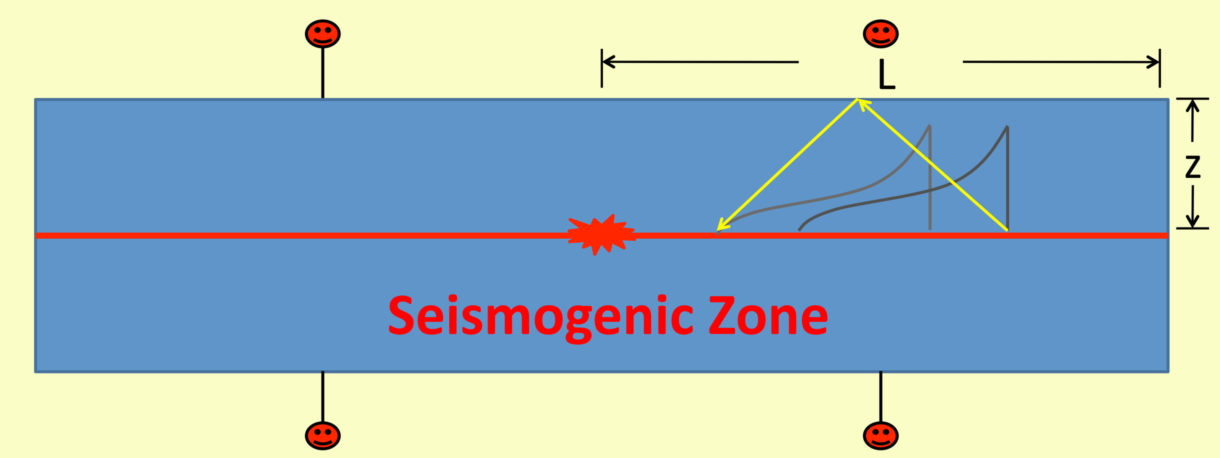
Dynamic Slip Pulses in a 2D Slab and Implication for Low-velocity Fault Zone

Yihe Huang (yihe@gps.caltech.edu), Jean-Paul Ampuero, Seismological Laboratory, California Institute of Technolgy, Pasadena, CA 91125

