Proposed Method to Generate Heterogeneous Initial Conditions For the '100 Runs' Project

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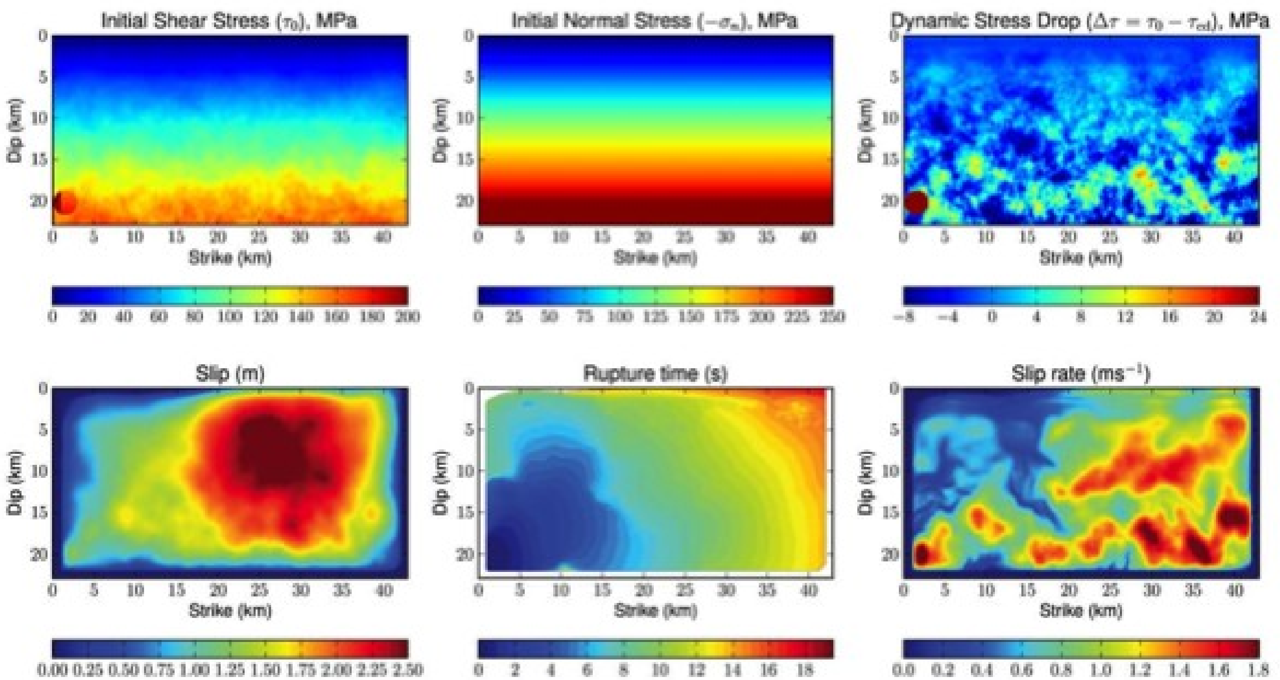

SAN DIEGO STATE UNIVERSITY

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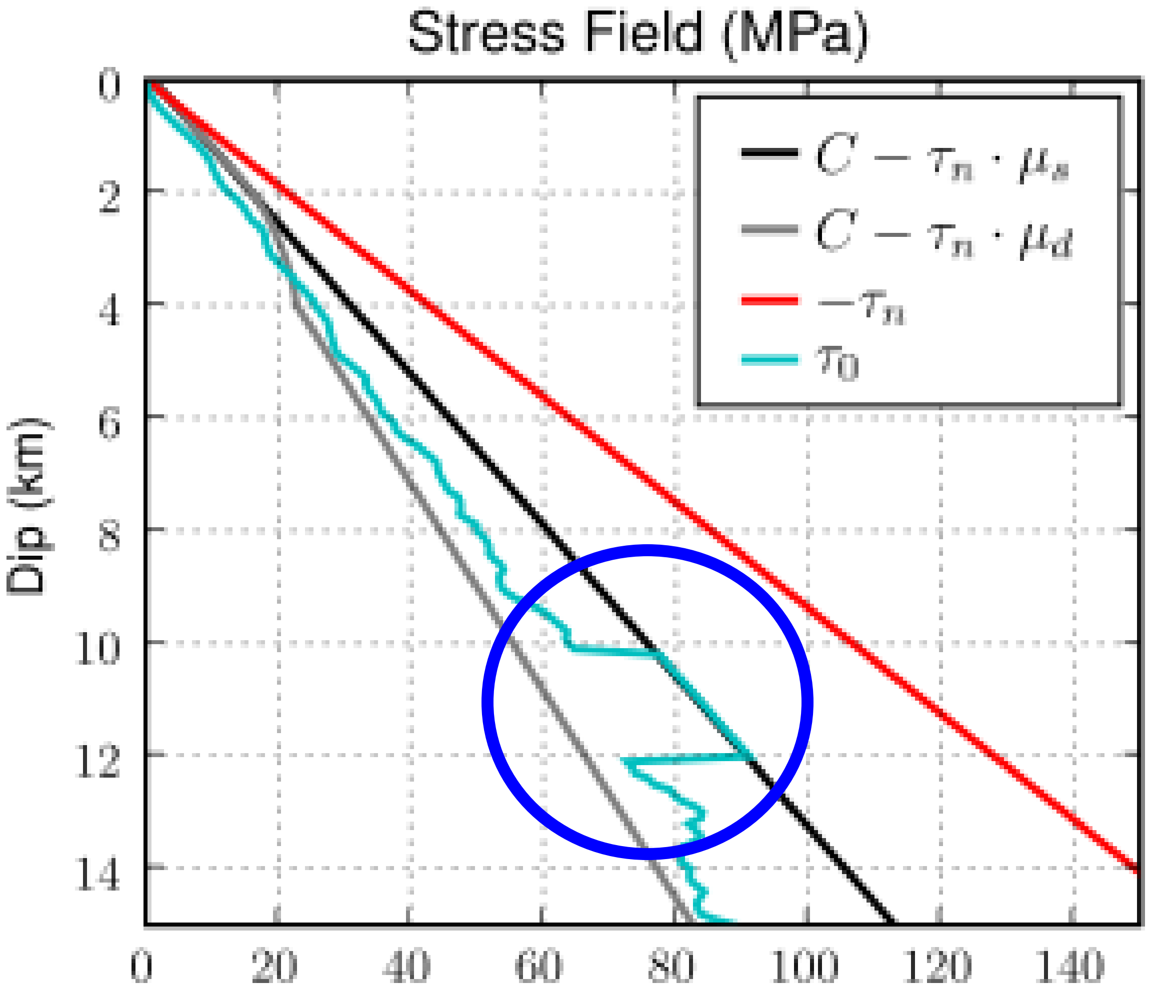
Outline

- Description of depth-dependent initial conditions
- Near-surface velocity strengthening, effect on near-field ground motions
- Examples of normal-fault earthquakes, strike-slip event
- Comparison of simulated ground motions to NGA relationships

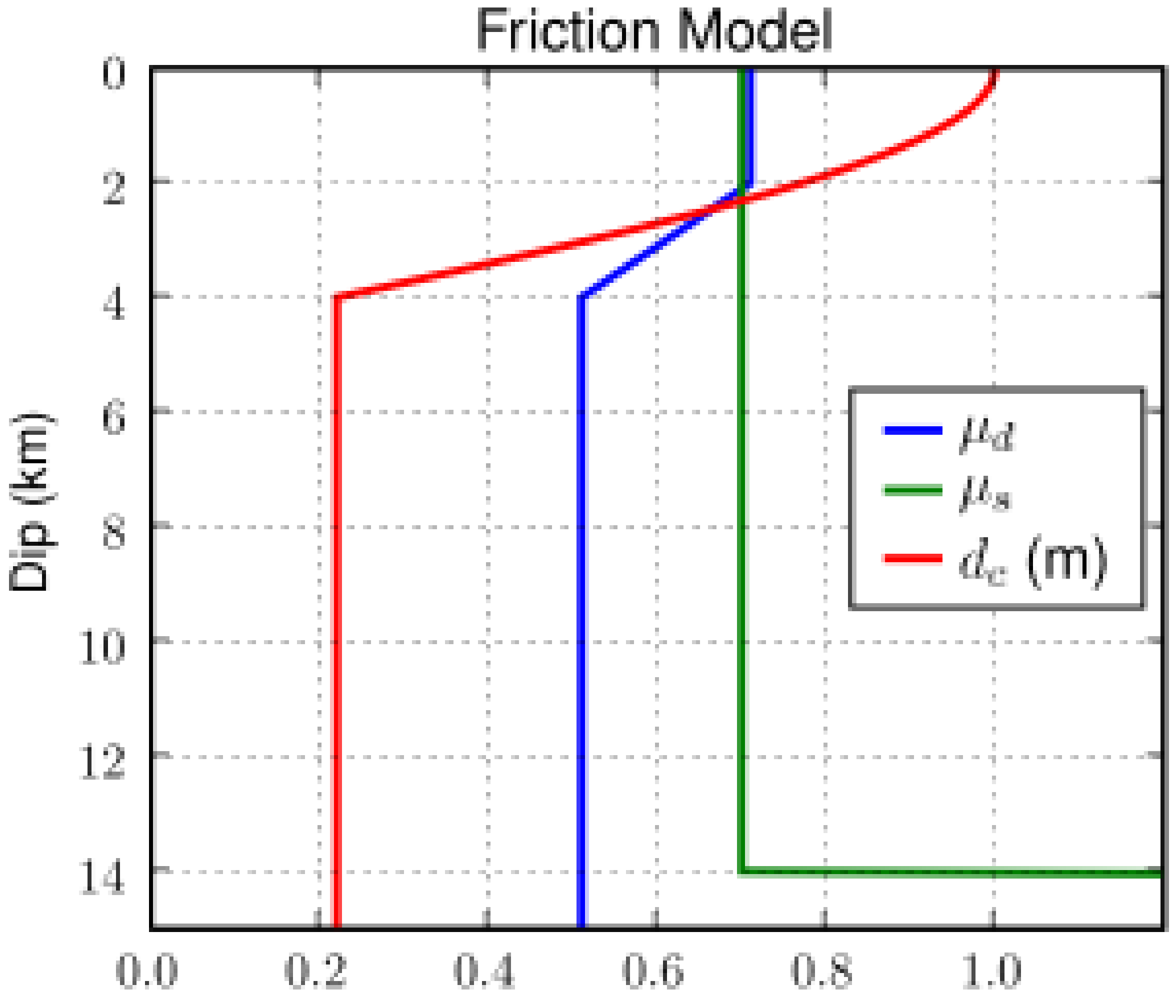
Linear Slip Weakening Friction Law

$$\mu_f(l) = \begin{cases} \mu_s - (\mu_s - \mu_d)\, l/d_0 & \text{if } \; l < d_0 \\ \mu_d & \text{if } \; l \geq d_0. \end{cases}$$

