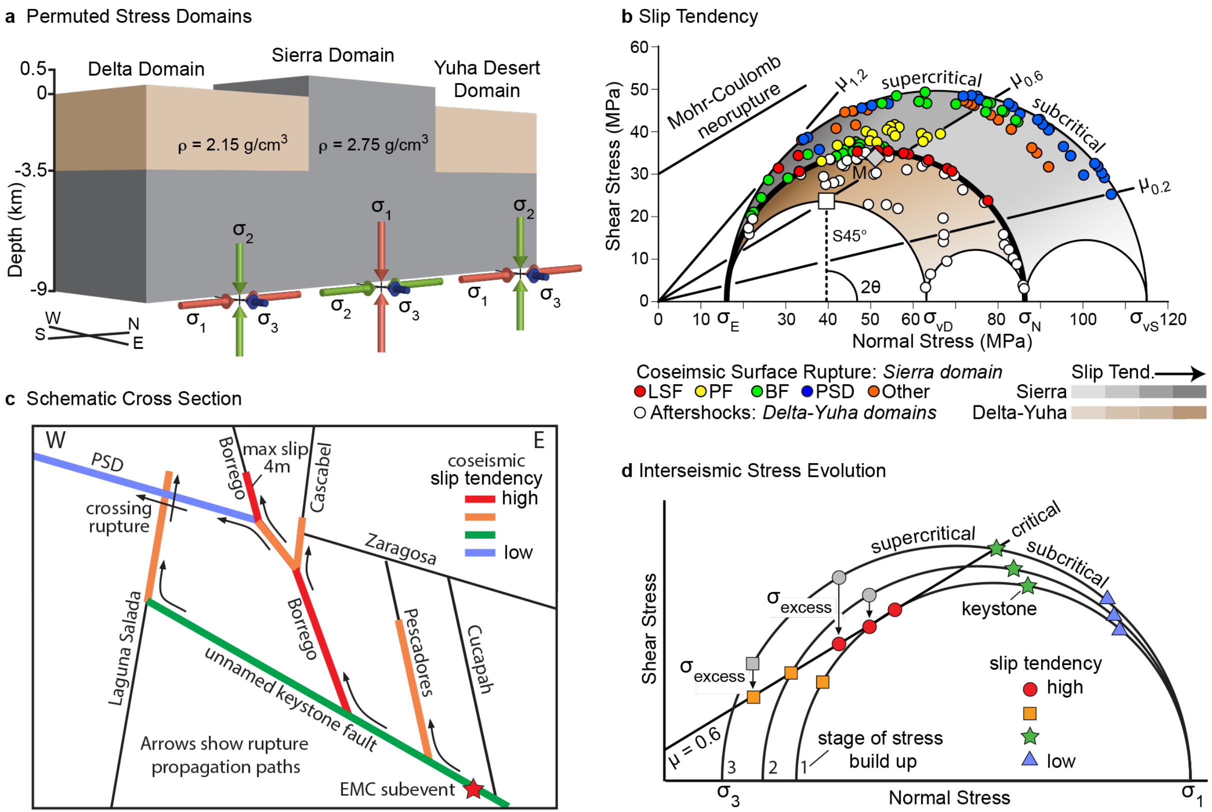
SCEC

Southern California Earthquake Center

Mechanics of Multifault Ruptures

A) Regional permuted stress allows the calculation of absolute stress at seismogenic depths.

B) Apparent friction of progenitor fault agrees with experimental data, but other faults greatly exceed known strength limits.

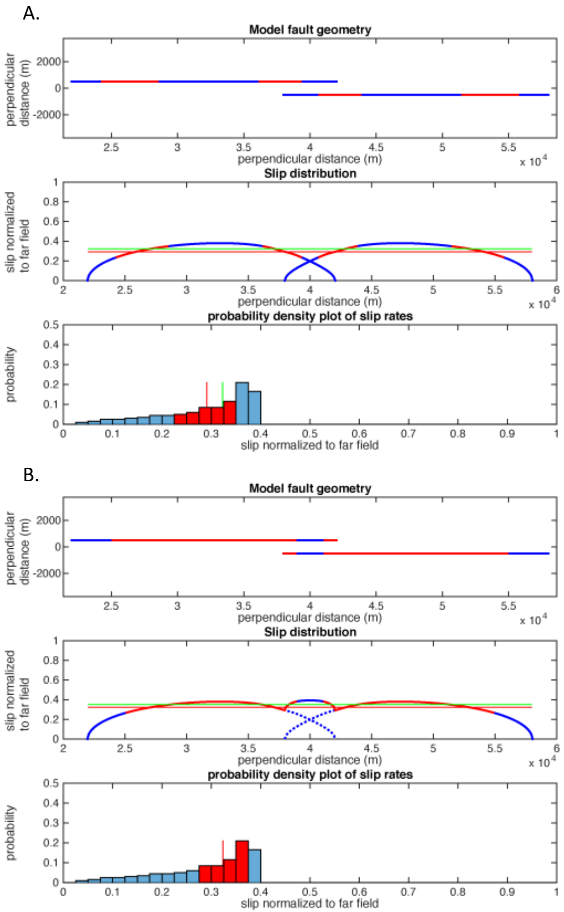


C) As regional stress builds, slip on optimally oriented faults is regulated by pinning intersections with a misoriented keystone fault.

D) Static failure of keystone fault spontaneously spreads to other faults that had reached critical loading earlier in the interseismic cycle.

Fletcher, Oskin and Teran, 2016, Nature Geoscience

Models of idealized fault systems reveal how step geometry can affect the distribution of slip

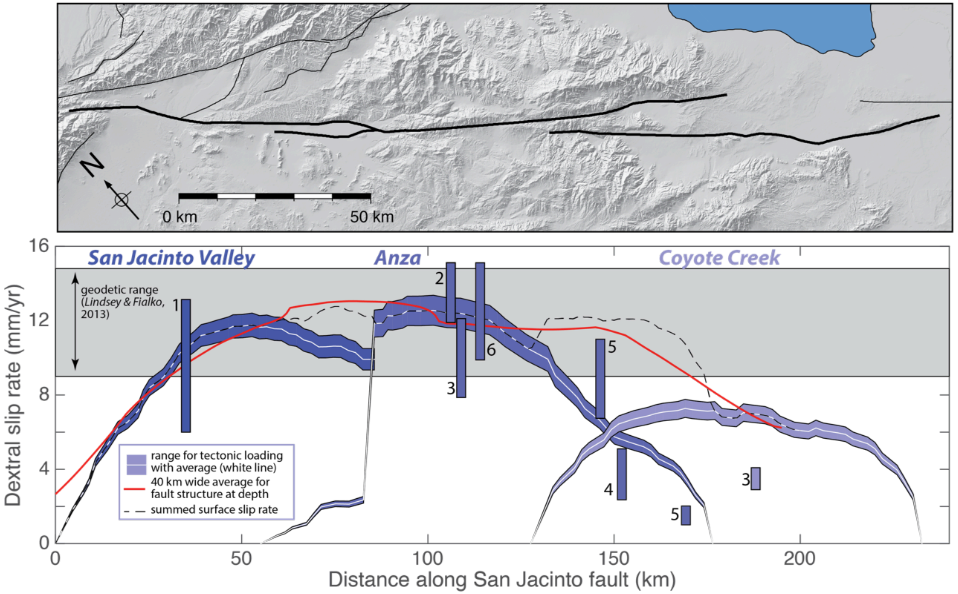


- Numerical models of extensional stepovers indicate random geologic sampling is unlikely to yield representative slip rates (red regions/values, top)

- Summing slip rates on overlapping segments significantly improves the likelihood of obtaining representative rates (bottom)

Resor, Cooke, Marshall, and Madden
Poster 15

A model of the San Jacinto fault illustrates how geometry impacts slip rate along a real fault system



Resor, Cooke, Marshall, and Madden
Poster 15

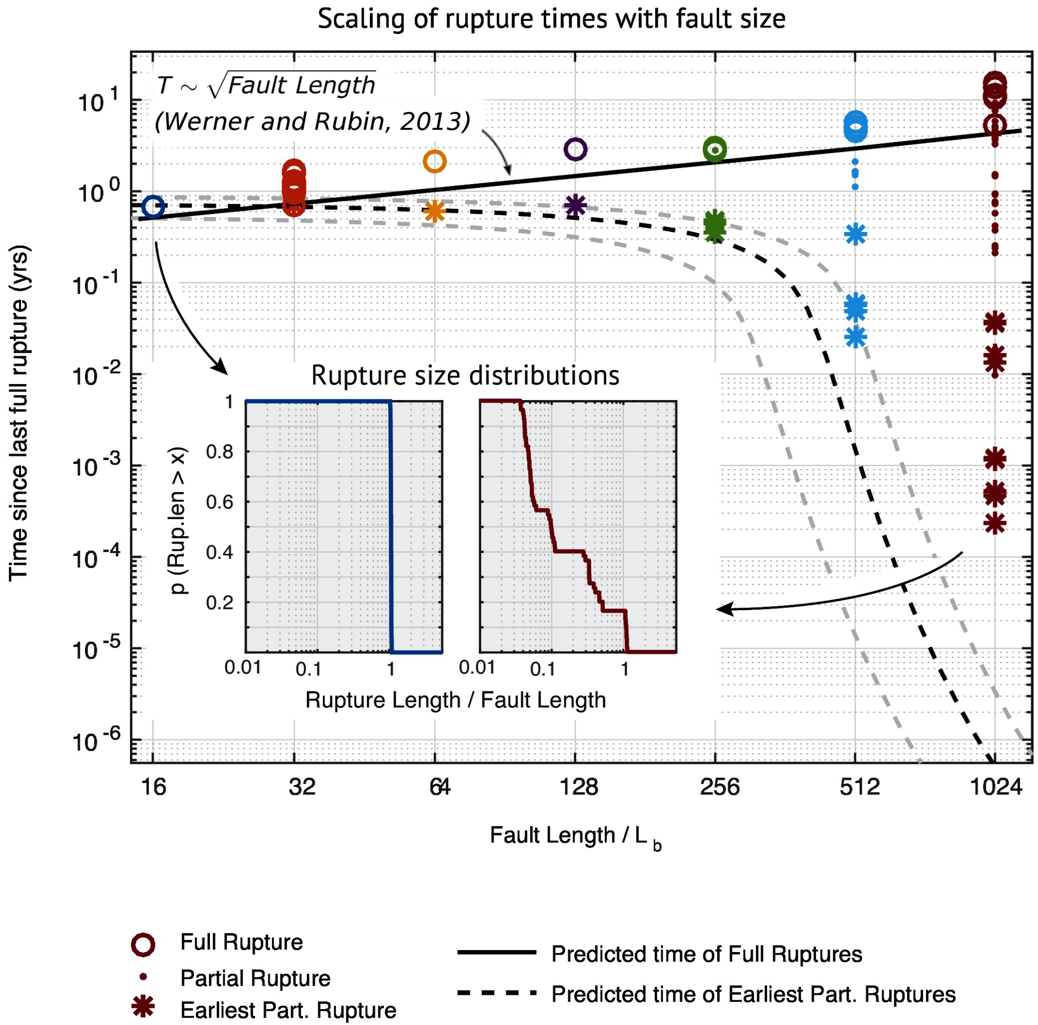
- The location of geologic slip rate studies may govern their suitability for hazard estimates
- Models can be used to put point measurements of slip into the context of slip distribution throughout a fault system
- Summing of model slip rates across overlapping segments yields values that are more similar to geodetic slip rate estimates.

Poster #44

Effect of fault size on recurrence intervals and size distribution of events in simple fault models

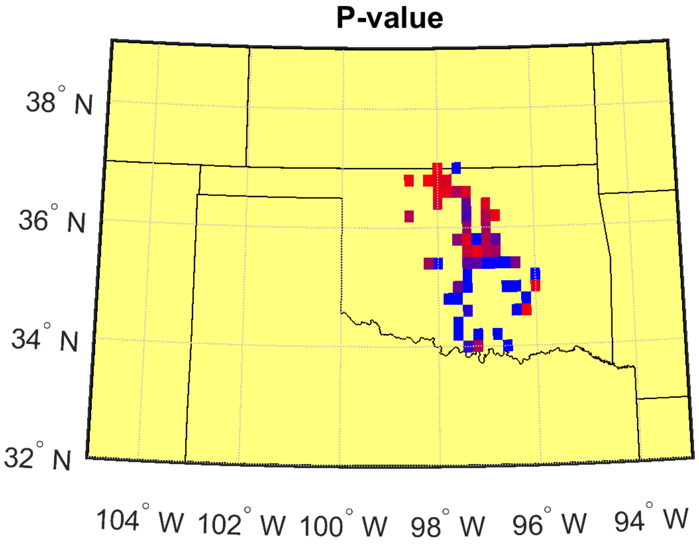
Camilla Cattania and Paul Segall

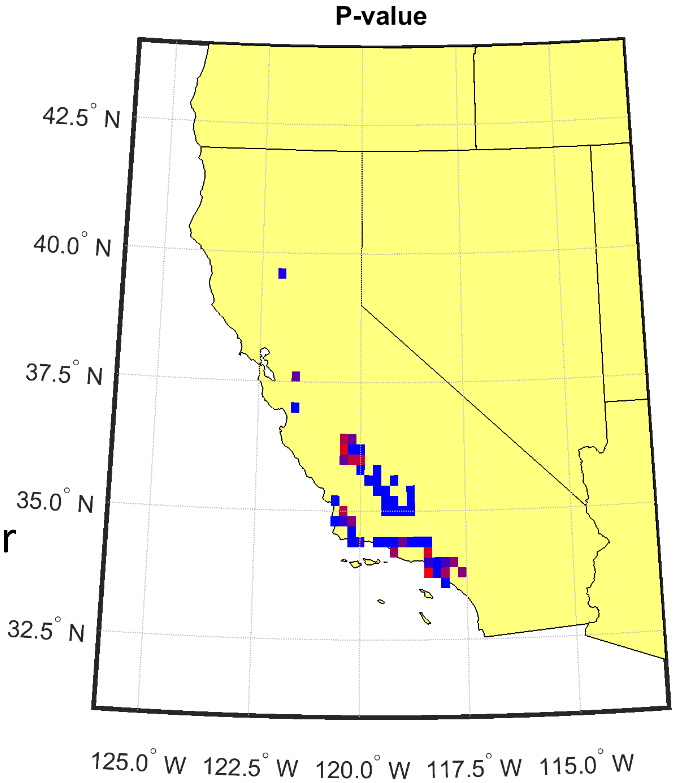
Recurrence variability is greater for longer faults and results from interaction between time to accumulate strain for full ruptures, and time to trigger partial ruptures due to penetration of creep.



Identifying Potentially Induced Seismicity

(McClure et al., 2016)



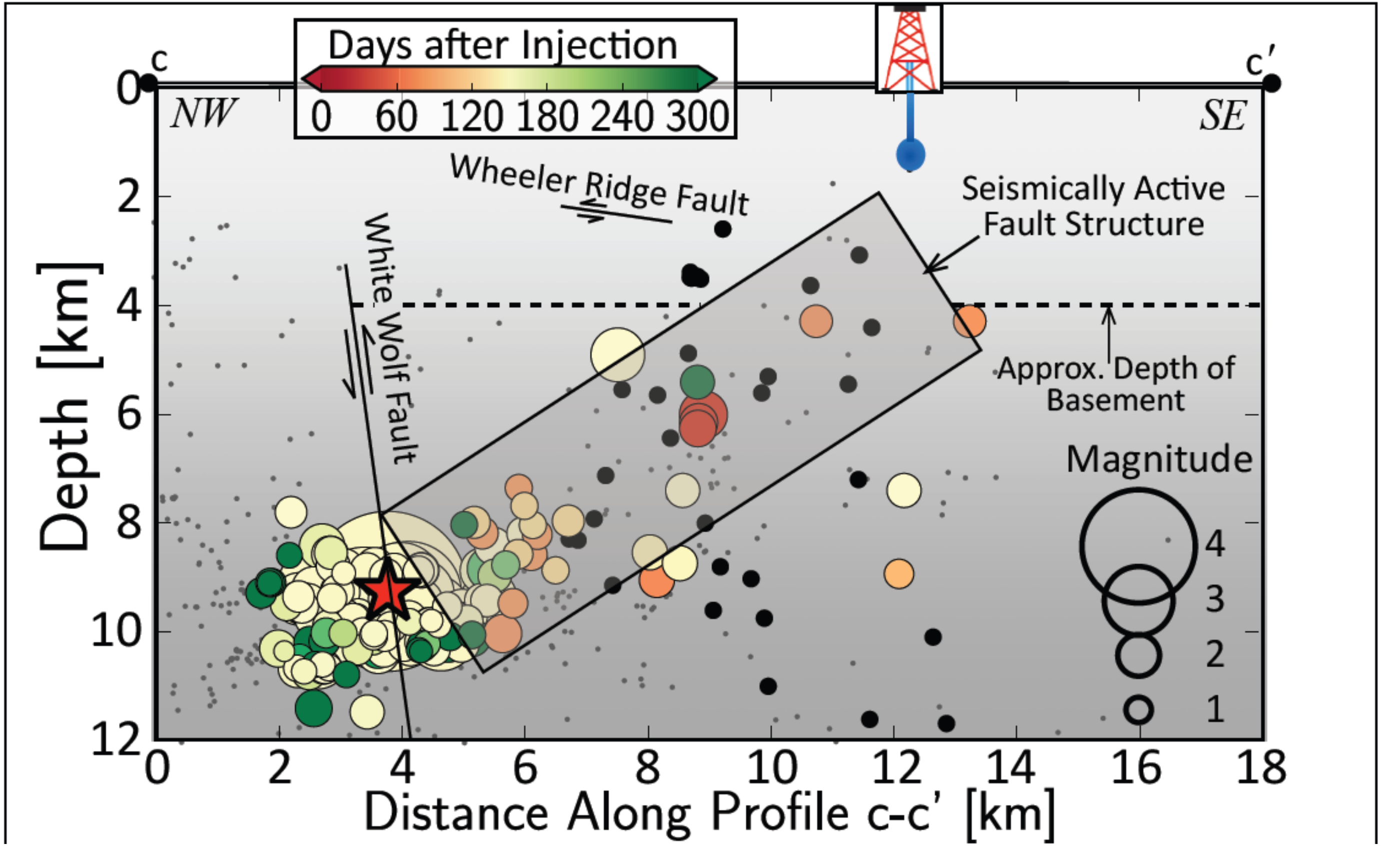


Statistical correlation between earthquakes and wastewater disposal volumes in OK (2000-2013) and CA (1980-2013).