1. Motivation

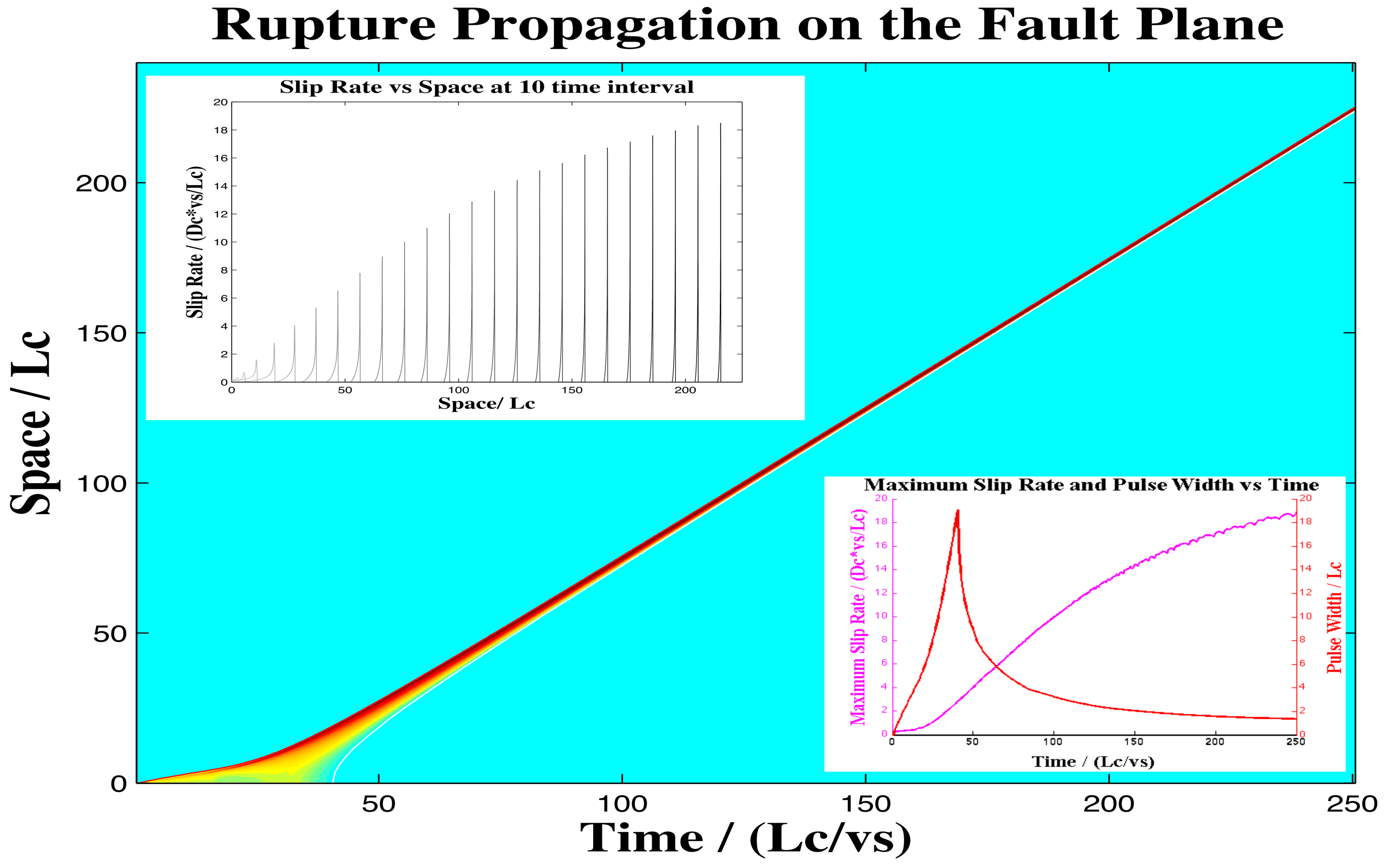
Earthquake ruptures are believed to propagate predominantly as self-healing pulses yet the dynamics of these pulses is not completely understood: what controls their rise time and rupture and healing speed? Moreover, low-velocity fault zones (LVFZ) are found in most mature faults. Here we explore the effects of LVFZs on slip pulses. We first assumed the host rock is very rigid so that the boundary of the LVFZ behaves like a fixed displacement boundary. The problem reduces to a 2D elastic slab of finite thickness. Slip pulses are generated naturally by waves reflected on the fault-parallel slab boundaries. The slab thickness also affects the rupture speed, slip, slip rate and rise time. We then study the case of a finite velocity contrast between LVFZ and host rock. We found that for large enough contrasts the waves reflected from the boundary of the LVFZ can heal the slip. This is a new mechanism for the generation of rupture pulses (short rise time).

