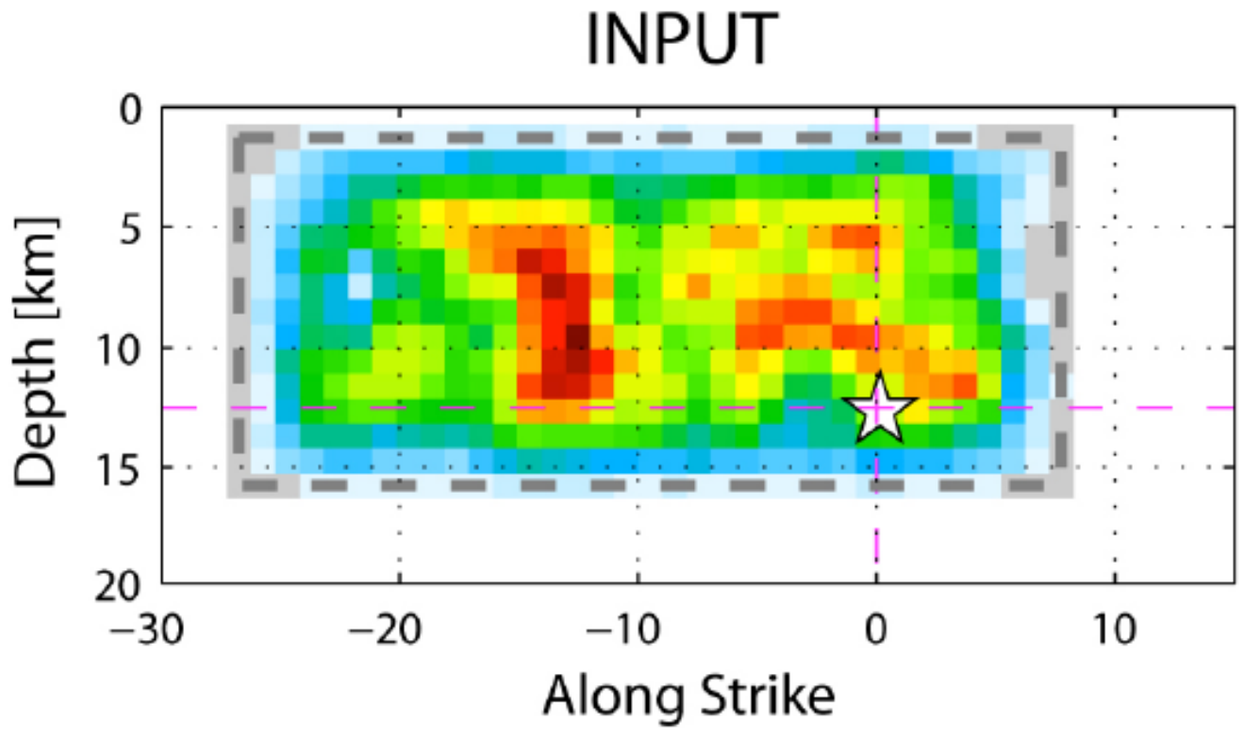
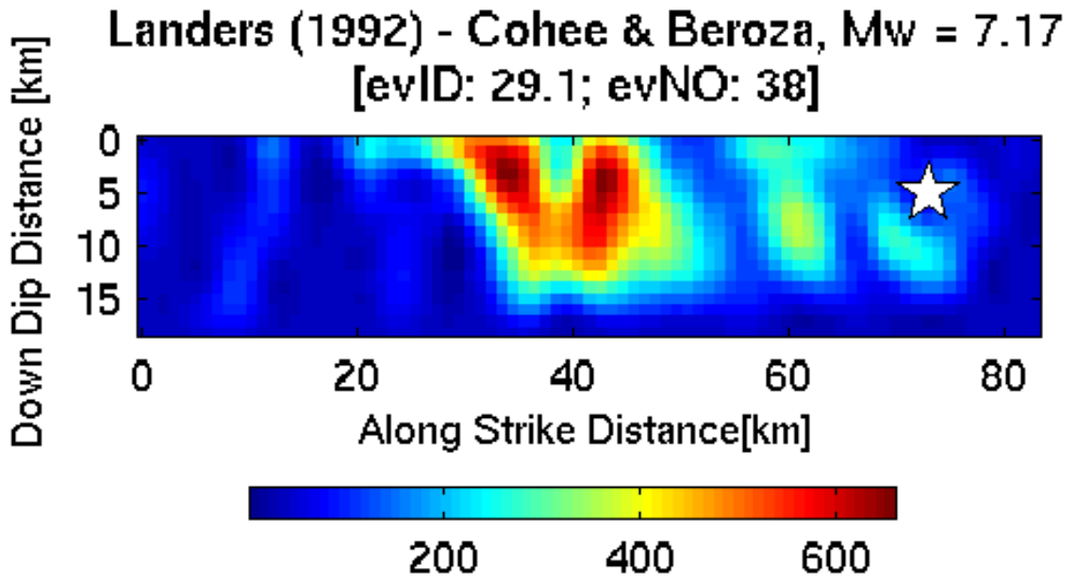
Source Inversion Validation (SIV)

