Meet a New Code: Daub Finite Difference

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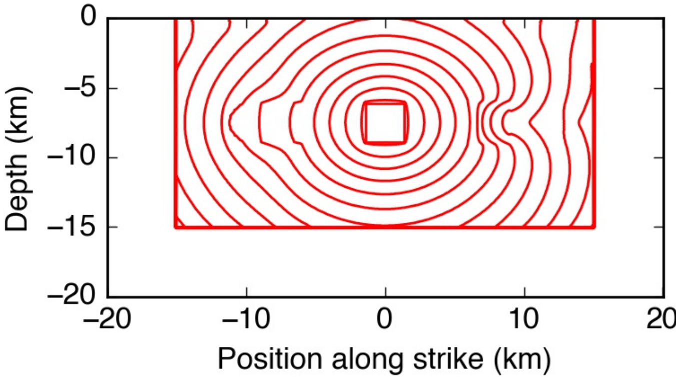
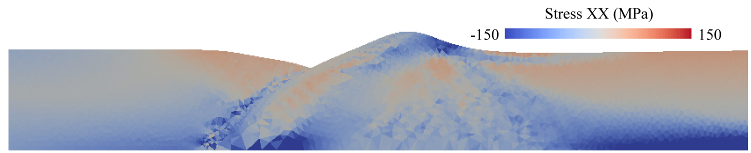
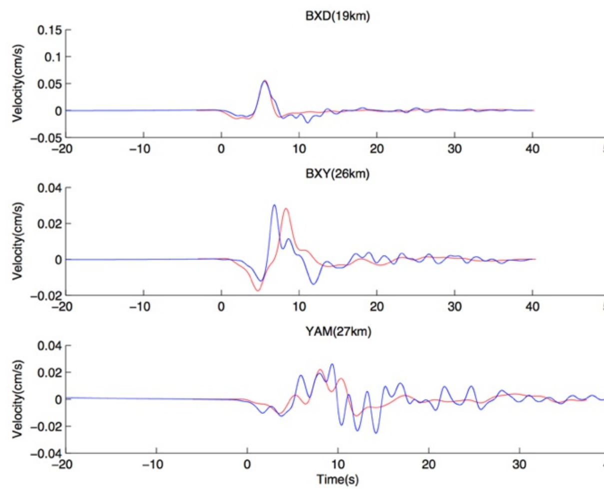
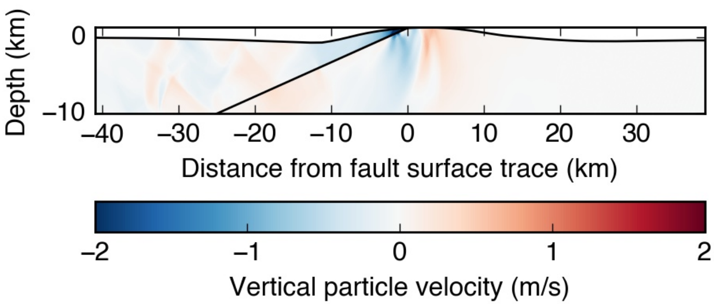