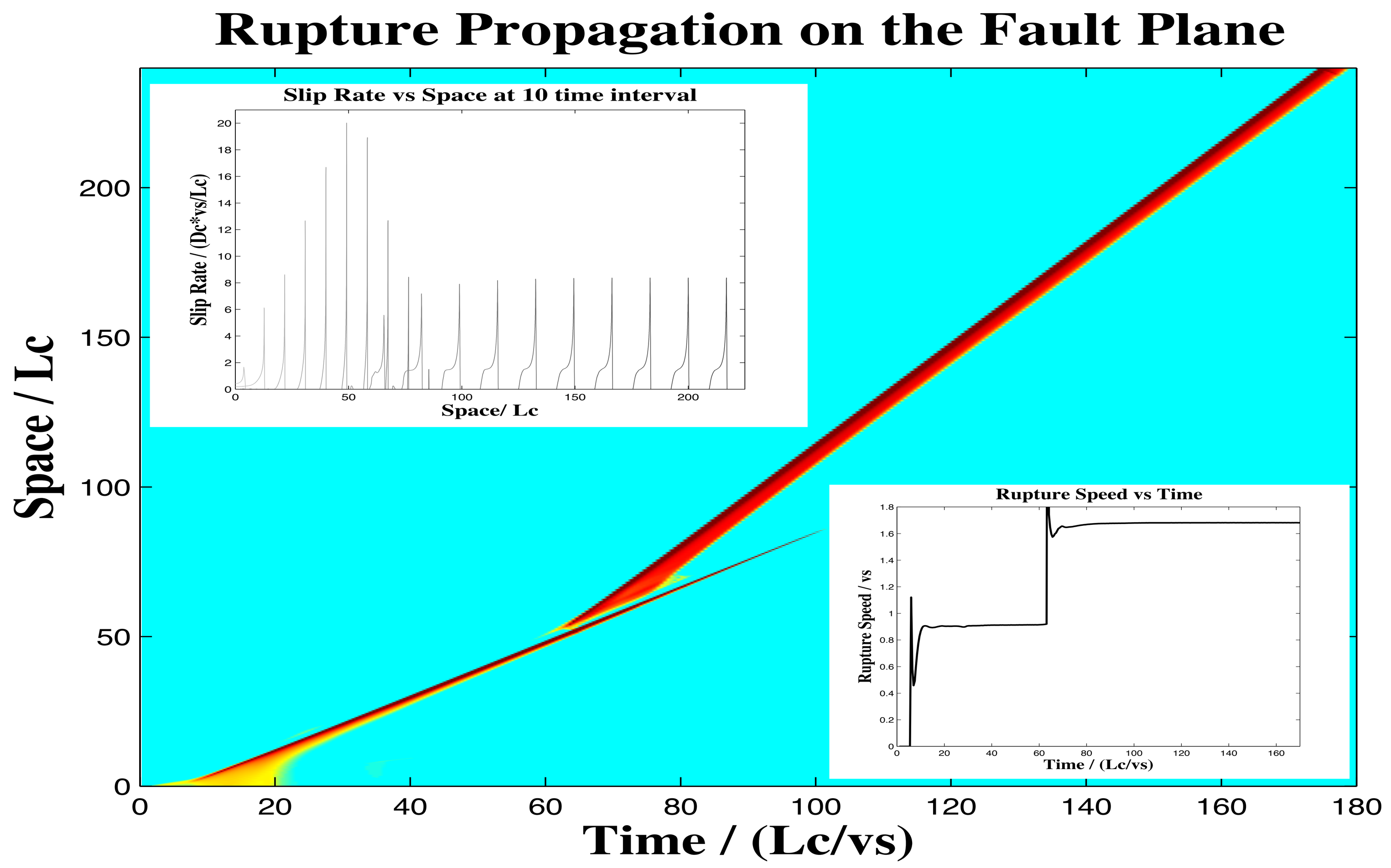
2. Method

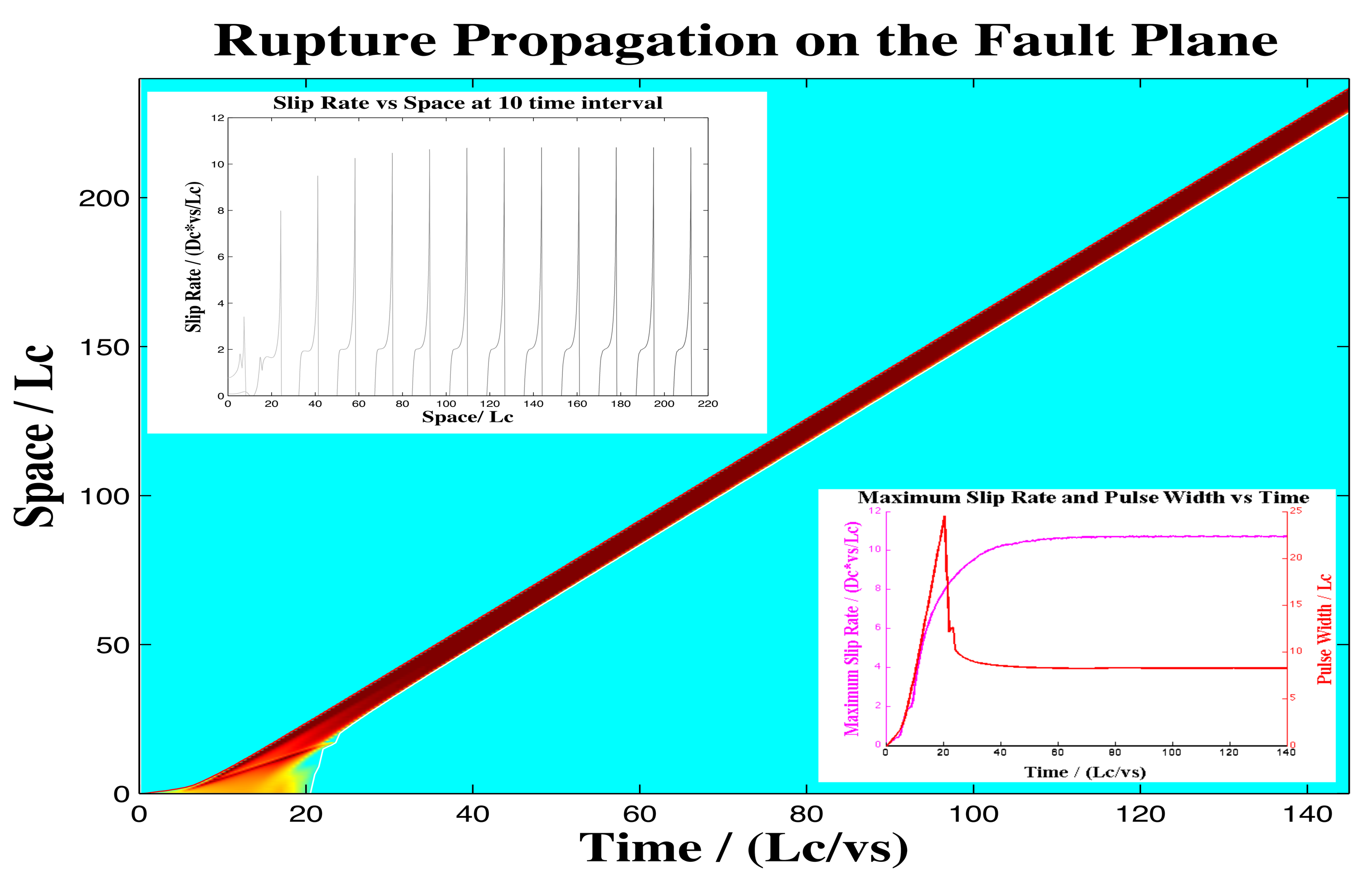


The model is calculated using SEM2DPACK (Ampuero, 2002), a spectral element method code for 2D wave propagation and rupture dynamics. Infinitesimal strain and linear elasticity are assumed in current stage. The fault is governed by slip-weakening. To nucleate the rupture, time-weakening is superimposed. We exploit the symmetries of the elastic problem to restrict the computations to the top-right quarter of the domain. We used normalized quantities: $x^*=x/L_c$, $t^*=t/(L_c/v_s)$ where $L_c=GD_c/(\sigma_0(\mu_s-\mu_d))$, G is shear modulus, D_c is critical slip, σ_0 is normal stress, μ_s is static friction coefficient, μ_d is dynamic friction coefficient and v_s is shear wave speed.