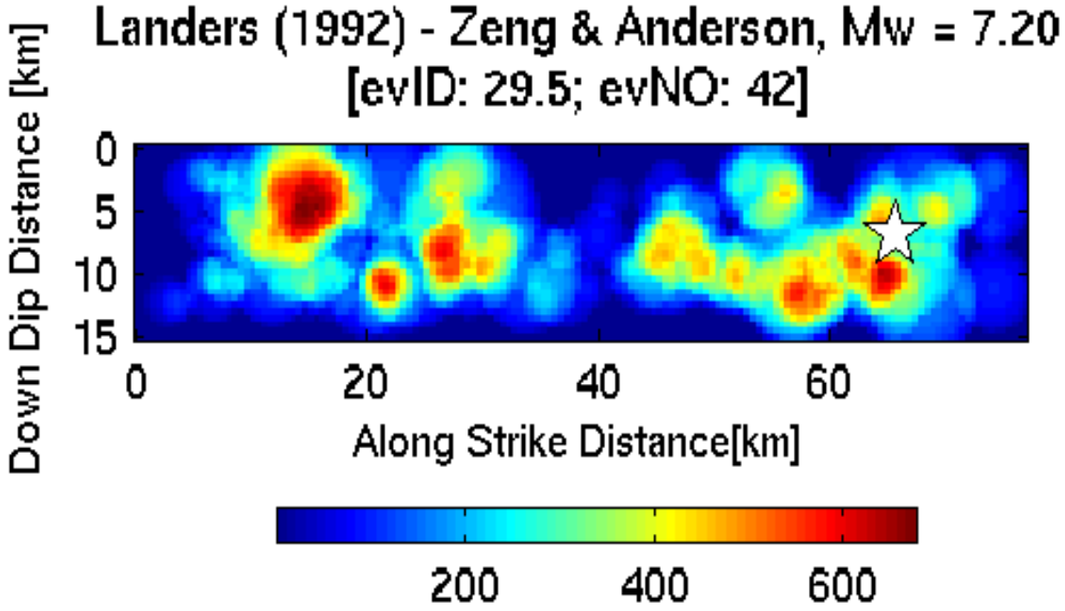
Past, Present, and Future

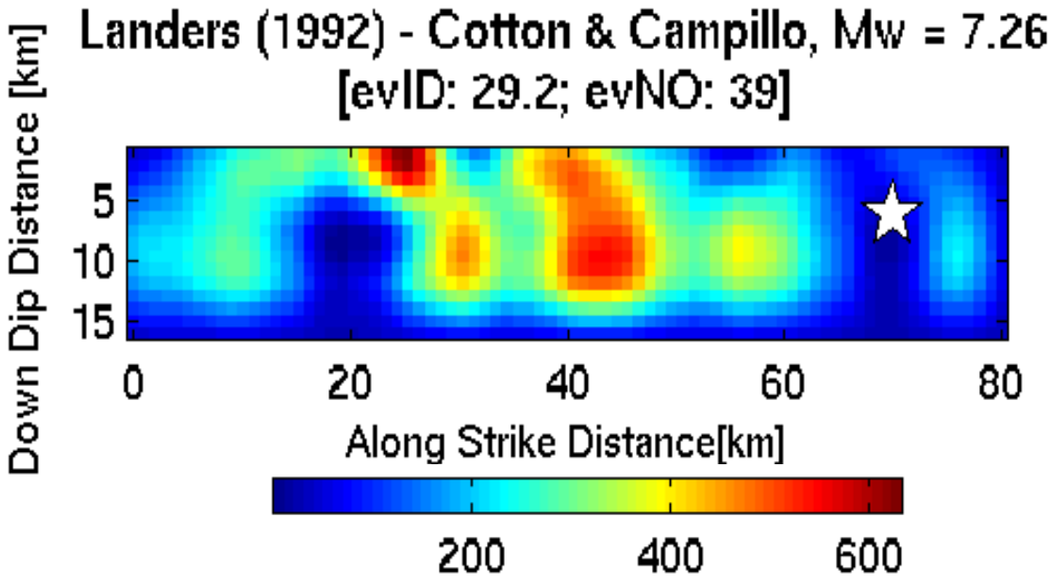


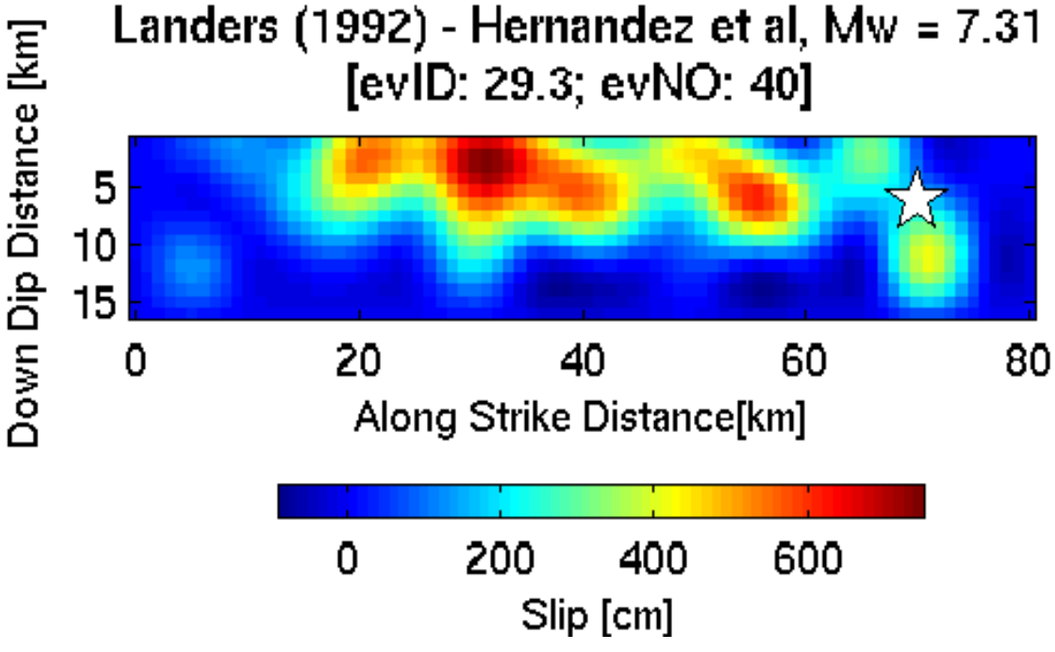
Morgan Page
Martin Mai
Danijel Schorlemmer

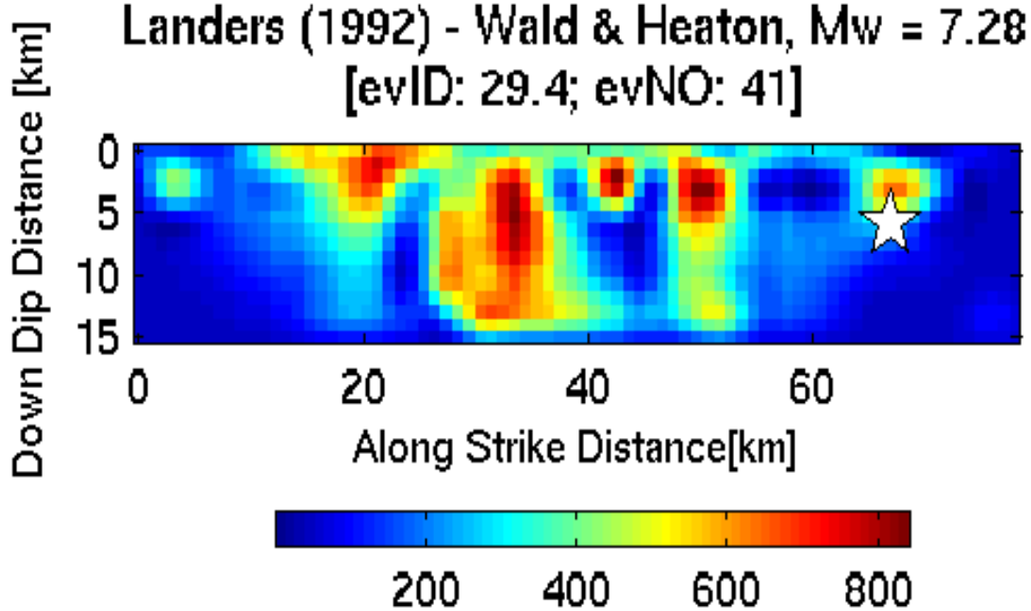
Different inversion methods, model parameterizations, constraint choices, and data sets lead to different results.



