

Fault Rupture Modeling of the 2004 Parkfield Earthquake

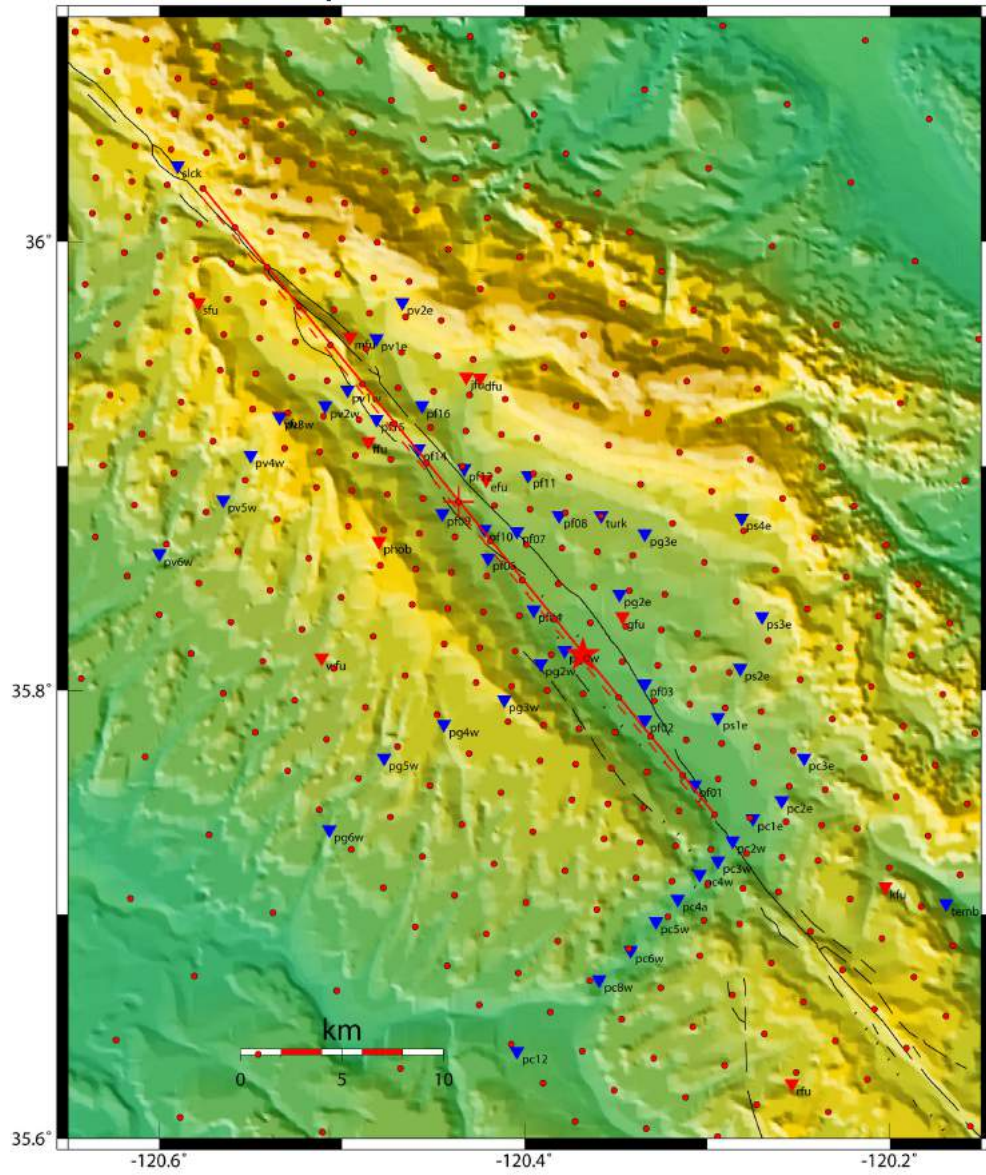
Arben Pitarka
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Laboratory