- Far from uniform in Oklahoma
- Slightly below uniform in California

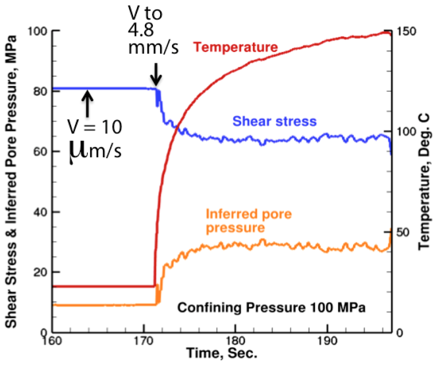
Assessing fault zone structure and permeability in regions of active faulting and fluid injection: Can fault maps and structure help evaluate induced seismicity in southern California?

(Brodsky & Goebel)



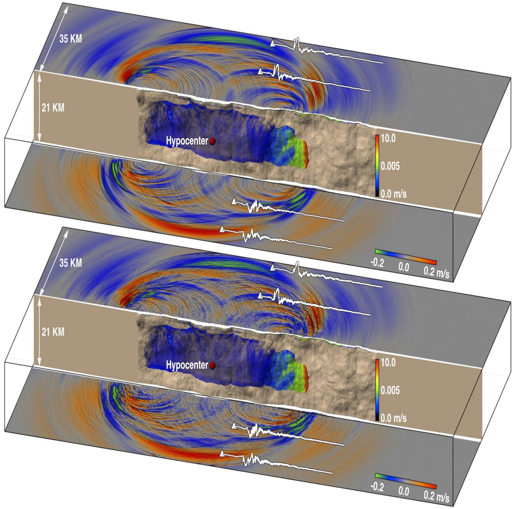
3. Evolution of Fault Resistance During Seismic Slip

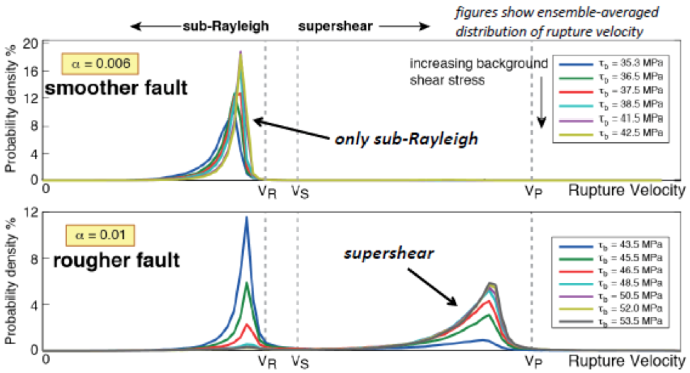
Fluid Pressurization in the Lab (Tullis and Goldsby)



Permeability = 6.1*10^{-18} m^2

High-F Simulations with Fault Roughness (*Cui et al.*)





Supershear on Rough Faults *(Bruhat et al.)*

Laboratory Experiments on Fault Shear Resistance Relevant to Coseismic Earthquake Slip

T. Tullis et al.

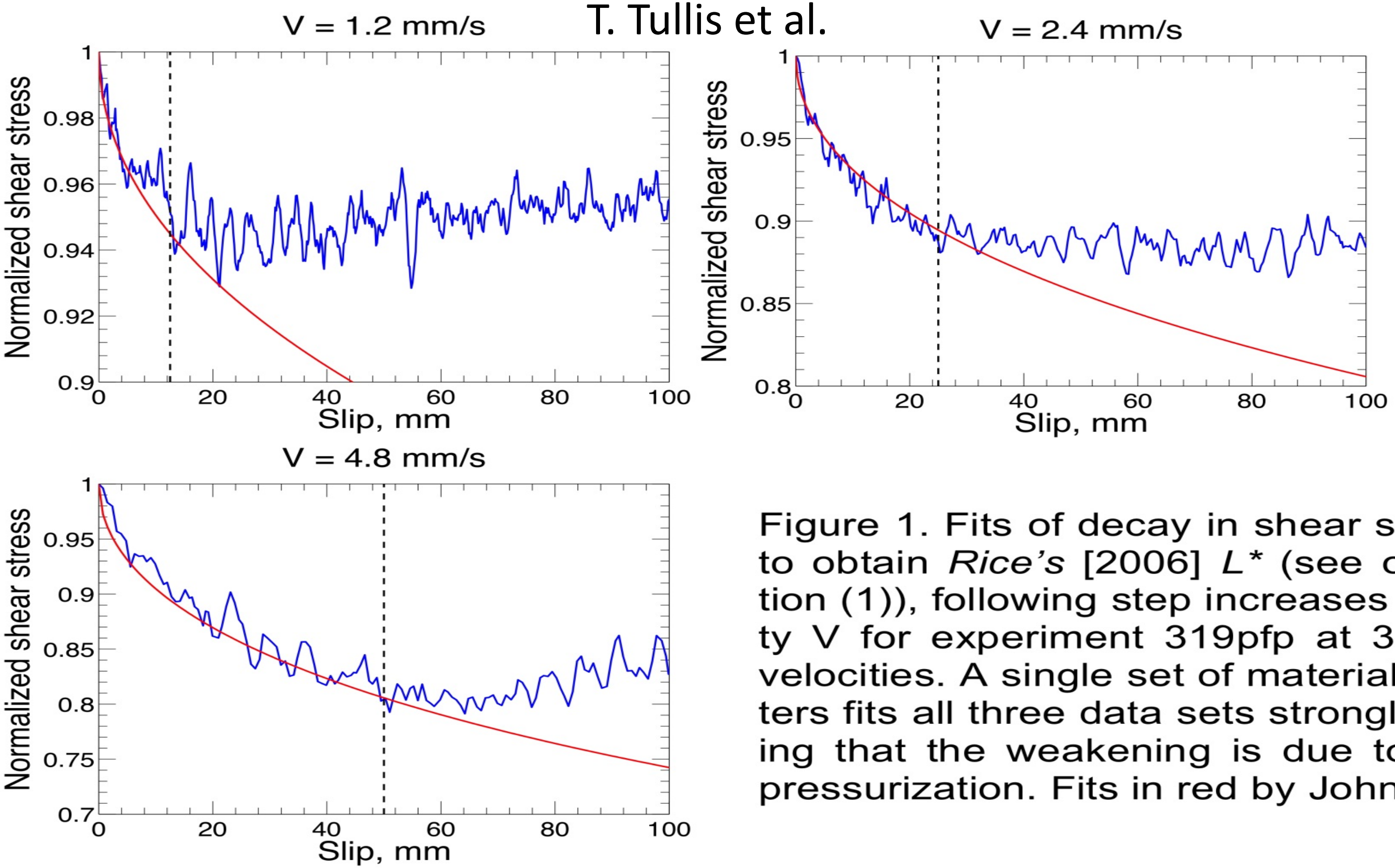
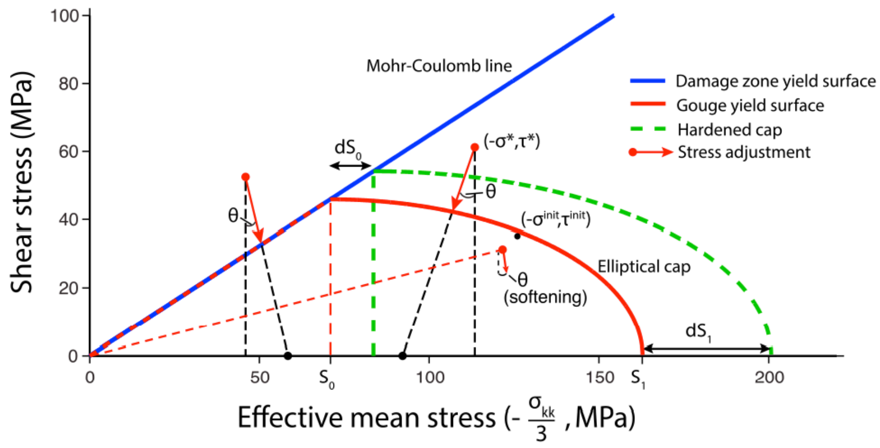
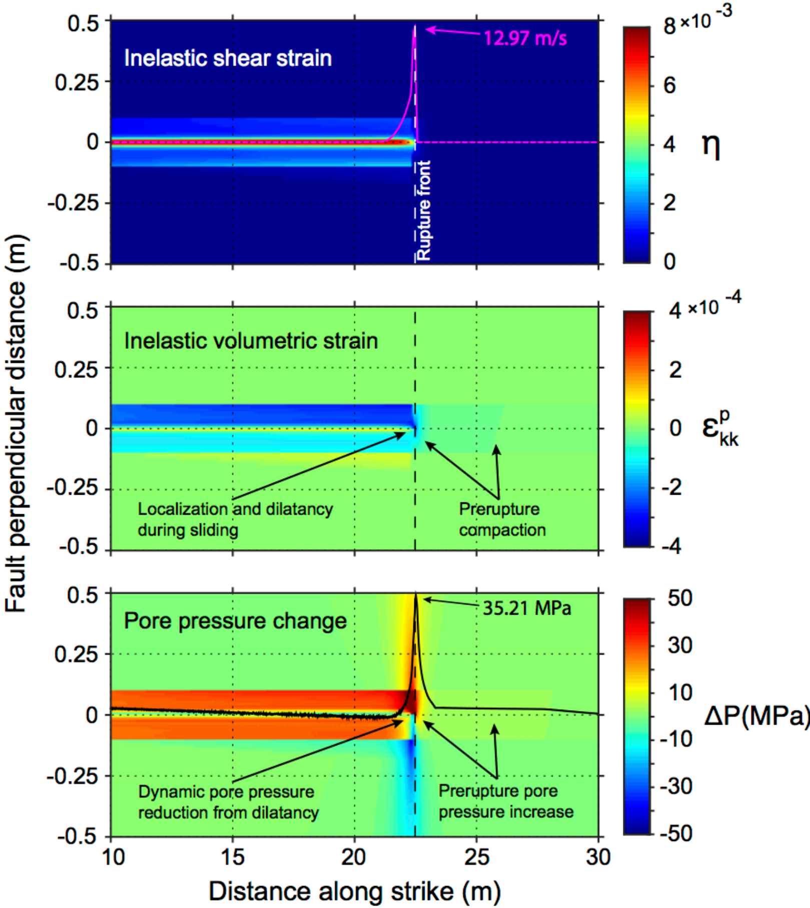


Figure 1. Fits of decay in shear stress $\tau(\delta)$ to obtain *Rice's* [2006] L^* (see our equation (1)), following step increases in velocity V for experiment 319pfp at 3 different velocities. A single set of material parameters fits all three data sets strongly indicating that the weakening is due to thermal pressurization. Fits in red by John Platt.

End Cap Modification to Mohr-Coulomb Criteria

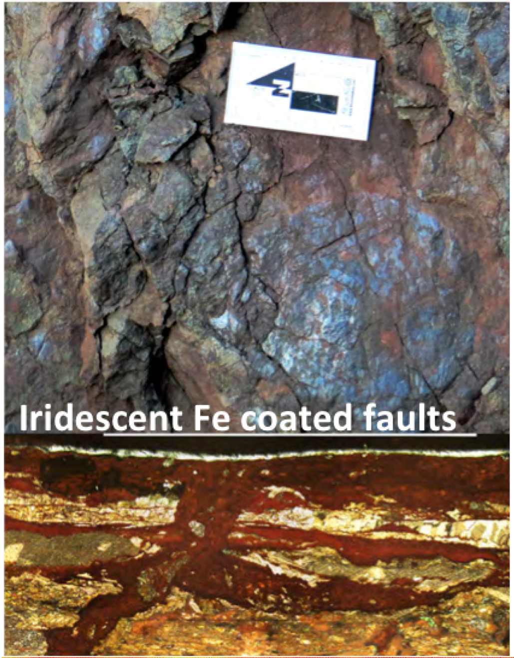


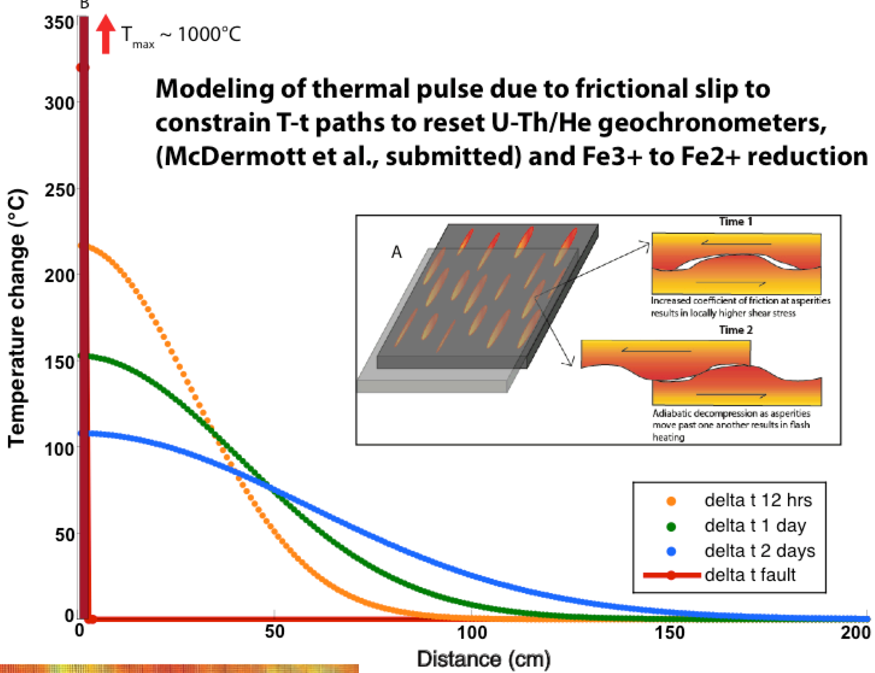


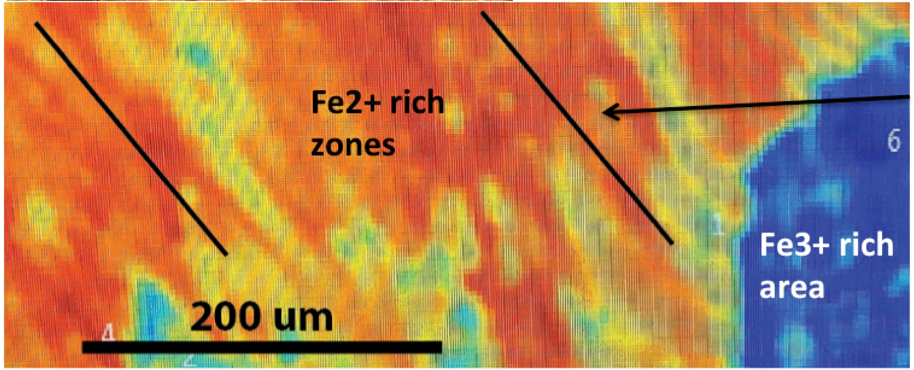
Shear stress increase in front of rupture causes gouge compaction, pore pressure increase, and results in less inelastic strain during rupture.

Unlike other dynamic weakening mechanisms, it acts before slip occurs.

Hirakawa and Ma (2016)



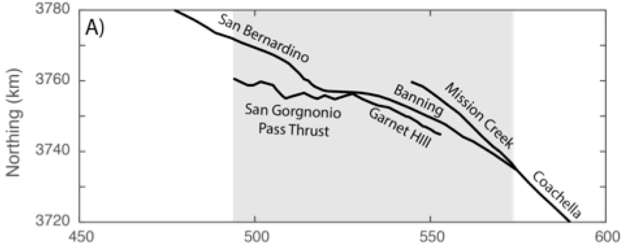




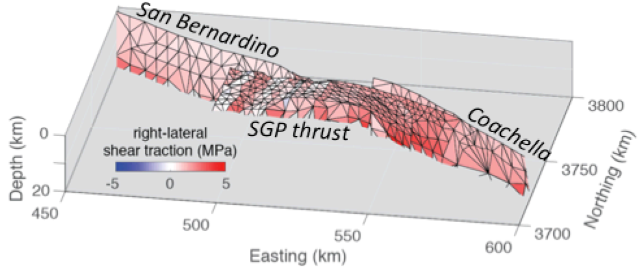
Preliminary X-Ray mapping with a synchrotron light source (Stanford) shows that we can map sites of reduced Fe, V, Mn, and Cr on fault surfaces. Modeling constrains T-t paths, and reduction establishes T slip > 570°C.