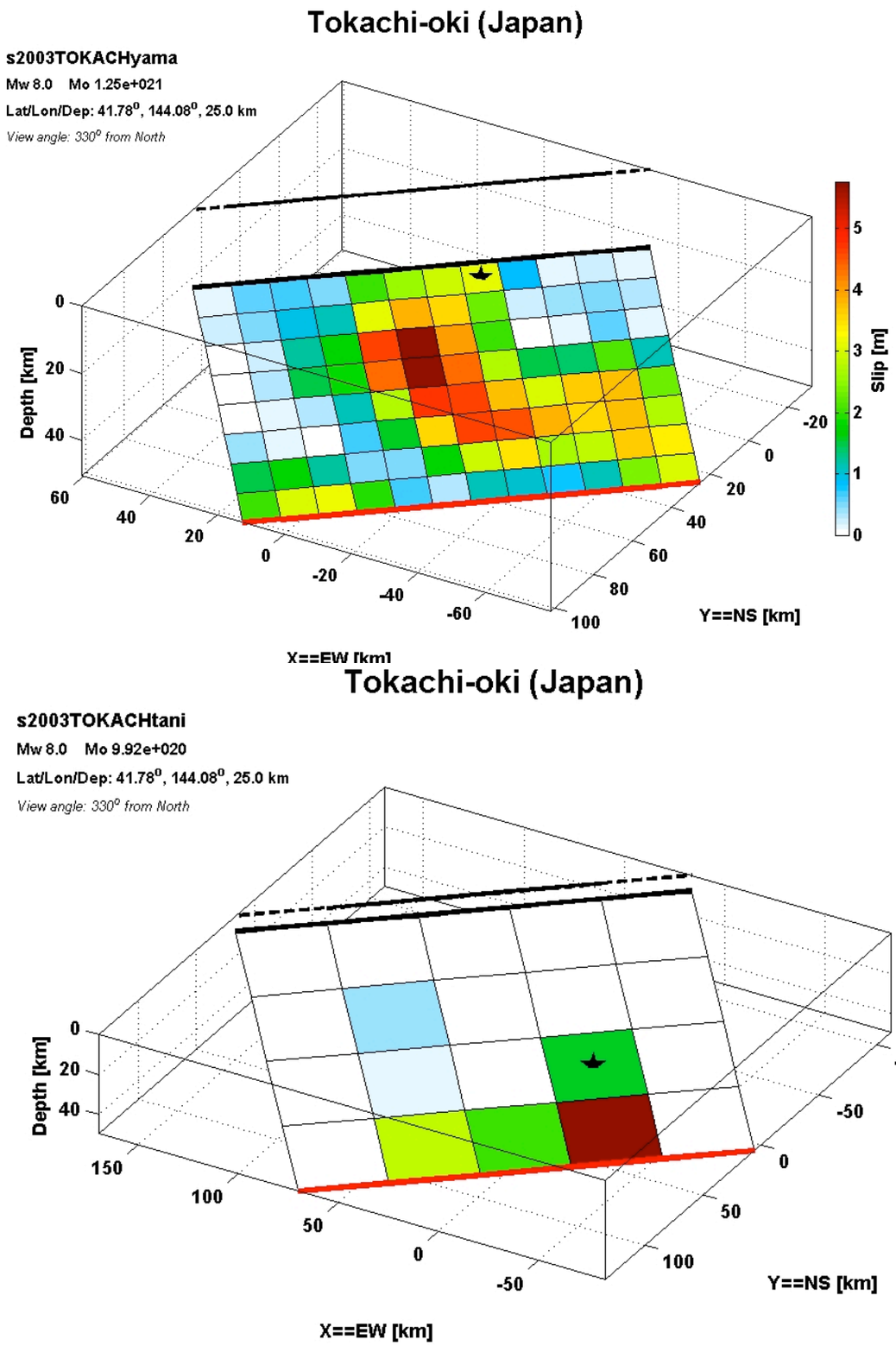


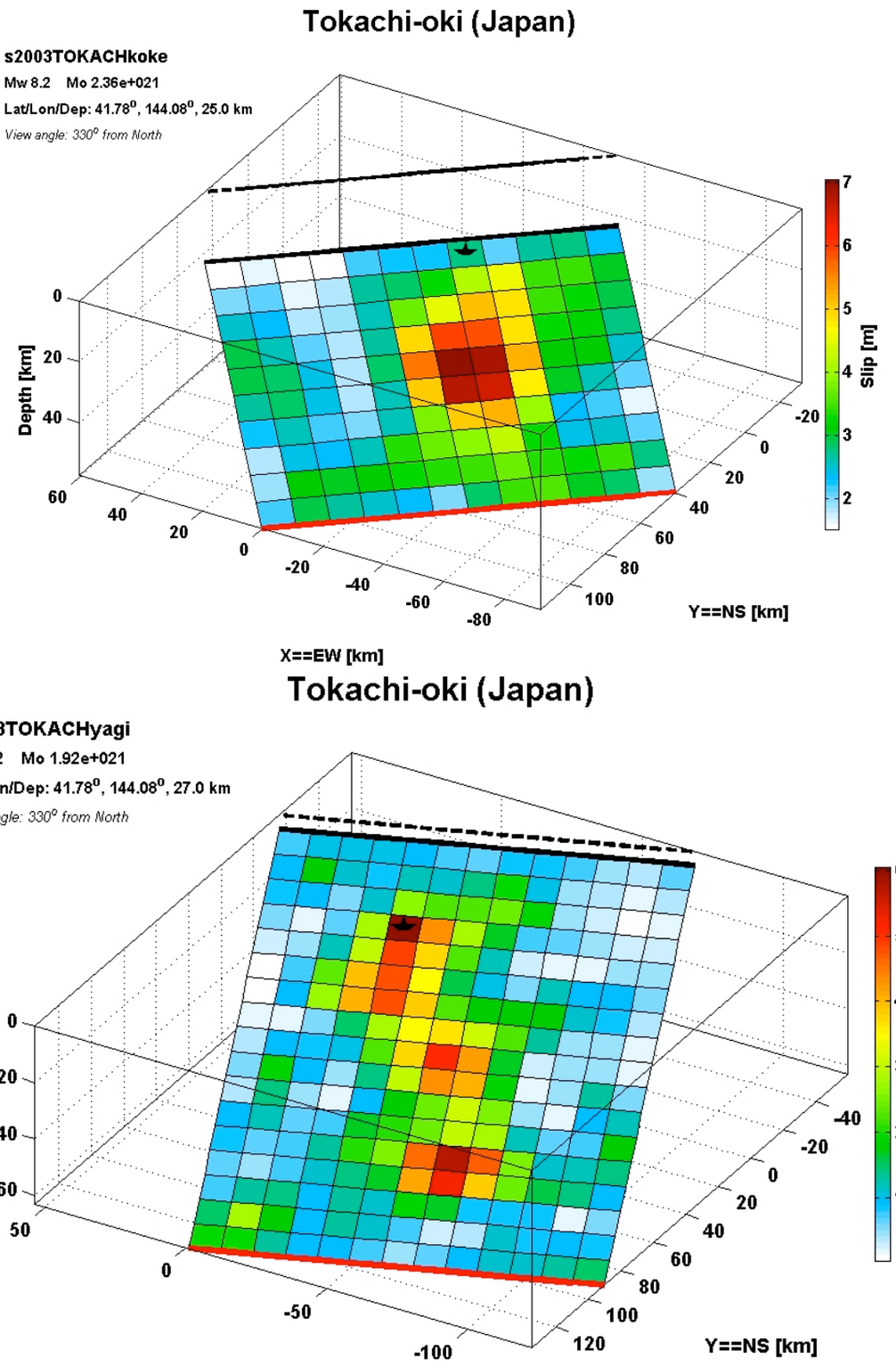






Another example -- the Tokachi-oki earthquake





Martin Mai's Databse of Finite Source Models, http://www.seismo.ethz.ch/staff/martin/research/srcmod/srcmod.html

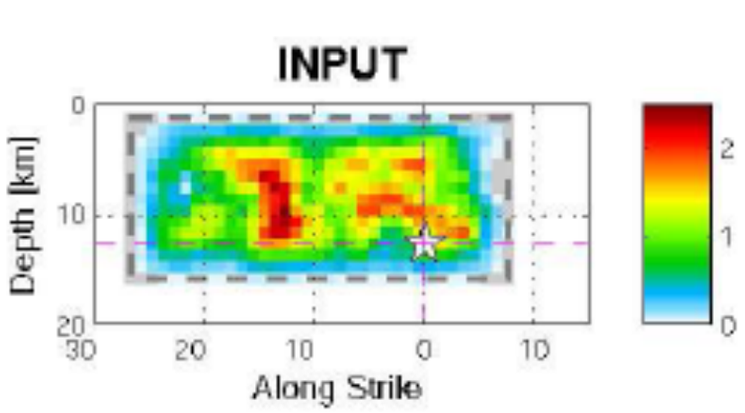
Questions about kinematic inversions

- What are the robust features of the models?
- How do the constraints and model parameterization affect the model result?
- Why do different inversions have such different slip models?
- How can we improve kinematic inversions to make the results more reliable?

Testing kinematic source inversions

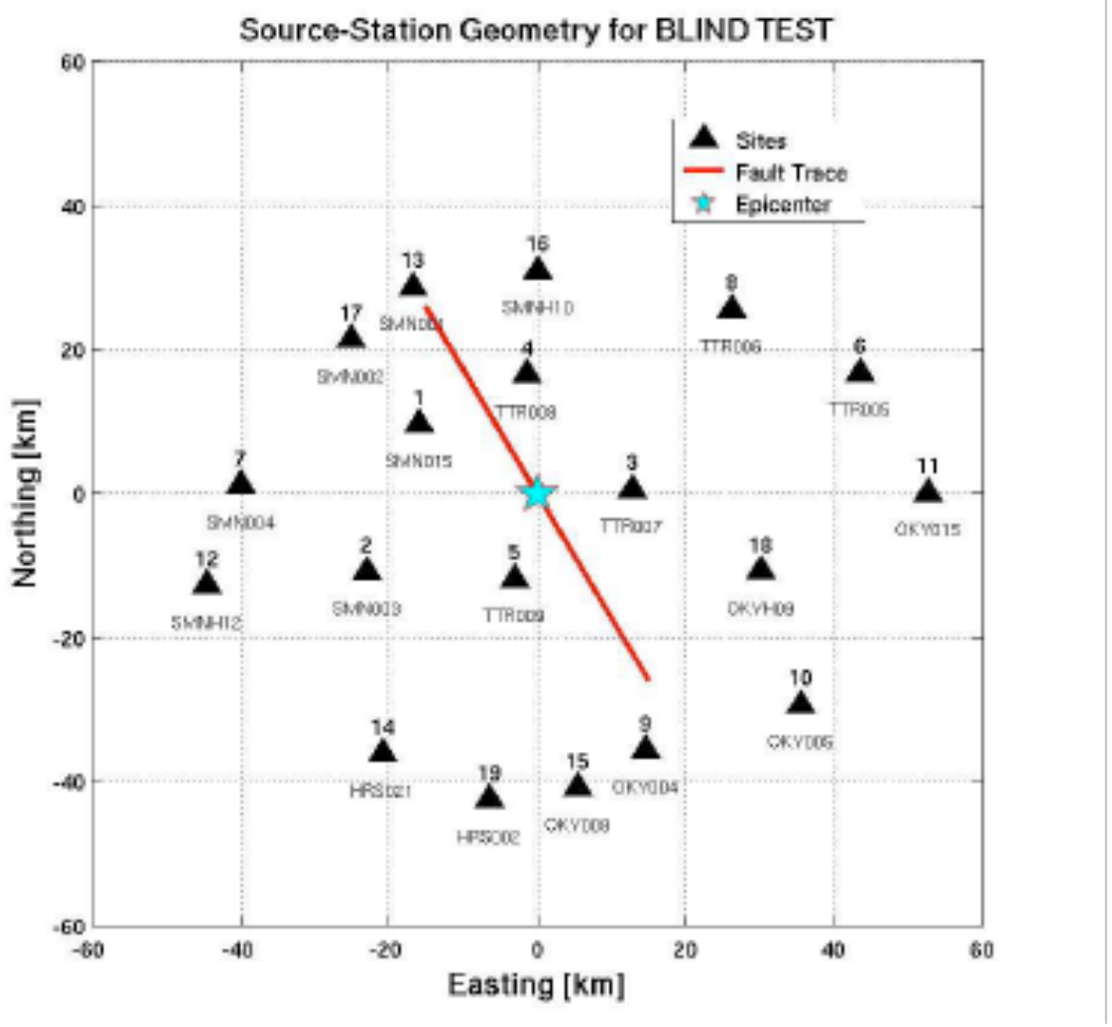
Martin Mai's SPICE Blind Test

Unknown to modelers, input model had a constant rise time, constant rupture velocity, and a triangular SVF