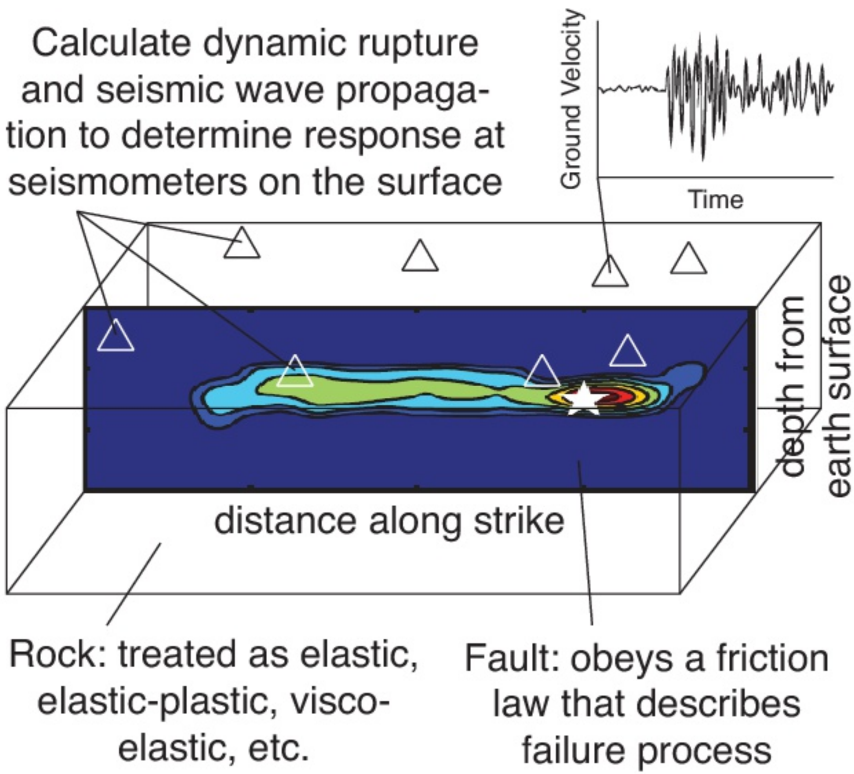






Earthquake Rupture Code

Finite Difference Code: developed for research, teaching, and (potentially) outreach purposes.



Necessary Features:

-- Easy for students to learn to use

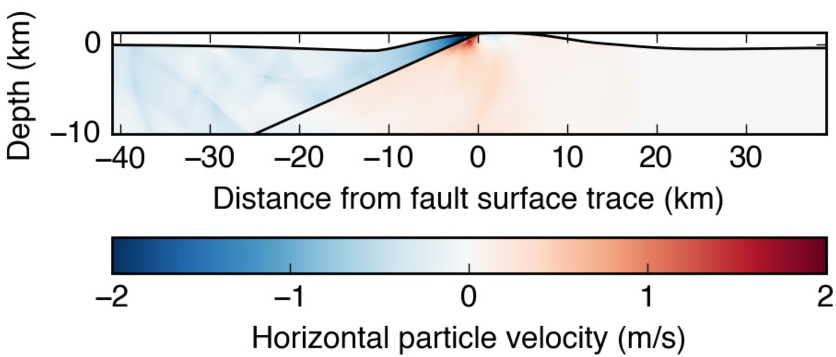
-- Interface with higher level language (Python)

-- No external mesh generator (-> finite difference)

