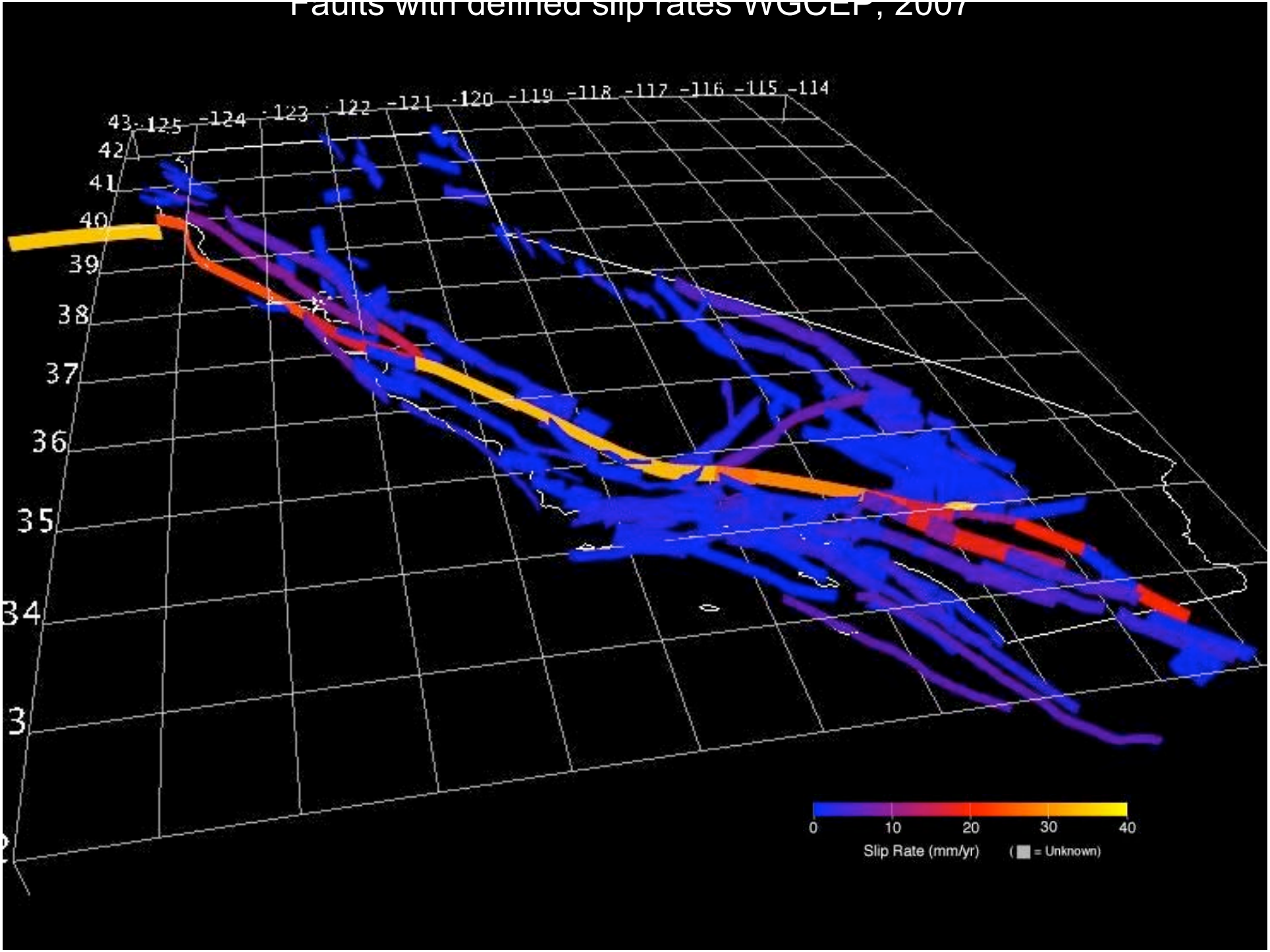
Faults with defined slip rates WGCEP, 2007