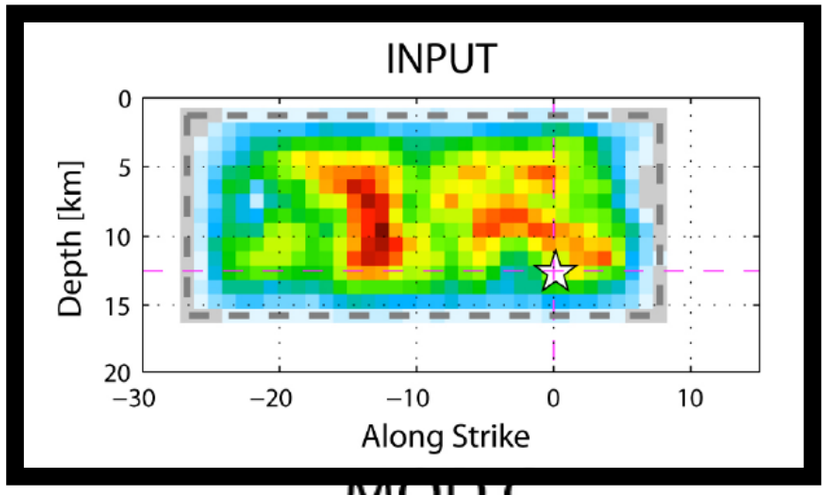
Modelers were given:

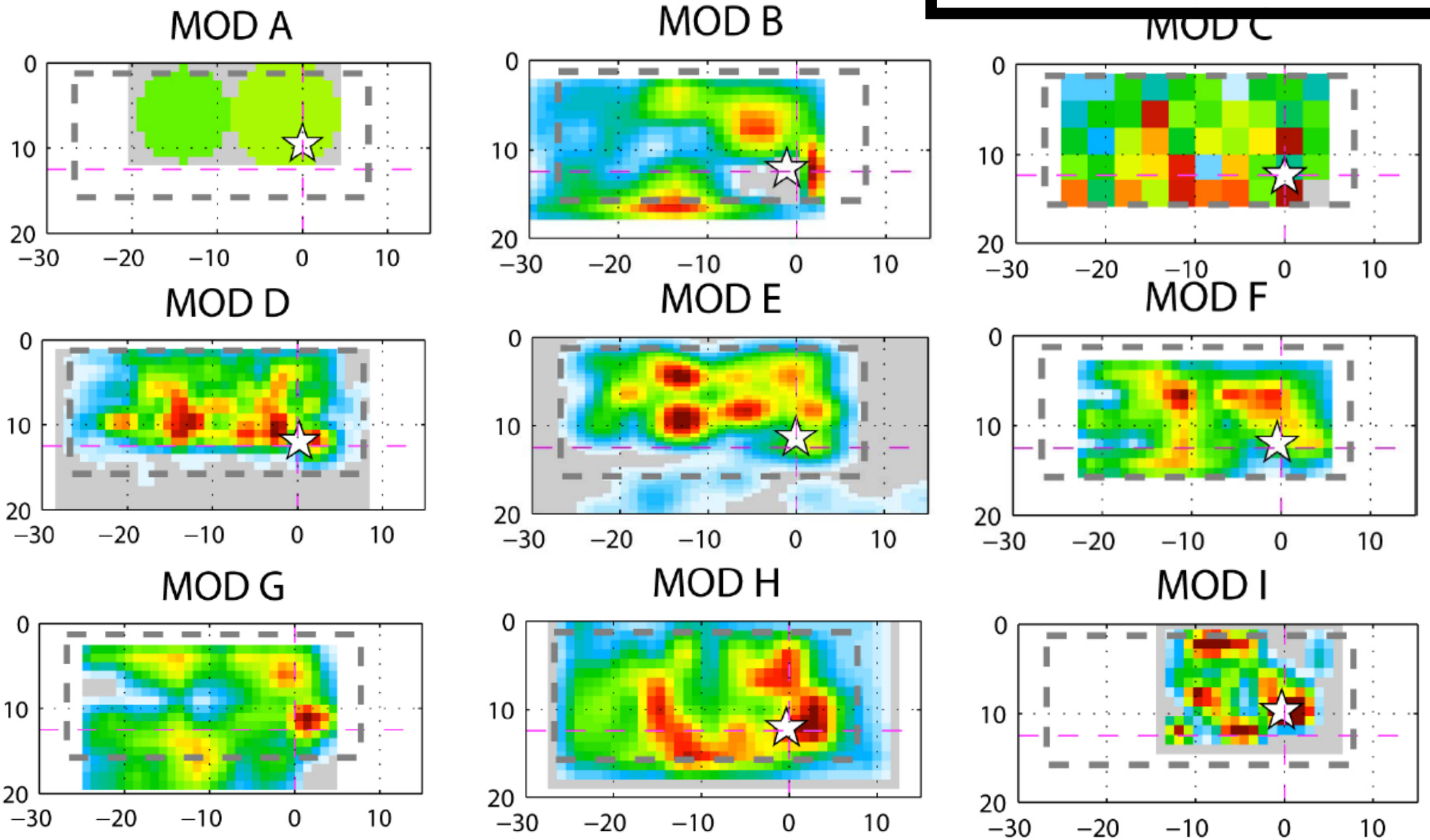
- seismic moment
- strike, dip, and rake
- hypocentral depth
- velocity-density structure
- noise-free synthetics



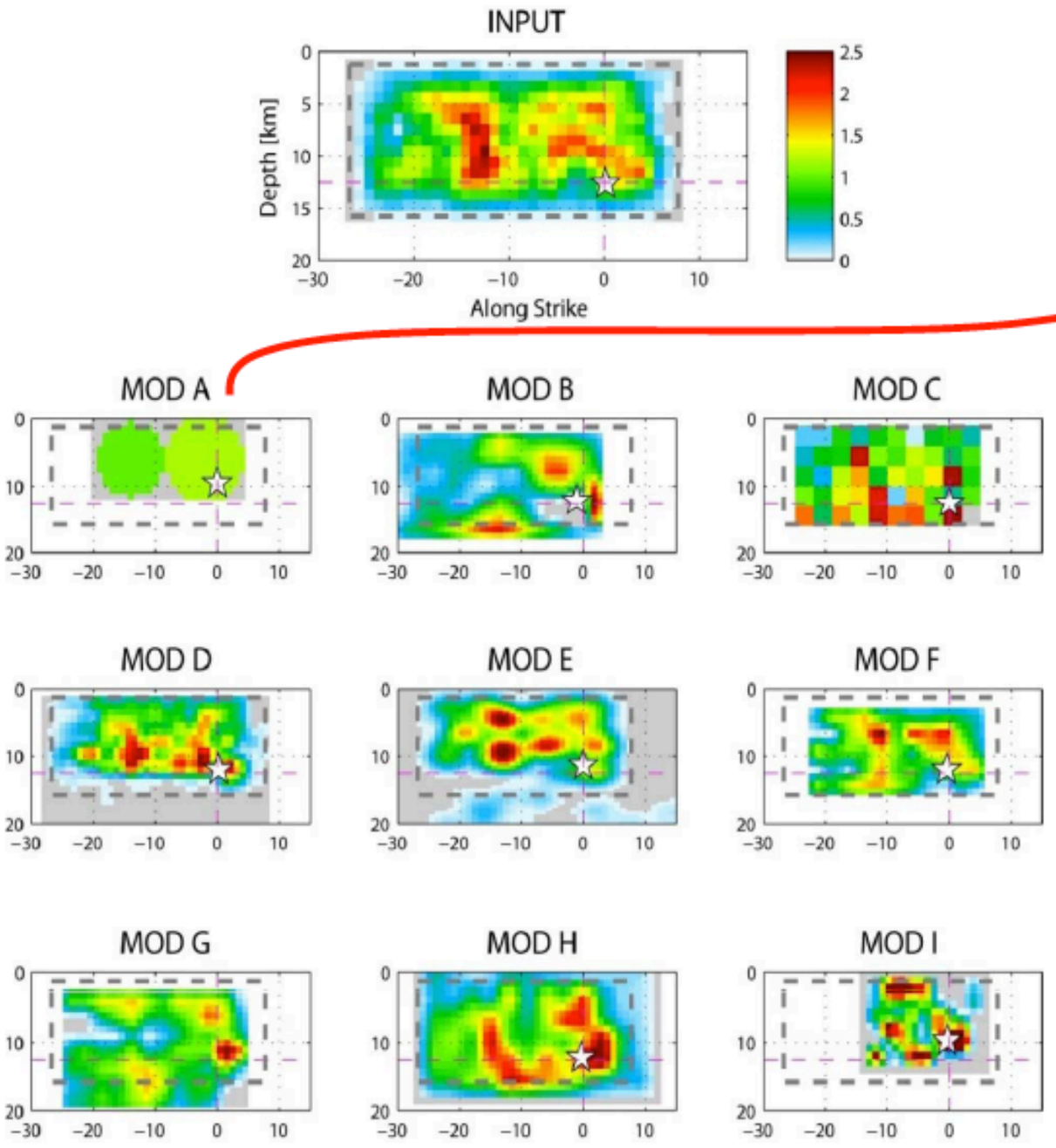
Mai, P. M., G. Festa, C. Francois-Holden, J. Burjanek, S. Di Carli, A. Emolo, A. Zollo, B. Delouis, and R. Madariaga, 2006.

