Simulation of Earthquakes Using the Burridge-Knopoff Model

Junchao Xia
Clark University

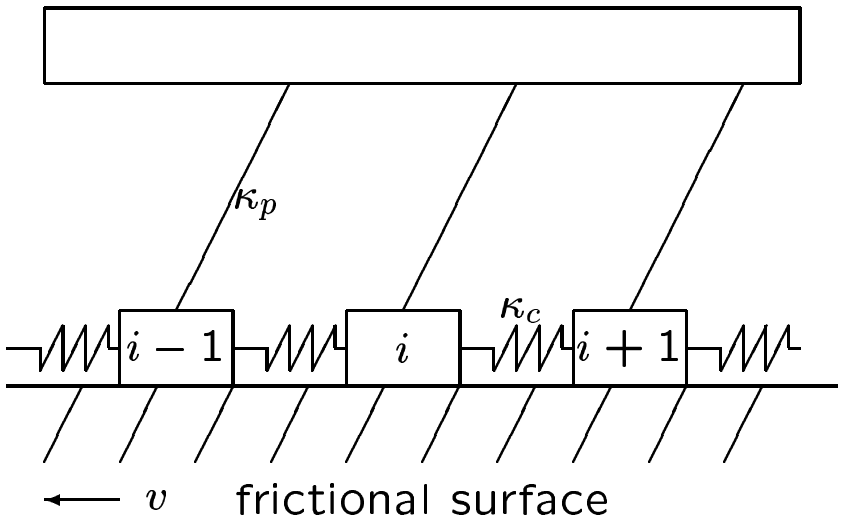
in collaboration with
Harvey Gould
Clark University

William Klein
Boston University and Los Alamos National Laboratory

October 18, 2003

Burridge-Knopoff Model

Block-spring model representing a lateral fault



Equation of motion:

$$m\ddot{x}_j = \kappa_c(x_{j+1} - 2x_j + x_{j-1}) - \kappa_p x_j - F(v + \dot{x}_j)$$

Velocity-dependent frictional force F:

$$\begin{aligned} F(\dot{x}) &= F_0\phi(\dot{x}/\tilde{v}), \\ \phi(y) &= \frac{1-\sigma}{1+|y|/(1-\sigma)}\mathrm{sgn}(y)\,. \end{aligned}$$

Parameters:

$$\ell^2 = \frac{\kappa_c}{\kappa_p} = 100,\ \nu = \frac{v}{\omega_p D_0} = 0.0,\ 2\alpha = \frac{\omega_p D_0}{\tilde{v}} = 20,\ \sigma = 0.01$$

Scaling of Events and Moments

According to Gutenberg and Richter, real earthquakes averaged over all faults obey

$$\#\text{ of events of size M} \sim M^{-b} \qquad (1)$$

with $b \cong 2$.

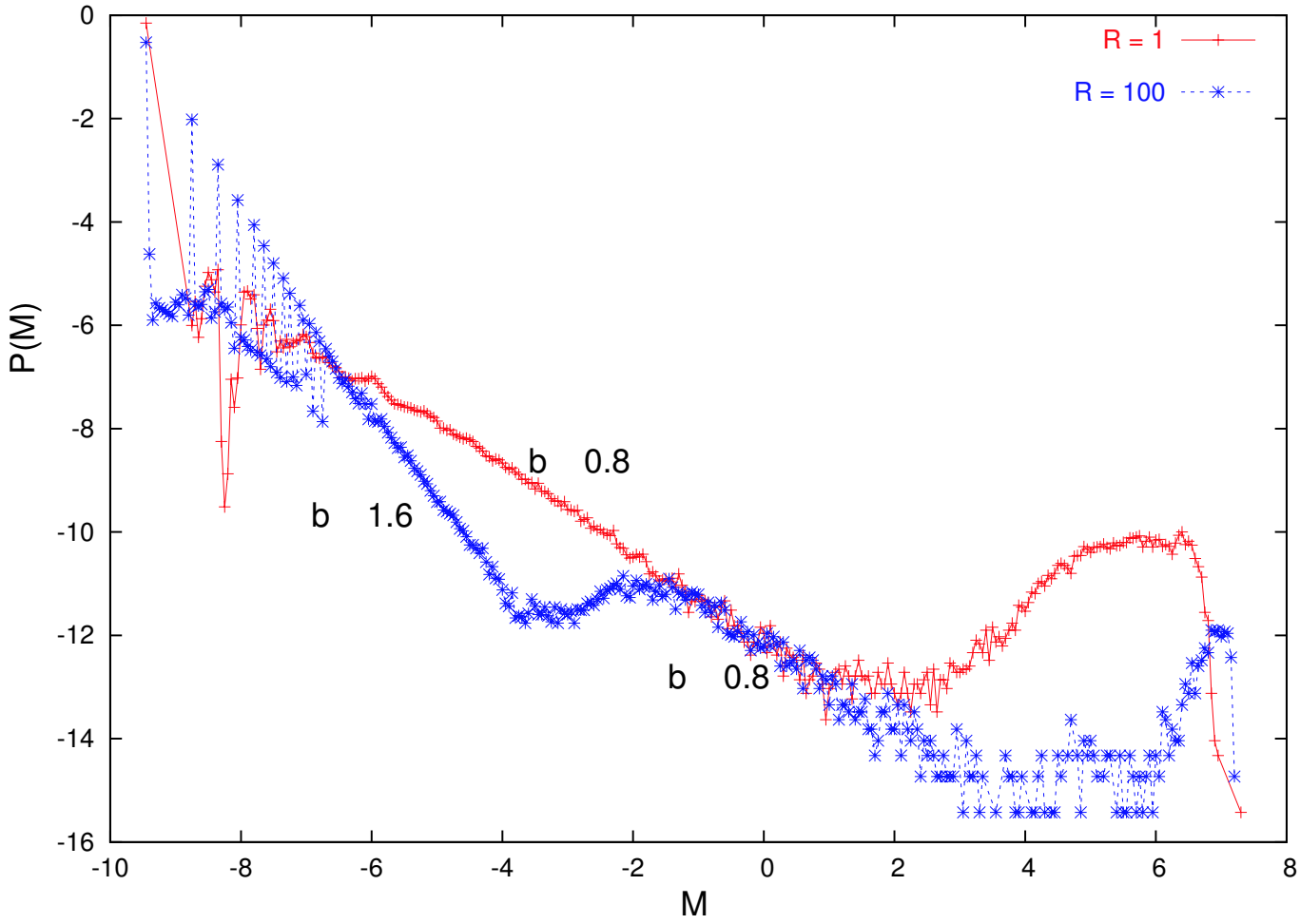
Carlson and Langer (1989) simulated the Burridge-Knopoff model and found limited scaling region for nearest-neighbor 1D model ($R = 1$).

What happens when interactions between blocks are long-range as in realistic faults?

An event is defined as a group of moving blocks within the interaction range. The size M of an earthquake is

$$M = \sum_j \delta u_j, \qquad (2)$$

where δu_j is the relative displacement of the jth block to the substrate.



Magnitude distribution for $N = 1000$ with zero-loading velocity.

Summary

1. The magnitude distribution of events (earthquakes) for nearest-neighbor interactions is similar to Carlson and Langer. Only one scaling region corresponding to localized events is found.

2. Near-mean-field effects are simulated by considering longer range interactions. Our results suggest the existence of two scaling regions, corresponding to different types of events.

3. Preliminary results suggest that as the interaction range increases, the scaling region corresponding to microscopic events becomes better defined, while the scaling region corresponding to localized events becomes poorly defined.