Outline

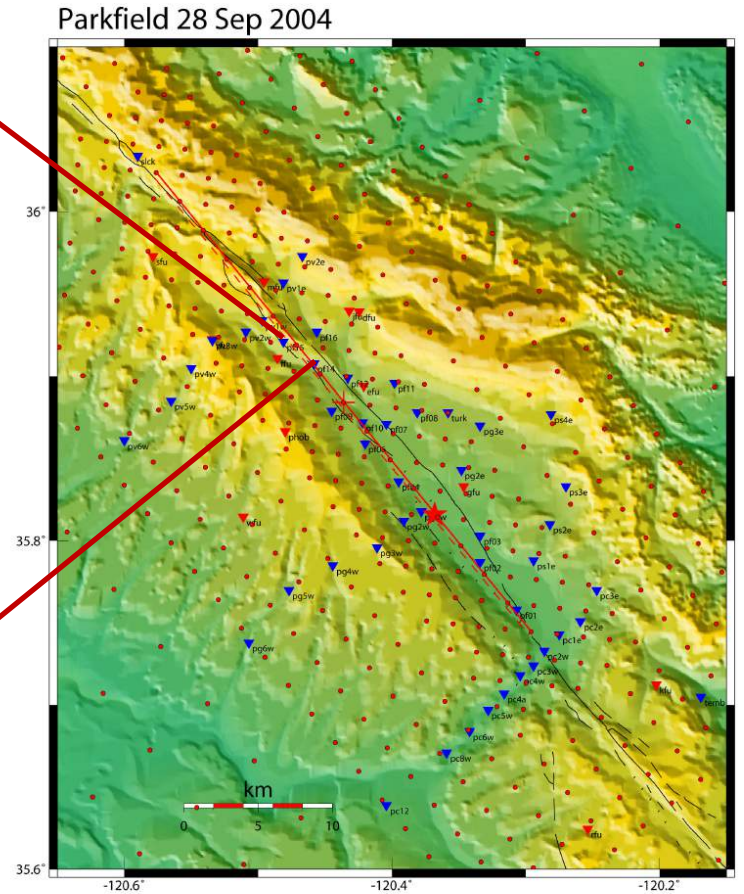
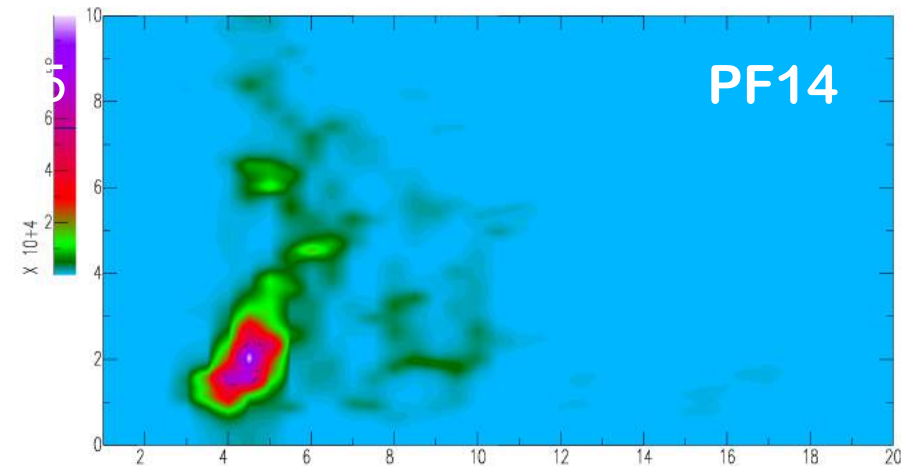
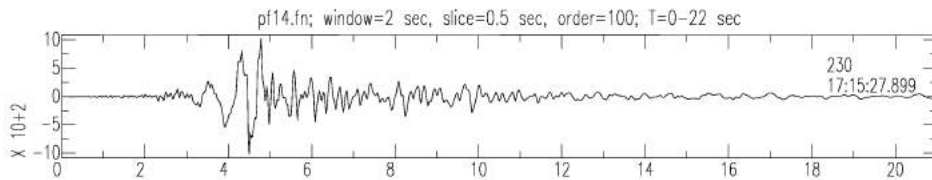
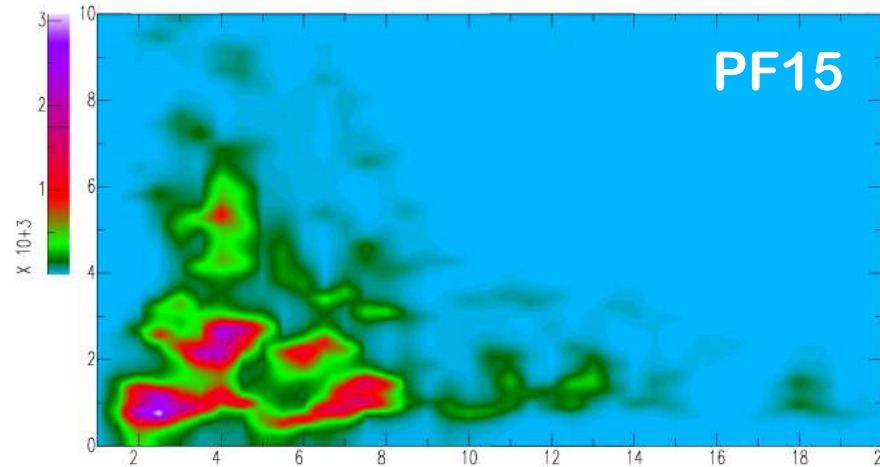
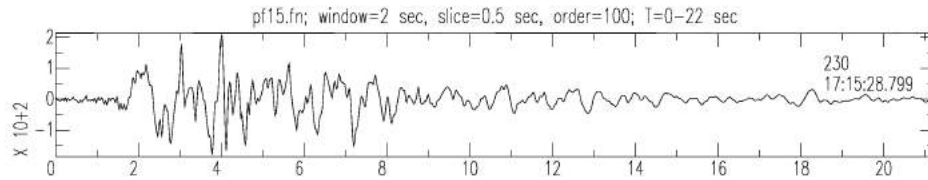
- Recorded ground motion characteristics
- Kinematic rupture model using a linear inversion of ground motion velocity
- Dynamic rupture model using a trial-and-error scheme and 3D spontaneous rupture modeling

Stations Location



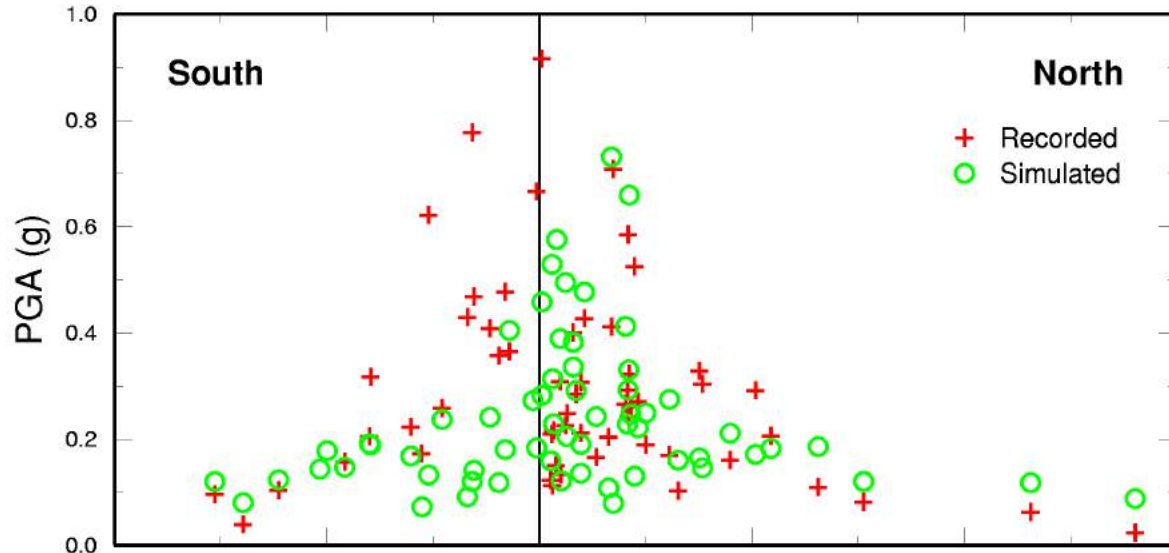
- ▼ USGS Stations
- ▼ CGC Stations
- Simulation Stations