Depth Dependent Initial Conditions (following Gritz and Day, 2009; Dalguer and Mai, 2008)

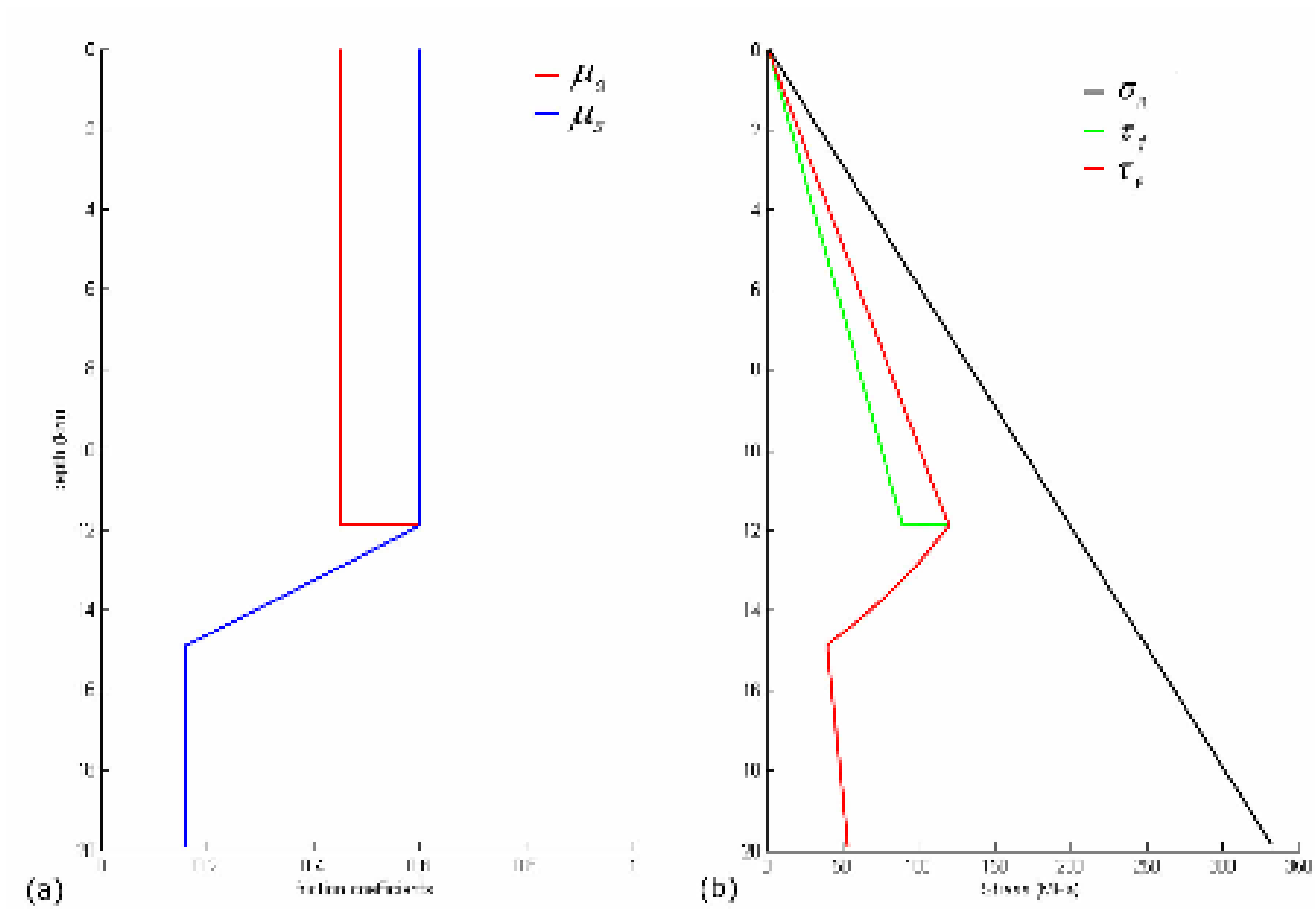


Near-surface velocity strengthening



Depth Dependent Initial Conditions

(following Gritz and Day, 2009)



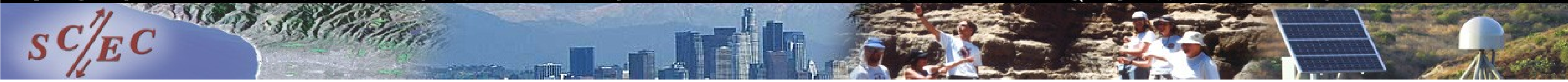
Correlation Distances and Hurst Exponent

$$a_x \approx 2.0 + \frac{1}{3} L_{eff}$$

$$a_z \approx 1.0 + \frac{1}{3} W_{eff}.$$

H ~ [0.5,1.0], magnitude independent Mai and Beroza (2002)

0.75 Tsai (1997)



Accuracy of Dynamic Simulations

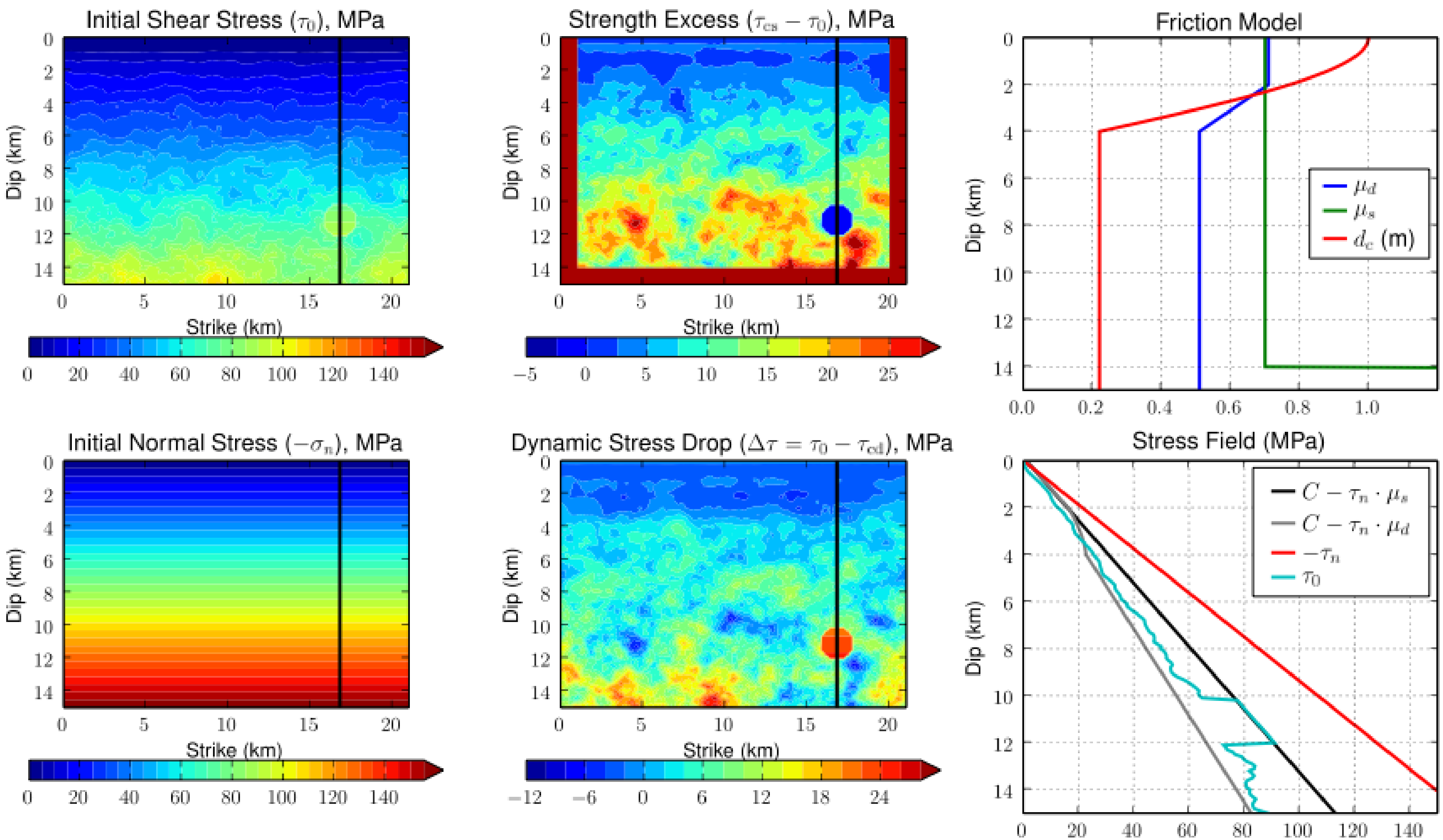
$$\frac{C_1}{C_2}\left(\frac{\mu d_c}{\Delta\tau}\right)^2\frac{1}{L}$$

$\Delta\tau$ = 3 MPa, μ = 3e10 Nm, L = 5000 m, d_c = 0.22 m -> cohesive zone resolved by more than 5 points