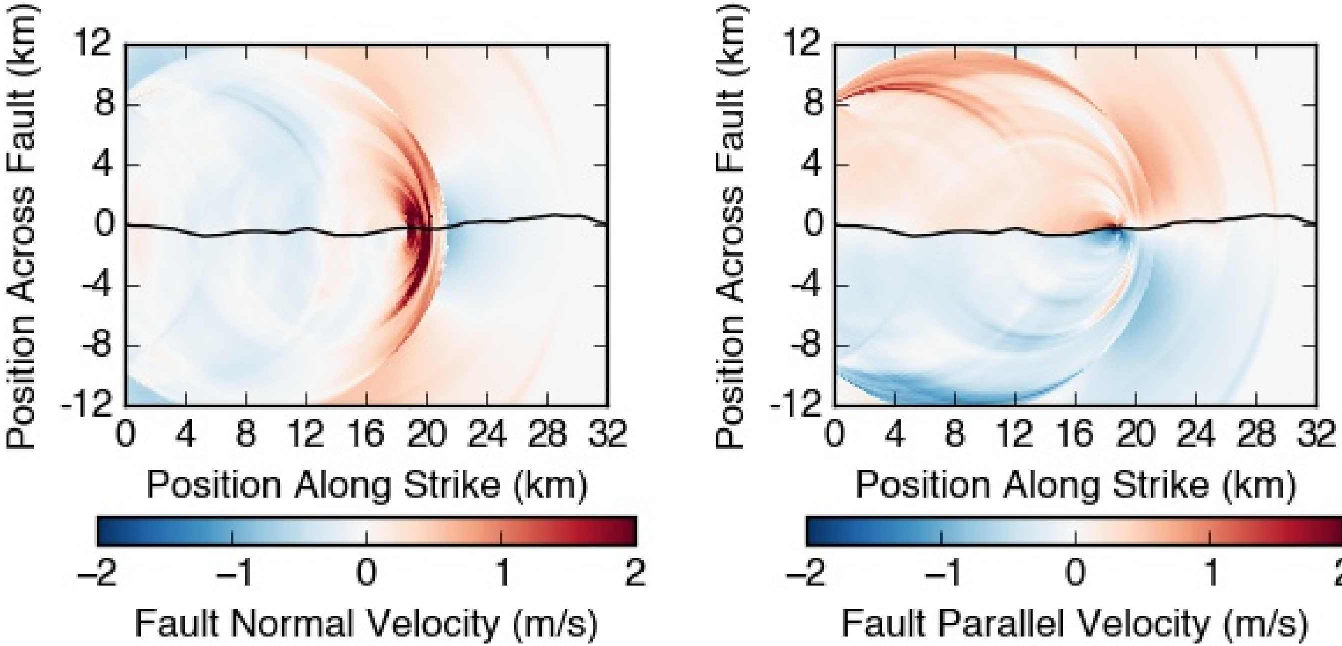
-- Flexible handling of friction laws

Code Details

-- Solves elastic (or elastic-plastic) wave equation for frictional failure/wave propagation problems
-- Uses SBP/SAT method developed by Stanford group (my changes are implementation details only)
-- Slip weakening and STZ Theory friction laws, but future development aims to add user-specified friction laws
-- Heterogeneous velocity structures (block-like, or fully heterogeneous like TPV34)
-- Complex geometries through coordinate transformations



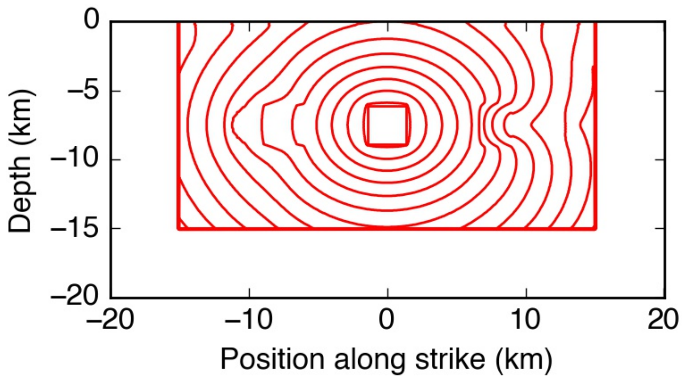
Code Details



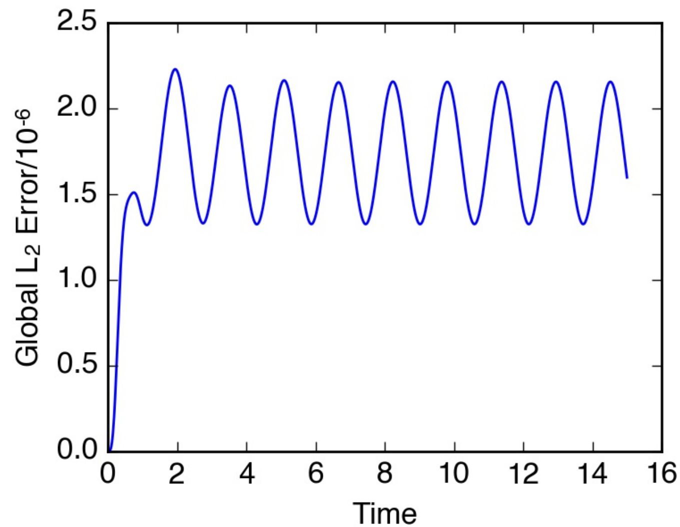
-- Parallelized (C++ with MPI) via domain decomposition
-- Extensive Python interface for constructing complex problems (I have found this very useful for both research and teaching purposes), generates all necessary input files and checks inputs
-- Python and MATLAB scripts for data analysis