Evans, Bradbury, Moser, Ault, McDermott, Janecke

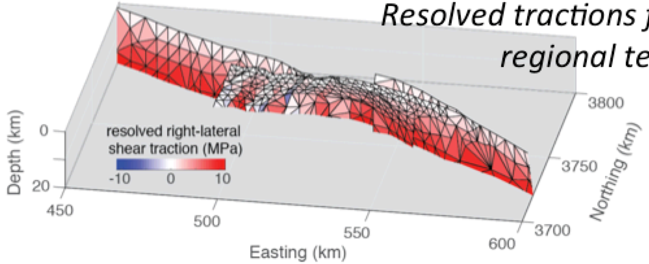
Quasi-static crustal deformation models estimate absolute shear tractions within the San Gorgonio Pass

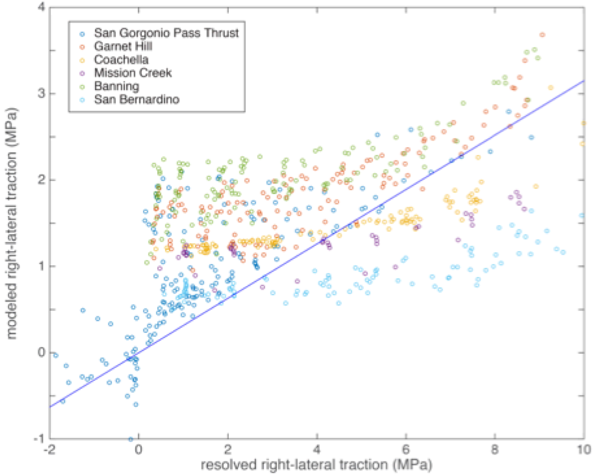


Model considers interseismic loading since last ground rupturing event for each segment



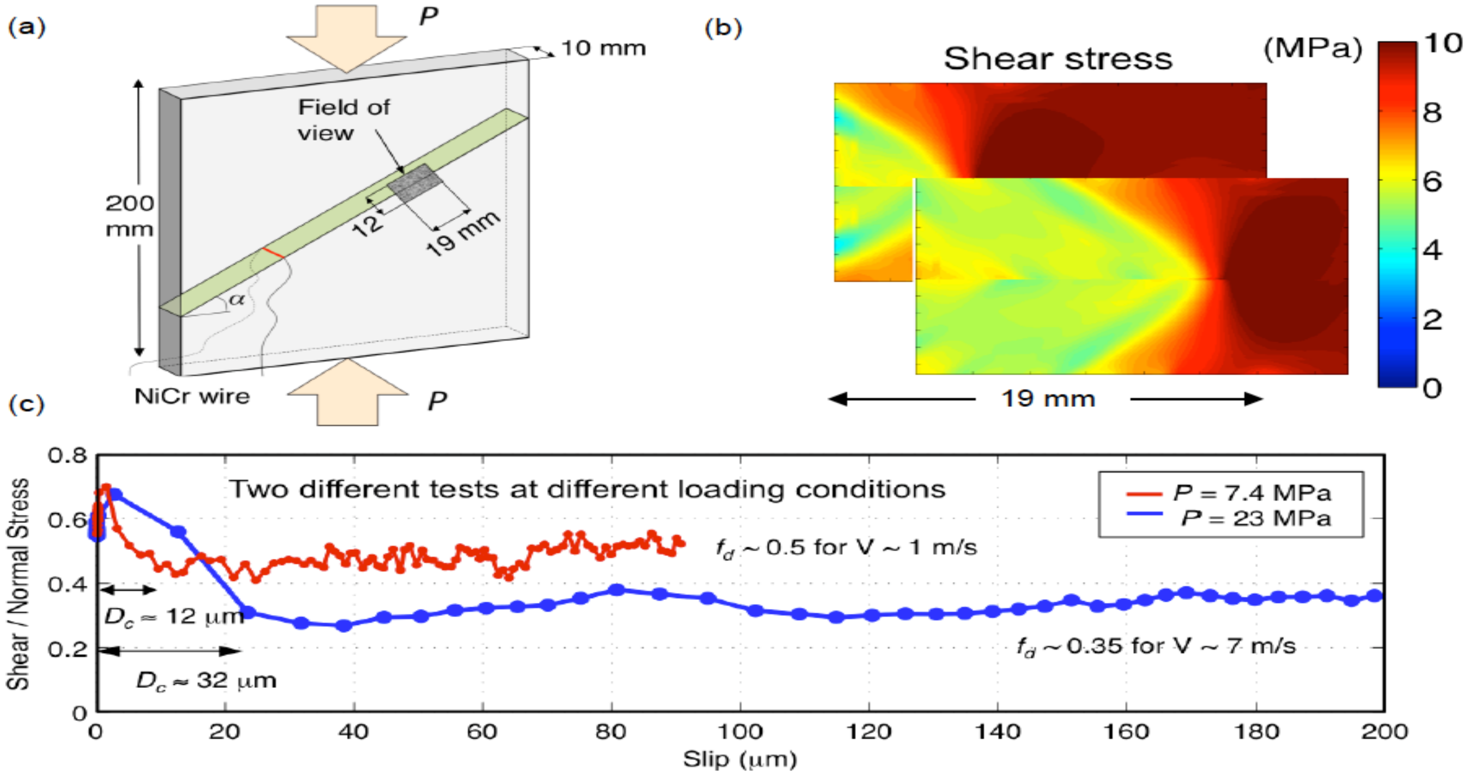
Resolved tractions from regional tensor





*Right-lateral shear tractions are only 61% correlated with tractions resolved from remote stress field – **rupture models should consider effects of interseismic stressing history on initial tractions.***

Reconciling supershear transition of dynamic ruptures with low fault prestress and implications for the San Andreas Fault

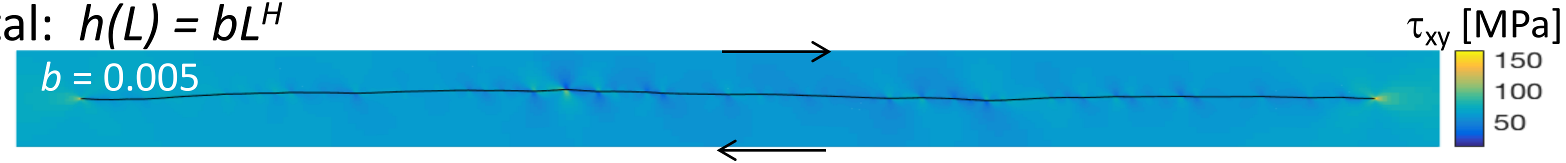


Dynamic imaging of full-field stresses and friction in laboratory earthquakes obtained with the newly developed ultra high-speed digital image correlation method.

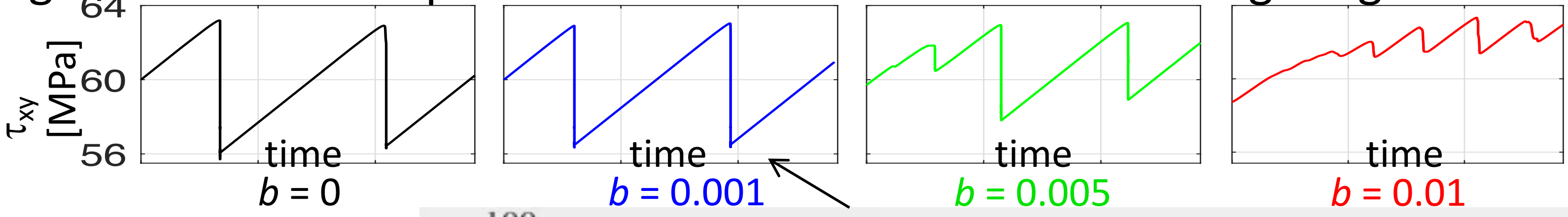
The effect of roughness on the nucleation and propagation of shear rupture

Yuval Tal and Brad Hager, EAPS,MIT

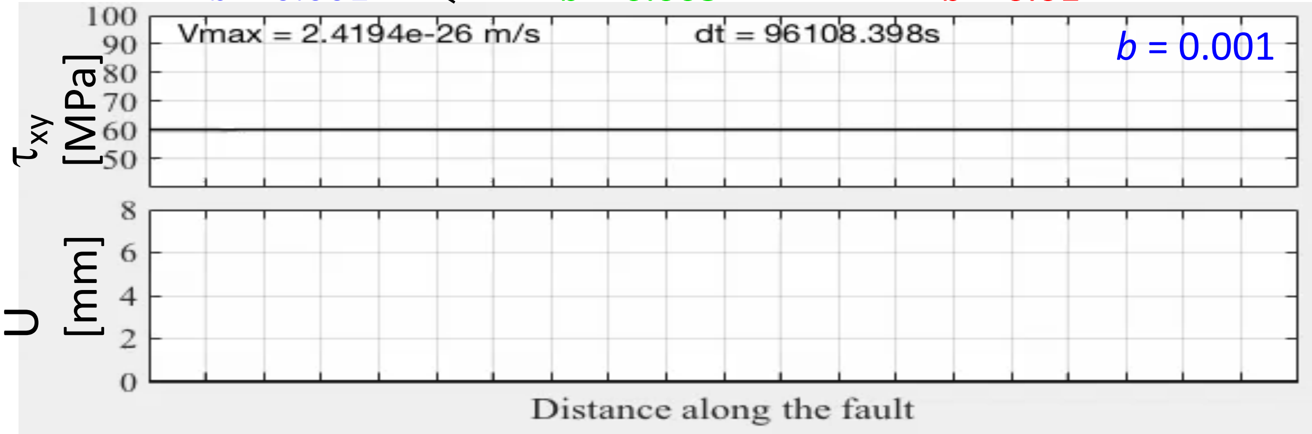
Self-affine fractal: $h(L) = bL^H$



The average static stress drop on the fault decreases with increasing roughness



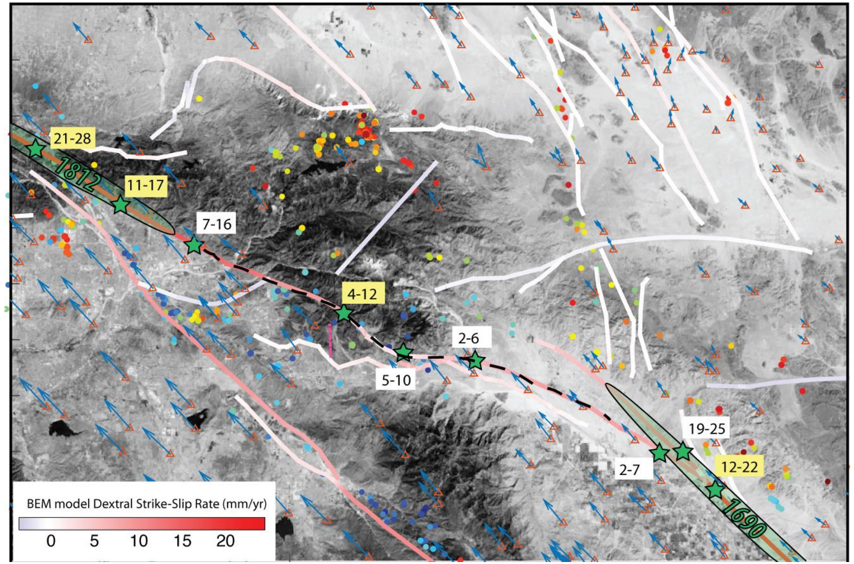
Complex nucleation and propagation of the rupture



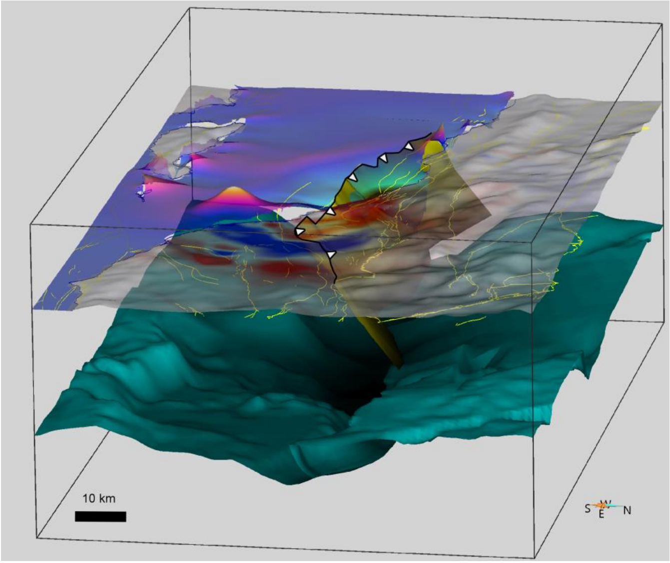
Massachusetts Institute of Technology

4. Structure and Evolution of Fault Zones and Systems

San Gorgonio Pass SFSA



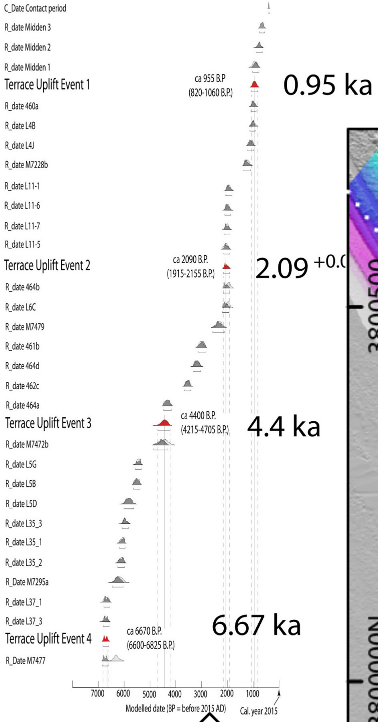
Ventura SFSA



Ongoing work on Statewide Community Velocity and Community Fault Models

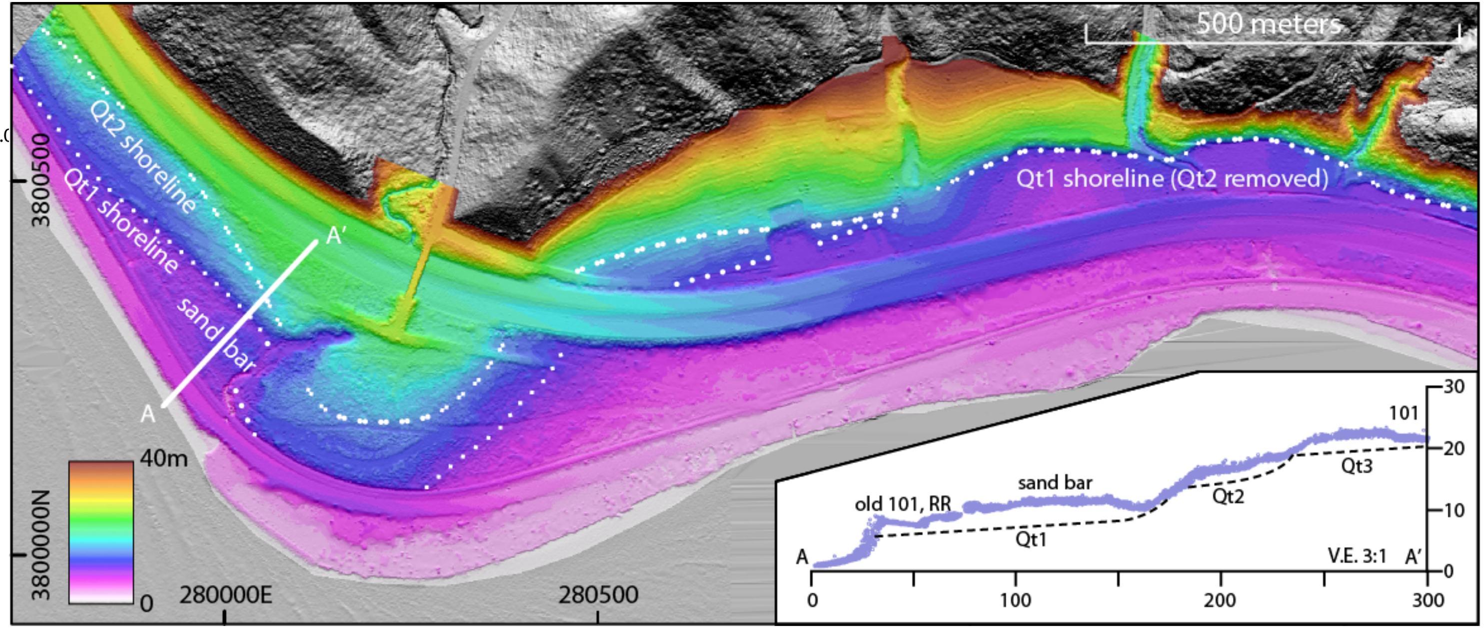
Ventura Special Fault Study Area

Pitas Point terrace chronology



Preserved shorelines in lidar topography of Pitas Point confirm abrupt, large uplift events in hangingwall of Ventura-Pitas Point Thrust.

Rockwell et al., BSSA in press



Uplift event ages from Oxcal model combining new and archival, re-calibrated ^{14}C dates

Mechanical Models: Ventura-Pitas Point Fault

Scott Marshall (Appalachian State), Gareth Funning (UCR), Susan Owen (JPL)

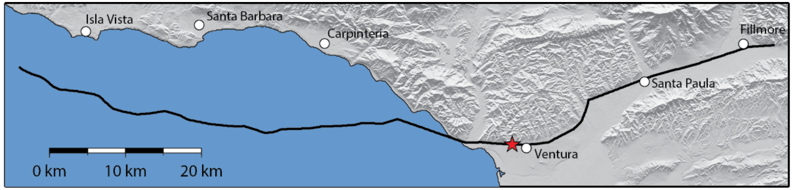
Forward Models Driven by Geodetic Shortening Rates

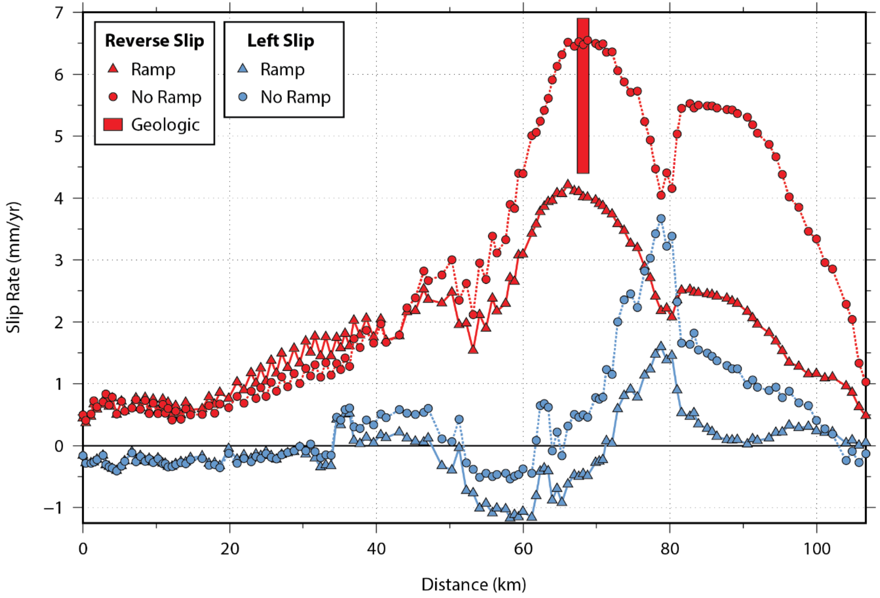
In General:

- Models using CFM5.0 fit slip rate data better than previous CFM versions

The Ventura-Pitas Point Fault:

- Max slip rates near coast where past slip estimates were made (e.g. Hubbard et al.)
- Slow slip in Santa Barbara Channel
- Flat ramp geometry
  - Slightly under-predicts long term slip
  - Produces better slip rates on other key faults