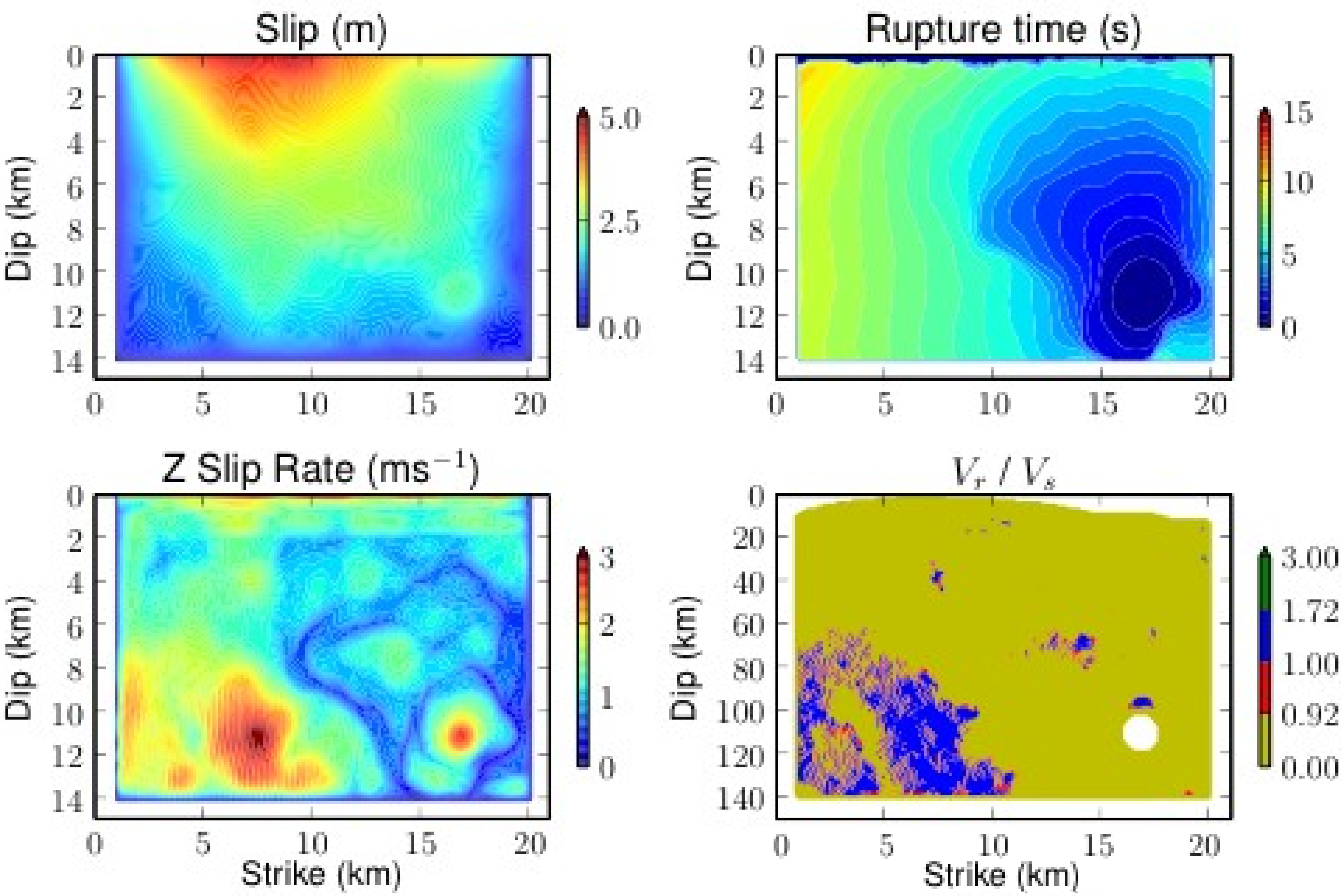
Parameters for M6.5 Test

L = 19 km (from W&C 1994)	ρ = 2000 kg/m3
W = 14 km (from W&C 1994)	$\mu_s = 0.70$
a_x = 5.7 km	$\mu_d = 0.51$
a_z = 4.8 km	$d_c = 0.22$
V_p = 5000 m/s	Δh = 100m
V_s = 2900 m/s	Δt = 0.008s

Dynamic Parameters



Excluding Near-Surface Velocity Strengthening



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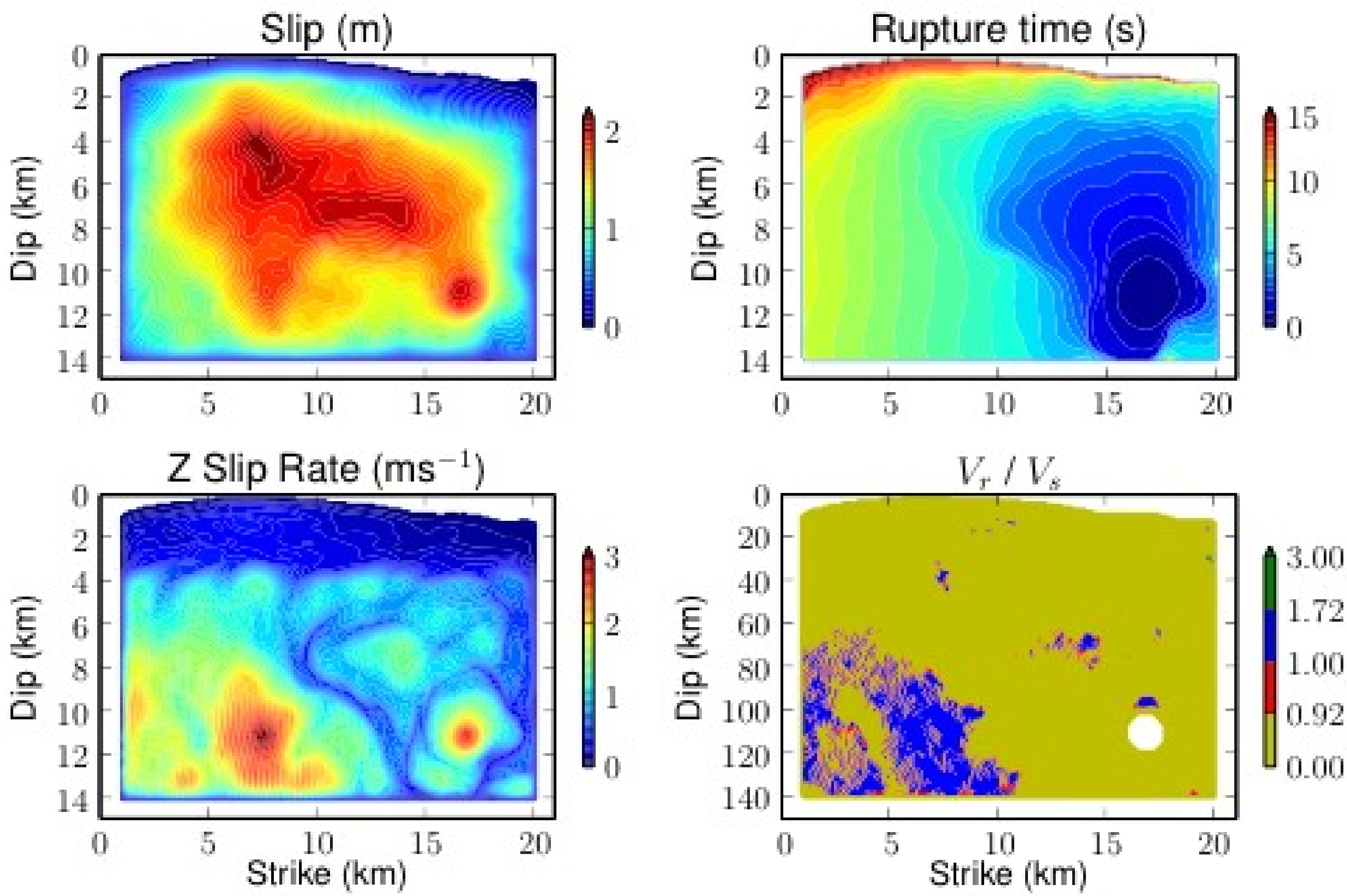
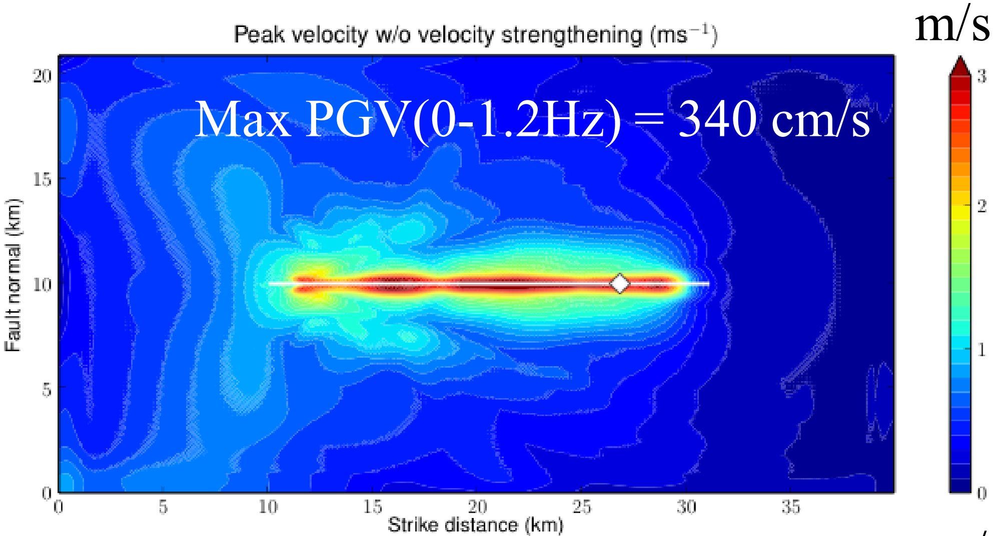
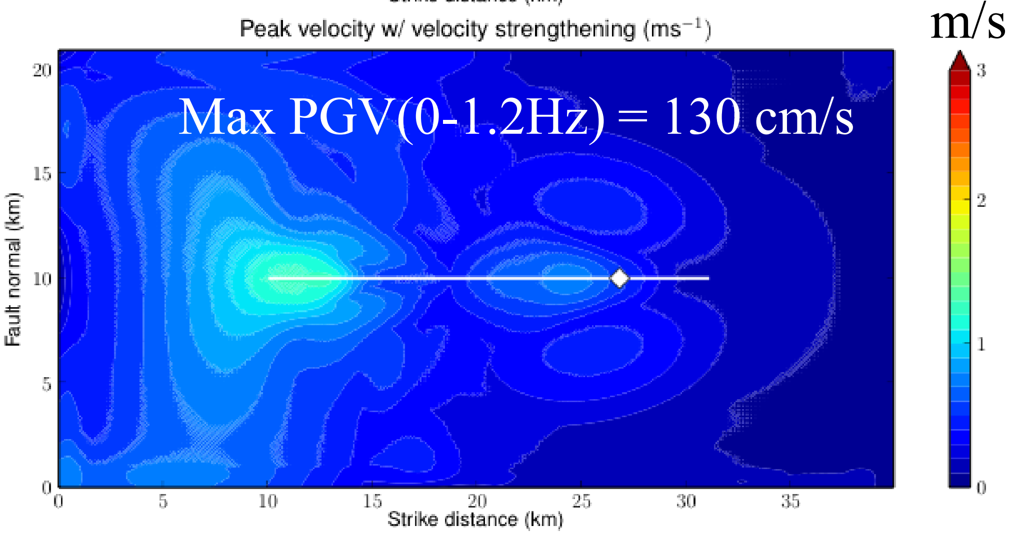
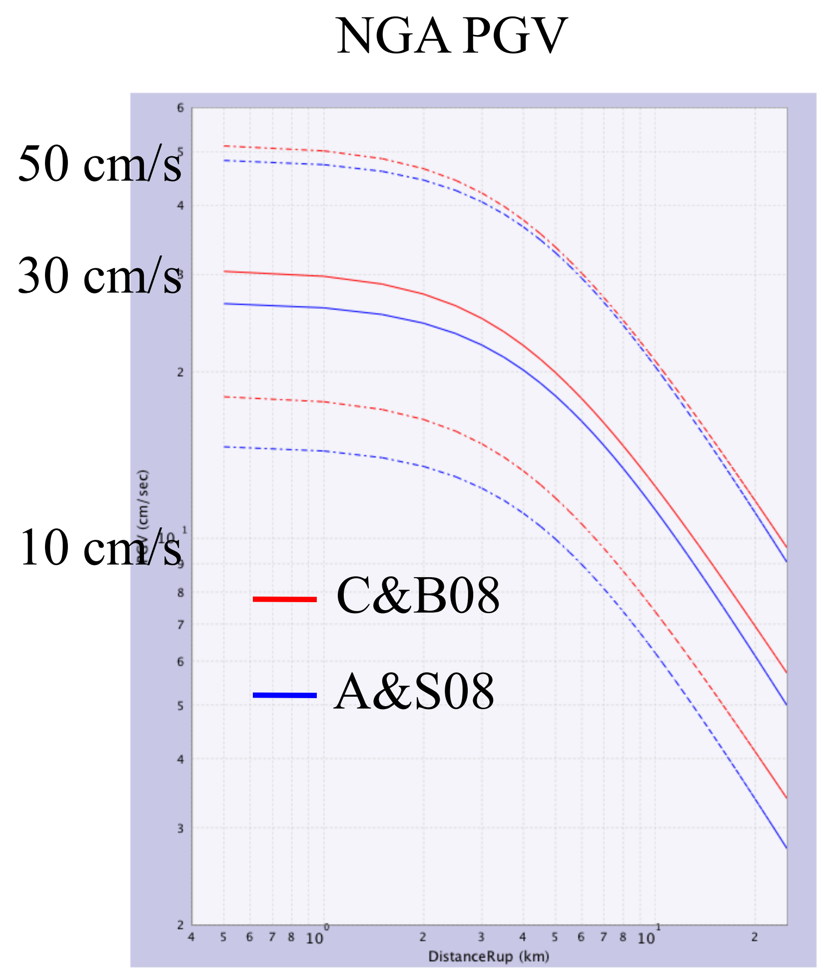