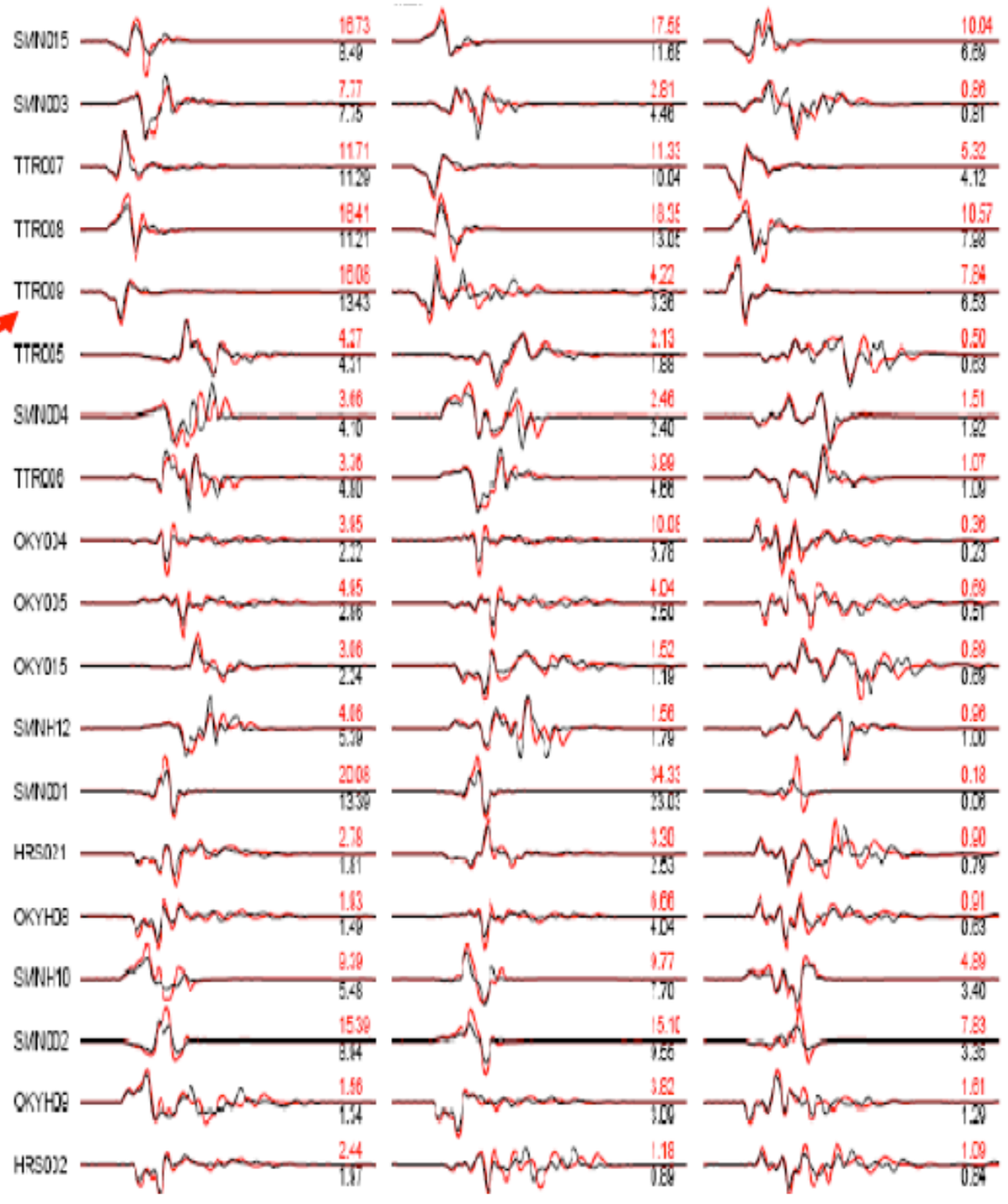
Blind Test Results





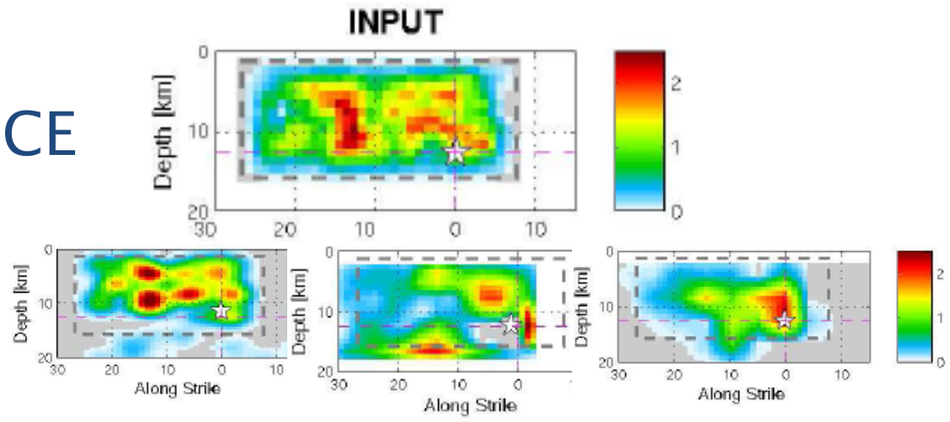
Data fit ≠ Model fit





Source Inversion Validation (SIV)

Martin Mai, Morgan Page, and Danijel Schorlemmer



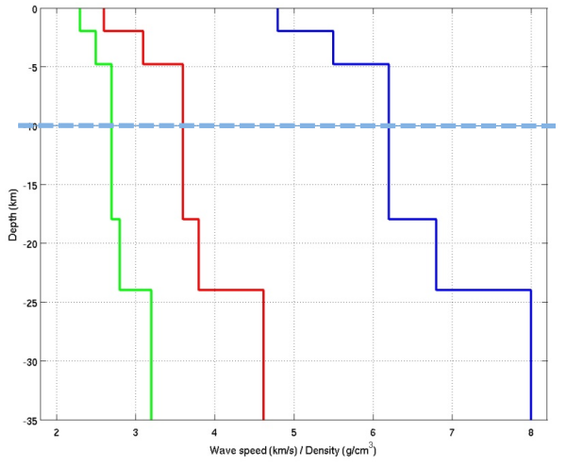
Previous Source Inversion Validation Exercise (SPICE Test) showed large variability between models

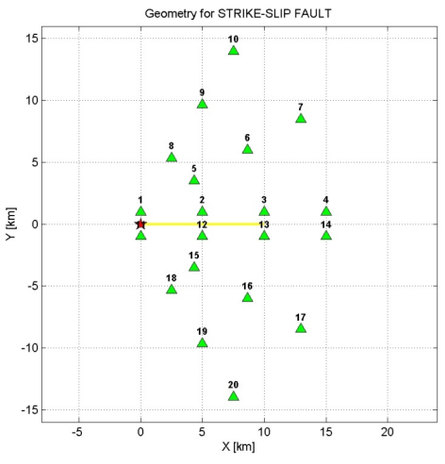
SIV Goals:

- Verify that the forward problem is being done correctly by all modelers
- Assess reliability, resolution, and robustness of different inversion strategies
- Develop testing center to host inversion "experiments" of varying complexity

First Steps:

- Problem 1a: Point-Source Green's function test)
- Problem 1b: Extended Source Green's function test)
- Problem 2: Simple Inversion