**Extreme spatial variability
(site effects ?)**

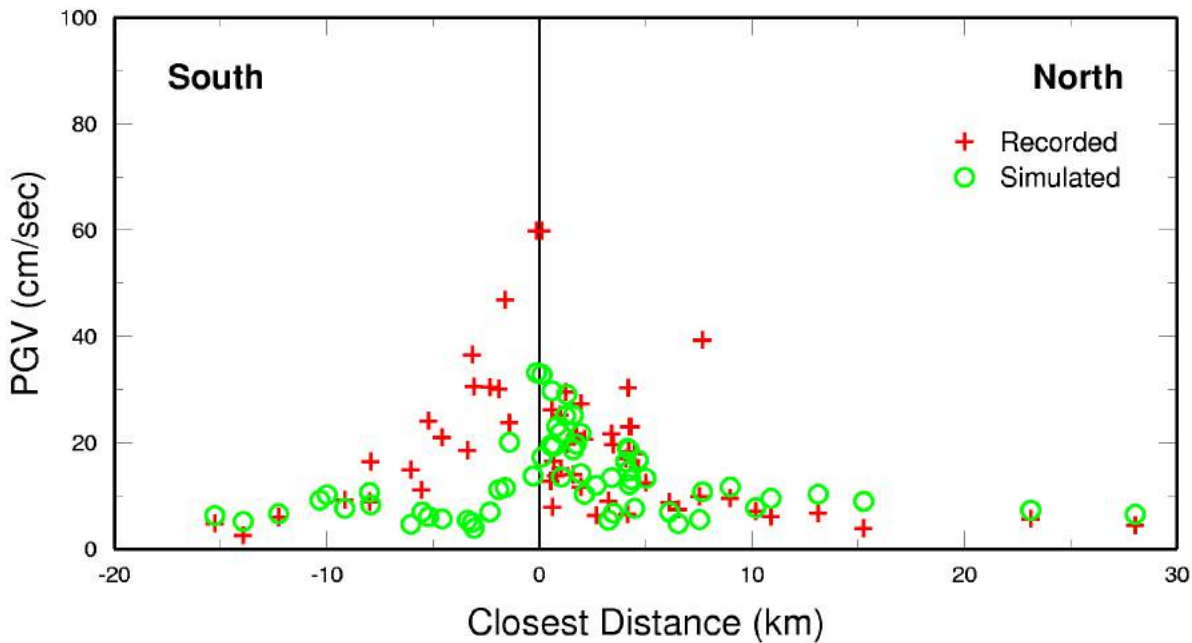


- ▲ USGS Stations
- ▼ CGC Stations
- Simulation Stations

Recorded and Simulated Peak Ground Acceleration and Velocity



PGA

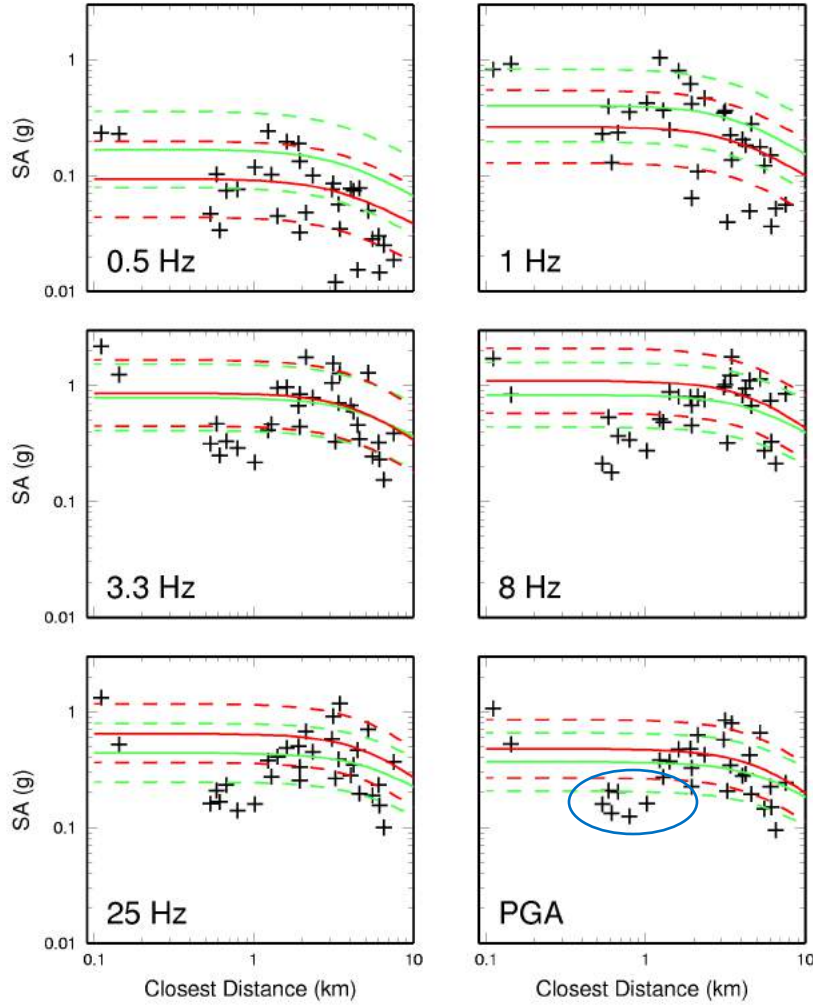


PGV

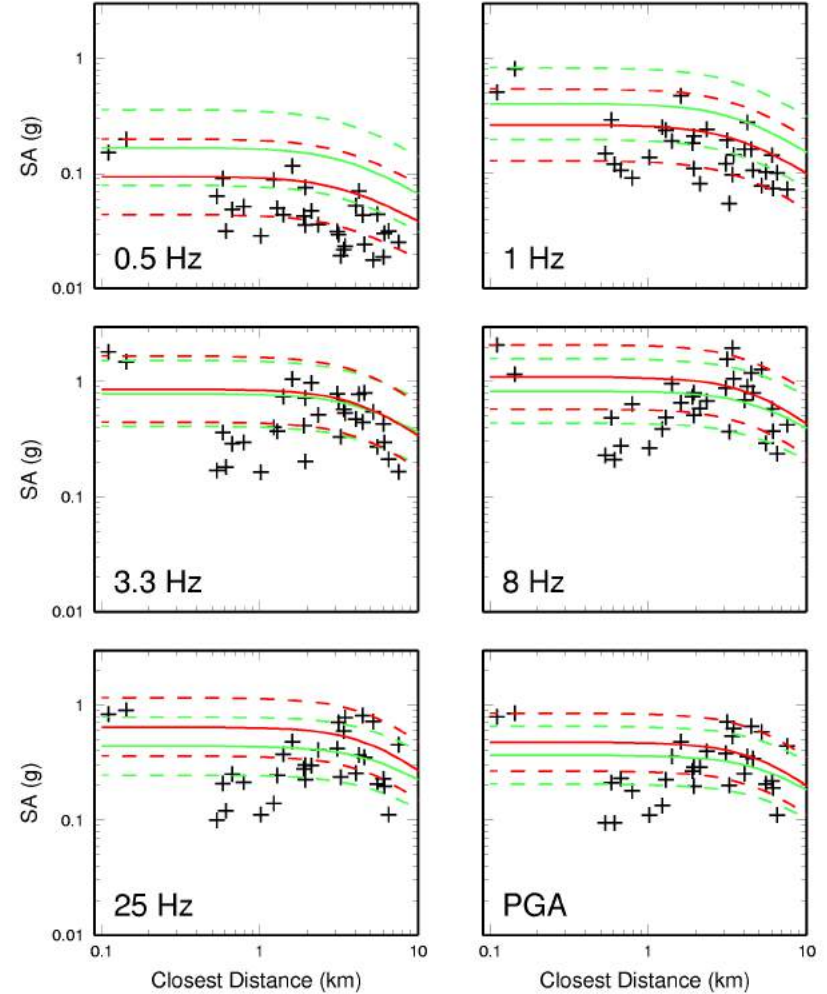
Rupture directivity effects up to at least 3Hz