Comparison Against NGA



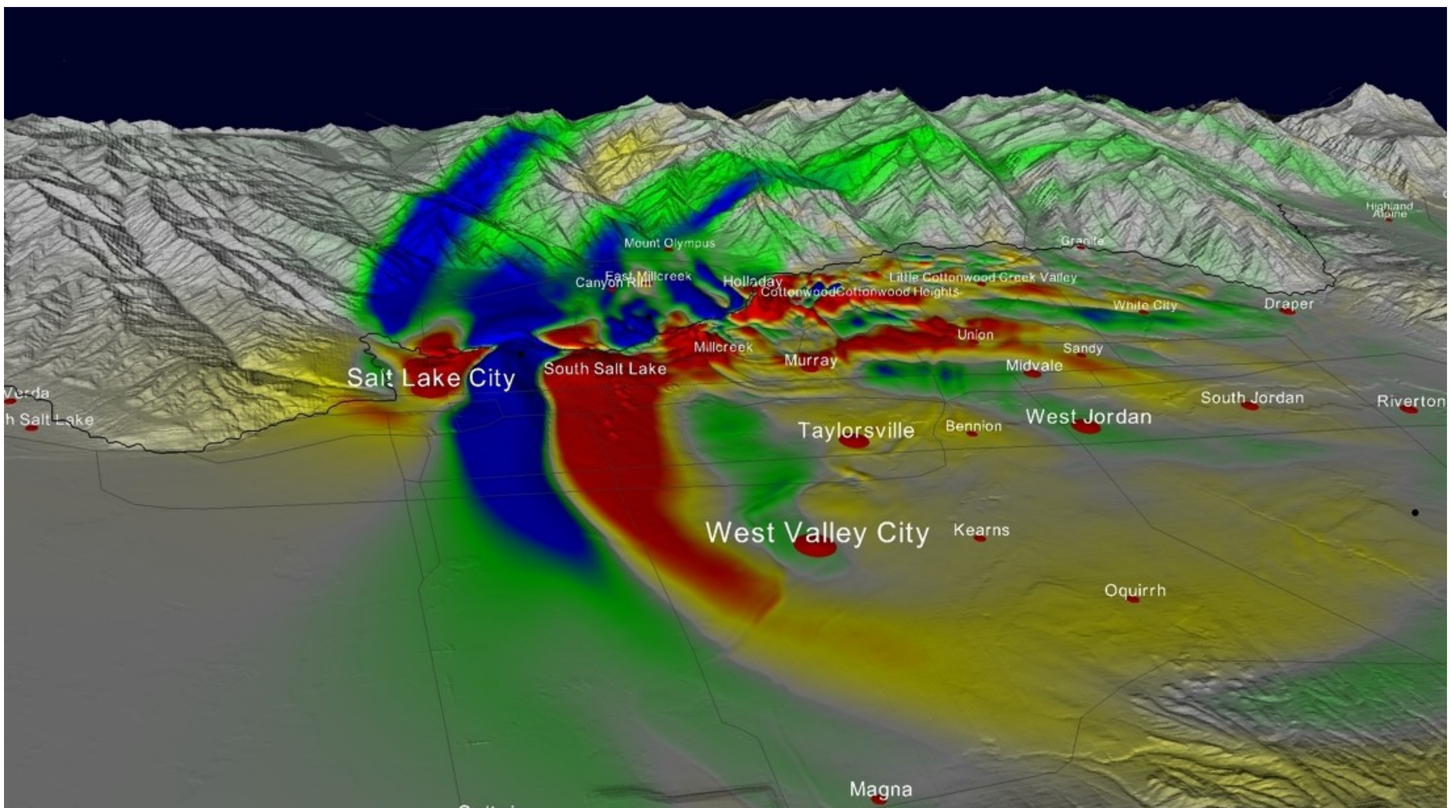


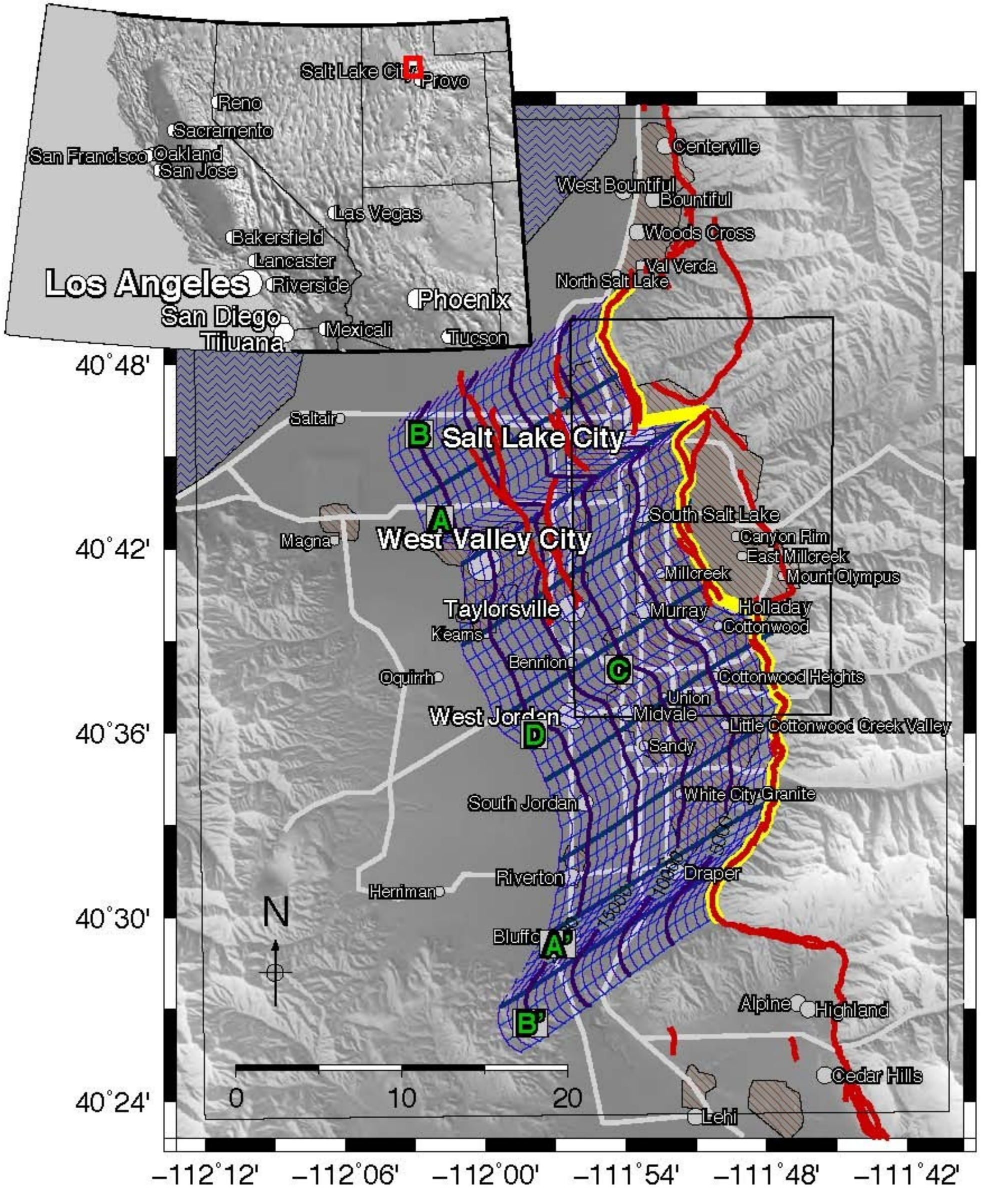


Example I

Ground Motions for M7 Scenarios on the Wasatch Fault, Utah

Roten, Olsen, Pechmann, Cruz-Atienza, Magistrale