3.1 Pulse-like Ruputure

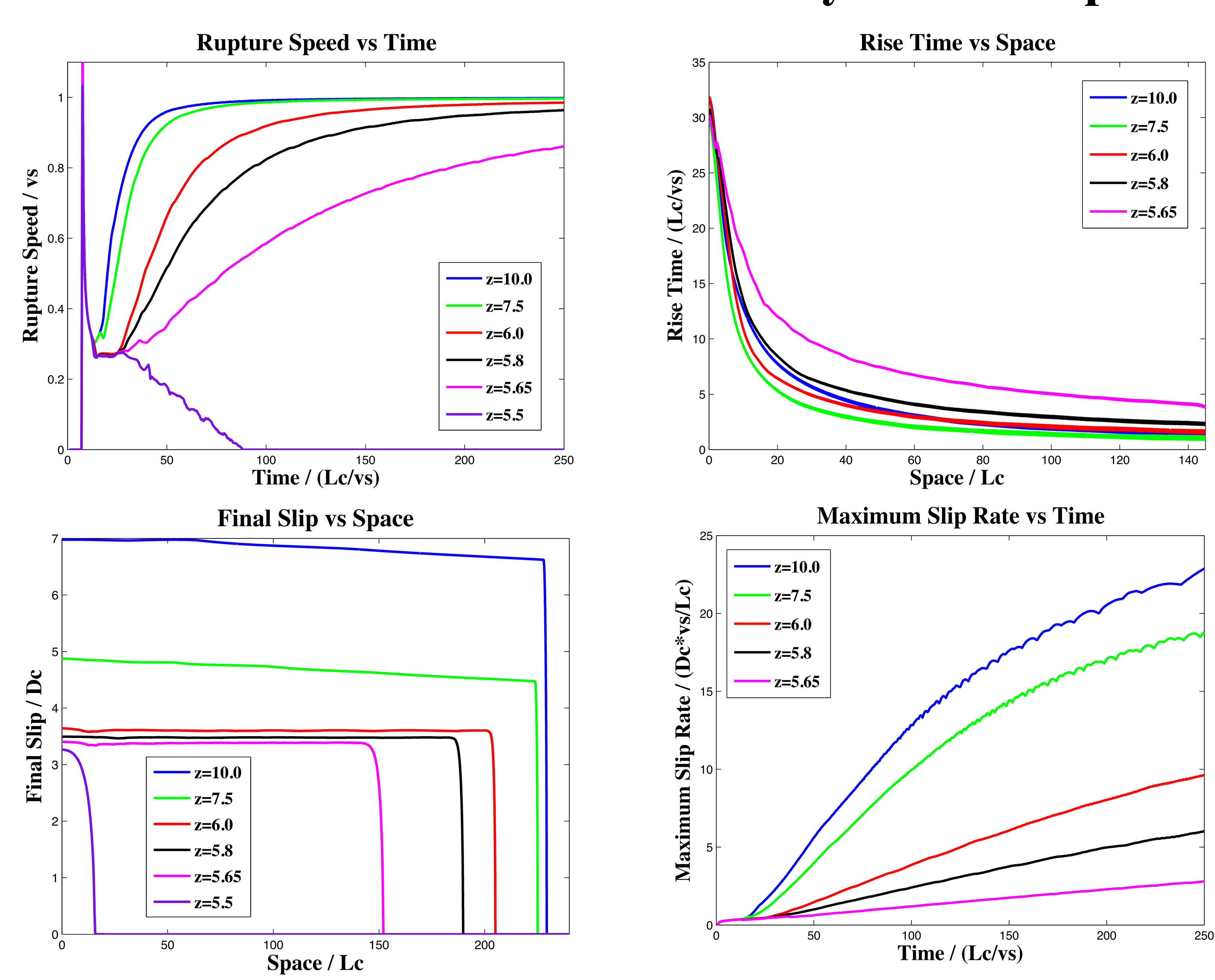






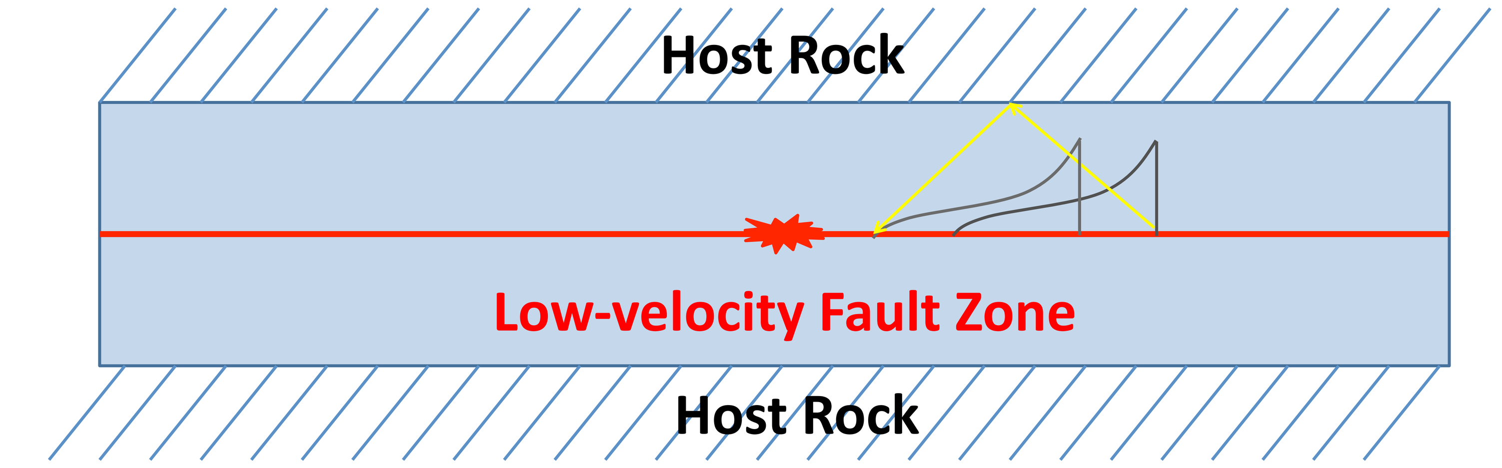
Above: Pulse-like Rupture Propagation for antiplane shear, subshear to supershear transition and supershear (from top to bottom).