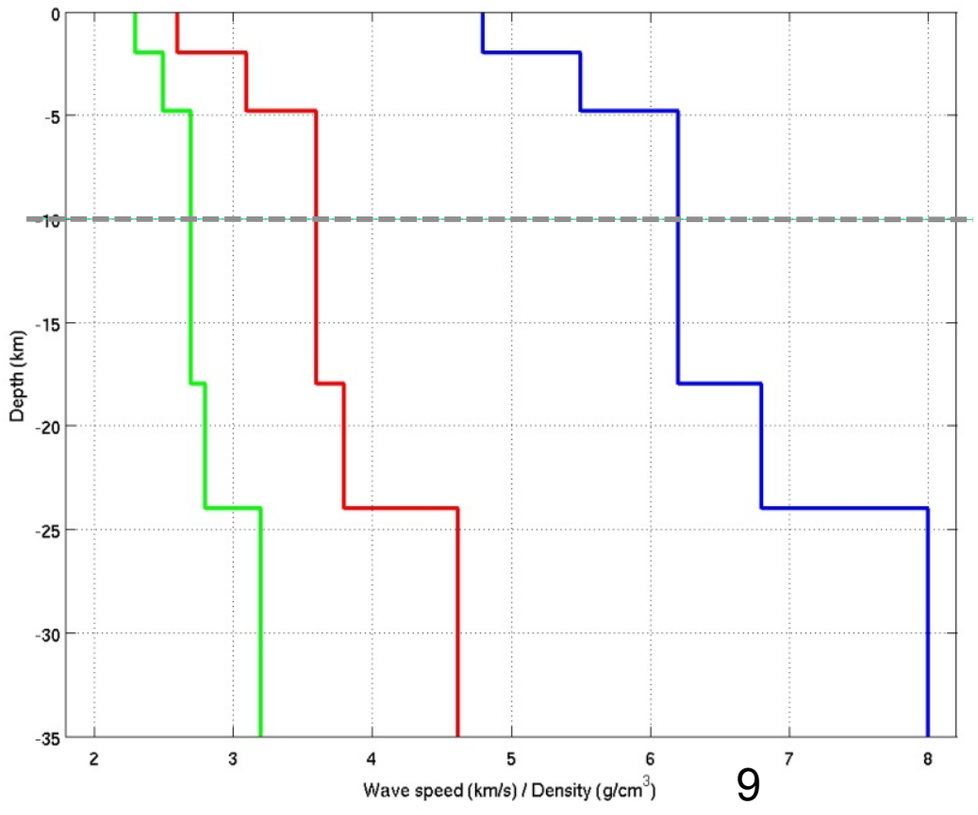


Source Inversion Validation http://siv.usc.edu

Problem 1a: Green's Function Validation (point source)

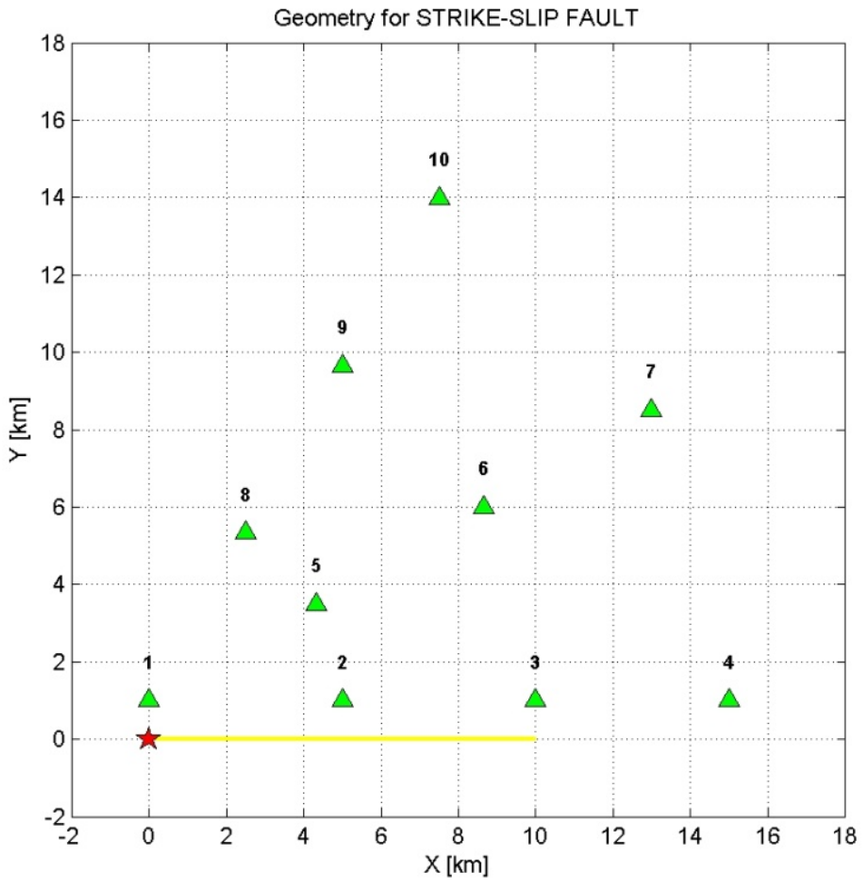
- **During the 2008 SCEC workshop, it was questioned if all groups participating in the blind test calculated the Green's functions correctly**
- **The SIV-project thus starts with a test to verify GF-computations:**
  - "point-source" at 10 km depth, parameterized as a 1 x 1 km^2 slip patch with homogeneous slip and boxcar slip-function of duration t_r = 0.2 sec
  - The shear-modulus at the given depth result in: M_w 4.992, M_0 = 3.4992 x 10^{16}

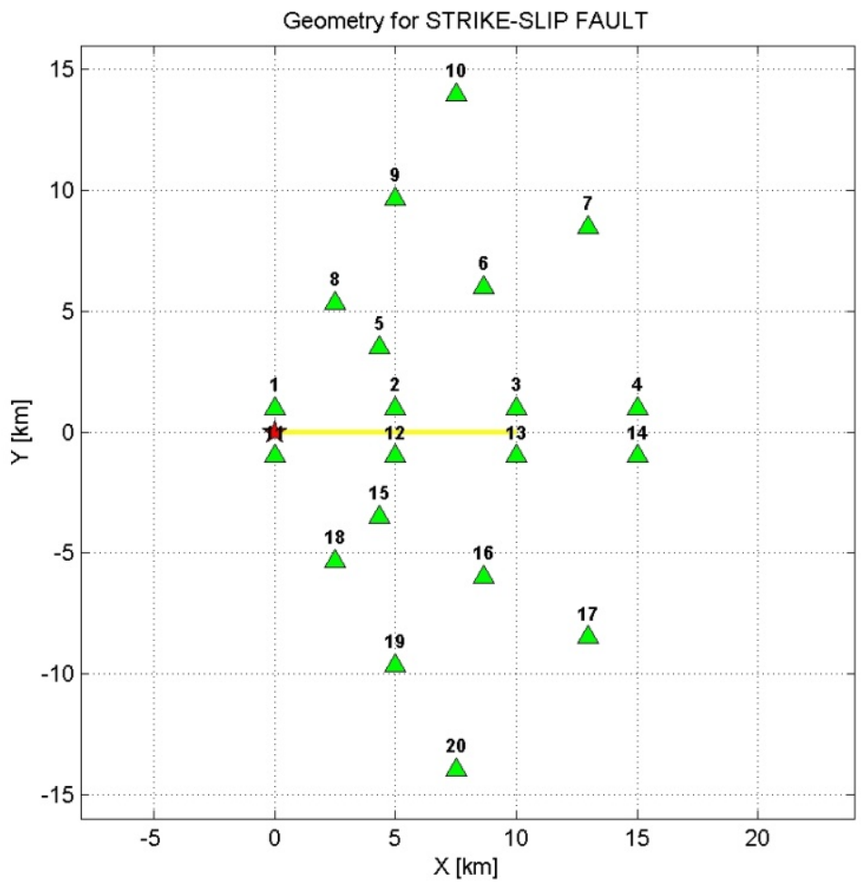
Depth [km]	**V_P** [km/s]	**V_S** [km/s]	**Density** [g/cm^3]
0.0	4.8	2.6	2.3
-2.0	4.8	2.6	2.3
-2.0	5.5	3.1	2.5
-4.8	5.5	3.1	2.5
-4.8	6.2	3.6	2.7
-18.0	6.2	3.6	2.7
-18.0	6.8	3.8	2.8
-24.0	6.8	3.8	2.8
-24.0	8.0	4.62	3.2
-45.0	8.0	4.62	3.2



Problem 1a: Green's Function Validation (point source)

- **Two cases are considered for the Green's function test**
  - purely left-lateral strike-slip rupture on a vertical fault
  - purely thrust-motion on a 40° dipping fault
  - Stations at Y = 1 km parallel to surface projection of fault plane, and two arrays that are 30° and 60° rotated from the fault-parallel direction