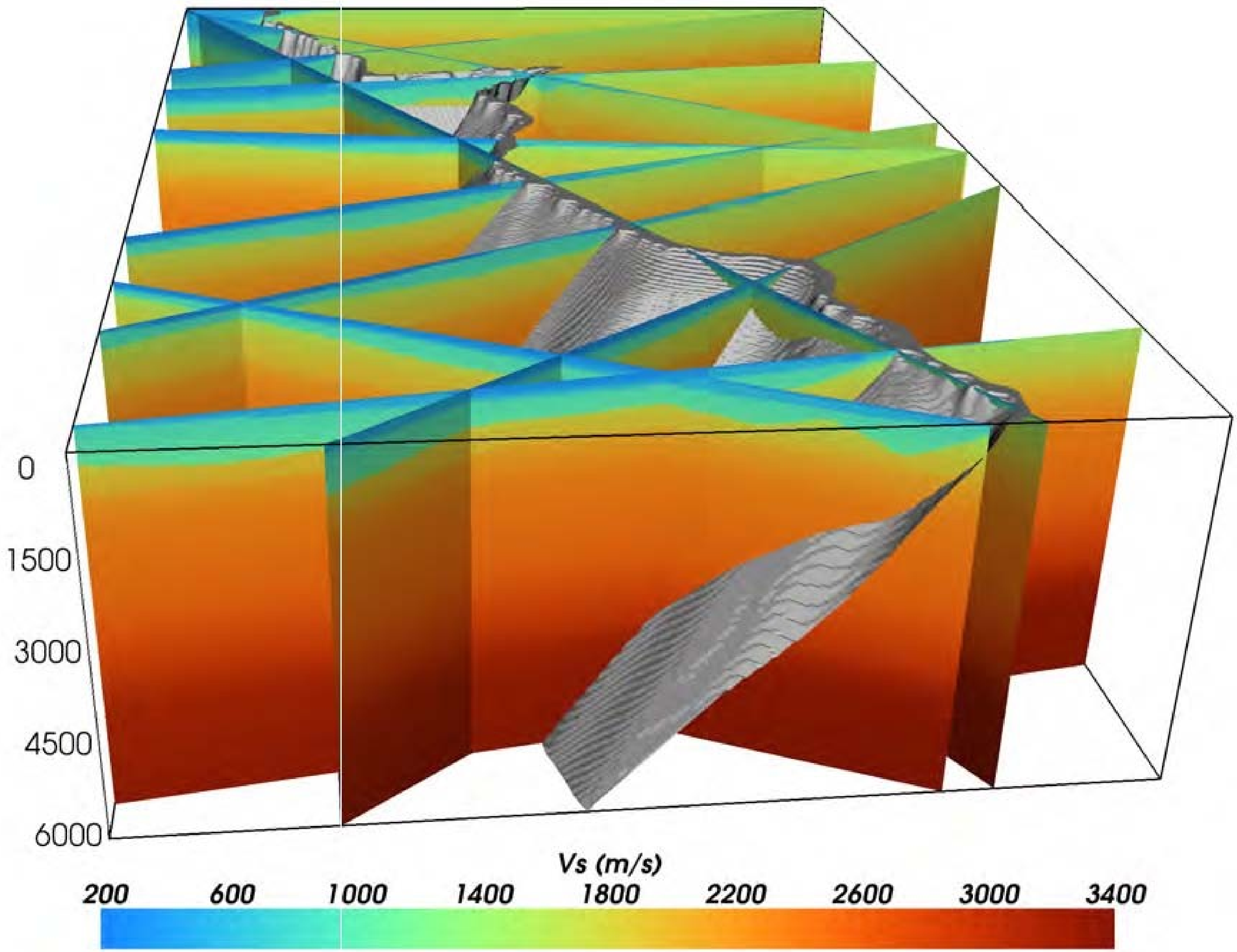




6 Different Hypocenters:

- Deep and shallow
- North and south

Wasatch Front CVM



Modeling Procedure

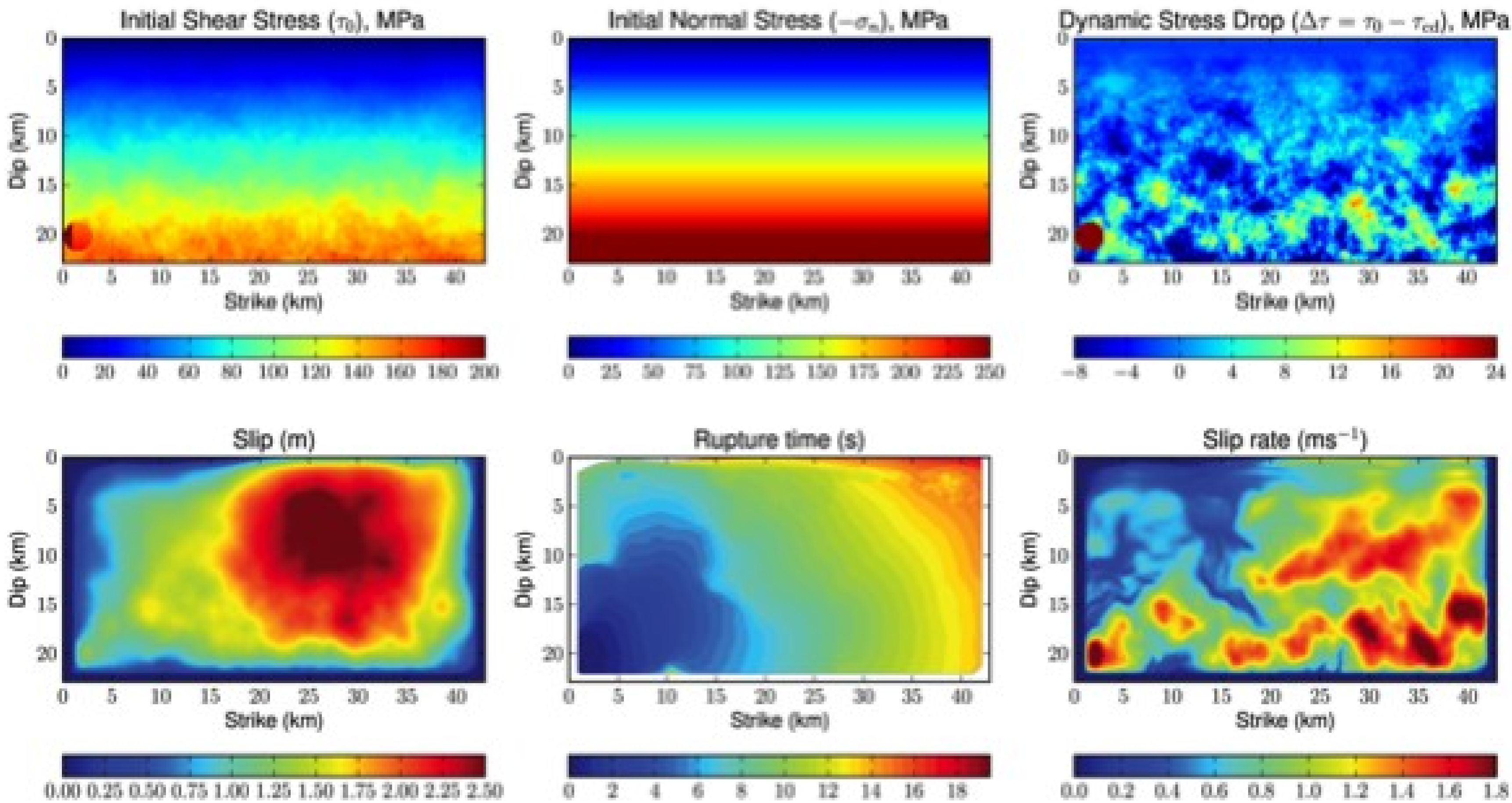
- Two-step procedure:

  1) Rupture simulated on vertical planar fault (SGSN)