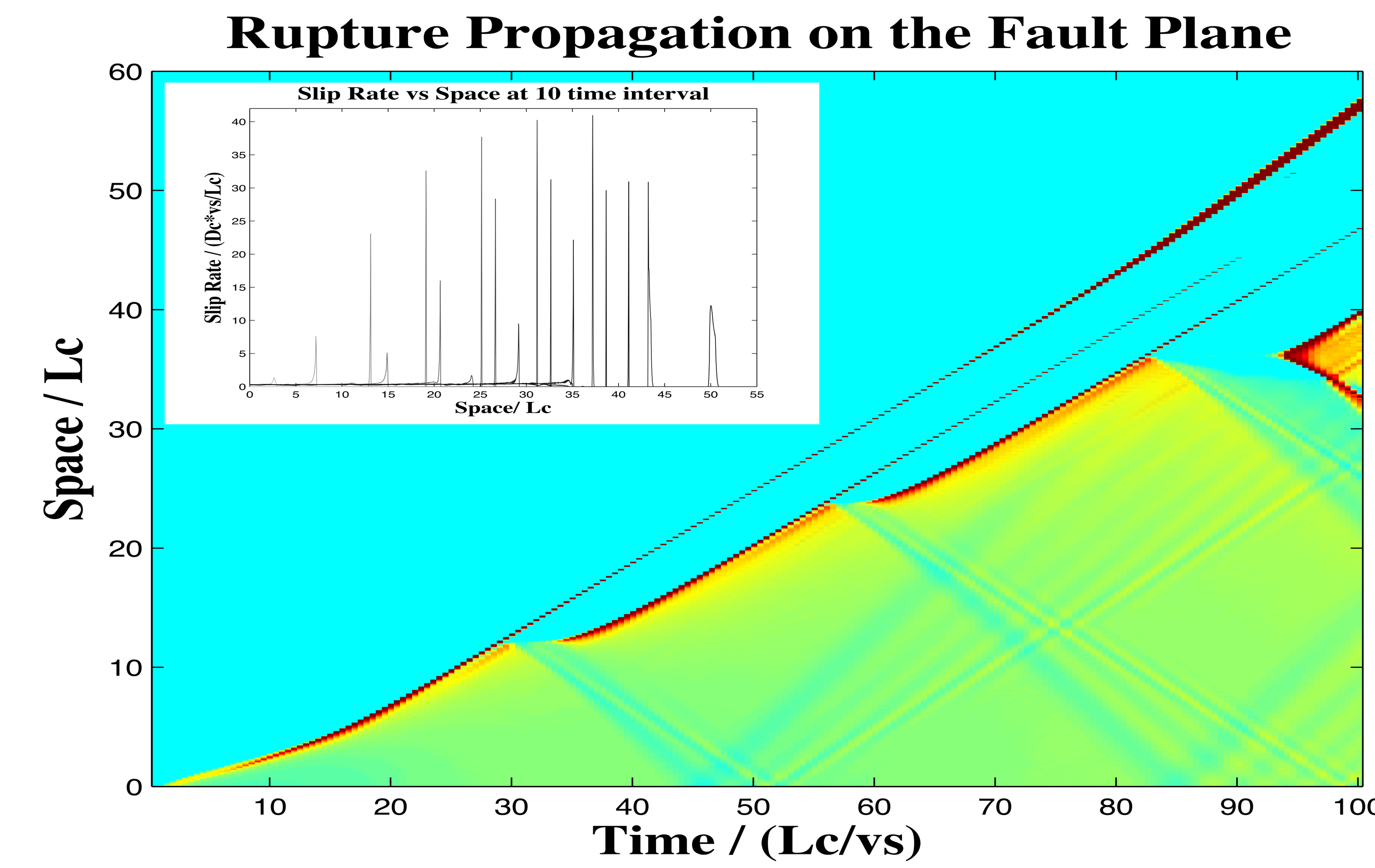
3.2 Effects of Slab thickness on Dynamic Properties