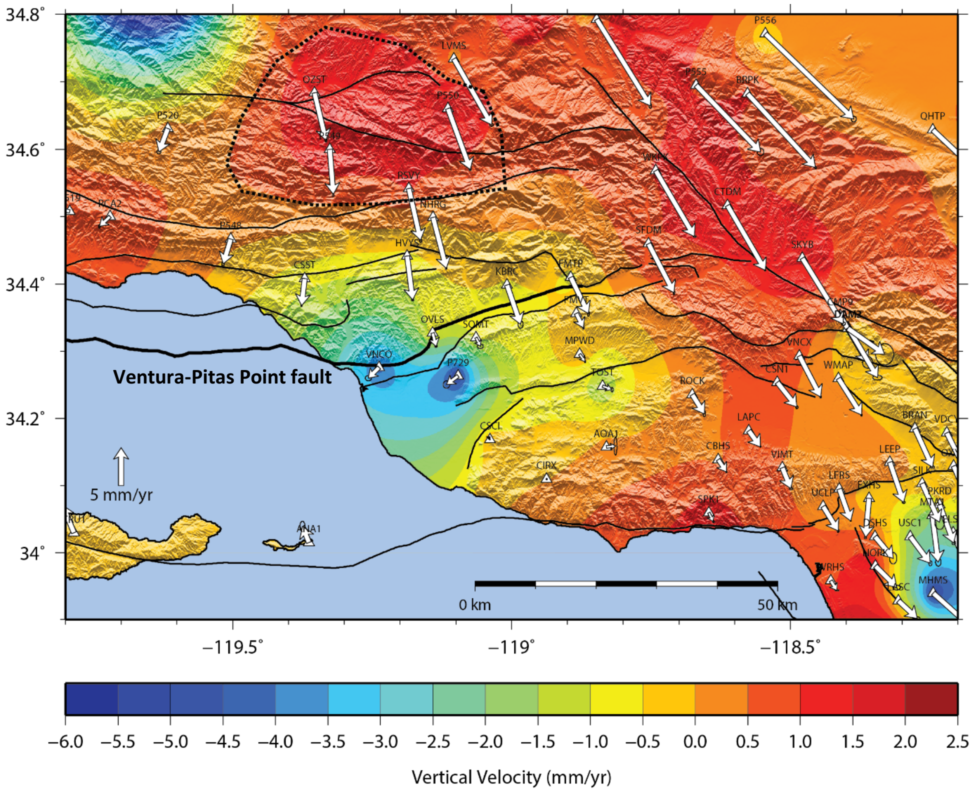
Poster #151

Vertical GPS Velocities: Ventura, CA

Scott Marshall (Appalachian State), Gareth Funning (UCR), Susan Owen (JPL)

Continuous PBO GPS data

- Shows uplift north of Ventura Basin (dashed line)
- Consistent with interseismic deformation on the Ventura-Pitas Point fault with a flat ramp geometry
- Subsidence near Oxnard/Ventura consistent with groundwater extraction



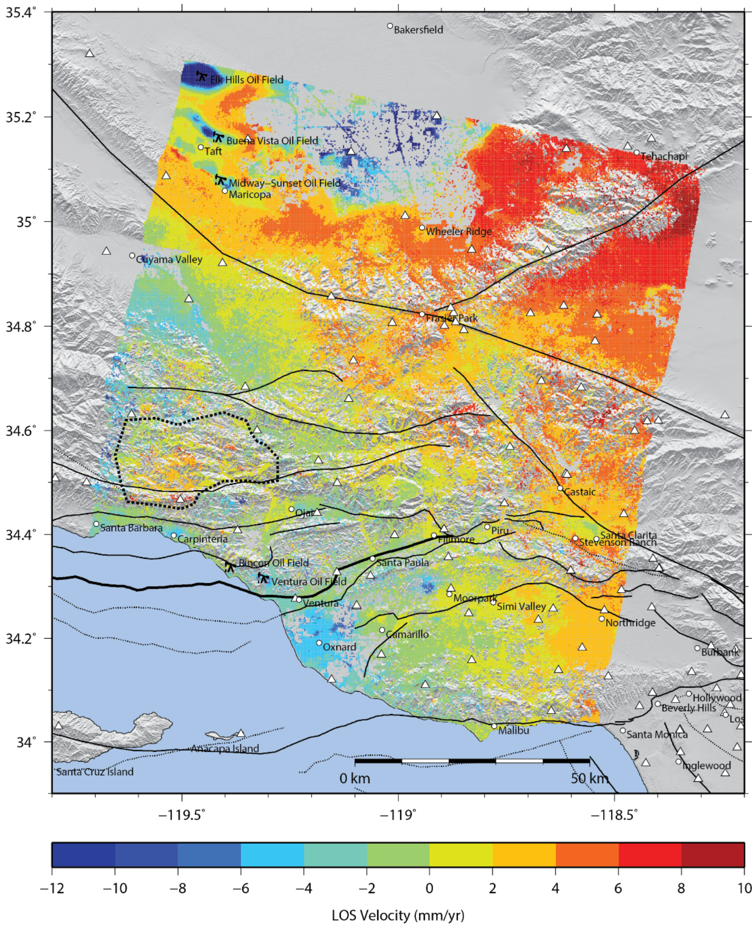
Poster #167

Persistent Scatterer InSAR: Ventura, CA

Scott Marshall (Appalachian State), Gareth Funning (UCR), Susan Owen (JPL)

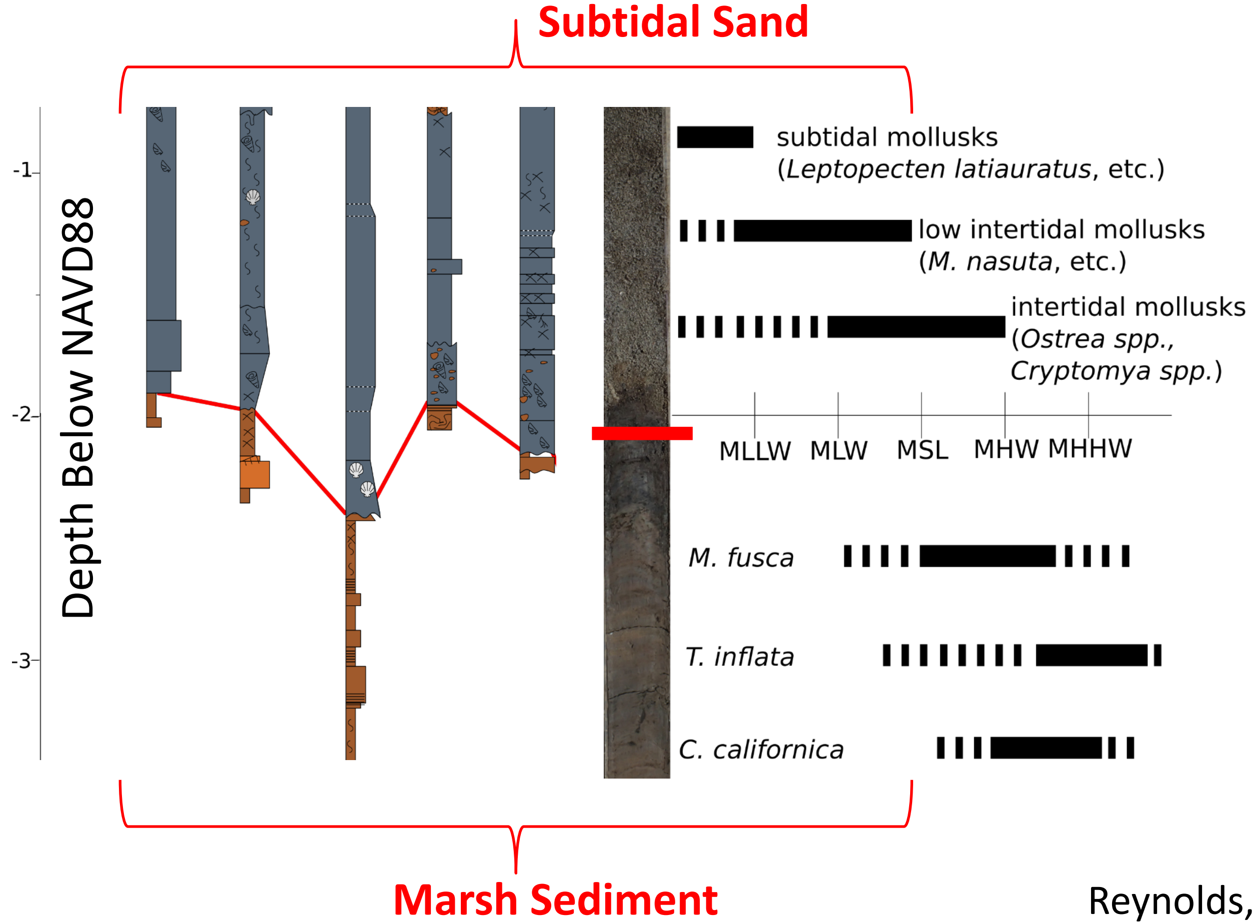
InSAR LOS Velocities from Envisat

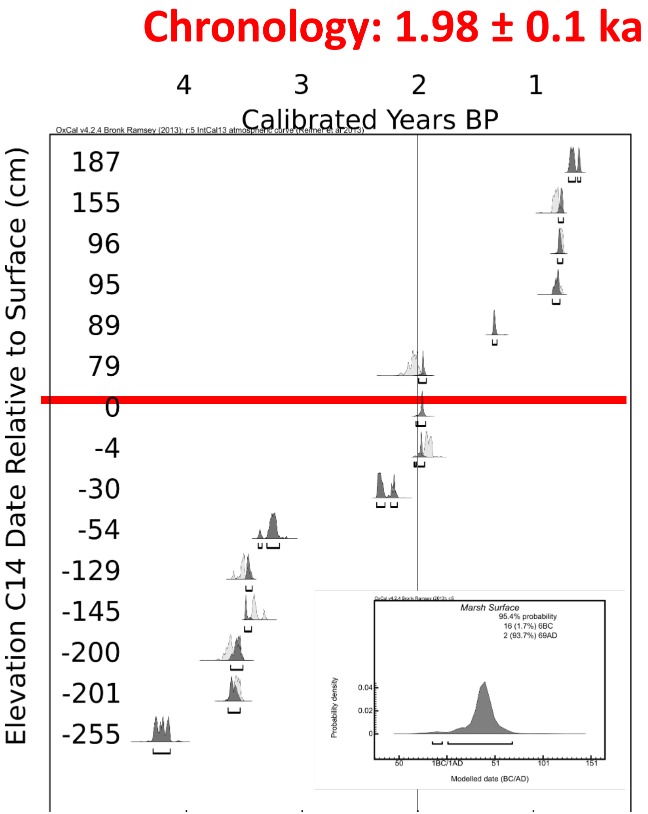
- Shows uplift north of Ventura Basin (dashed line)
- Consistent with interseismic deformation on the Ventura-Pitas Point Fault with a flat ramp geometry
- Subsidence near Oxnard/Ventura consistent with groundwater extraction
- Subsidence in the Central Valley due to groundwater and hydrocarbon extraction



Poster #167

Evidence for Abrupt Subsidence Event in Carpinteria Marsh at 1.98 ± 0.1 ka

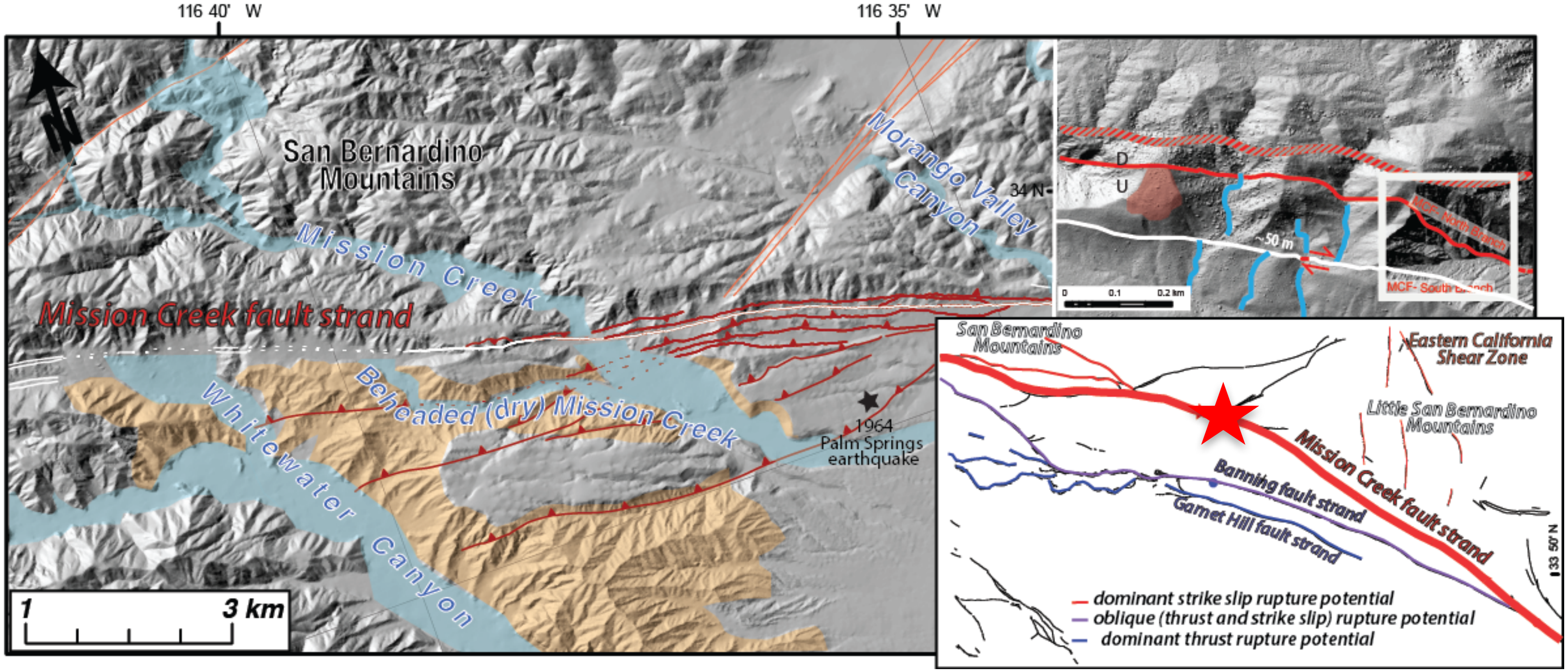




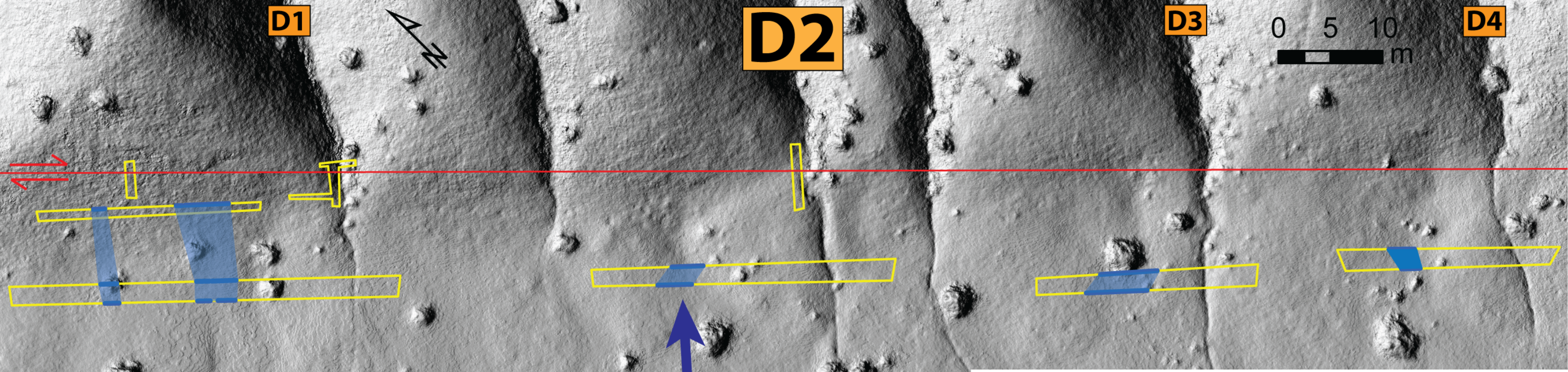
Reynolds, Simms, Rockwell, Bentz, Peters

Slip rates of 21-26 mm/yr for the past 100 ka on the Mission Creek strand of the SAF

- Geomorphic mapping and sediment provenance studies in the San Bernardino and Little San Bernardino Mountains combined with new $^{36}Cl/^{10}Be$ burial dating and previously published dates of these buried alluvial deposits show the Mission Creek strand is active in the San Gorgonio Pass at Mission Creek.
- Propose reverse fault of Mission Creek strand active during 1964 Palm Springs Earthquake

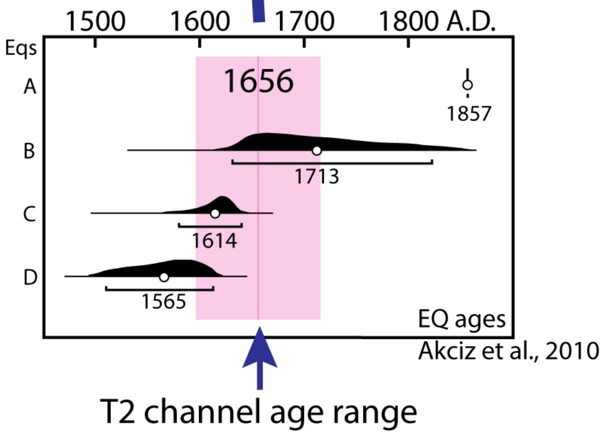


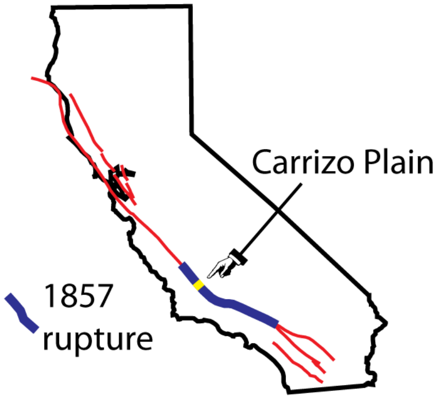
PI: Kim Blisniuk (SJSU) & collaborators: Julie Fosdick (Uconn), Louis Wersen, (IU), Kate Scharer (USGS), Roland Burgmann (UCB), Greg Balco (BGC)