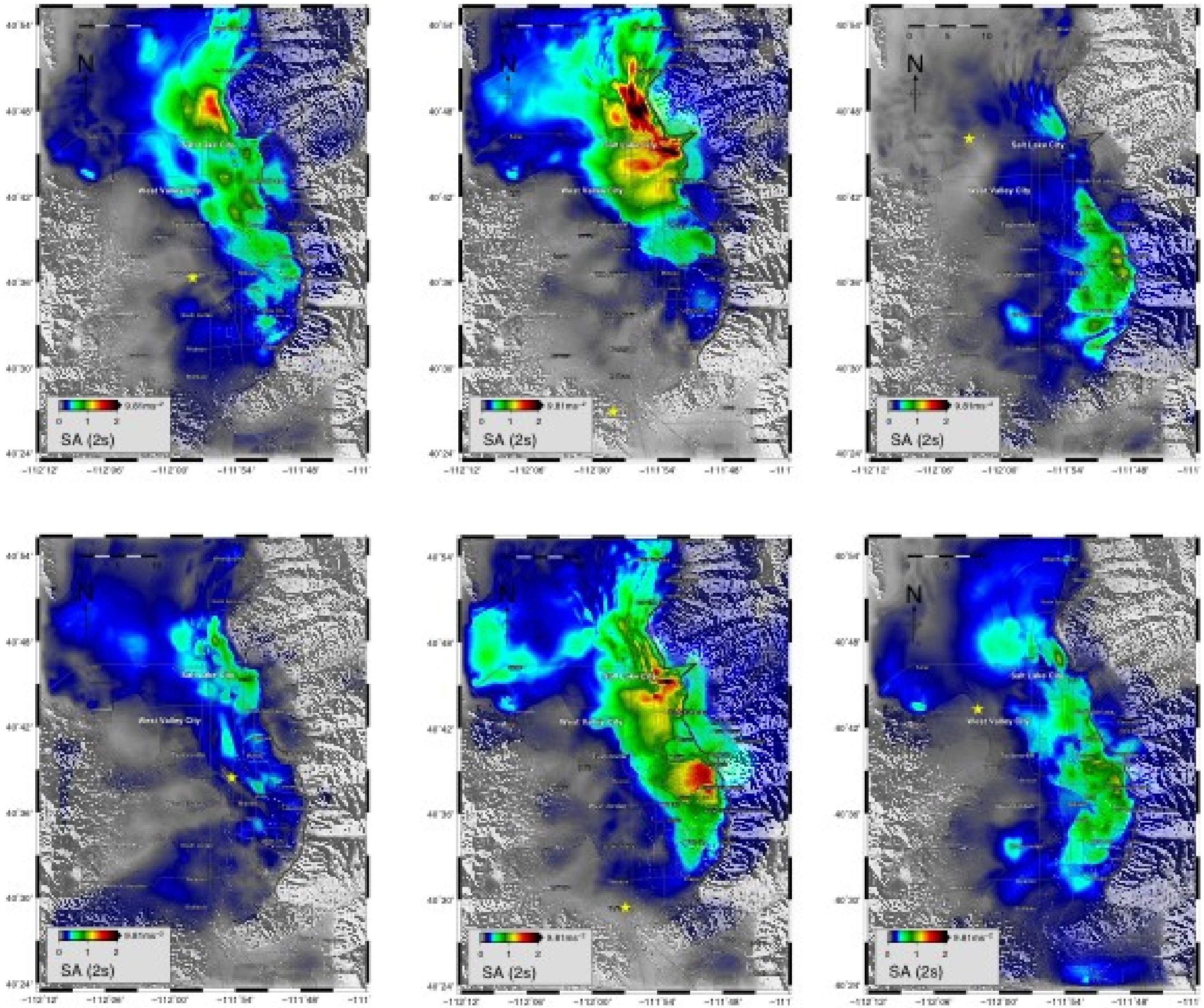
  2) Moment rates from 1) inserted on non-planar fault conforming to geology (FD)

- Velocity strengthening included. Otherwise peak motions are much larger than expected from NGA