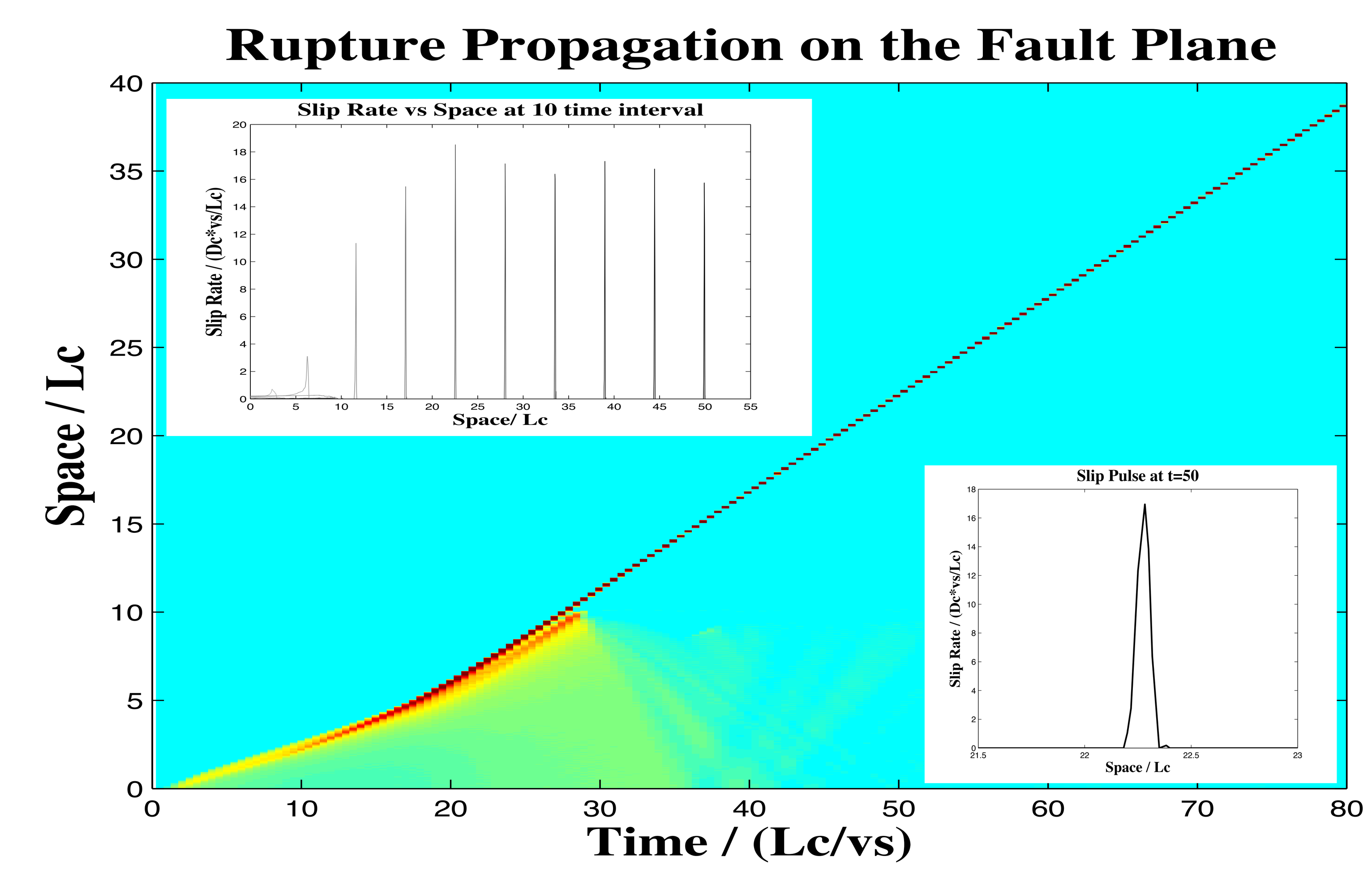


Above: Rupture speed, rise time, final slip and maximum slip rate for different slab thicknesses for antiplane shear rupture.

3.3 Implication for Low-velocity Fault Zone







Above: Pulse-like Rupture Propagation generated by boundary of low-velocity fault zone of 40 percent velocity reduction for antiplane (top) and inplane (bottom).

The low-velocity fault zone is a significant source of earthquake complexity. As proved in our simulation, the low-velocity fault zone can also generate slip pulses due to reflected waves from the boundary. This is in contrast to results by Harris and Day (1997). We are working on linking our numerical simulations to the complexity in observations.