Long-term earthquake rate models with simulators

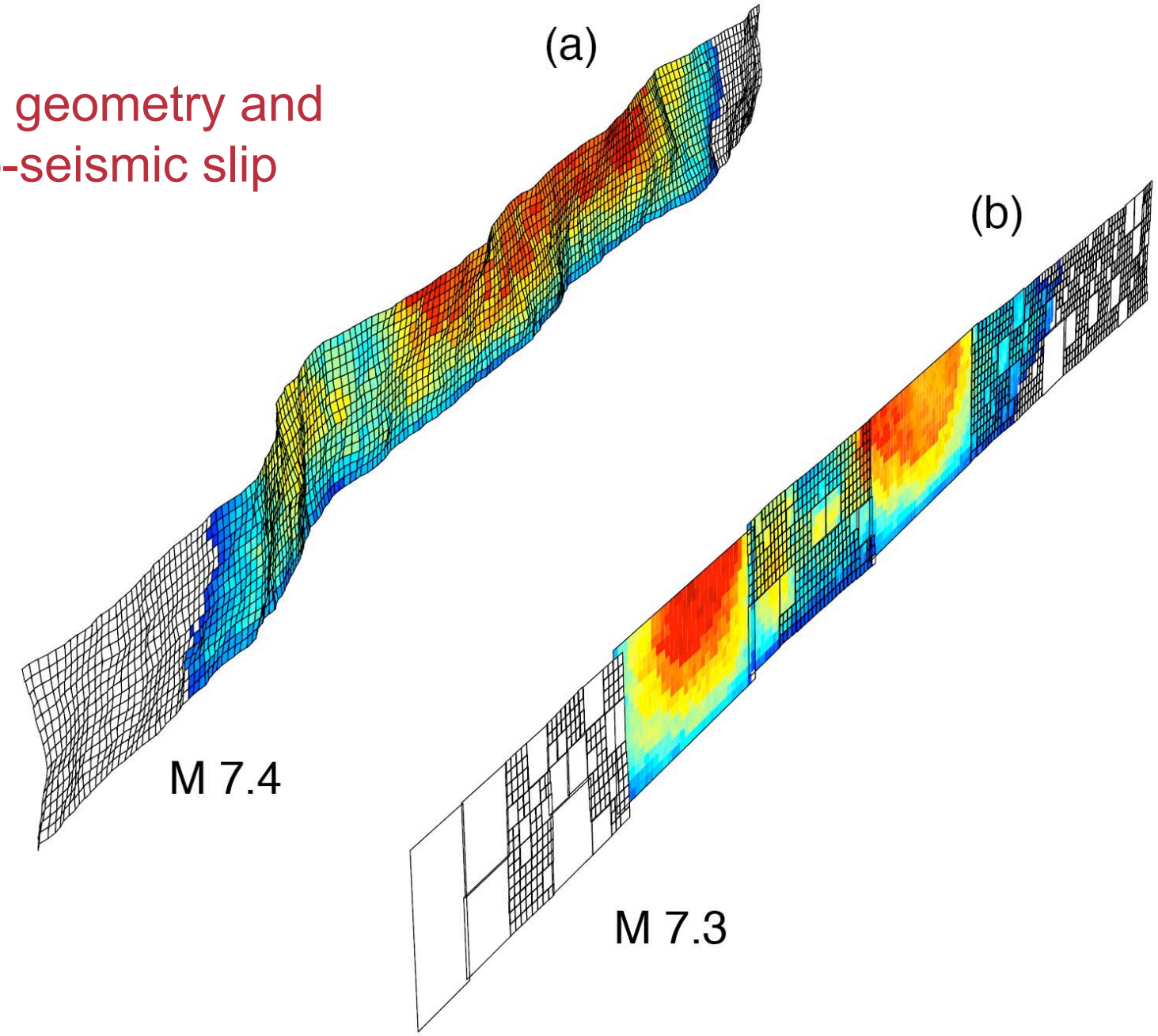
Earthquake simulators

- Fault systems represented as arrays of boundary elements ® accurate representation of elastic fault interactions
- Fault constitutive properties ® earthquake slip events arise spontaneously and result in stress redistribution (constrained by stress drops, slip, recurrence time)
- Repeated simulations of long catalogs over a range of earthquake magnitudes (1km resolution, up to 10^6 earthquakes per simulation)
    - Generate robust statistics on recurrence
    - Explore uncertain parameter space
    - Internally consistent
    - Rupture jumping, branching, multi-segment