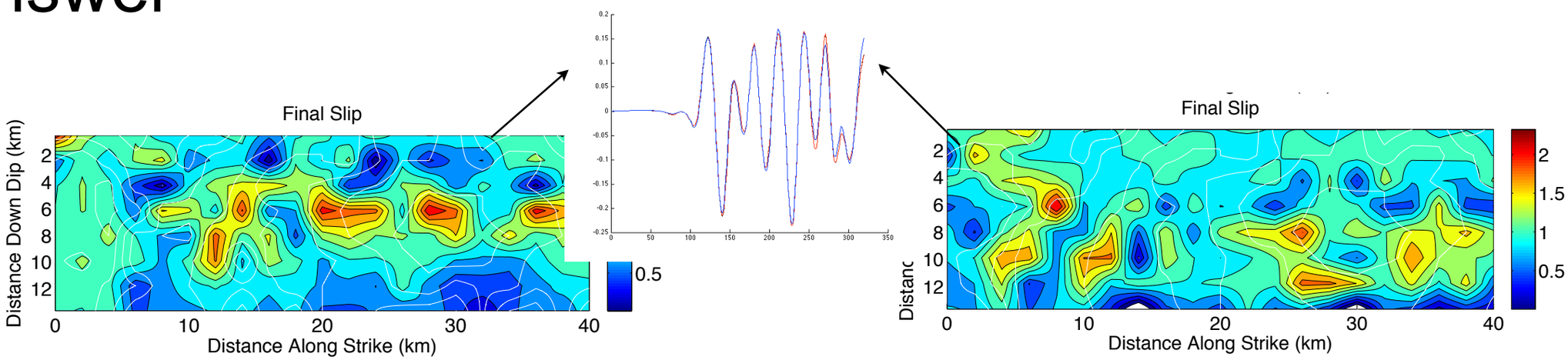


Differences between Dynamic Code Validation and Source Inversion Validation

- Must be blind (there is the possibility of tuning)

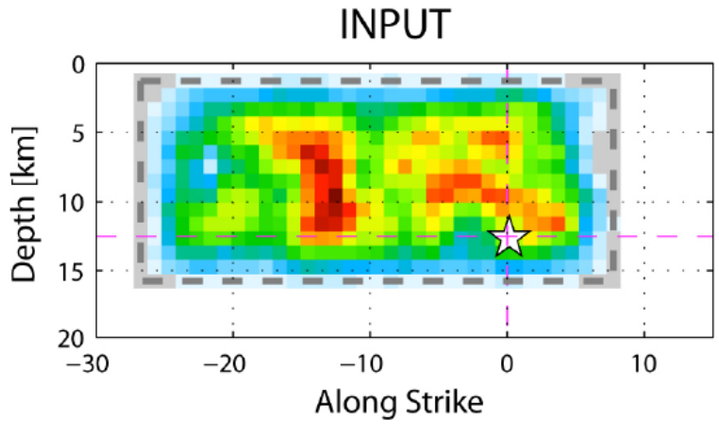
  Amount of smoothing/regularization, geometry choices, data weights

- Nonuniqueness: there is more than one “correct” answer

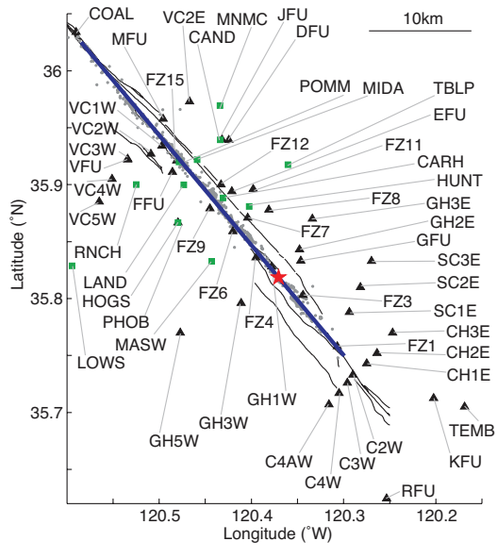


Types of Inversion Tests

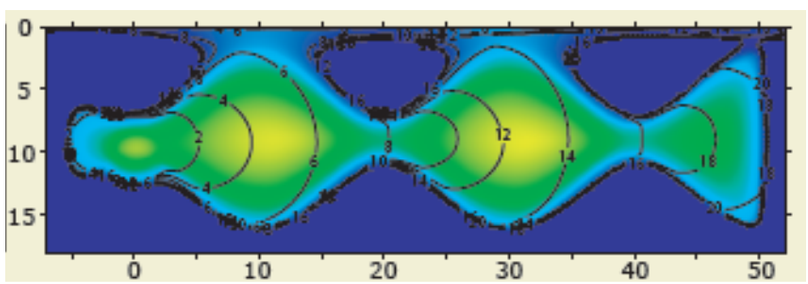
- Kinematic Models (like original SPICE-test)



- Real Earthquakes
  - construct earthquake from empirical Green's functions, or
  - use subset of stations to produce synthetics at remaining stations

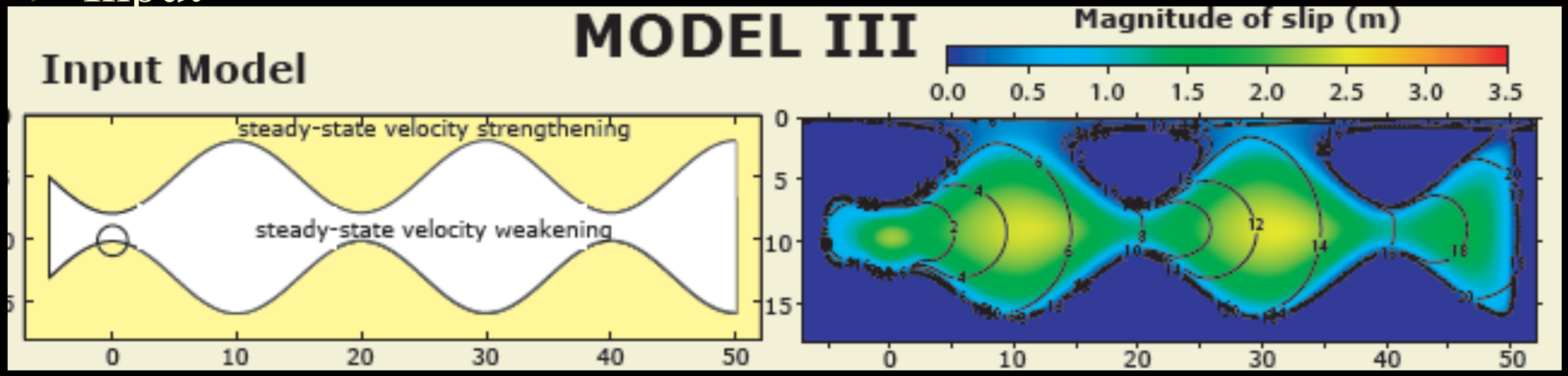


- Dynamic Models
  - best of both worlds: can be realistic; true slip model is known