Fault Normal

Fault Parallel

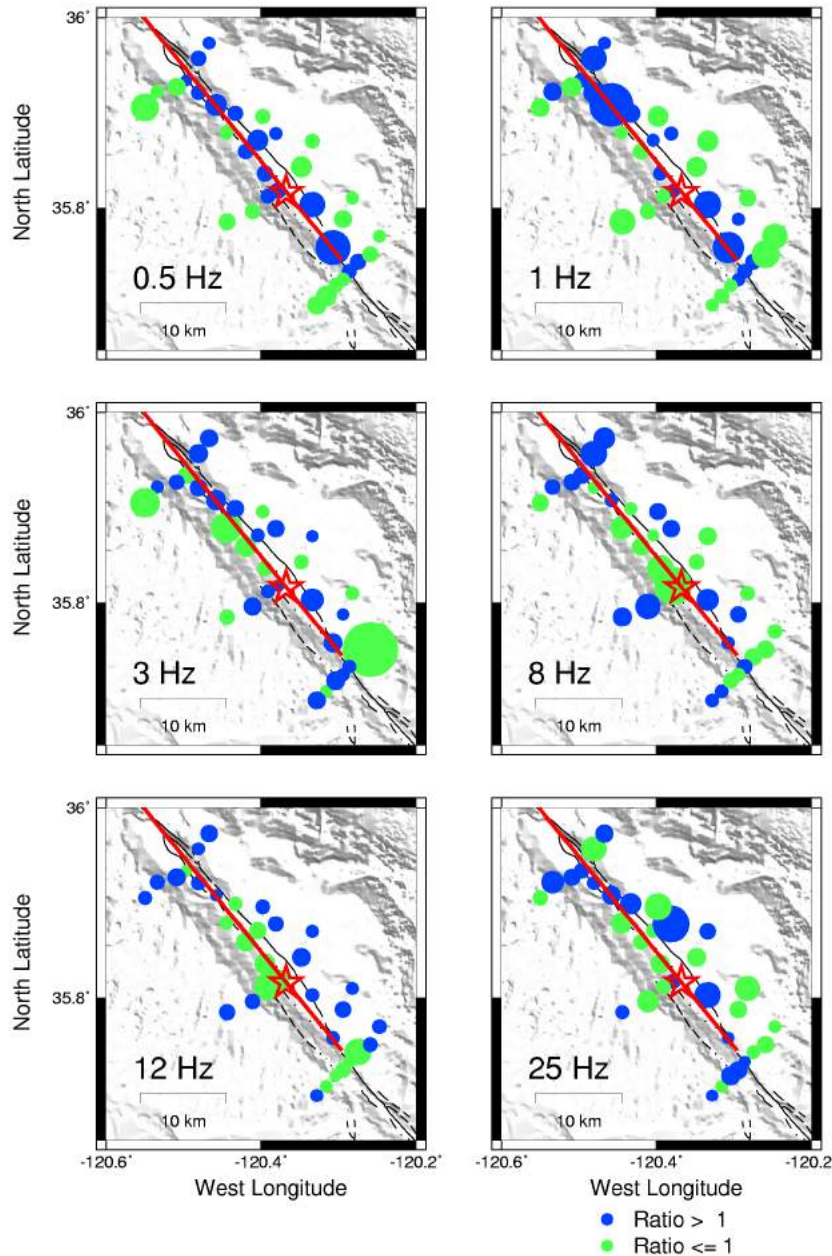


Fault Normal
Recordings



Fault Parallel
Recordings

FA_i / FA (Average of all Stations)



Local Site Effects (Koalinga earthquake)

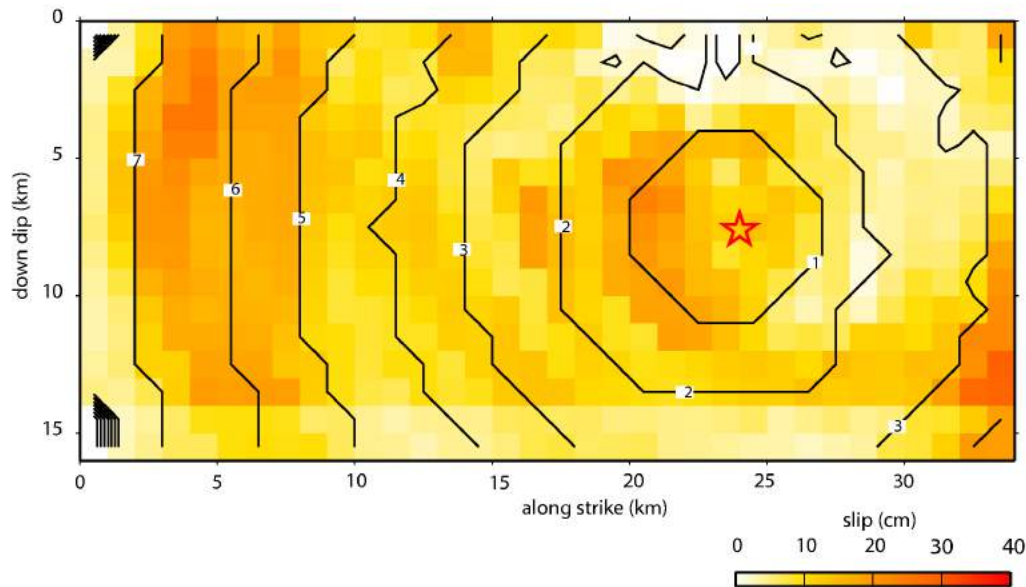
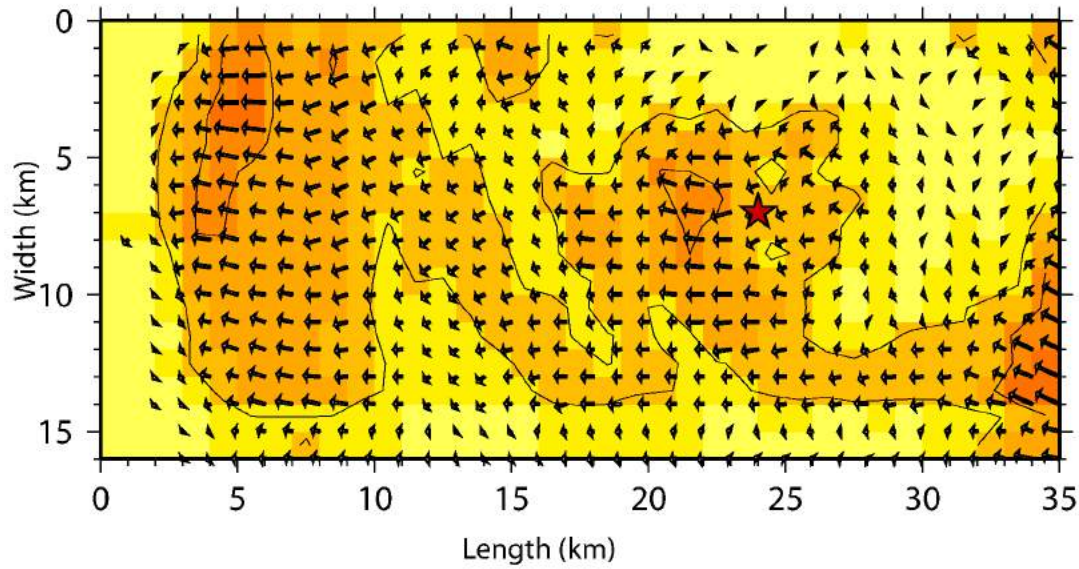
Very near-fault sites:

- Amplification at $f < 3\text{ Hz}$
- Deamplification at $f > 3\text{ Hz}$

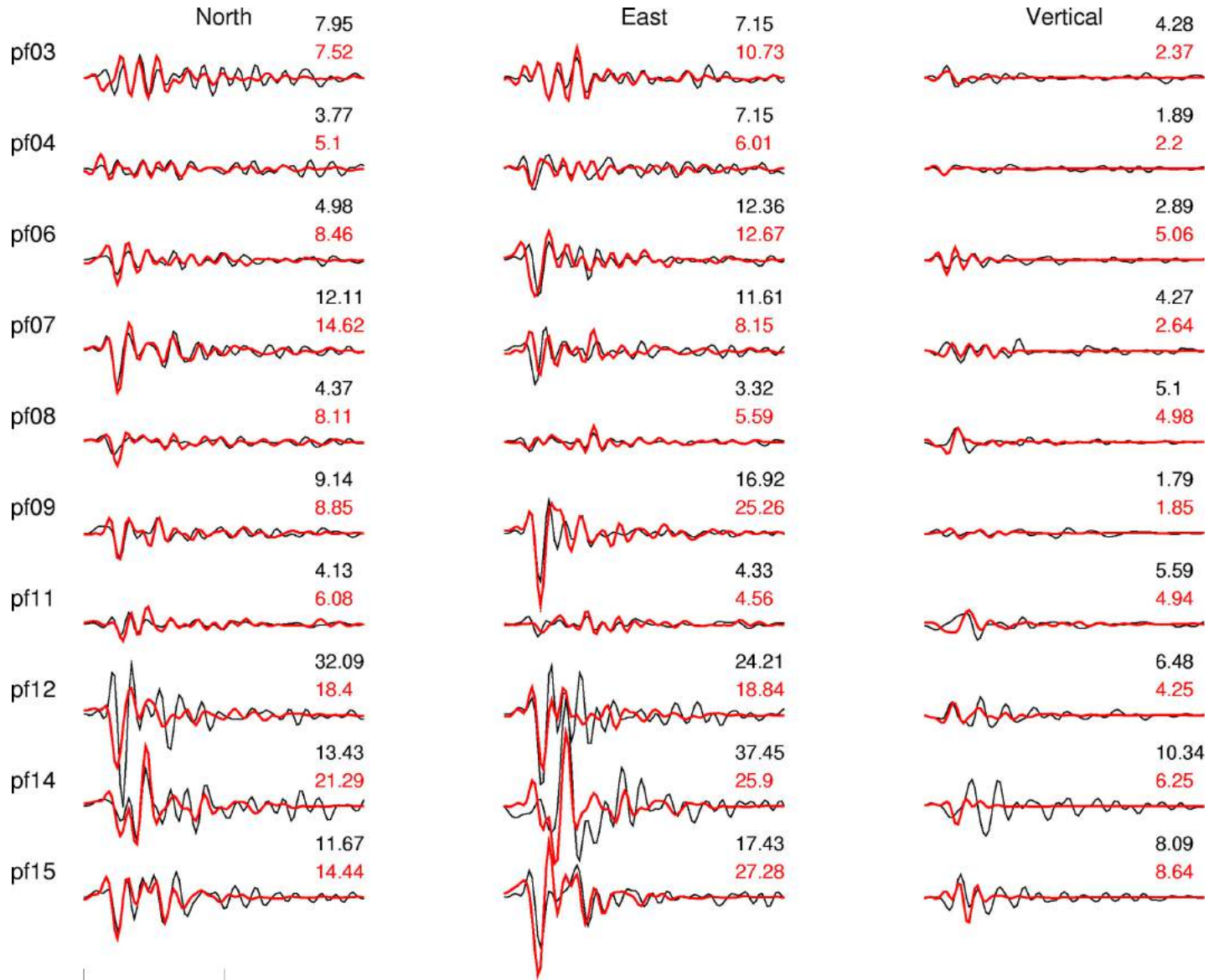
Fault zone effects (scattering?)