Code Testing Status

TPV5 Rupture Front Contours



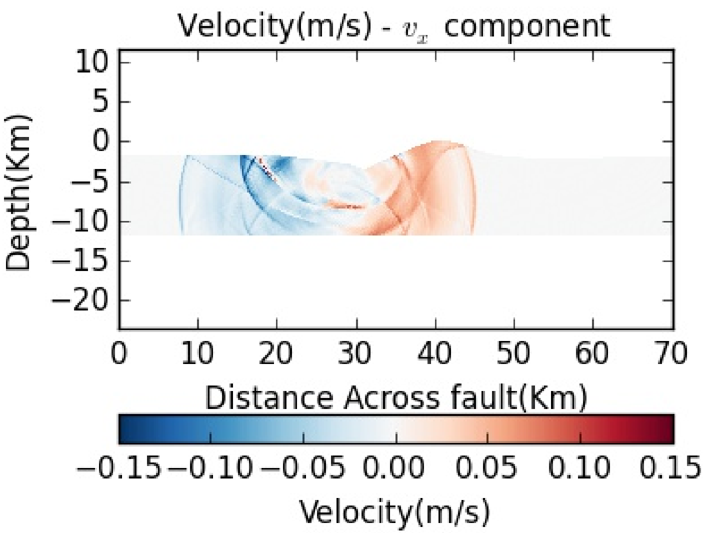
2D MMS Problem Error



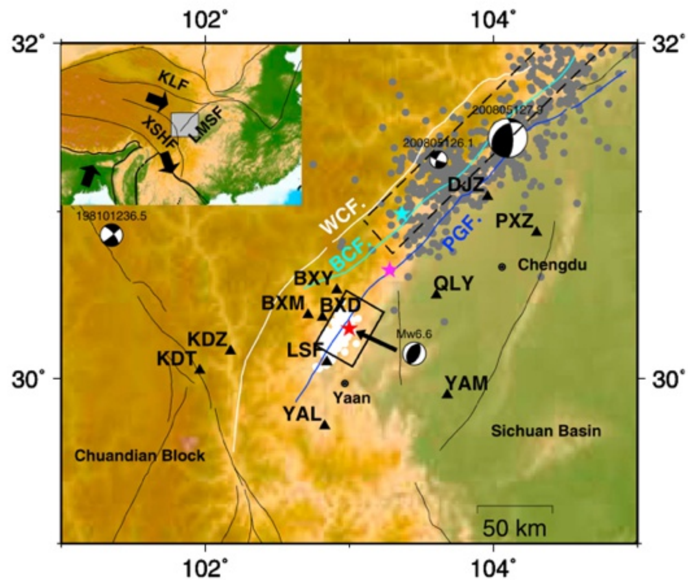
-- Code is well tested in 2D. 3D less comprehensively tested, but additional efforts are in progress
-- Benchmarks: TPV5, TPV12-2D, TPV13-2D, TPV33, TPV34
-- MMS tests in 2D and 3D to verify order of accuracy
-- Ongoing effort to run previous benchmarks (in particular, need to test non-rectangular geometries in 3D)