Inputs for earthquake rate models

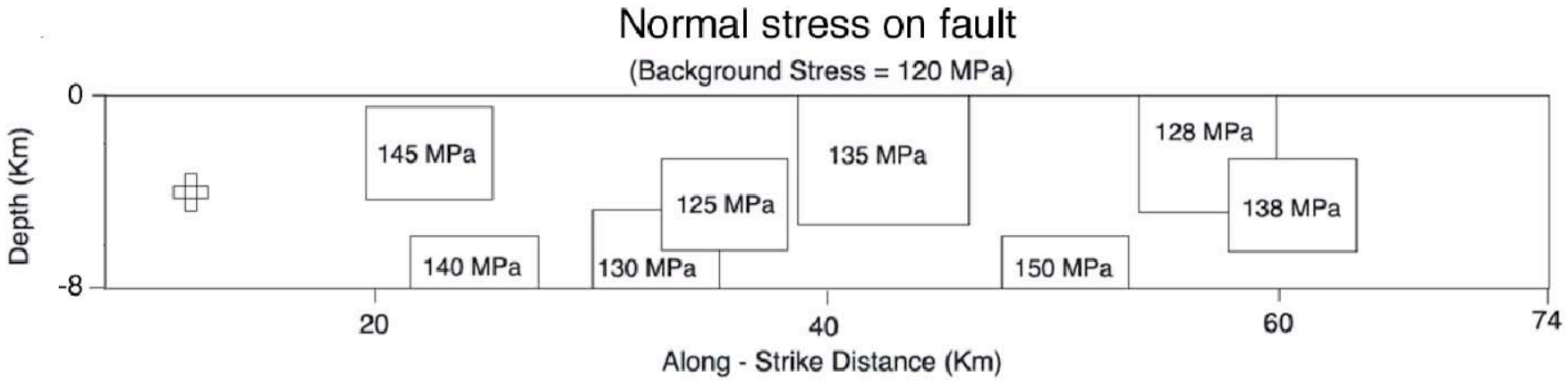
- Fault system geometry + seismic depth
- Long-term fault slip rates (deformation model)
- Information on recurrence intervals (adjusted by stress drop)