Kinematic Rupture Model

NW



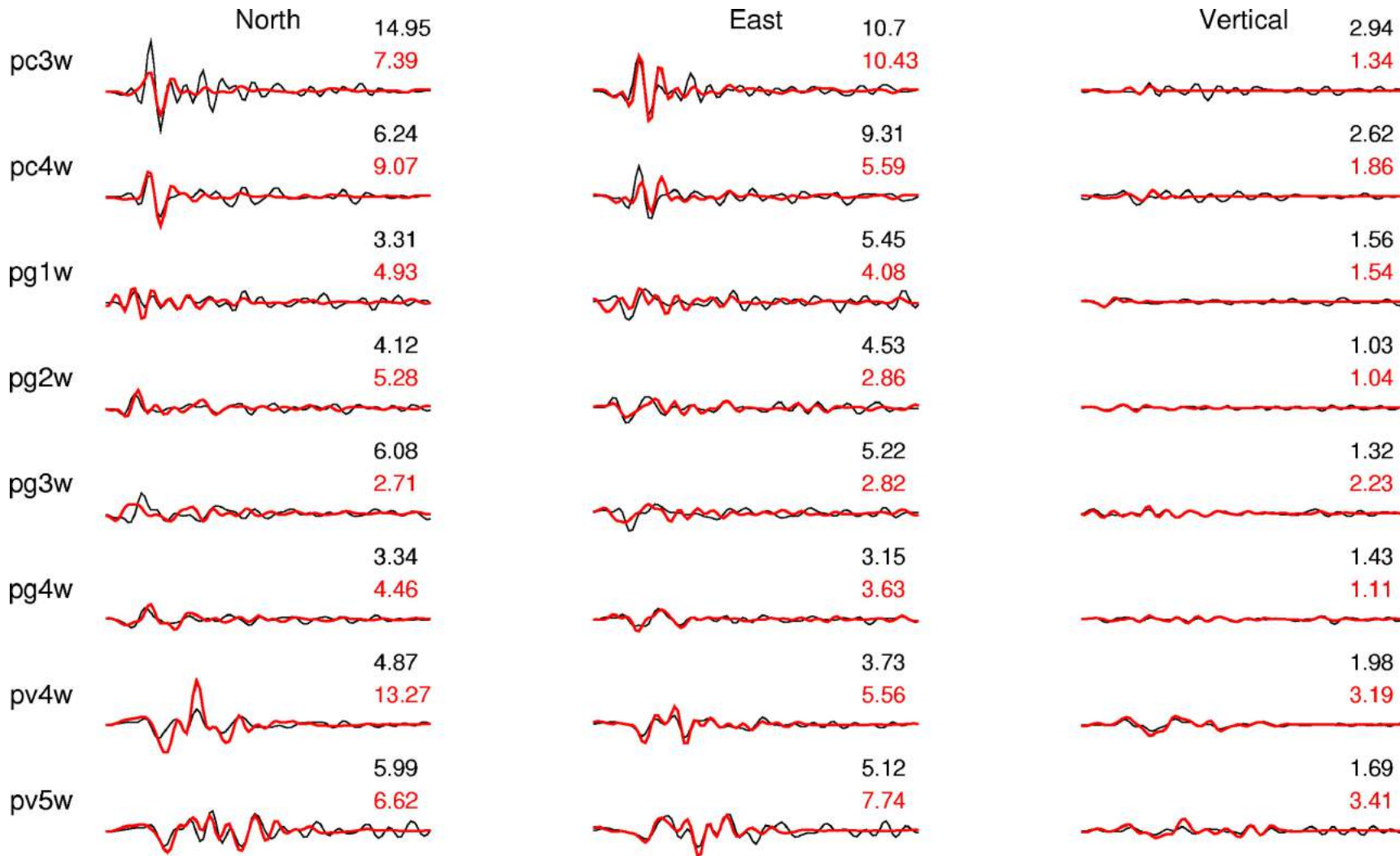
Comparison Between Synthetic and Recorded Velocity Near-Fault CGS Stations



10 seconds

Velocity Time Histories - Units are cm/s/s
Observed=Black; Synthetic=Red

Comparison Between Synthetic and Recorded Velocity Distant CGS Stations



10 seconds

Velocity Time Histories - Units are cm/s/s
Observed=Black; Synthetic=Red

Spontaneous Rupture Modeling Method

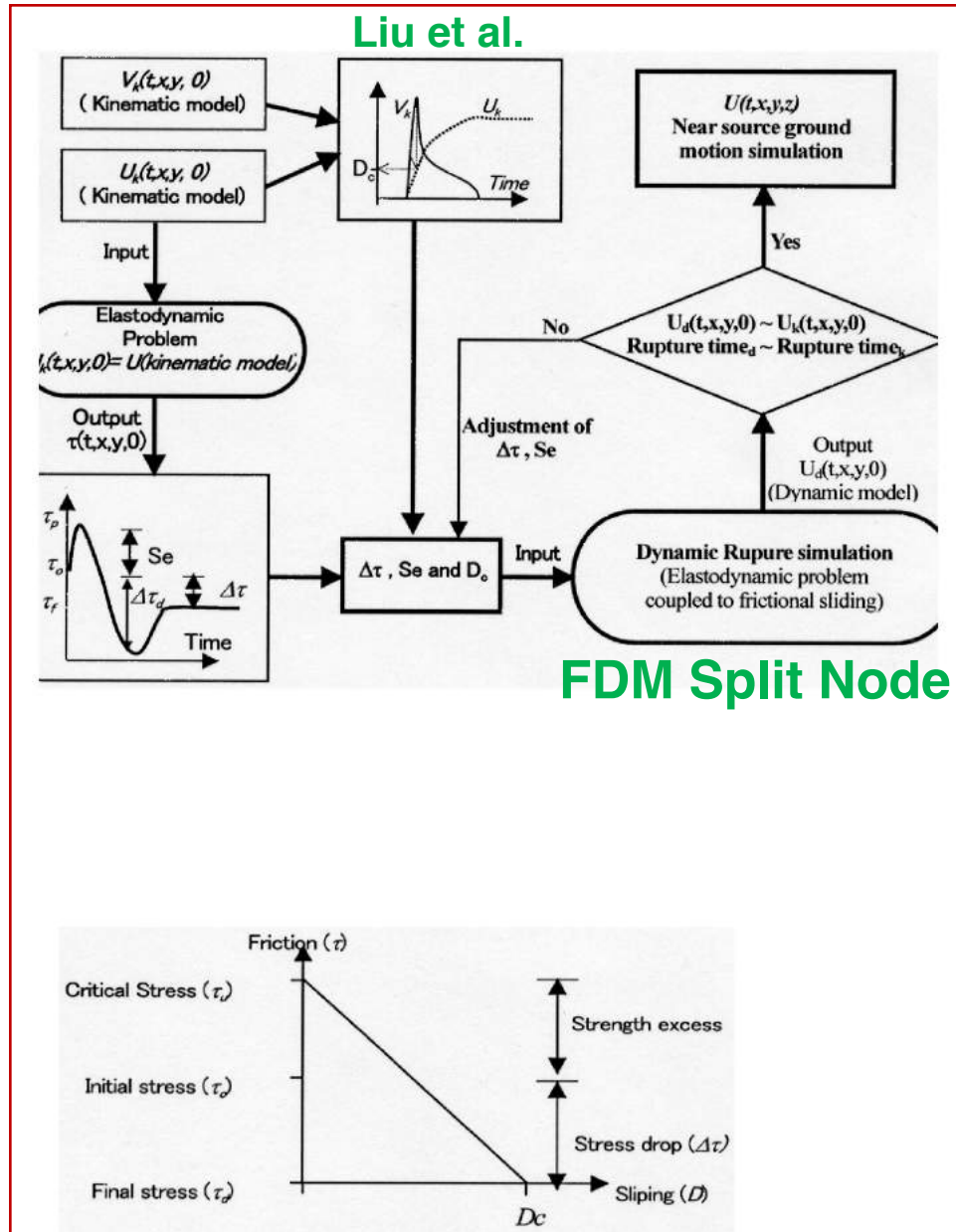
- Fourth-Order 3DFD Staggered Grid Scheme With Variable Grid Spacing of Pitarka (1999)
- Rupture Dynamics FD Implementation Scheme Using Planar Fault and Split Node Method (Dalguer and Day, 2004)
- Slip Weakening Friction Model (Andrews, 1976)