Example Student Uses of Code

Coupling Geodynamic and Dynamic Rupture Simulations

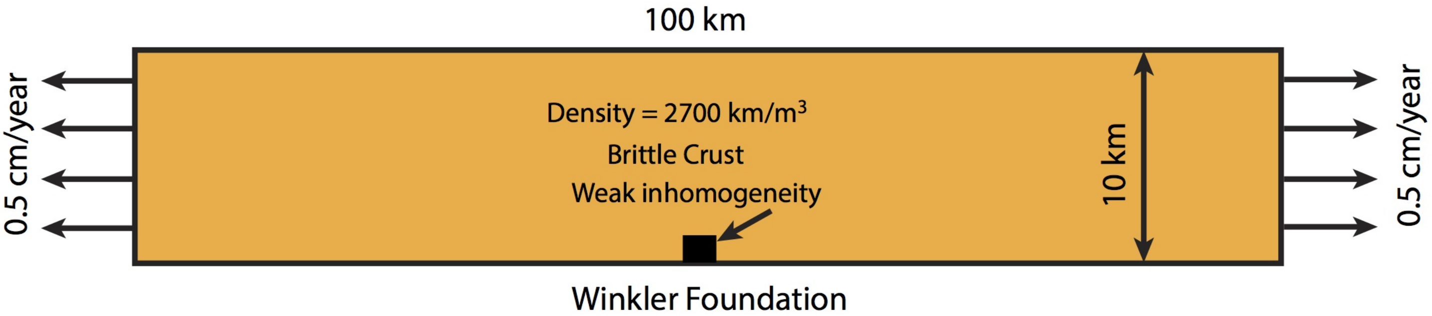


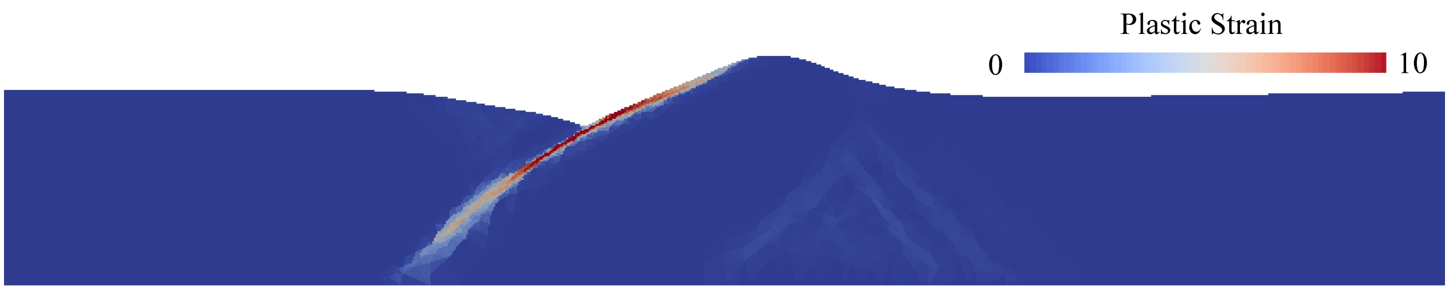
Simulations of 2013 Mw 6.6 Lushan Earthquake



Coupling to Geodynamics

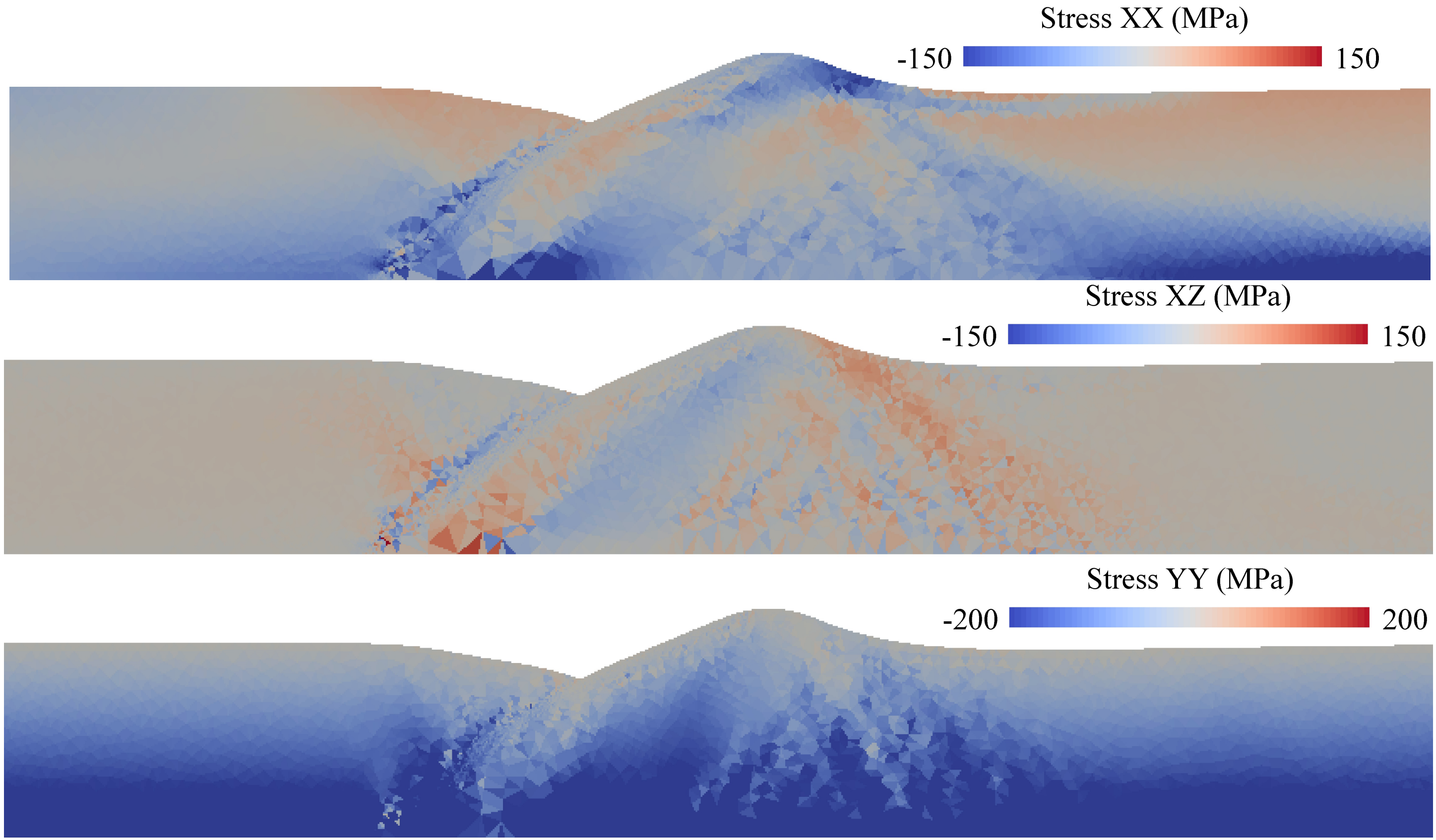
Work by Sabber Ahamed (PhD student) to generate geometry and initial conditions for a rupture simulation from a long term tectonic model (quasi-static)