Example of Initial Conditions

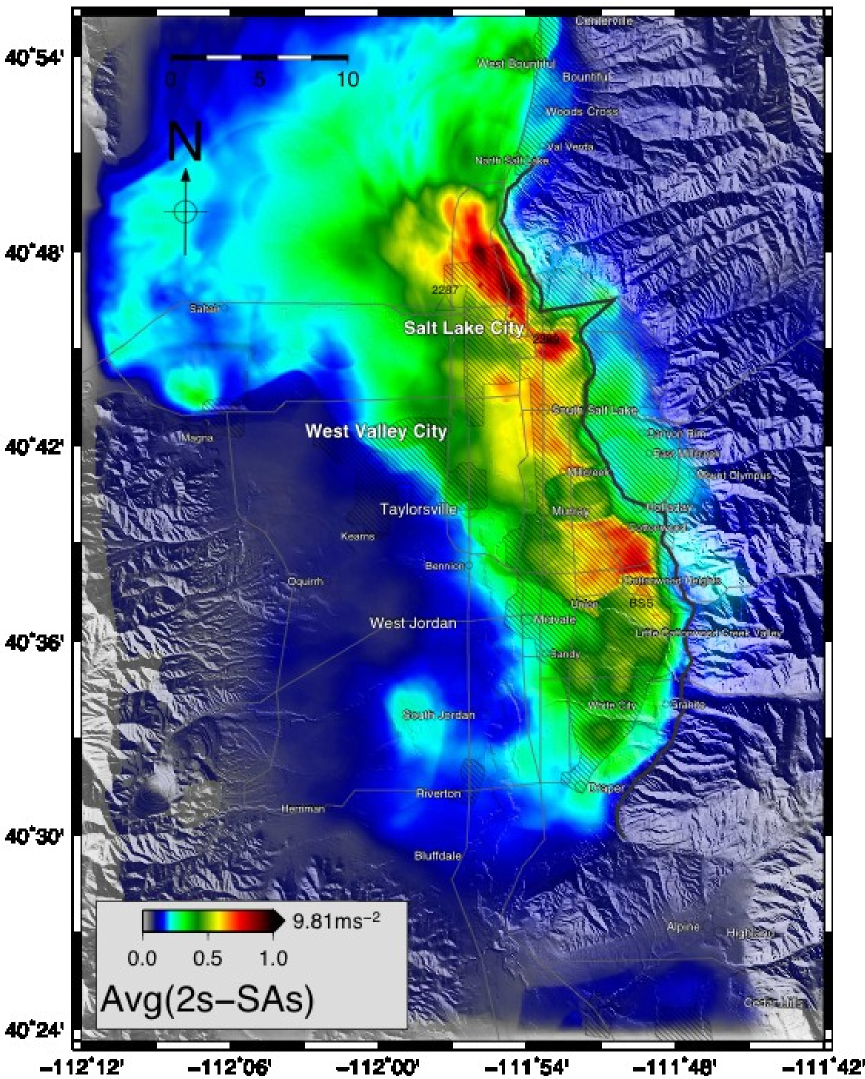


SA-2s for Six Scenarios

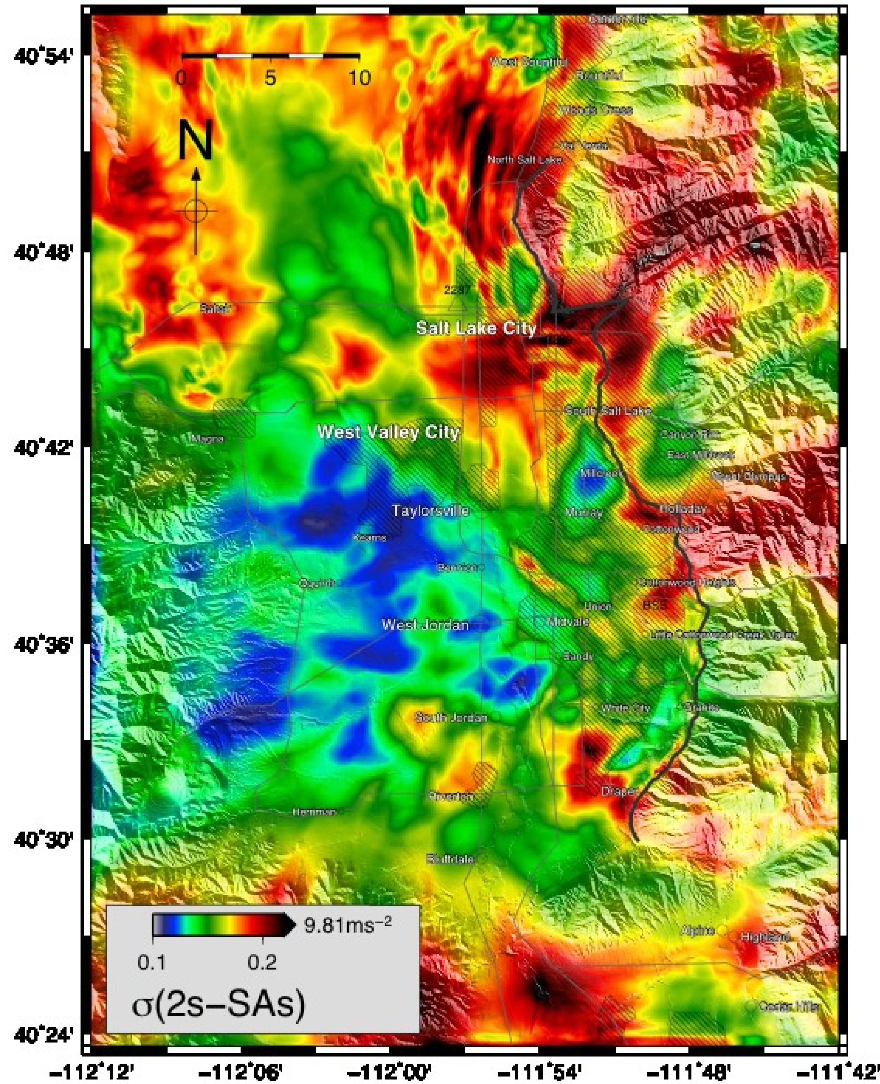


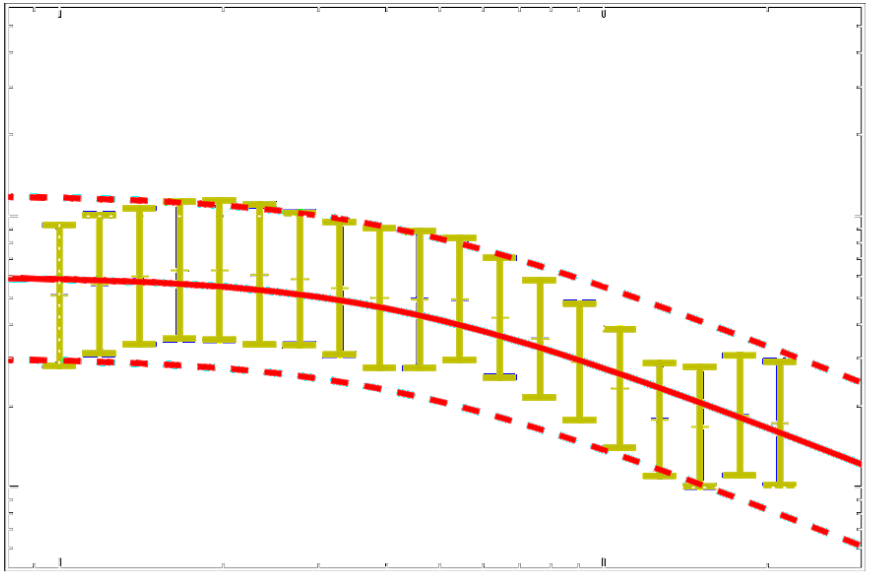
6 Scenario

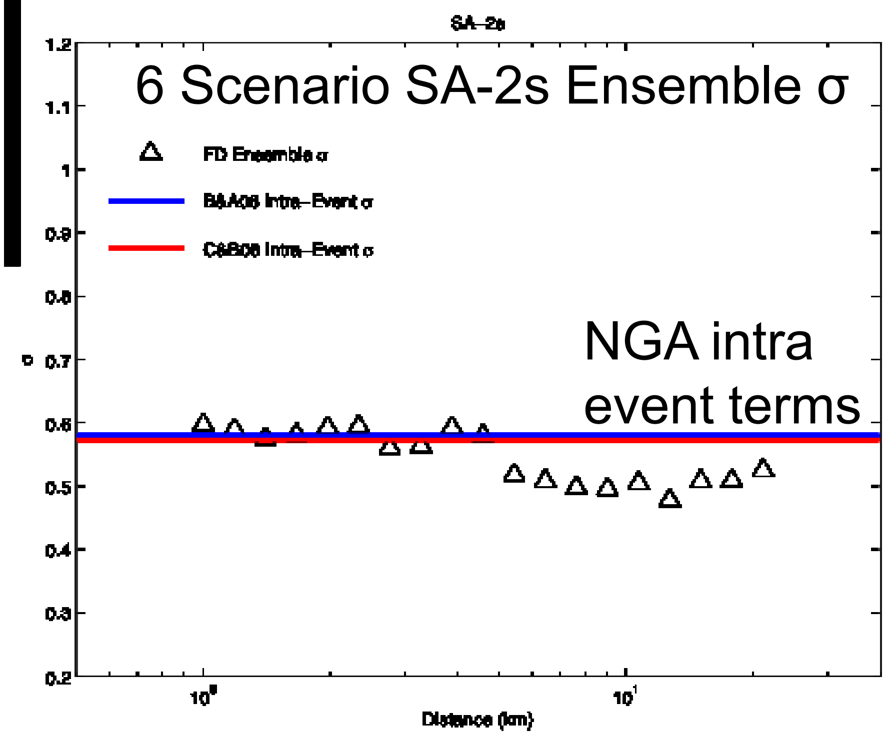
SA-2s Ensemble Mean



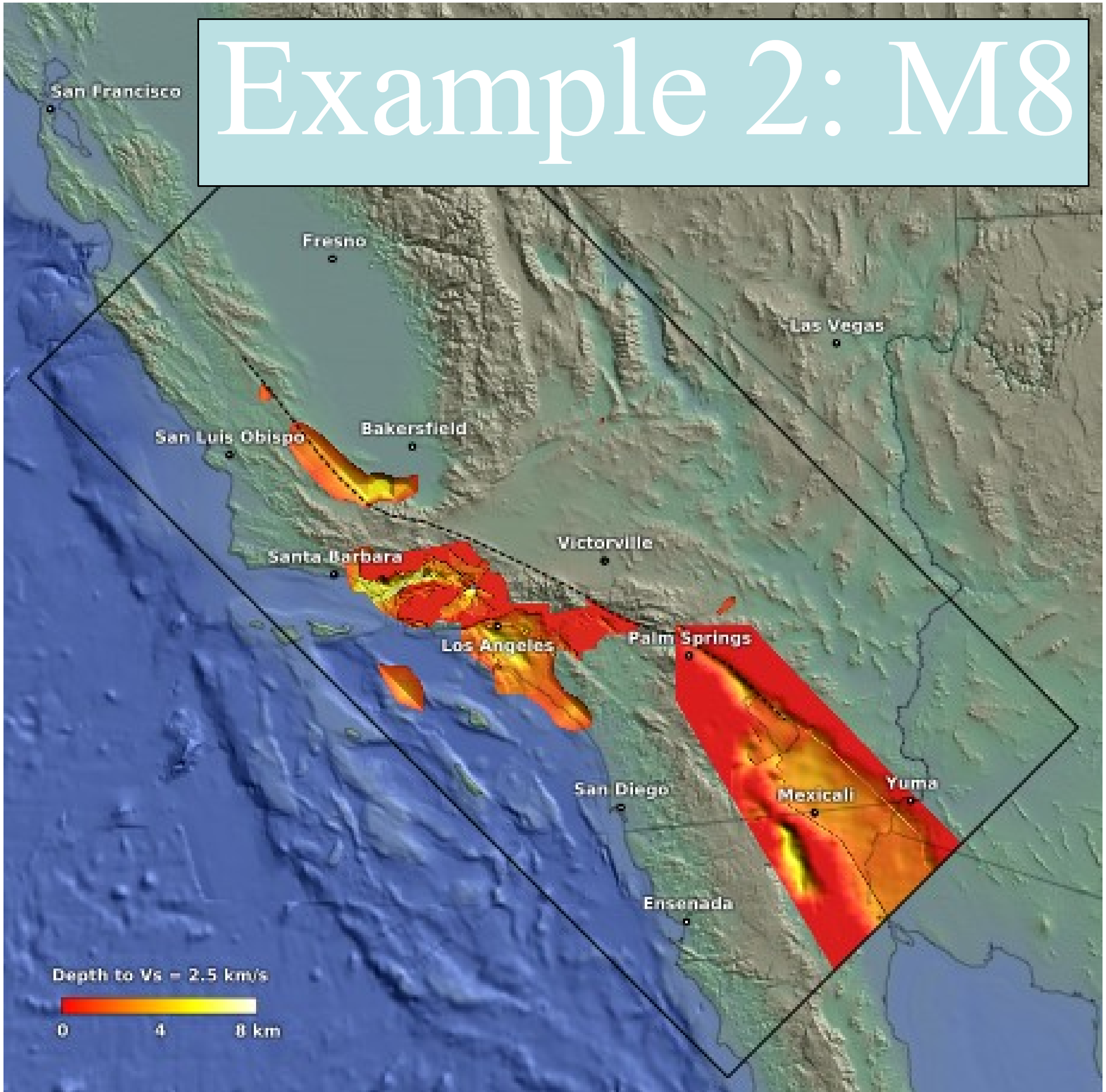
6 Scenario






SA-2s
6 Scenario SA-2s Ensemble σ
FD Ensemble σ
BA08 Intra-Event σ
CB08 Intra-Event σ
NGA intra event terms
σ
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
10^0
10^1
Distance (km)