Grid Spacing: 150 m

Trial-and-Error Inversion Scheme Dalguer (2002)

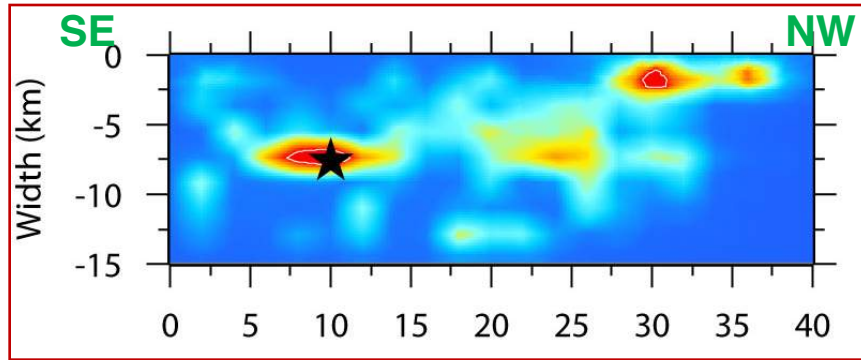
FDM

Smoothed slip time history in solving the elastodynamic equations on the fault plane
Liu et al., 2006

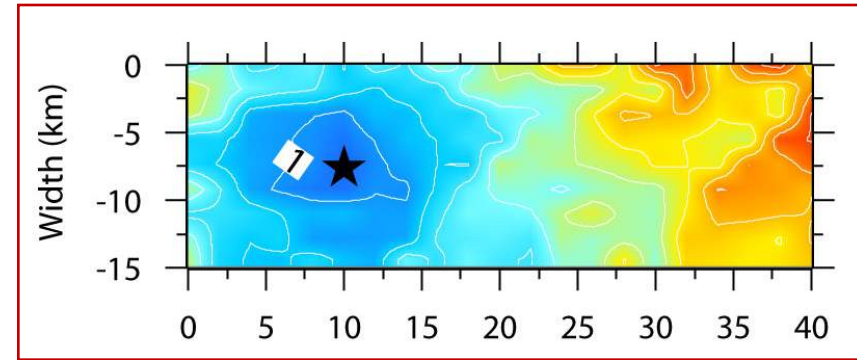


Comparisons of Dynamic and Kinematic Rupture Models

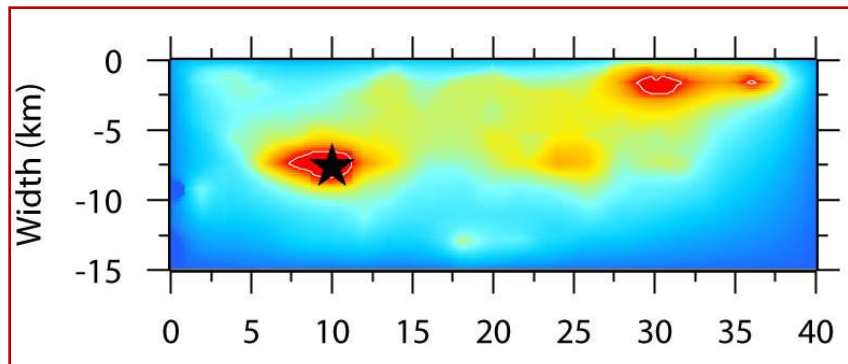
Kinematic Model Slip



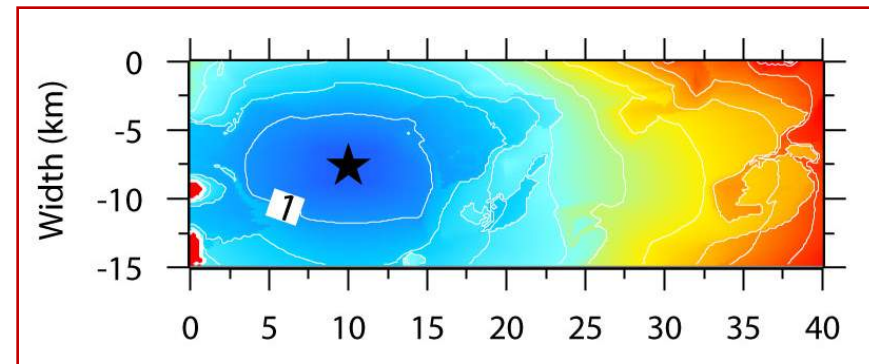
Kinematic Model Rupture Time