Coupling to Geodynamics

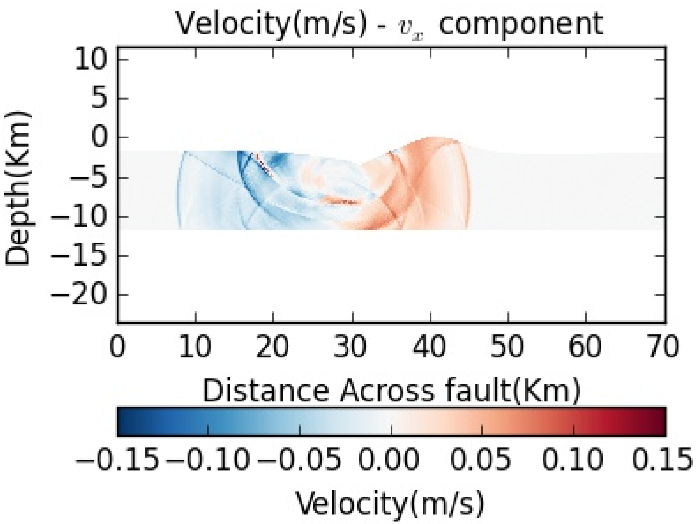
Heterogeneous stress fields from geodynamic models, use as initial condition on dynamic rupture model



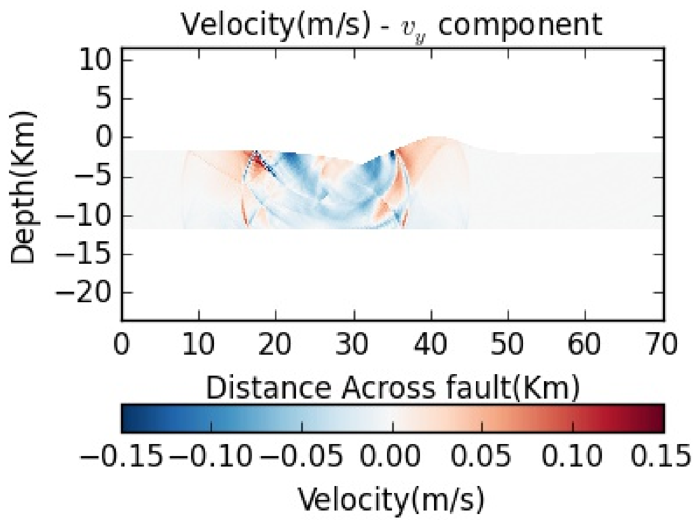
Coupling to Geodynamics

Dynamic rupture model derived from geodynamics simulation at 1 Myr. Domain and fault geometry, initial stresses interpolated from geodynamic unstructured mesh to rupture code structured mesh. Working on a reliable prescription for defining friction parameters.