Slip rate and slip per event studies on the Carrizo section, SAF

- D2 short term rate: 33 mm/yr
- D2: up to 8 m slip in penultimate event or 8 m of slip in previous 3 events
- Channels deposits D1, D3, D4 are too old to represent small offsets

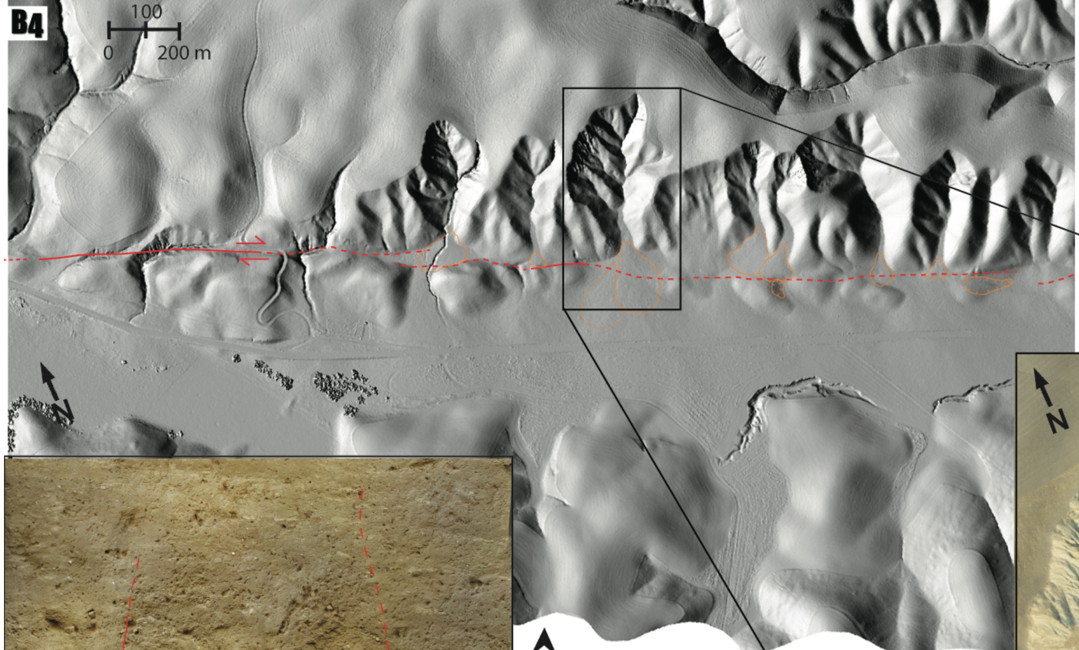


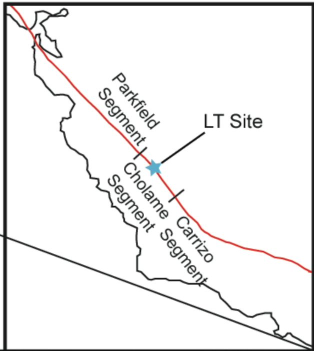


poster 130
Salisbury, Arrowsmith, Rockwell
Akciz, Brown, Grant Ludwig
Arizona State University

New Cholame section paleoseismic site

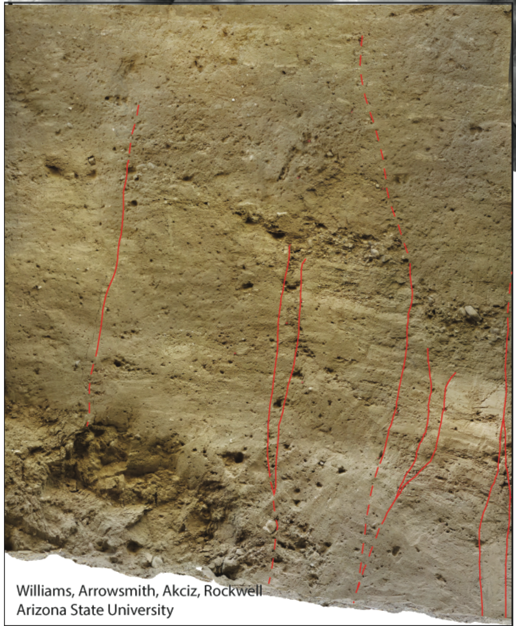
- Limited existing paleoearthquake data on this important link between Carrizo and creeping sections of SAF
- Trenches show good evidence for 3 paleoearthquakes and a young ground shaking event.
- Promising as abundant charcoal will enable dating





- B4 lidar of the LT paleoseismic site on the Cholame segment of the San Andreas fault
- Good evidence for 3 paleoearthquakes and a ground shaking event, poor evidence for an additional three ruptures

Trenches T2A, T2B, T2C and drainage basin



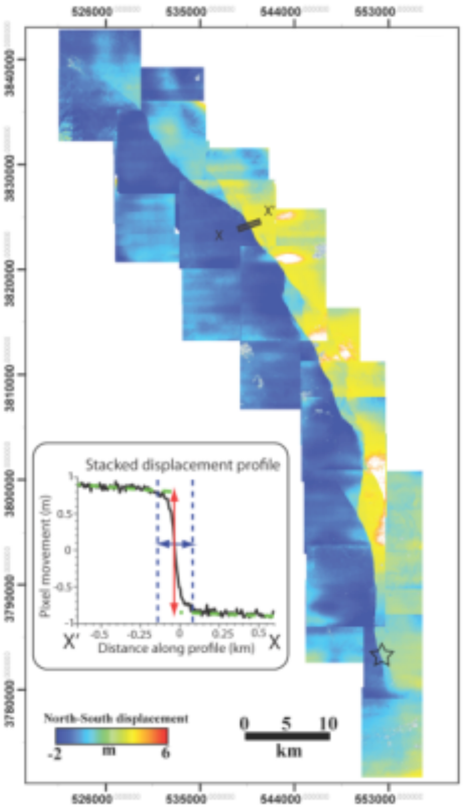
T2C NW SfM model displaying 2 paleoearthquakes, offset units, and onlapping sediments. Fault splays shown in red.

Poster 128 Williams, Arrowsmith, Akciz, Rockwell, Ludwig

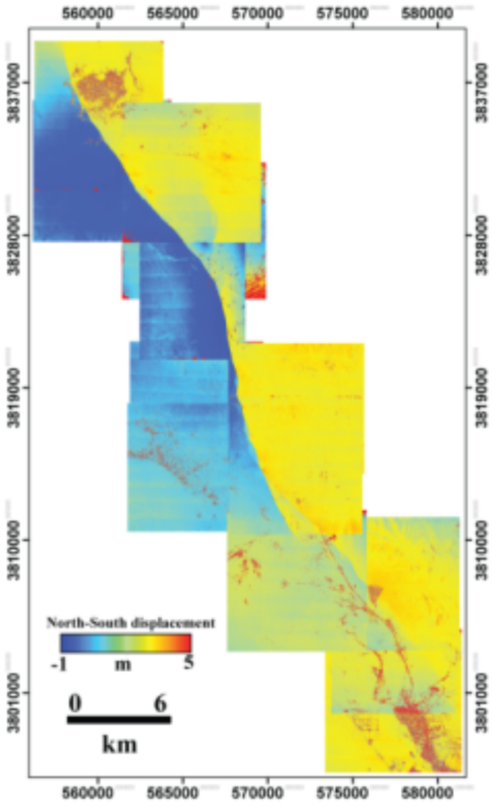
Arizona State University

COSICorr reconciles shallow slip deficit for complex earthquake ruptures

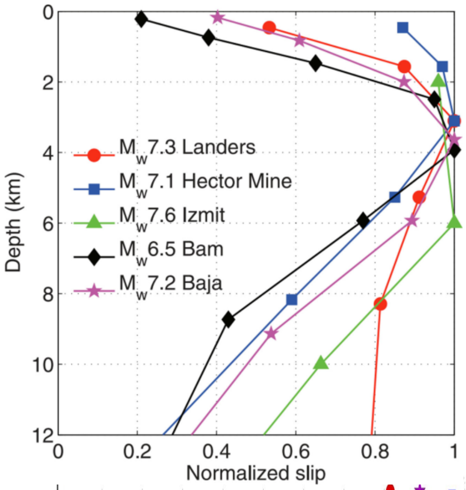
Milliner et al., 2015, 2016, and SoSAFE presentation



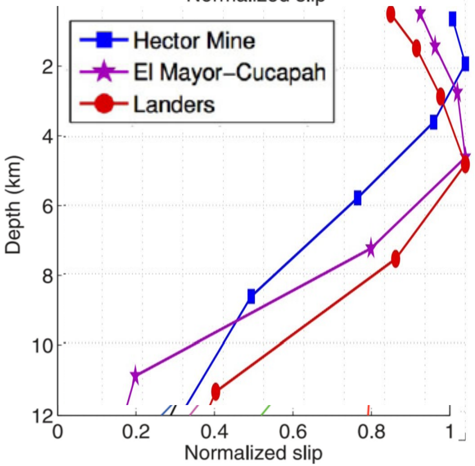
Landers EQ = More Complex 46 ± 10% Off-Fault Deformation



Hector Mine EQ = Less Complex 39 ± 10% Off-Fault Deformation



INSAR Only



+ COSICorr

Aerial2lidar3D: Development of a standard technique to measure 3D coseismic surface deformation for past and future large earthquakes that lack pre-event lidar data

J. Dolan

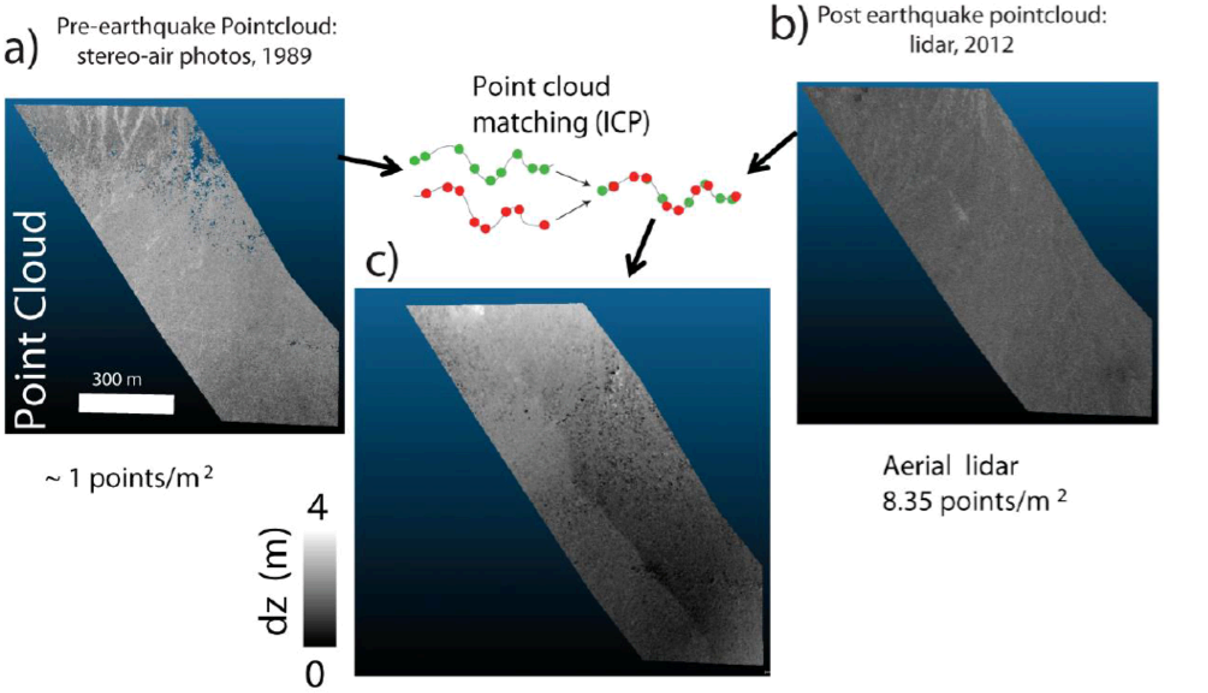
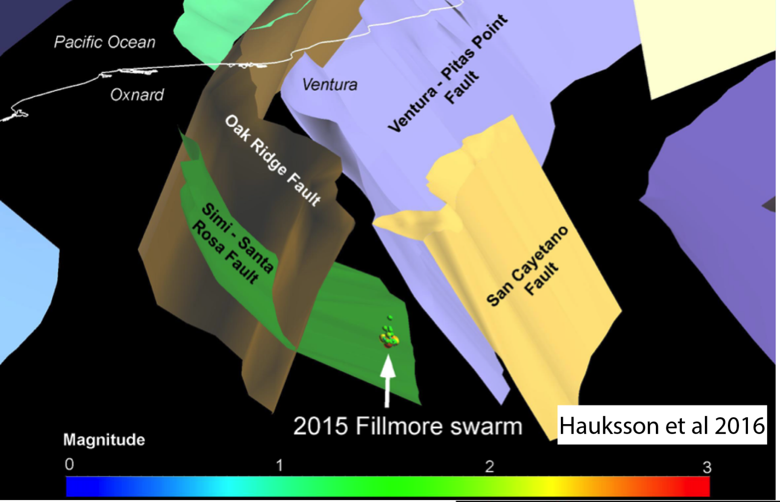
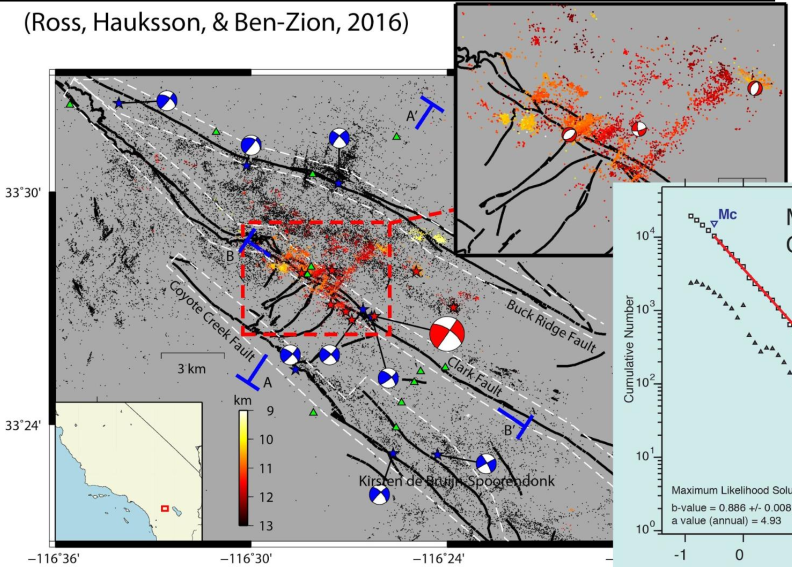


Figure 2. a) Point cloud result from pre-Hector Mine air photos produced using Agisoft Photoscan. Density of point cloud is ~ 1 point/m^2. **b)** Post-earthquake point cloud from lidar survey with higher density of 8.35 points/m^2. **c)** Successful vertical component detected from point cloud matching using ICP algorithm, which clearly reveals the vertical fault motion along the northern end of the Hector Mine rupture. Measurements from this fault scarp are shown in Fig. 3.

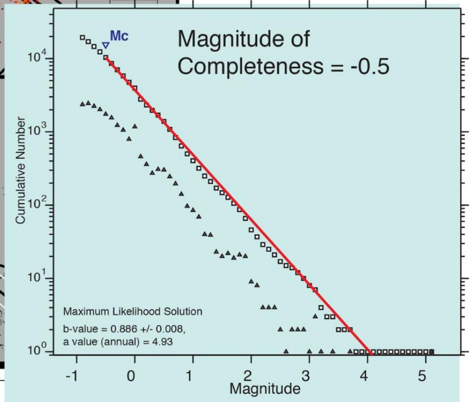


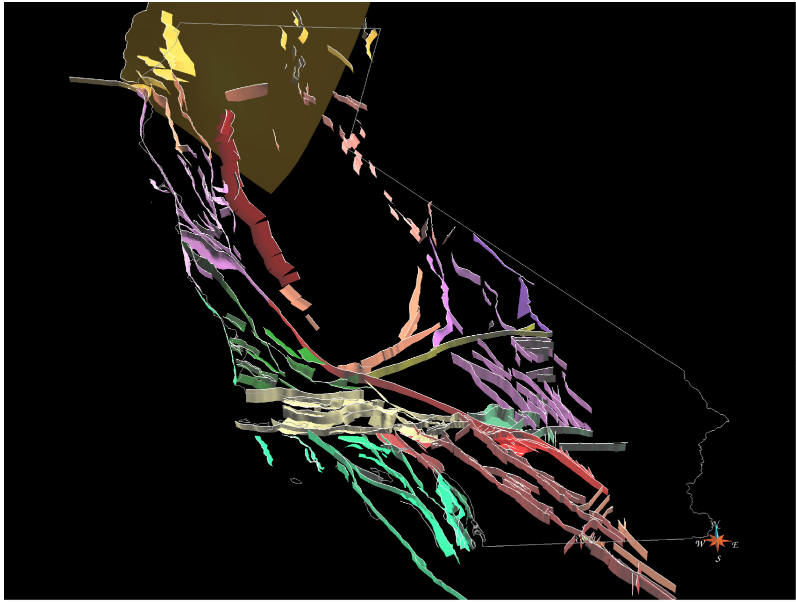
Ongoing efforts to improve understanding and representation of fault structure in key areas through improved earthquake detection and precision location.