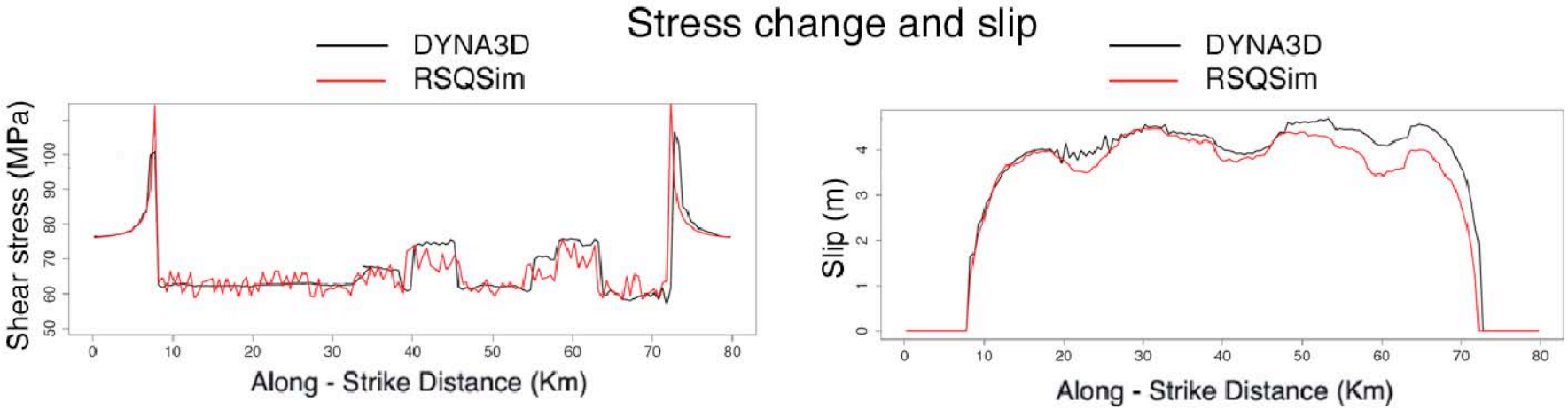
Fault geometry and co-seismic slip



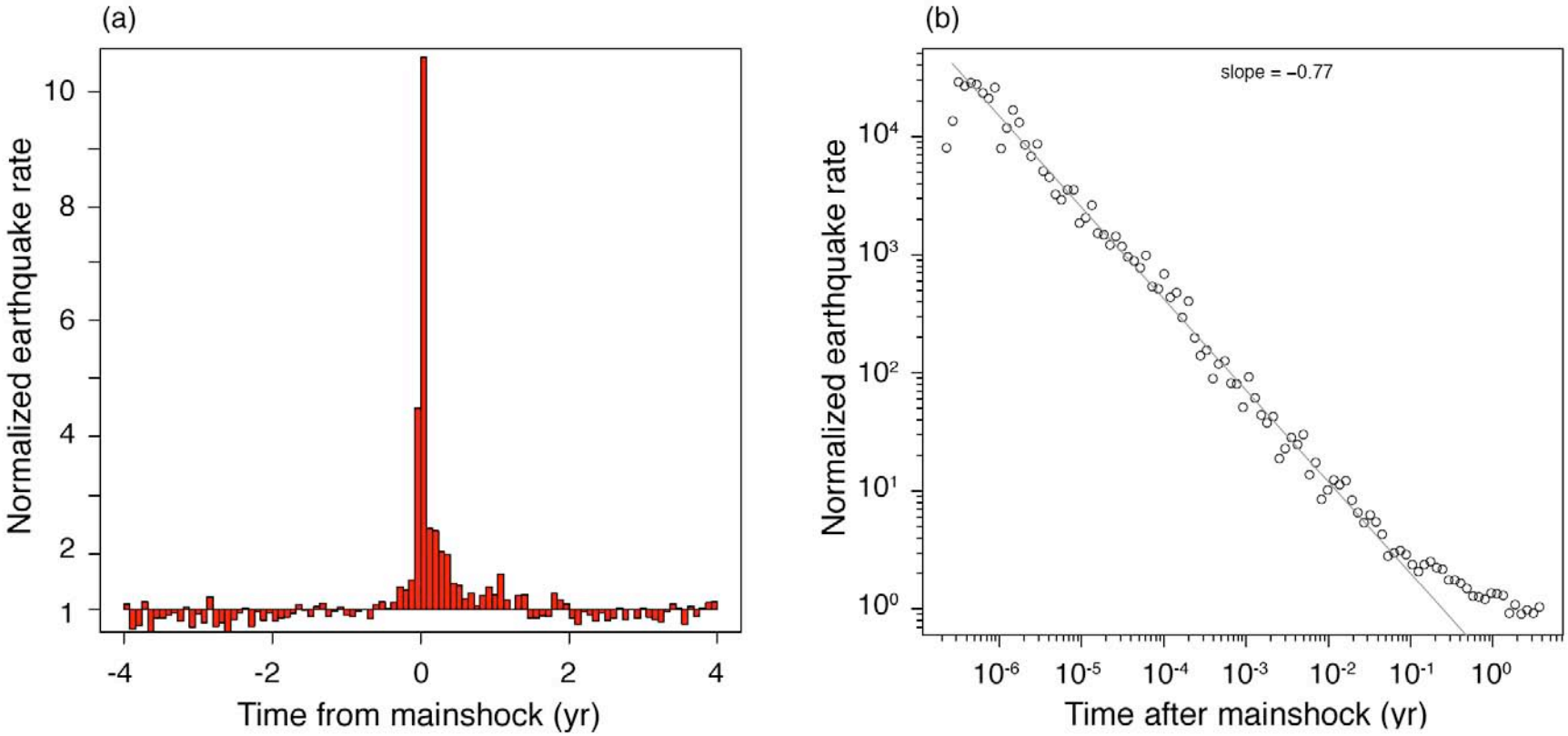
Dieterich and Richards-Dinger, in press, 2010