Example 2: M8



M8 ‘wall-to-wall event on the SAF

545 km rupture

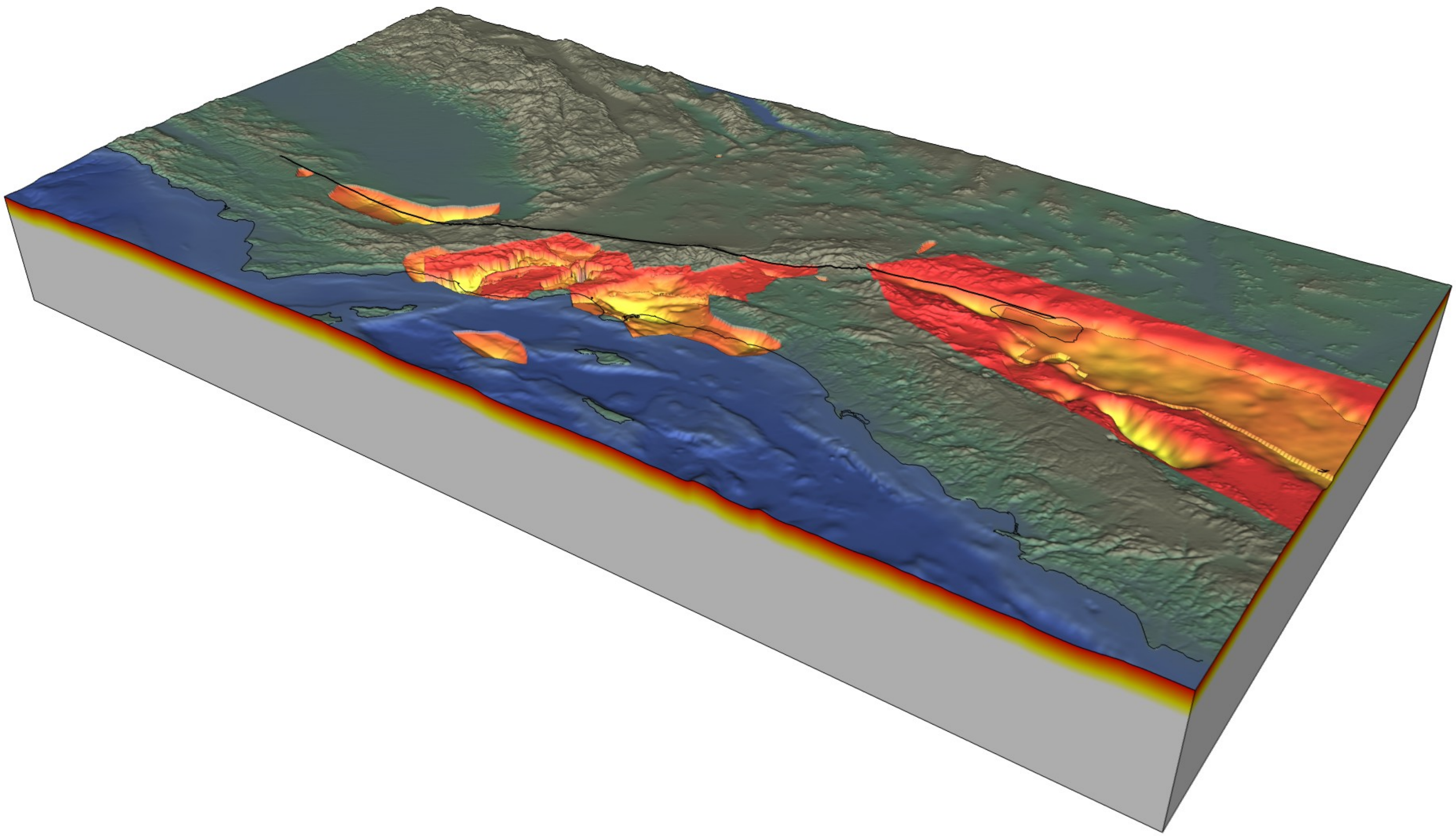
0-2Hz

435 billion grid points

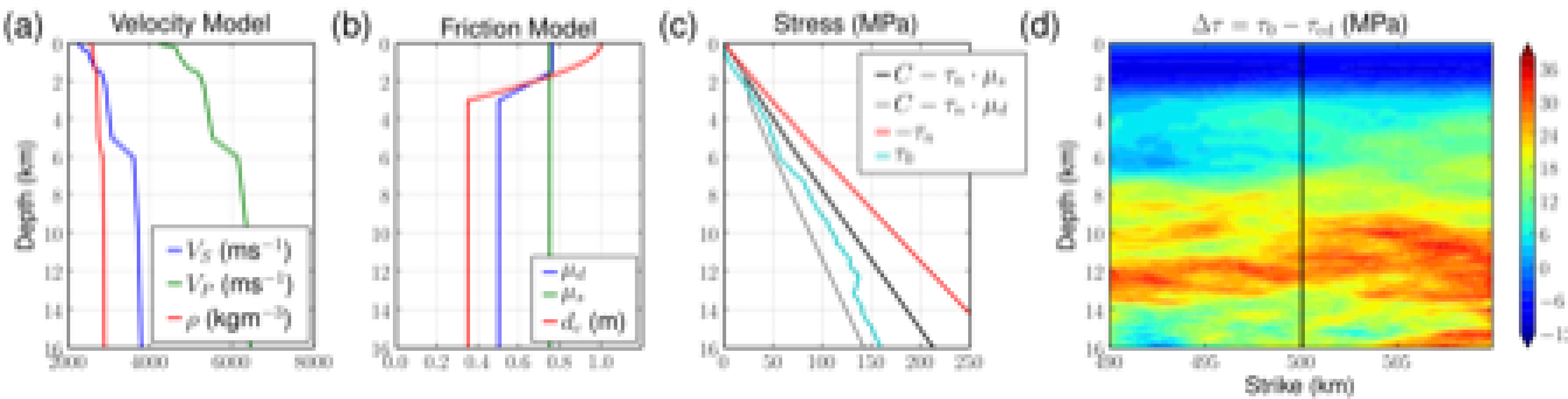
223,000 cores, 24 hrs

ORNL Jaguar

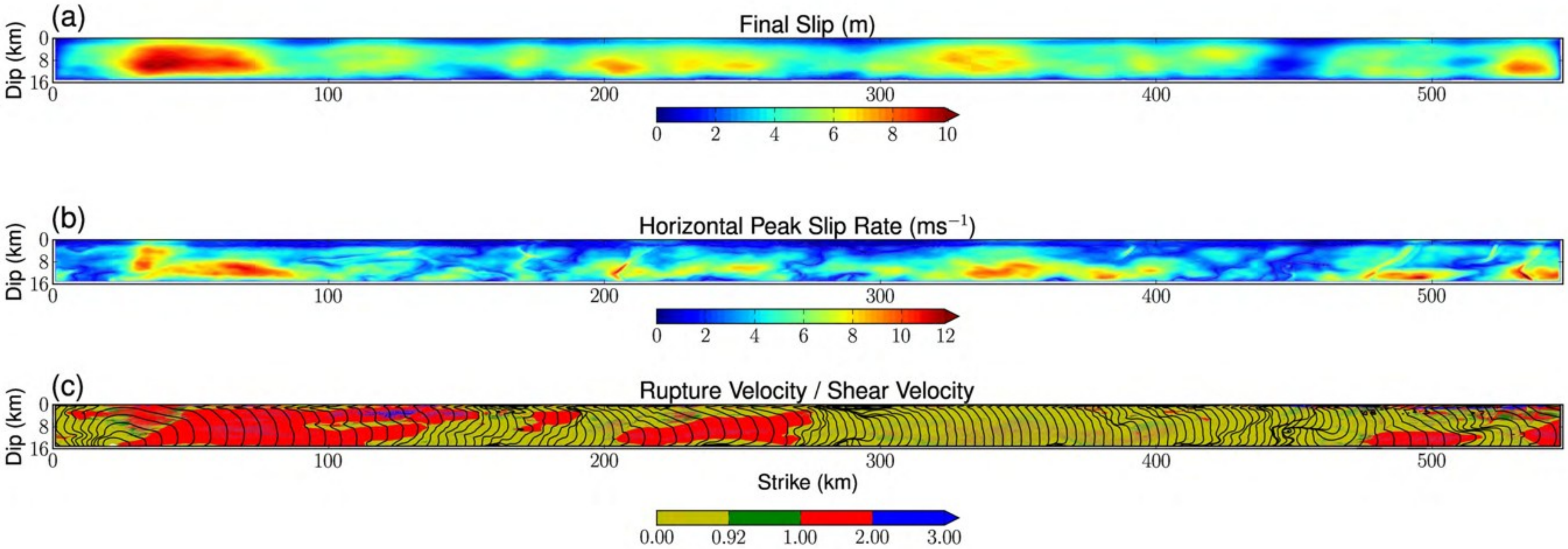
Velocity Model For M8

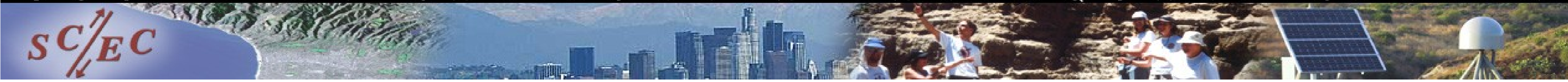


Initial Conditions for M8

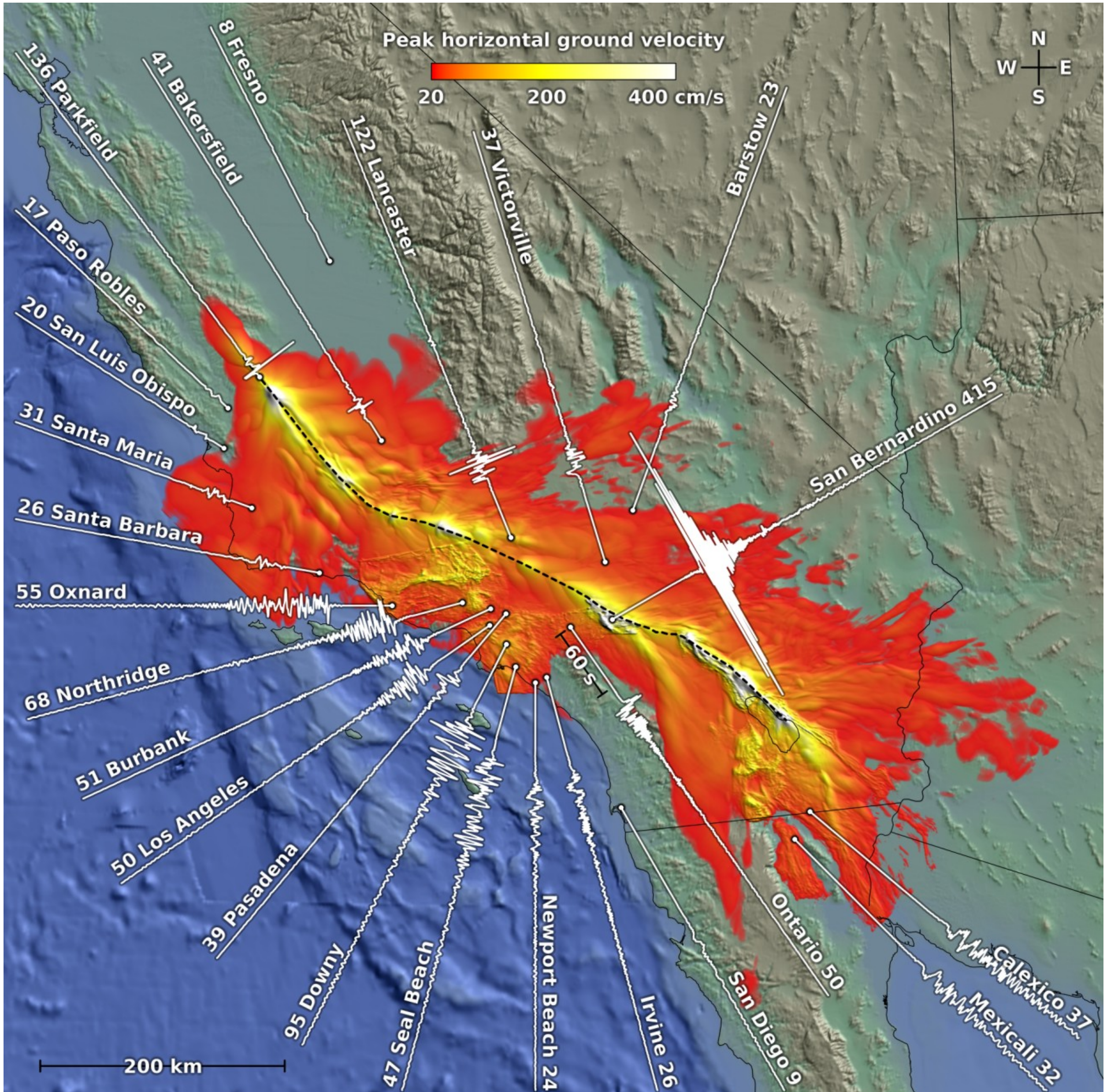


Rupture Propagation for M8





Horizontal 0-2 Hz PGVs For M8



Summary

- We propose a method using depth-dependent initial conditions (Gritz, 2009; Dalguer and Mai, 2008)

- Special near-surface modification of initial conditions (e.g., velocity strengthening) appears necessary to match NGA attenuation relations

- Heterogeneous initial stress from von Karman or fractal distributions

- SLV M7.0 normal fault SA-2s ensemble σ's close to NGA GMPEs intra-event terms (<~ 20 km)