(Ross, Hauksson, & Ben-Zion, 2016)



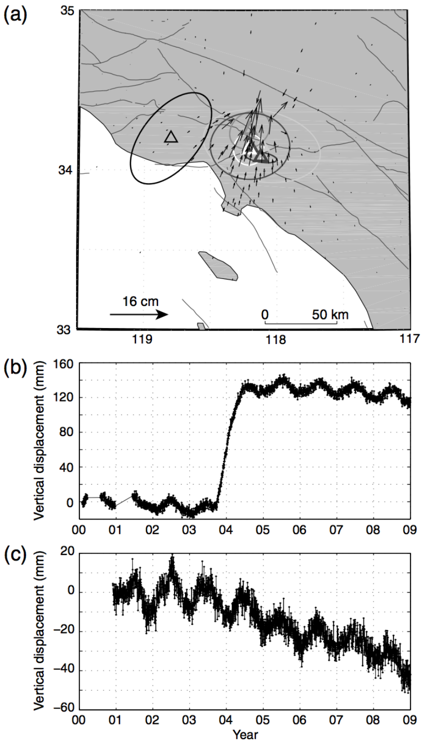
2016 Mw5.2 Borrego Springs Earthquake Sequence



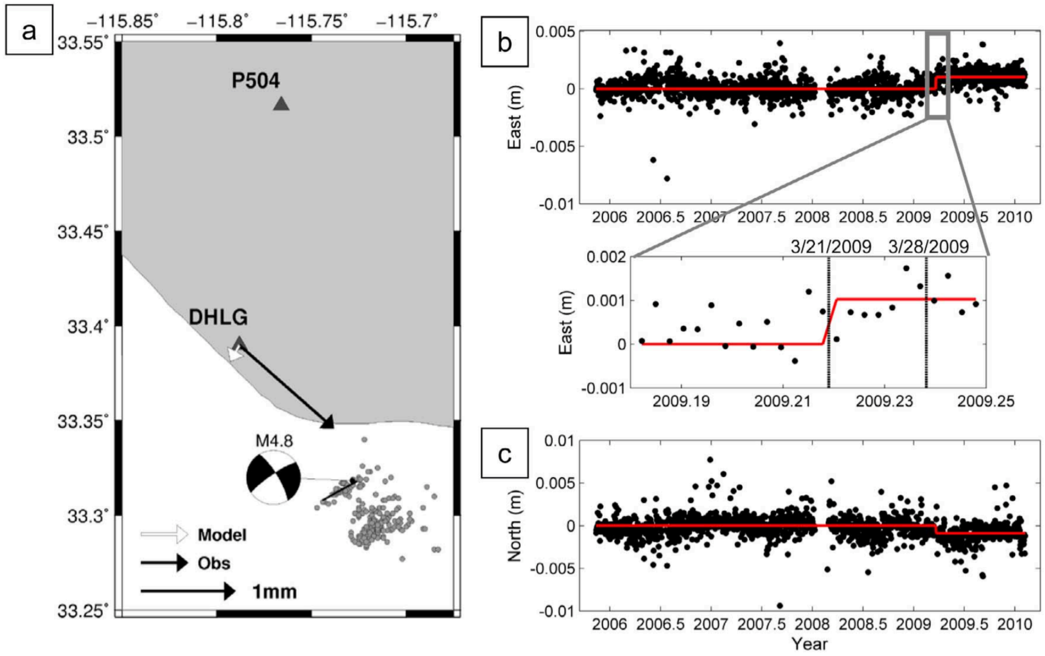


5. Causes and Effects of Transient Deformations

Transient Detection TAG
(*Lohman and Murray*)



Transient at Bombay Beach
(*Llenos and McGuire*)

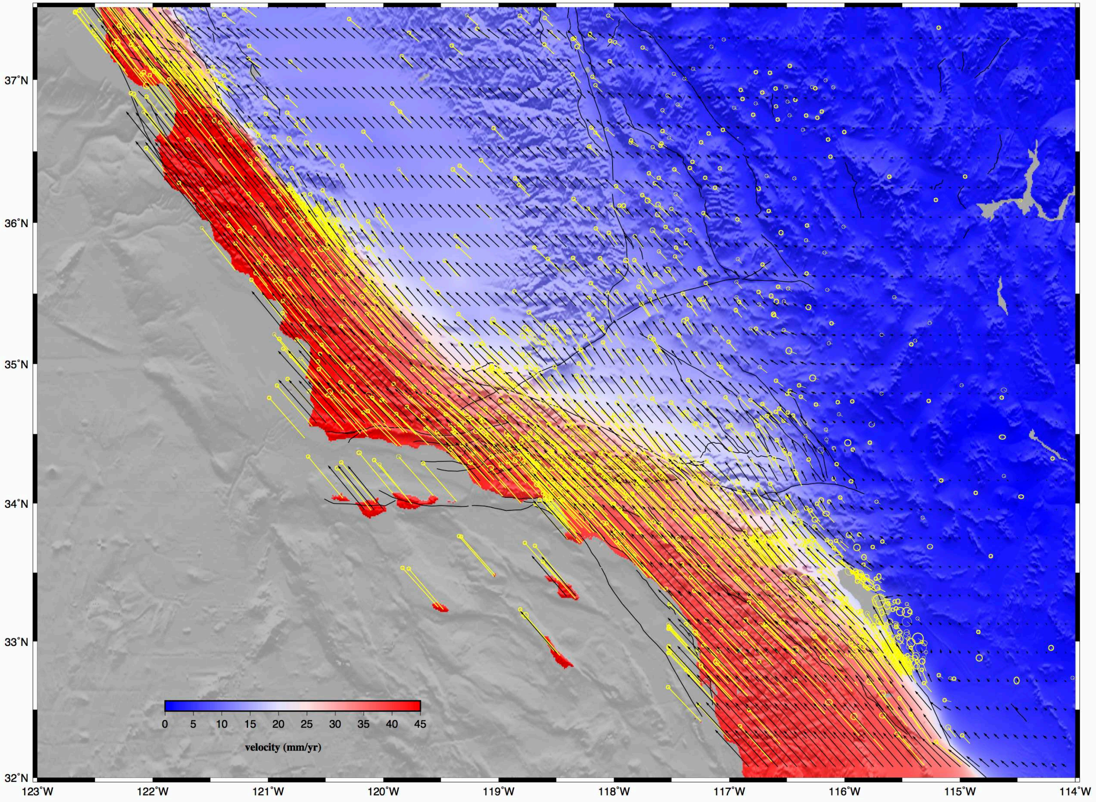


Community Geodetic Model V1 - GPS Secular Velocity Grid

GPS velocities from:
- PBO
- reprocessing of campaign data [Zeng and Shen, 2016]
- other dense GPS data [Crowell et al., 2013; McCaffrey et al., 2013]

Interpolation to 0.01˚ grid:
- 10 contributed models
- regridded to fit GPS data
- computed mean and standard deviation
- mean model matched GPS to 0.92 mm/yr.

Uses:
- constrain InSAR at long wavelengths
- expose areas of inadequate GPS coverage
- **assessment of off-fault strain rate**



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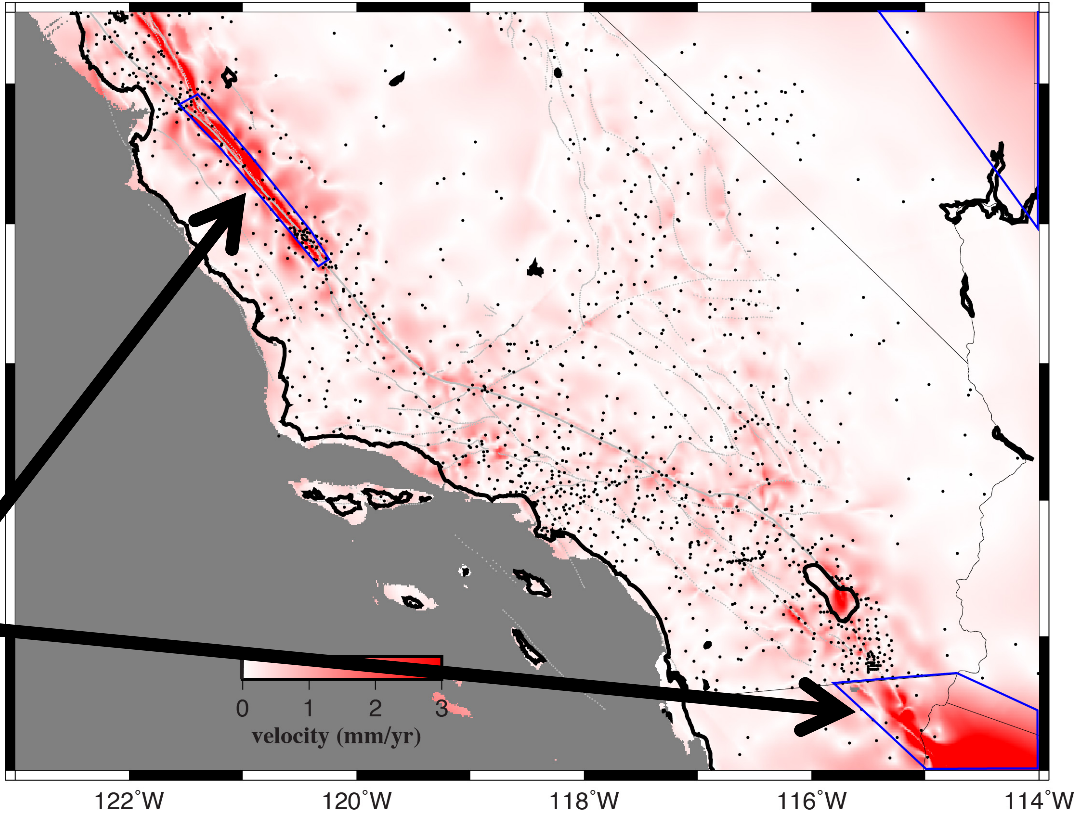
Community Geodetic Model V1 - GPS Secular Uncertainty Grid

GPS velocities from:
- PBO
- reprocessing of campaign data [Zeng and Shen, 2016]
- other dense GPS data [Crowell et al., 2013; McCaffrey et al., 2013]

Interpolation to 0.01˚ grid:
- 10 contributed models
- regridded to fit GPS data
- computed mean and standard deviation
- mean model matched GPS to 0.92 mm/yr.

Uses:
- constrain InSAR at long wavelengths
- **expose areas of inadequate GPS coverage**
- assessment of off-fault strain rate



poster 141

SCEC

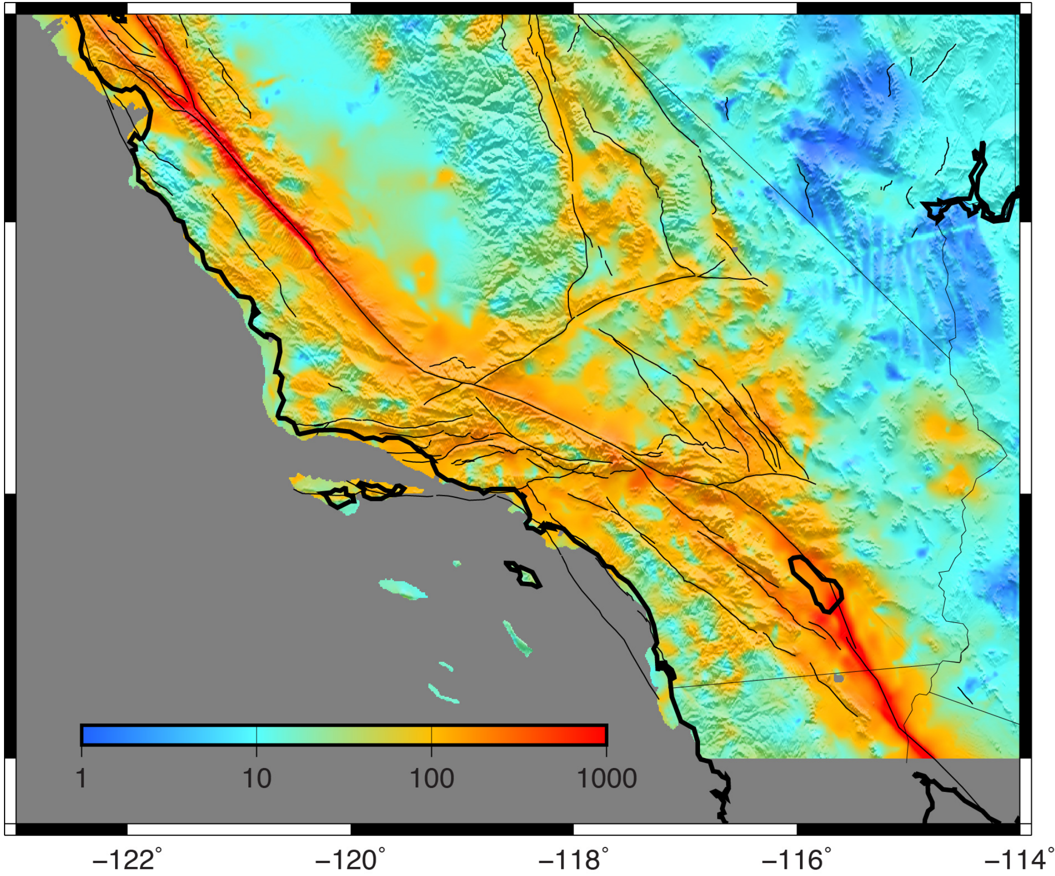
Southern California
Earthquake Center

Community Geodetic Model V1 - GPS Strain Rate Grid

GPS velocities from:
- PBO
- reprocessing of campaign data [Zeng and Shen, 2016]
- other dense GPS data [Crowell et al., 2013; McCaffrey et al., 2013]

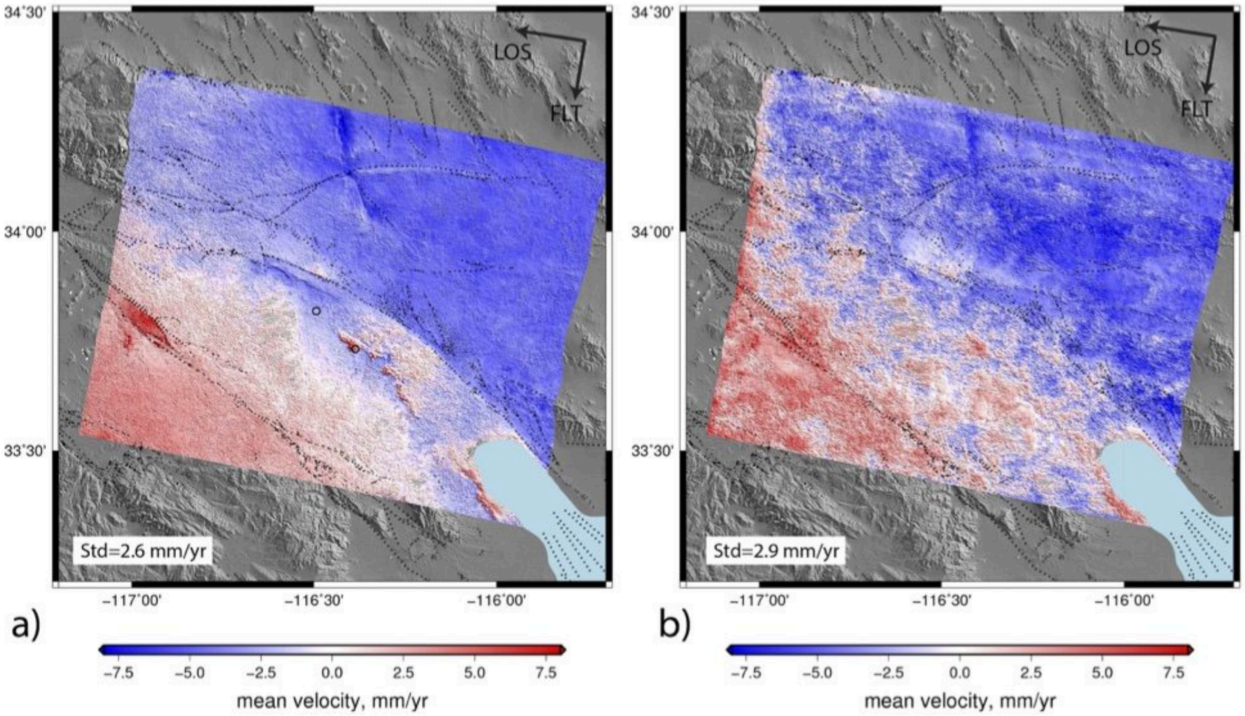
Interpolation to 0.01° grid:
- 10 contributed models
- regridded to fit GPS data
- computed mean and standard deviation
- mean model matched GPS to 0.92 mm/yr.

Uses:
- constrain InSAR at long wavelengths
- expose areas of inadequate GPS coverage
- **assessment of off-fault strain rate**



poster 141

Improved InSAR Processing

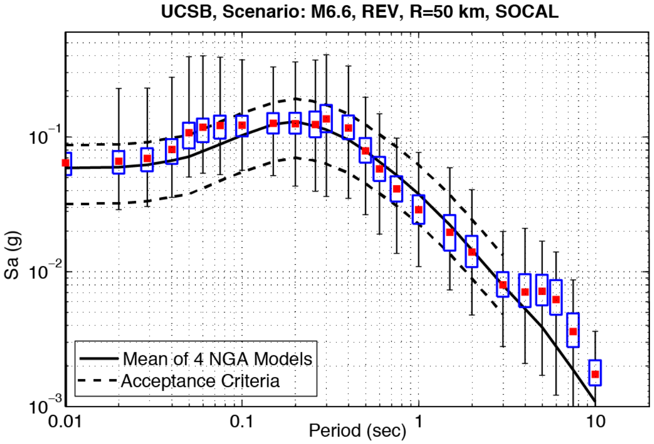


Schmidt et al. (2015) InSAR timeseries method incorporates pixel coherence into the covariance, which performs better than the traditional approach.