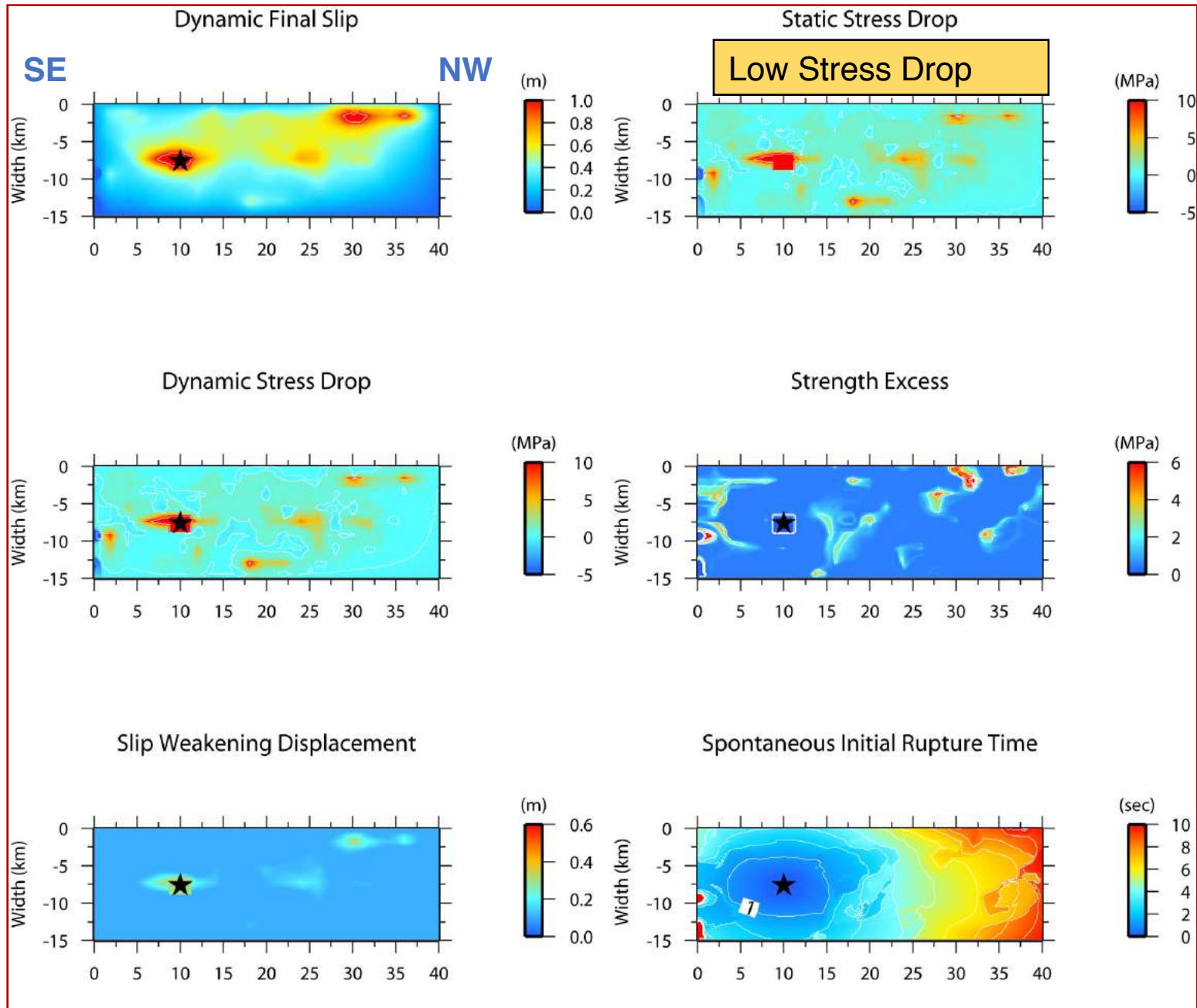
Dynamic Model Slip



Dynamic Model Rupture Time

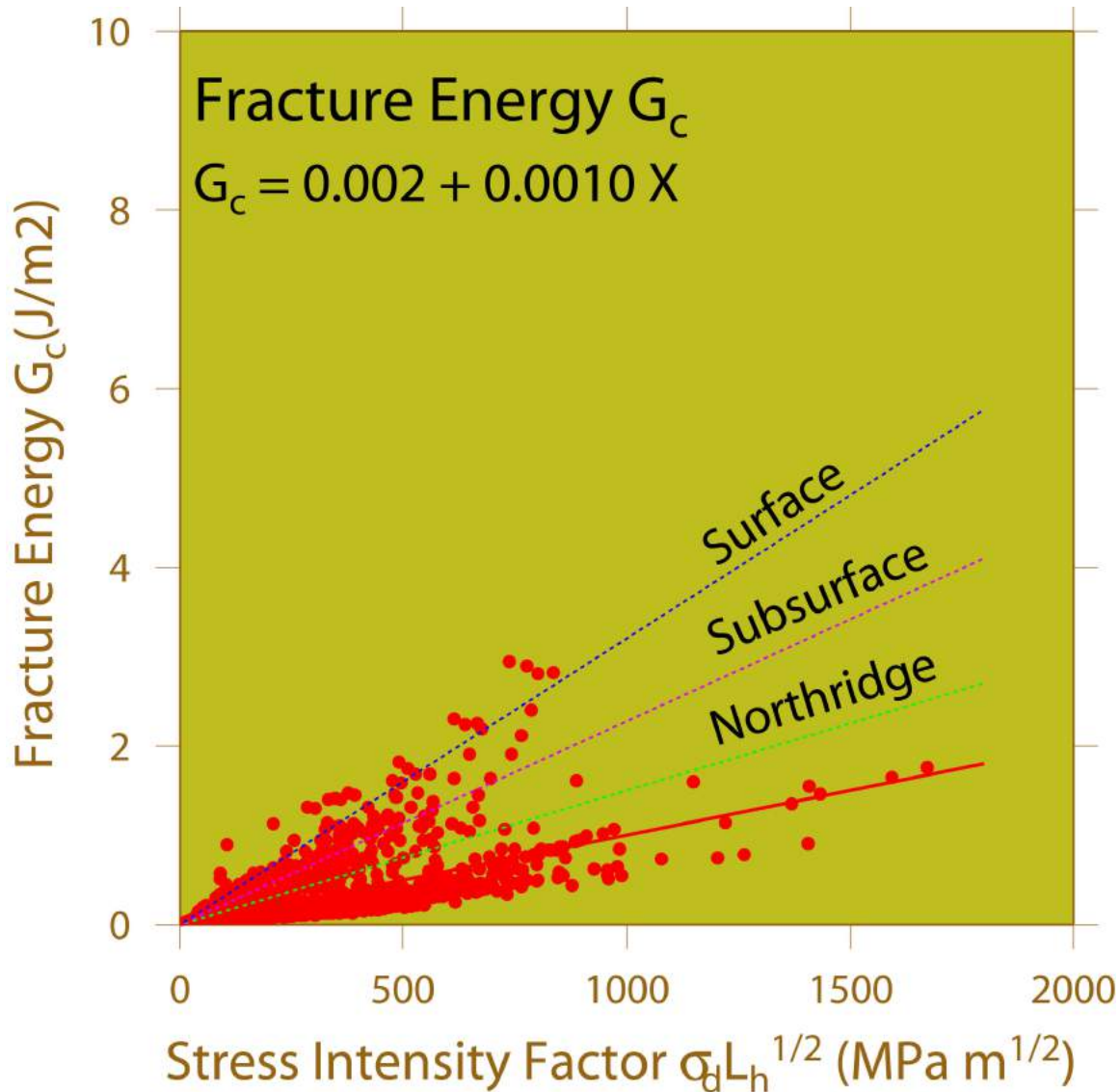


Dynamic Rupture Model



Scaling of Fracture Energy with Stress Intensity Factor

$$G_c = \beta_0 + \beta_1(\Delta\sigma L_c)^{1/2}$$



Acknowledgements

- Luis Dalguer for helping with his “trial and error” inversion scheme
- Ralph Archuleta and S. Custodio for providing Liu’s kinematic rupture model (2006)