Horizontal Velocity

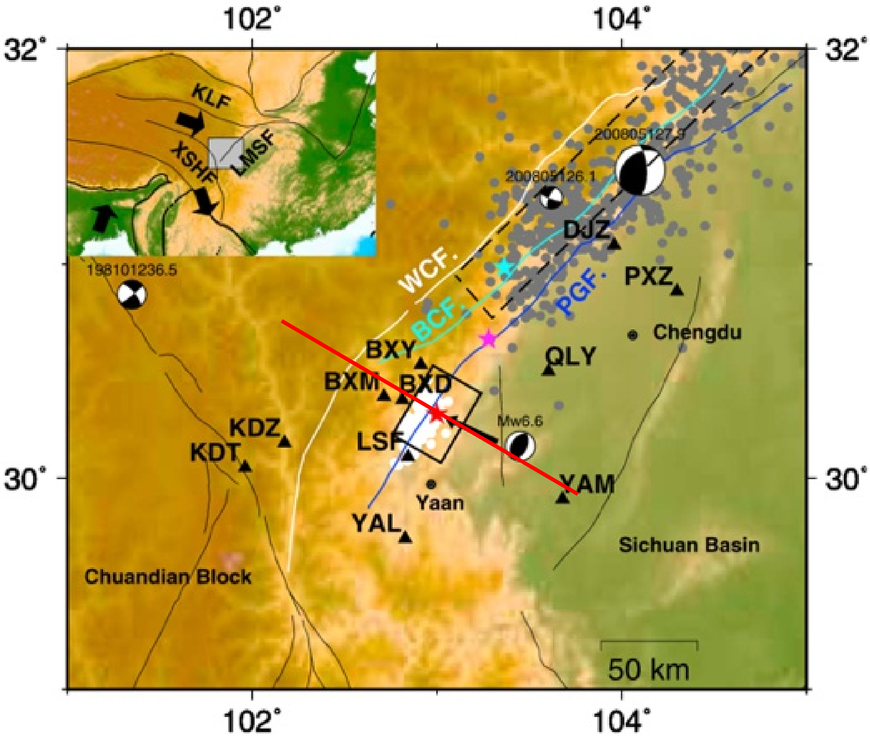


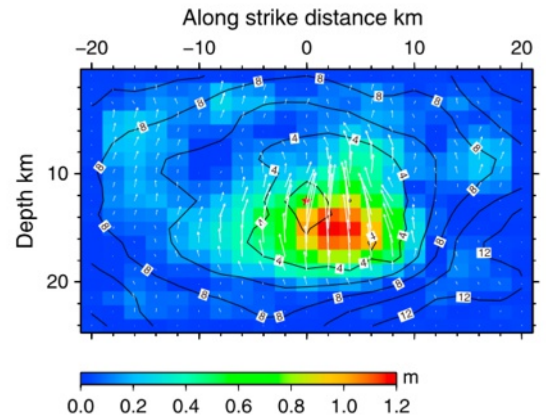
Vertical Velocity



Modeling 2013 Lushan Earthquake

Work by Yang Yang (PhD student) to produce a dynamic model based on a kinematic inversion and velocity structure