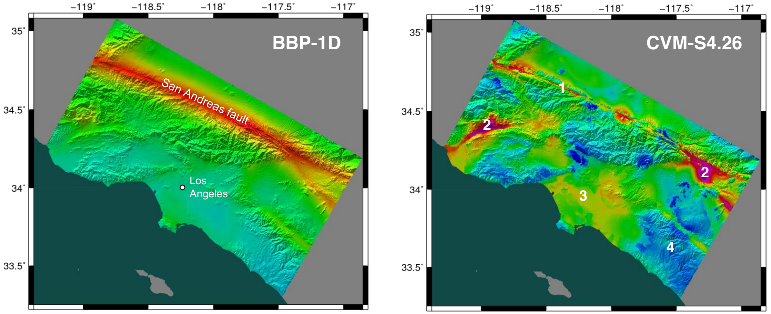
Example shows improvement in LOS velocity estimates for the Coachella Valley

6. Seismic Wave Generation and Scattering

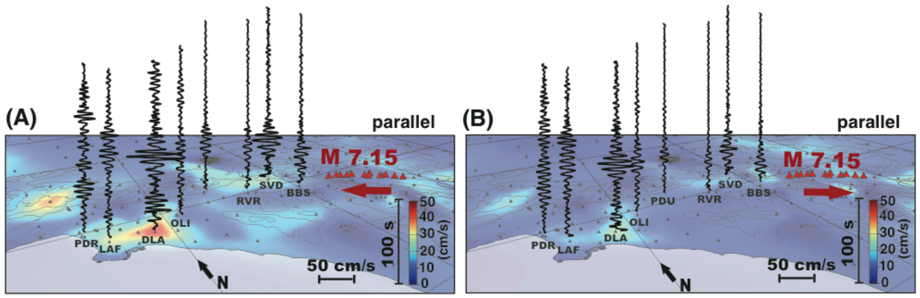
BBP Validation (*Dreger et al.*)



CyberShake Hazard Maps (*Jordan et al.*)



Waveguide-to-Basin Validation (*Denolle et al.*)

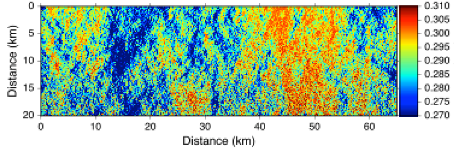


Kinematic Rupture Generator

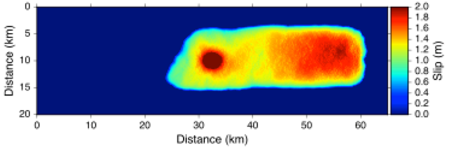
(Savran and Olsen, SDSU)

Dynamic Rupture Models → *One / Two-Point Statistics* → *Kinematic Sources*

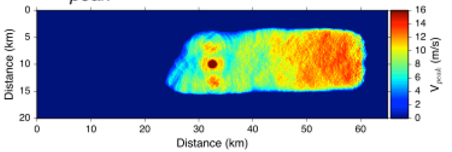
μ_0 (initial friction)



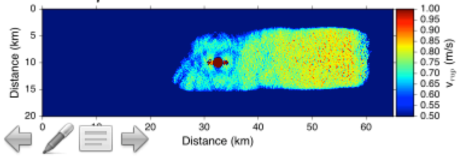
Δu (slip)



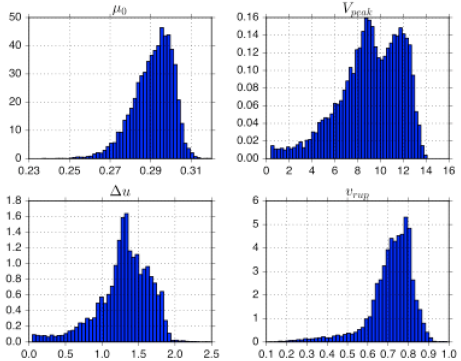
V_{peak}



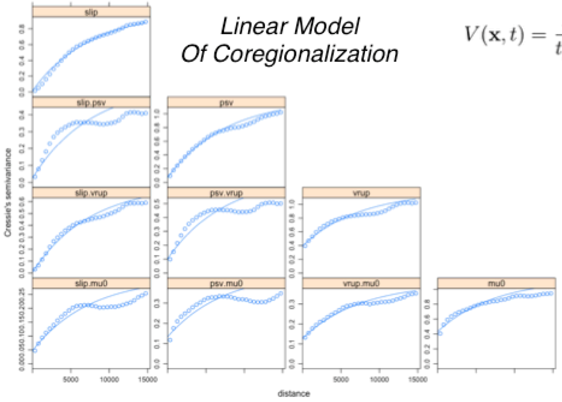
V_{rup}



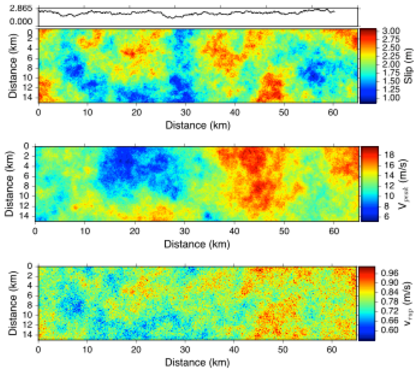
Mean and standard deviation



Linear Model Of Coregionalization



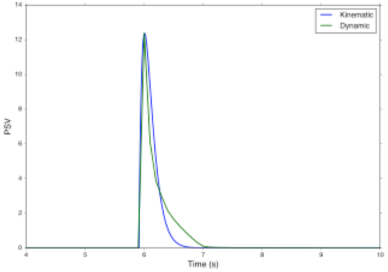
Sequential Gaussian Cosimulation of Δu, V_{peak}, v_{rup}



Source-Time Function

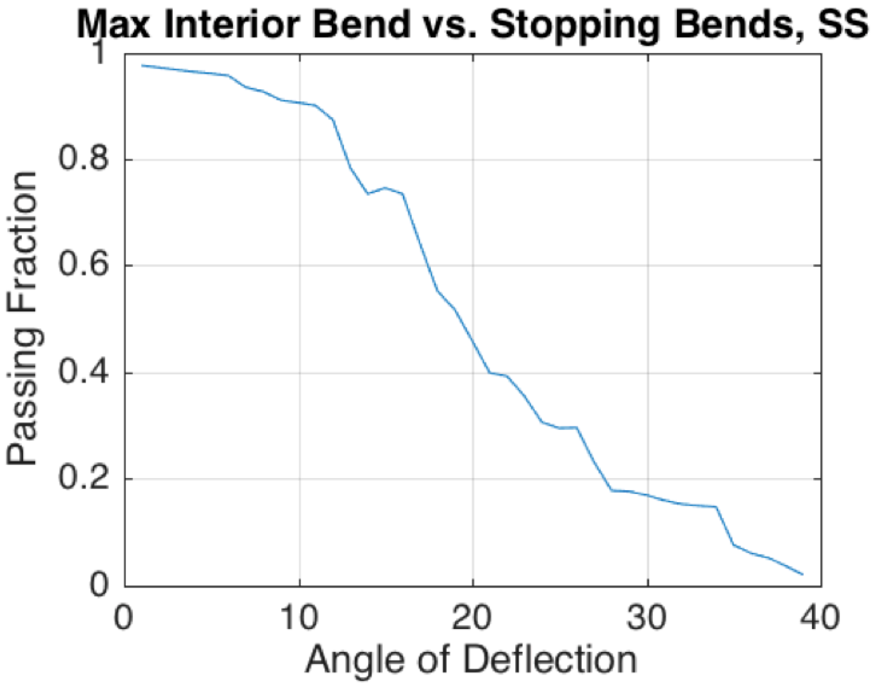
$$V(\mathbf{x},t) = \frac{\Delta u(\mathbf{x})}{t_{peak}(\mathbf{x})}\left(\frac{t - t_{rup}(\mathbf{x})}{t_{peak}(\mathbf{x})}\right)\exp\left[-\left(\frac{t - t_{rup}(\mathbf{x})}{t_{peak}(\mathbf{x})}\right)\right]$$

$$t_{peak}(\mathbf{x}) = \frac{\Delta u(\mathbf{x})}{eV_{peak}(\mathbf{x})}$$



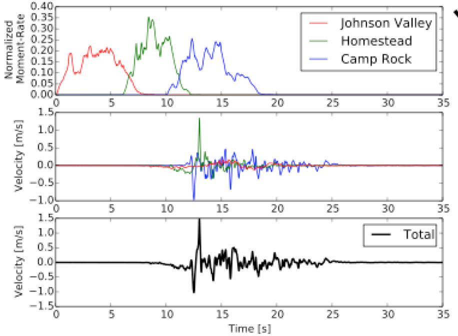
Empirical Data and Models Supporting Implementation of Complex Ruptures in the Broadband Platform

Glenn Biasi, University of Nevada, Reno

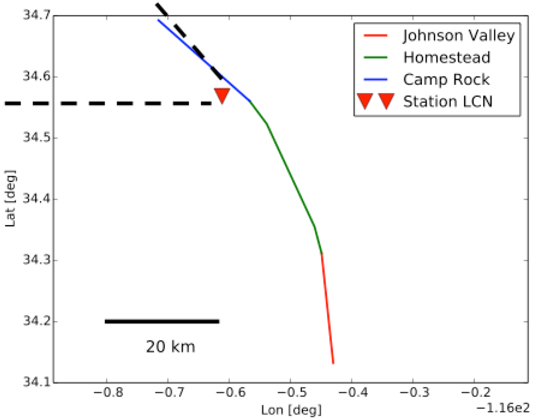


The project has developed the first empirical relation for the relative ability of fault bends to stop rupture as a function of bend angle.

Kinematic Rupture on Multi-Segment Faults: The UCSB Ground-Motion Simulation Method



We have extended the capabilities of the UCSB code for ground motion simulation by including fault bending, step-overs and multi-segment kinematic ruptures.



- Each fault segment has it's own nucleation point, which is consistent with dynamic rupture simulations.
- The timing of the rupture on the different segments is set such that they agree with dynamic ruptures simulations.
- Validations of the new capabilities have been tested for the 1992 Landers earthquake.

The upper figure shows:

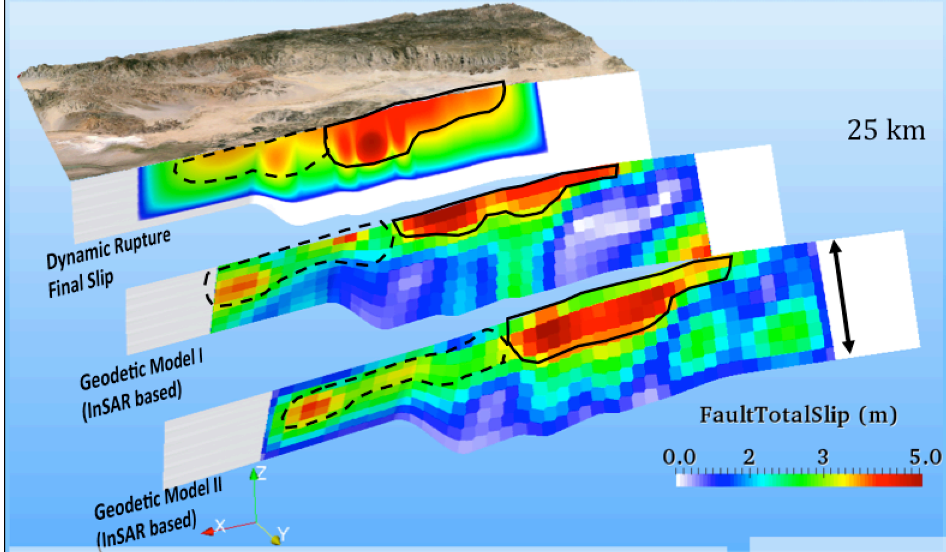
a) The normalized moment-rate functions at each fault segment.
b) Ground-motion velocity produced by each fault-segment.
c) Total ground motion produced at station LCN.

Geodetic and Dynamic Models of the 2010 El Mayor/Cucapah Earthquake

Kyriakopoulos, Oglesby, Funning

UC RIVERSIDE, UNIVERSITY OF CALIFORNIA
Earthquake Physics Laboratory

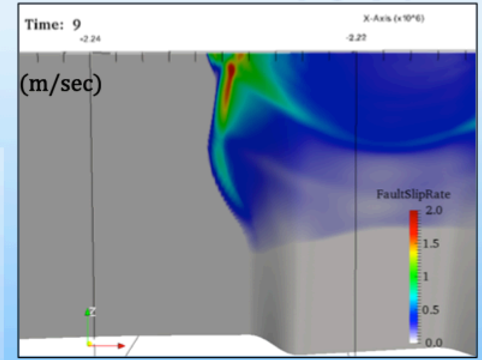
Geodetic Model vs Dynamic Rupture model (Final Slip Models)



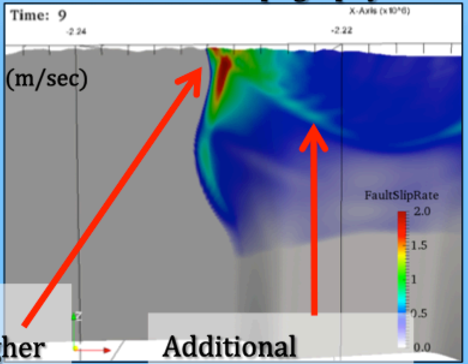
Fault geometry produces slip that naturally Matches Geodetic slip.
Surface topography produces complexity in Wave and rupture propagation.

Surface topographic effects on dynamic rupture (Snapshots of Fault Slip Rate)

No Surface Topography



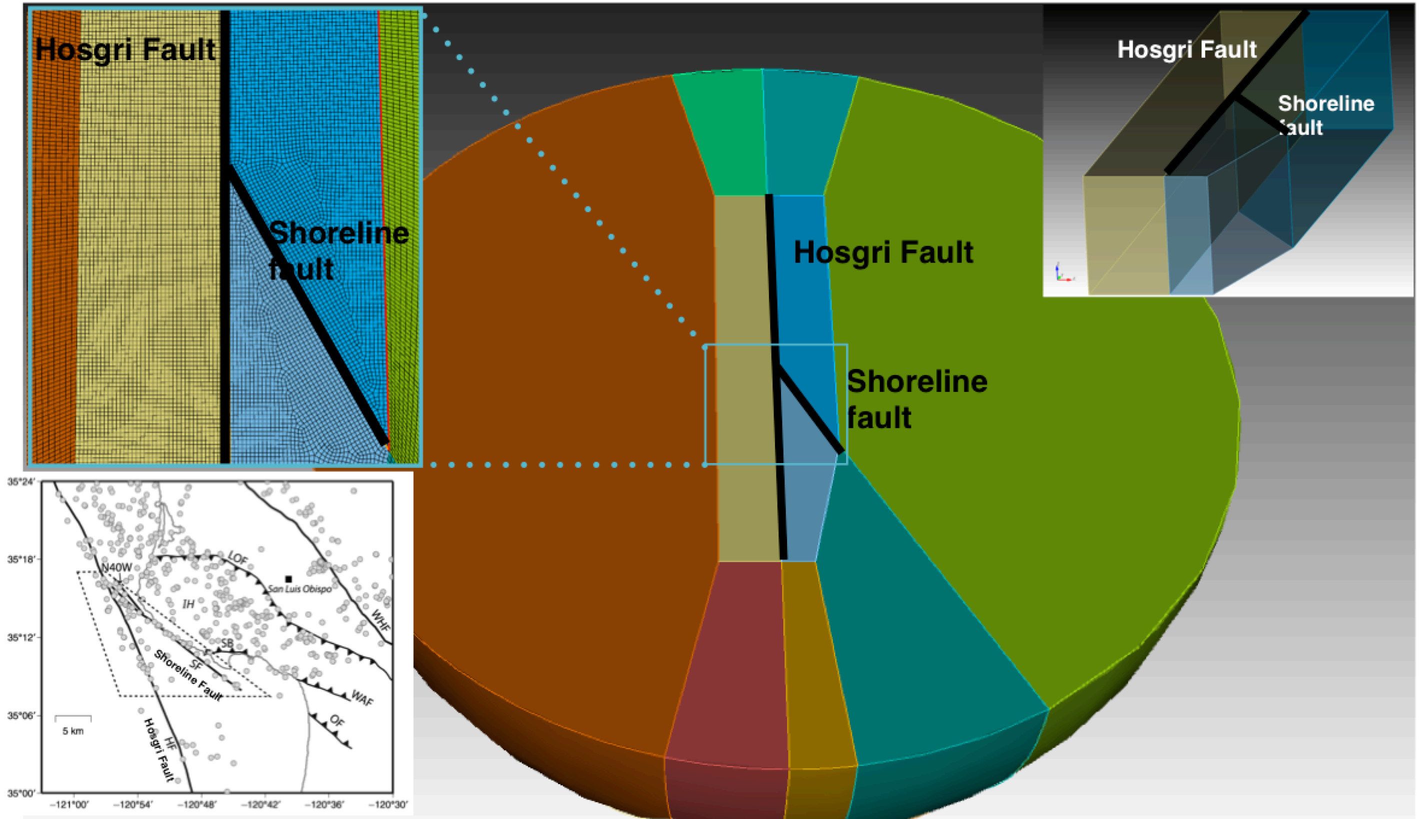
Surface Topography



Rupture front broken up; Higher fault slip rate at shallow depth

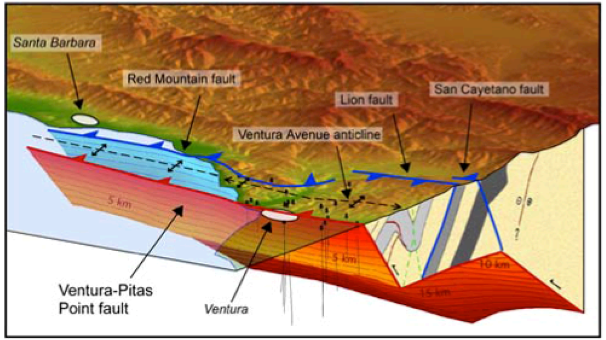
Additional reflected waves from free surface

3D Hosgri-Shoreline faults (Somerville et al.)