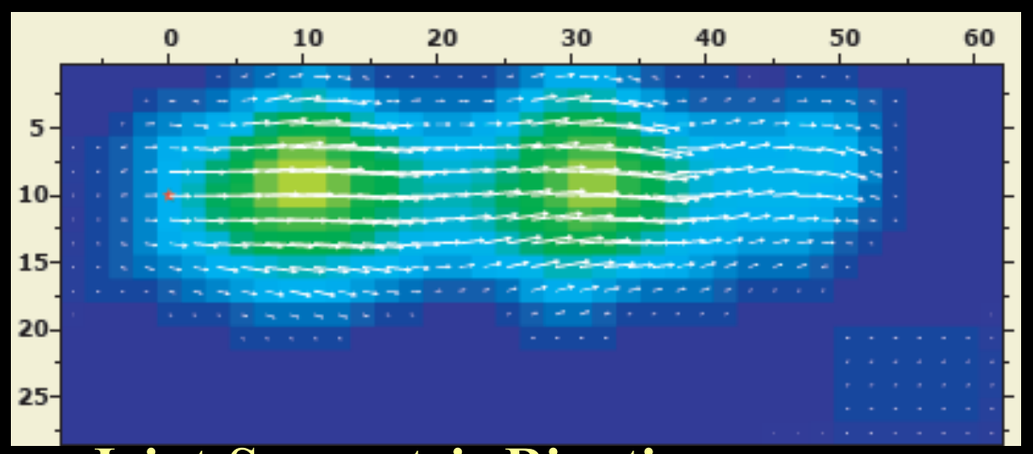
Model 3

- Input

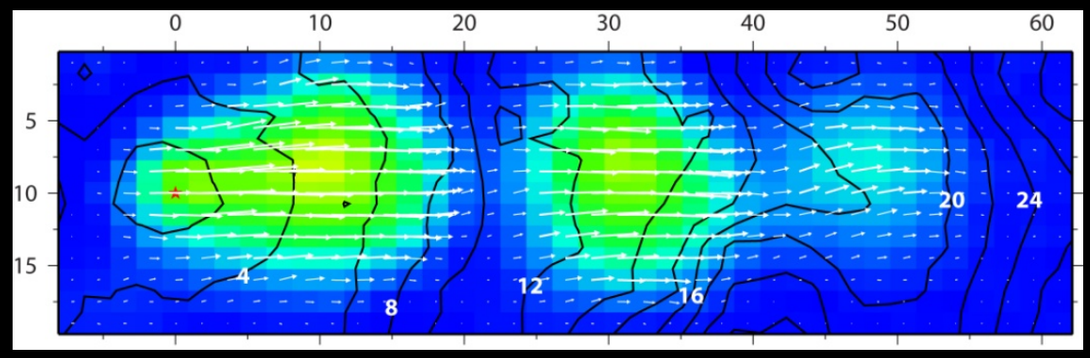


Inverted Kinematic Models

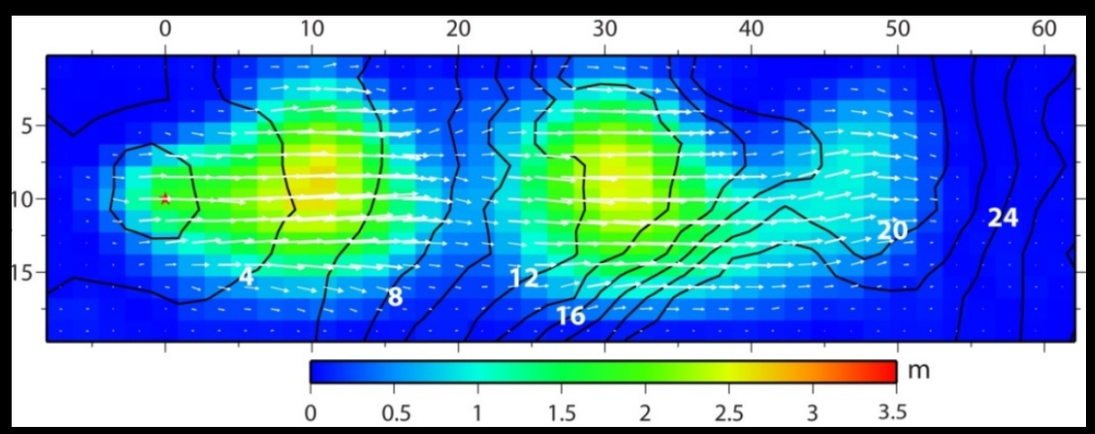
GPS model



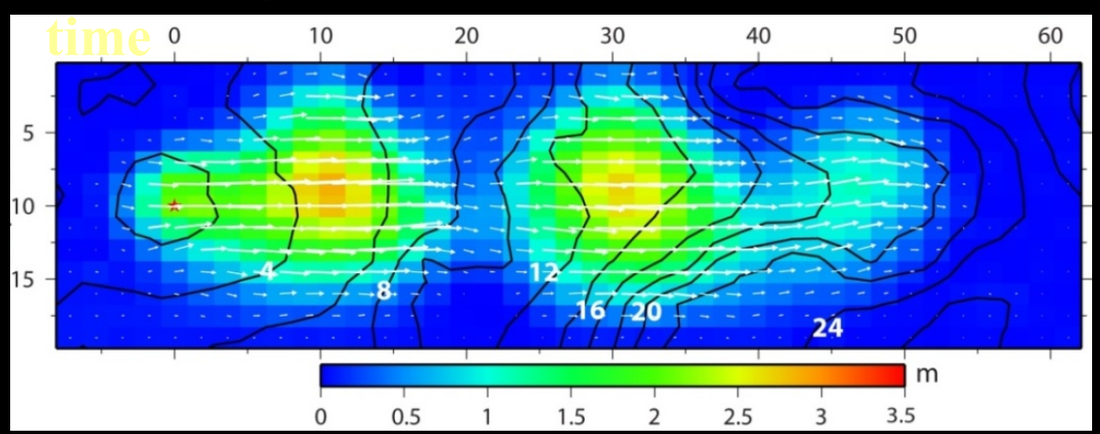
Seismic



Joint:Symmetric Rise time



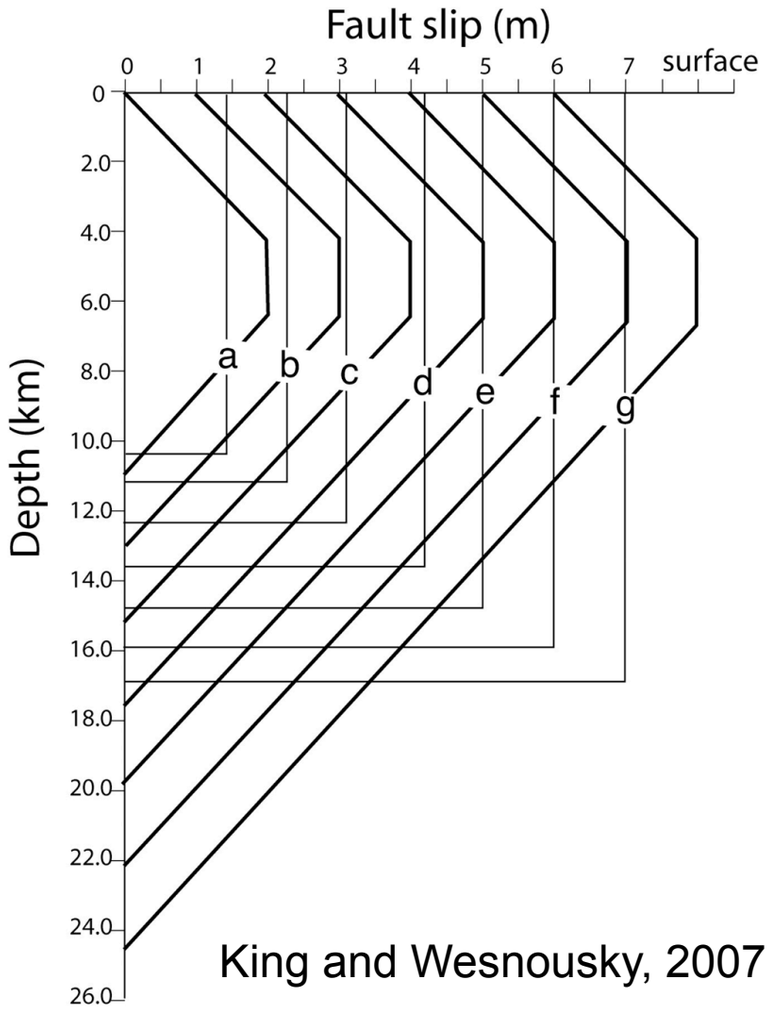
Joint: Asymmetric rise time



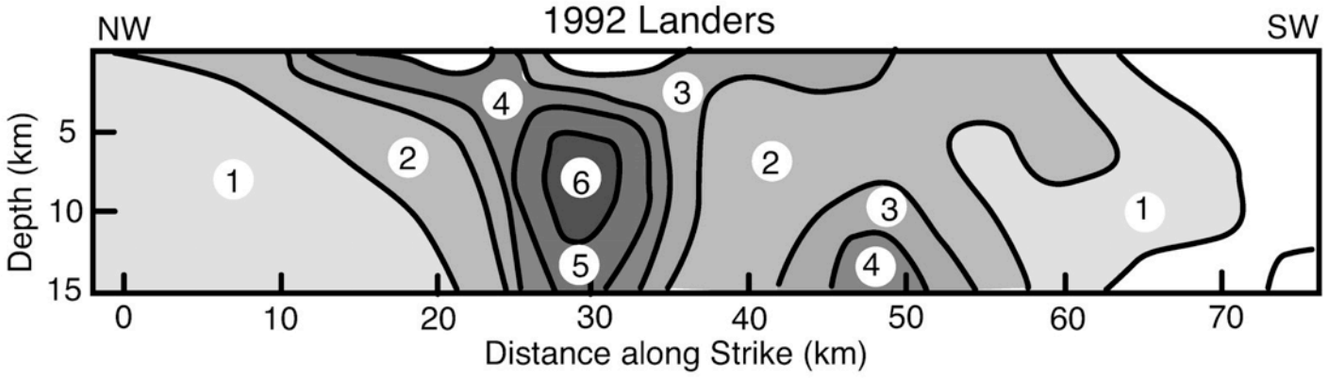
Slide: Konca, Kaneko, Lapusta, and Avouac

Things we can test in SIV

- Can we resolve deep slip?



King and Wesnousky, 2007



Wald and Heaton, 1994

Things we can test in SIV

- Can we resolve deep slip?

- Differentiate between crack-like and pulse-like ruptures?

- Resolvability of various parameters:
  - Slip distribution
  - Rupture speed (can we resolve supershear?)
  - Rise time

Things we can test in SIV

- Can we resolve deep slip?
- Differentiate between crack-like and pulse-like ruptures?
- Resolvability of various parameters

Lots of potential for collaboration
between dynamic modelers and SIV!

Source Inversion Validation http://siv.usc.edu