RSQsim – DYNA3D Comparison



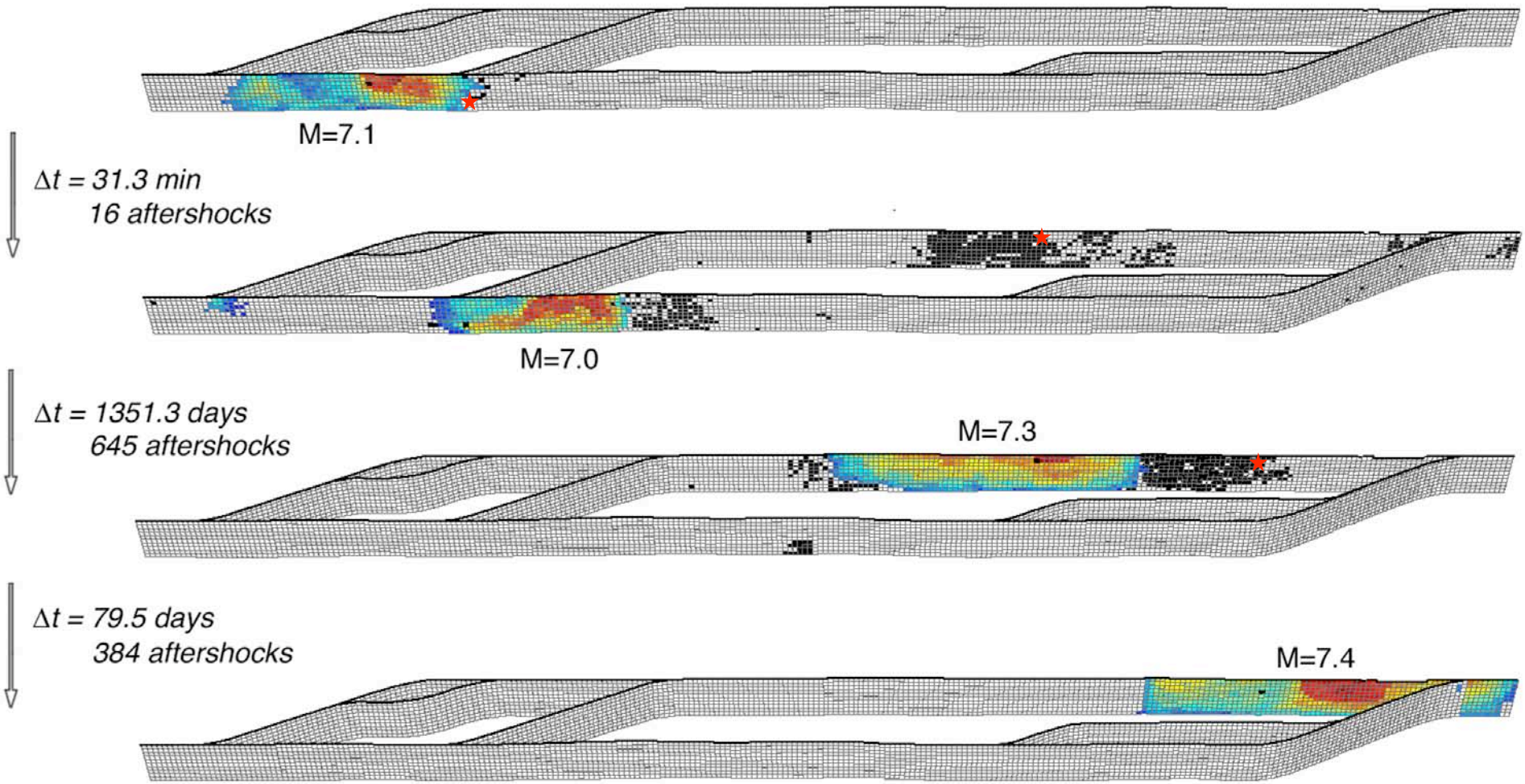


Foreshocks and aftershocks from a simulation of 500,000 earthquakes spanning 16,370 years



Stacked rate of seismicity relative to mainshocks 6>M<7 normalized by average background rate. Decay of aftershocks follows Omori power law t^{-p} with p = 0.77. Foreshocks (not shown) follow an inverse Omori decay with p = 0.92.

Dieterich and Richards-Dinger, in press 2010


M=7.1
Δt = 31.3 min
16 aftershocks
M=7.0
Δt = 1351.3 days
645 aftershocks
M=7.3
Δt = 79.5 days
384 aftershocks
M=7.4

Simulators – some applications/benefits

- Properly capture the intrinsic relations between stress and fault slip in 3D systems (vs. simple conceptual point models)
- Illuminate and quantify phenomena arising from system-scale interactions that cannot be represented with other approaches
  - Multi-segment & multi-fault ruptures, branching arise from system behavior and are internally consistent
  - Avoids problems associated with current point characterizations of segments (stress, and slip, and properties governing rupture propagation are spatially variable)
- Stress interactions and clock resets
- Clustering, Poisson and quasi-periodic behaviors are not mutually exclusive
- Repeated simulation of long catalogs over a range of earthquake magnitudes (1km resolution, up to 10^6 earthquakes/simulation)
  - Generate robust statistics ® empirical pdfs for recurrence
  - Explore uncertain parameter space
  - Rupture jumping, branching, multi-segment probabilities
  - Test bed for methods adopted by WGCEP

Simulators – Implementation issues for rate model

- Magnitude-frequency characteristics of fault sections are sensitive to model input parameters (characteristic vs G-R)
- Details of fault system geometry affect multi-segment ruptures, branching and statistics of large earthquake clusters
  - Characteristics of fault junctions (soft vs hard section boundaries)
  - Multiple realizations of geometry will probably be necessary
- Fault creep
  - Alters stressing on seismic portions of fault
  - Reduces total seismic moment
- Off fault deformation and seismicity