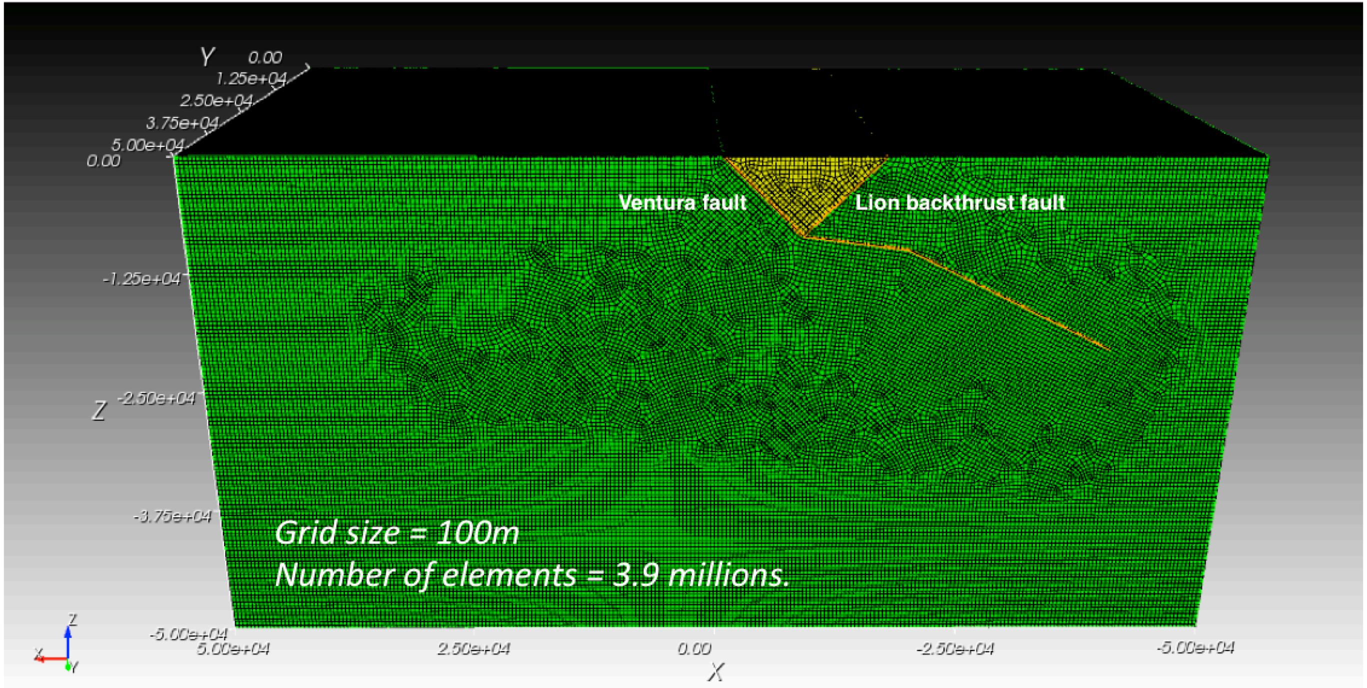
Hardebeck et al. (2013)

3D dynamic rupture modeling of the Hosgri-Shoreline faults. We built a robust and stable 3D mesh of the Hosgri-Shoreline faults using the state-of-the-art software CUBIT. In this mesh, the faults are represented by split nodes and we are able to generate Mw 7.2 earthquakes with branching ruptures using our dynamic rupture module in SPECFEM3D, (Galvez et al., 2014,2016). Our dynamic rupture simulations have been tested and passed the SCEC/USGS dynamic rupture benchmarks for 3D branching ruptures (TPV24-25) of Harris et al. (2009). The branching rupture scenarios produced here will serve as guidance to build kinematic models that will be used for strong ground motions simulations using the SCEC broadband platform.

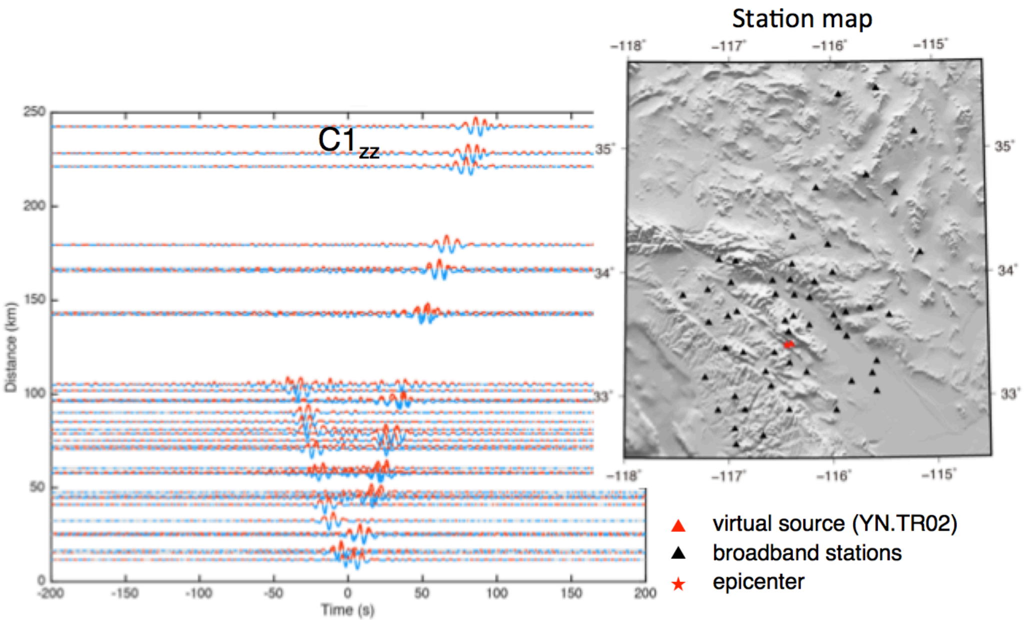


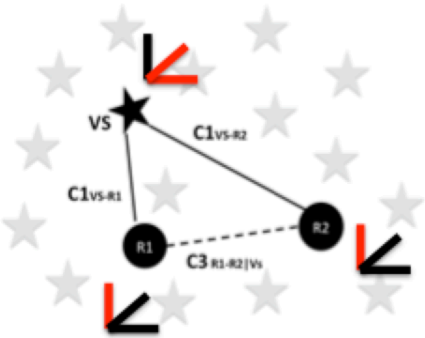
Ventura fault system (Somerville et al.)

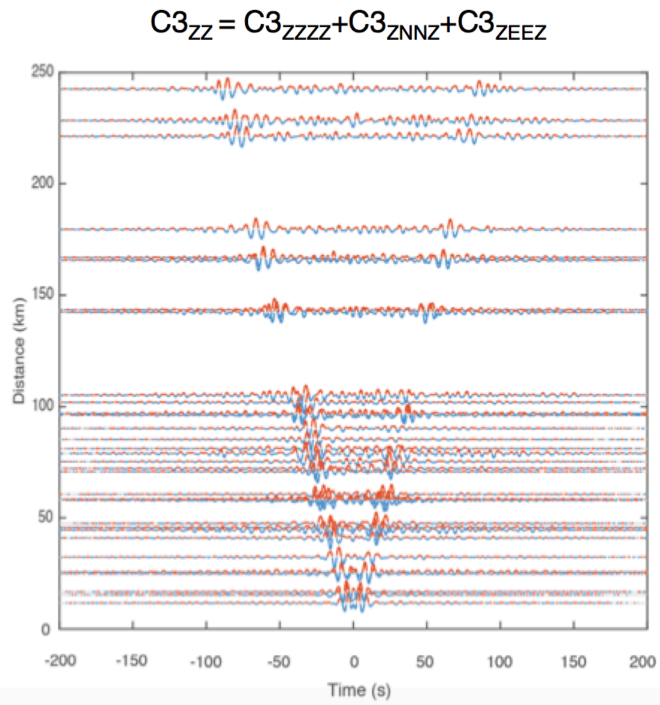
We built a stable and robust 3D mesh setting for the Ventura fault including the Lion backthrust. Using this mesh we perform dynamic rupture simulation to explore the potential of splay fault ruptures where the earthquake nucleates at depth on the Ventura fault. The dynamic parameters of the splay rupture will serve as guidance to build kinematic models that will be used for strong ground motion simulations using the SCEC broadband platform.



Higher order, multi-dimensional ambient field analysis improves Green’s function retrieval.





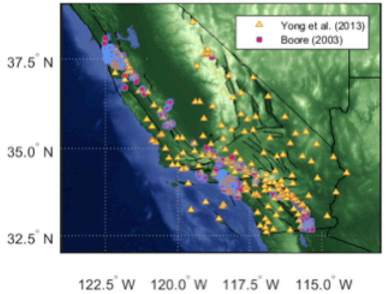


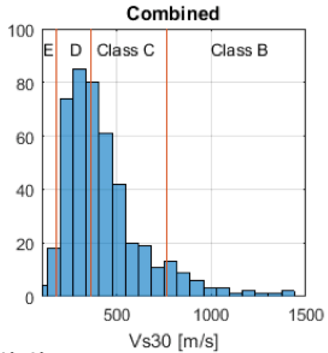
Sheng et al.
Poster #274

A stochastic Vs30-dependent velocity model of near-surface sediments in Southern California (GTL v2.0)

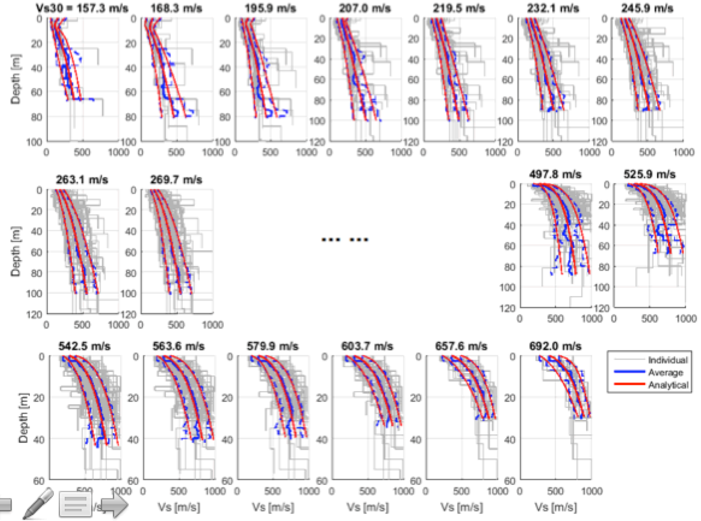
Shi, Asimaki, Taborda, Silva and Yong

400 velocity profiles

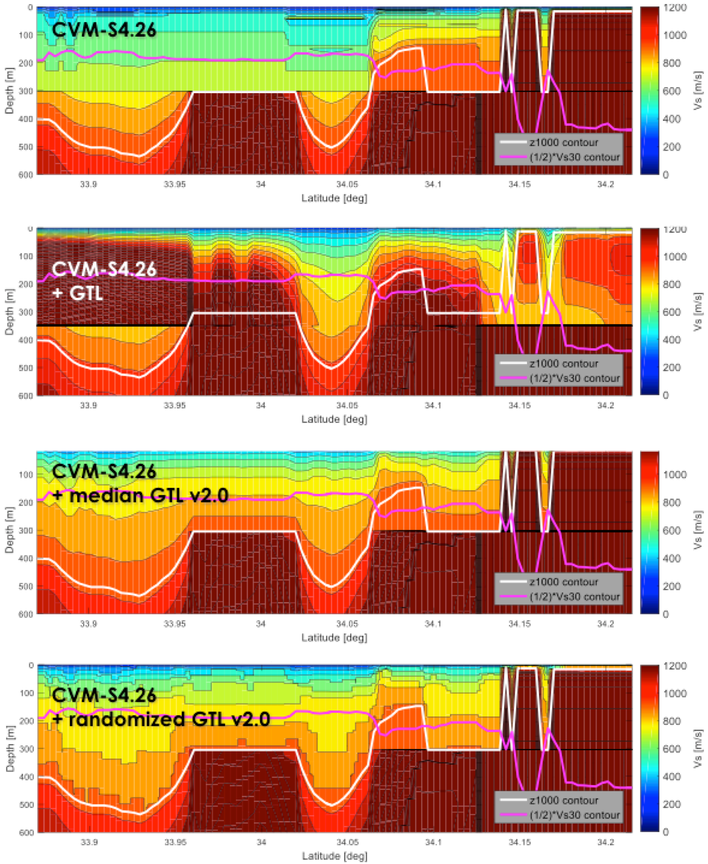




Profile statistics

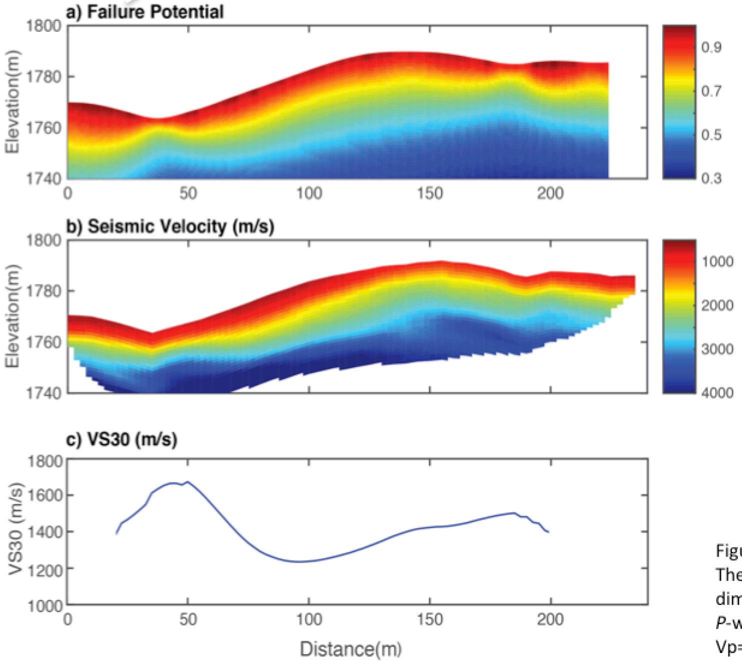


San Bernardino basin: GTL vs. GTL v2.0



SCEC Award #16076: Characterizing seismic site conditions in southern California based on topographically induced stress and bedrock fractures

Moon et al.



- To examine the potential control of topographic stresses on the local variability of Vs30, we measured the spatial distribution of near-surface seismic velocity at sites in the San Gabriel Mountains and the San Bernardino Mountains and compared the results with topographic stress model.

- Our results show that P-wave seismic velocity in the SGM site varies significantly (~ 25%) within hillslopes and does not linearly correlate with slope, while P-wave seismic velocity in the SBM site shows little variation within the hillslope.

- The correspondence between topographic stress proxy (failure potential for shear fracture) and P-wave seismic velocity in SGM site suggests that bedrock fracture and weathering patterns influenced by topographic stresses may affect the local variability of near-surface seismic velocity.

Figure. Comparison of topographic stress proxy and seismic velocity for SGM site. The vertical distribution of (A) the modeled failure potential from two-dimensional stress model with horizontal stress value of 2 MPa, (B) the measured *P*-wave velocity, and (C) the averaged *S*-wave velocity for upper 30 m assuming Vp=√3Vs .

Lin et al.
Poster #177

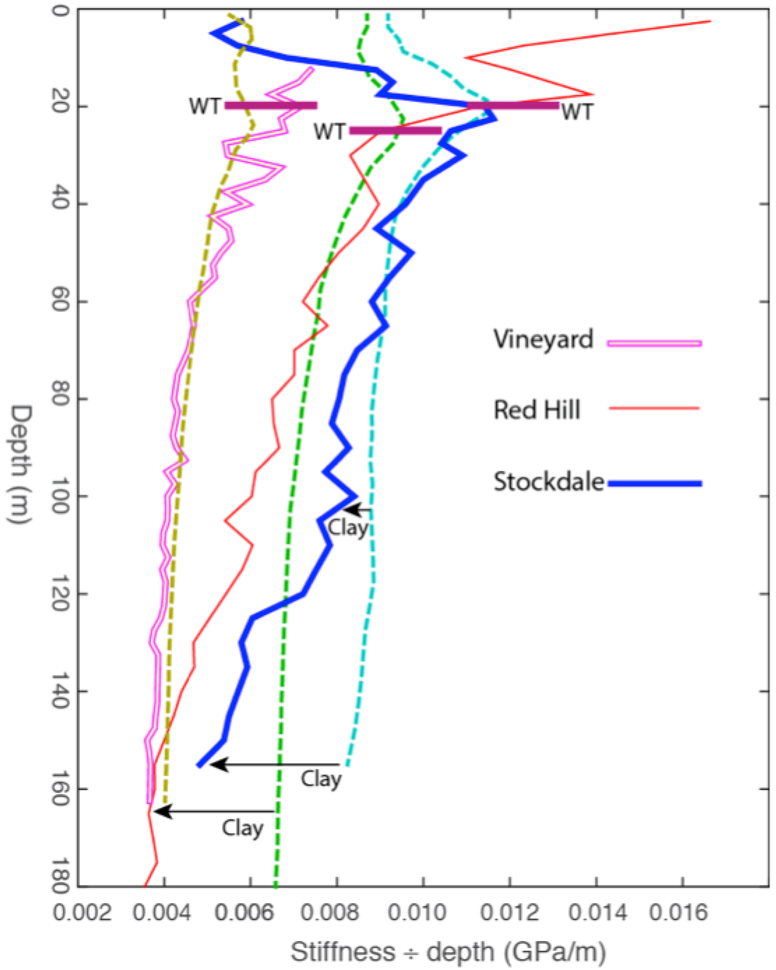
Frictional rheology for nonlinear attenuation: Implications for paleoseismology and strong S-waves

The shear modulus divided by depth versus depth

Notion is that strong shaking damages the shallow subsurface.

After a few events, the shear modulus self organizes such that frictional failure barely occurs

Sleep, Poster #279



Thank You

CA Earthquake Clearinghouse

http://www.californiaeqclearinghouse.org/

See Anne Rosinski (will be at the meeting until tomorrow morning)

UPCOMING CLEARINGHOUSE TRAINING OPPORTUNITY IN S. CALIFORNIA

- **CA National Guard Vigilant Guard 17-1**

  November 14-20, 2016

- Scenario: Mw6.0 earthquake near Las Vegas, followed 2 days later by Mw7.8 earthquake in Southern CA
- Use materials Clearinghouse developed for 2015 Capstone exercise
- **Understanding impacts to back-to-back earthquakes in neighboring states**
- **Information sharing in support of situational awareness, and understanding of interdependencies between critical infrastructure**
- **Overflight missions on both Blackhawk and Lakota helicopters; November 16, 2016**
- **Physical Clearinghouse at Los Alamitos, November 16, 2016. Become a registered Clearinghouse Disaster Service Worker partner**
- **Participate in afternoon briefing**
- **UPDATE ON USE OF DRONES IN DISASTER RESPONSE –** Use of drones during a disaster activation in California REQUIRES coordination with the California Office of Emergency Services, Air Coordination Group. Get the latest information on rapid certification to fly a drone following an earthquake.