Hao et al., 2013

Modeling 2013 Lushan Earthquake

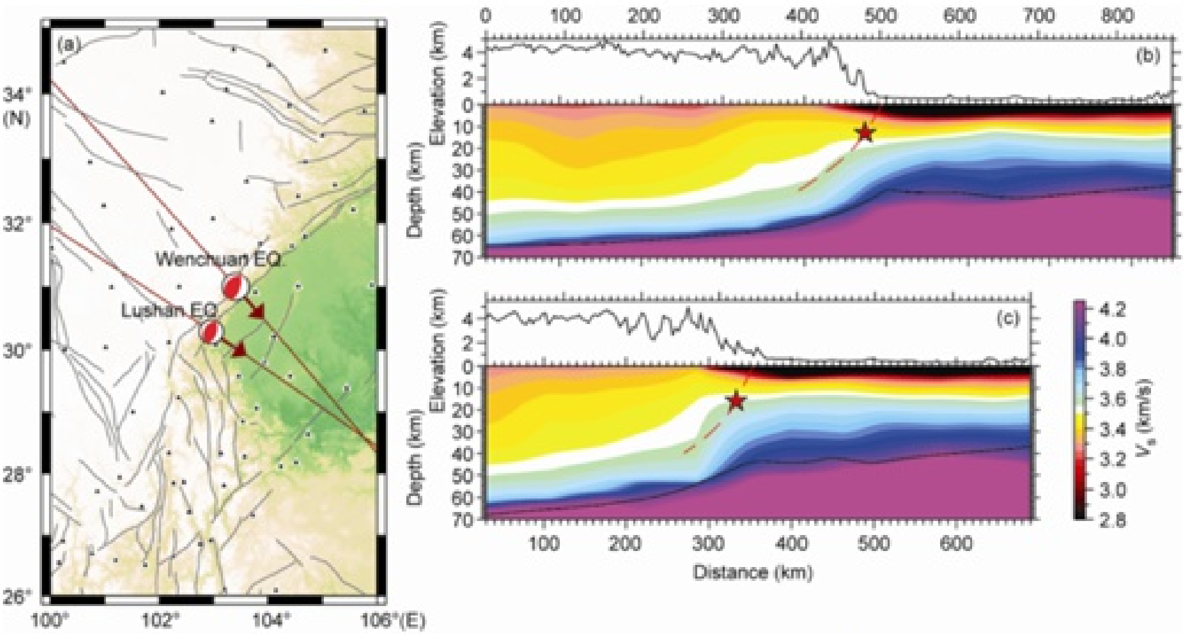
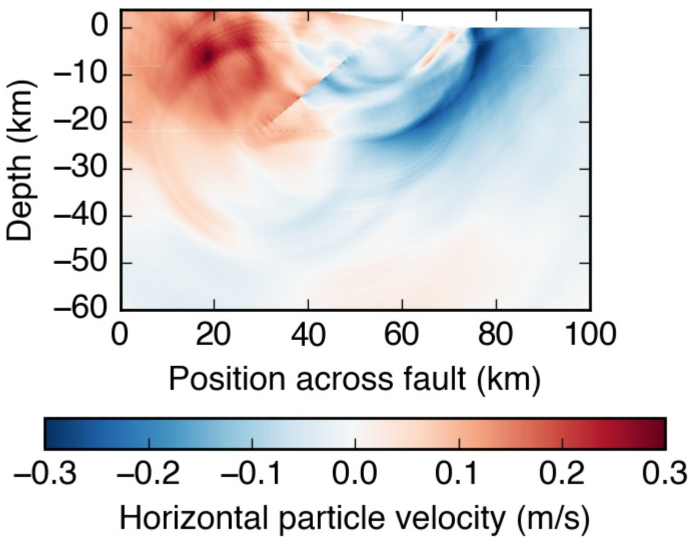


Figure 7 S velocity profiles across the longmen faults zone. (a) Profiles location across Wunchuan and Lushan earthquake. Profile directions are perpendicular to the strike direction of two earthquakes. (b) S velocity profile across Wenchuan earthquake; Top thin black line is the elevation variance at profile surface; bottom thick black line represent crustal thickness achieved by receiver function study; red thin line represent the suppositional inclined fault surface. (c) Same as (b) but structure profile across Lushan earthquake.

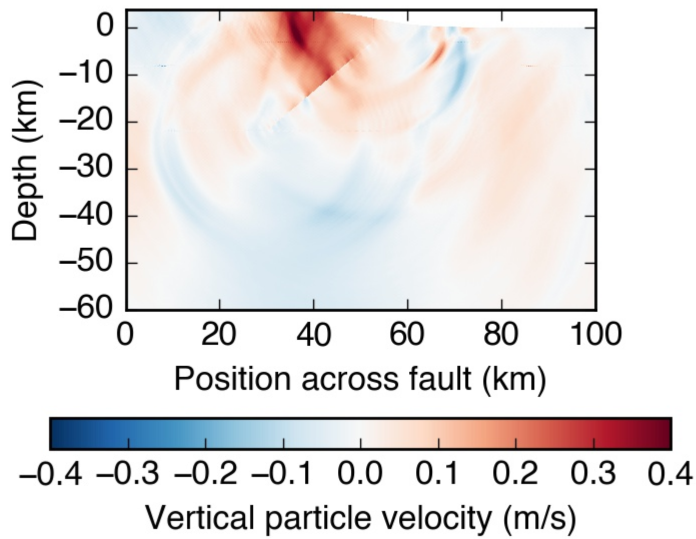
Yong et al., 2013

Modeling 2013 Lushan Earthquake

Horizontal Particle Velocity (t = 18.88 s)



Vertical Particle Velocity (t = 18.88 s)



Modeling 2013 Lushan Earthquake