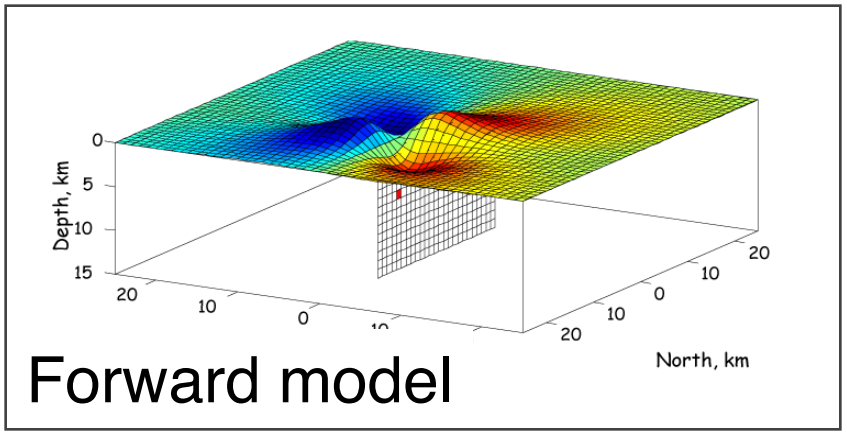
Geodetic Source Inversion Validation

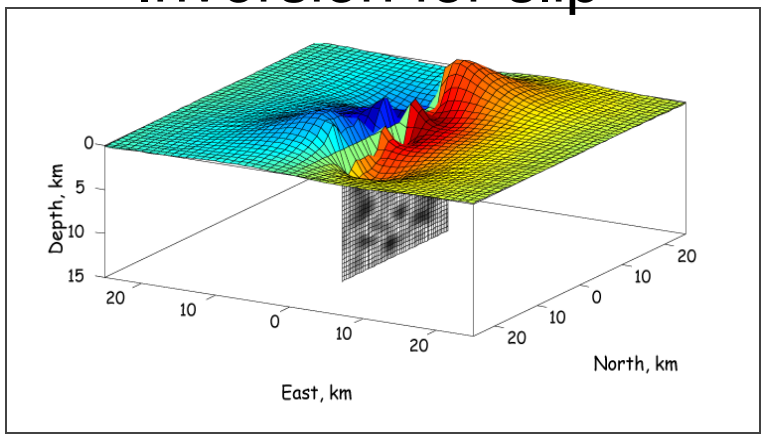
Massonnet et al., 1993

Data



Forward model

Inversion for slip



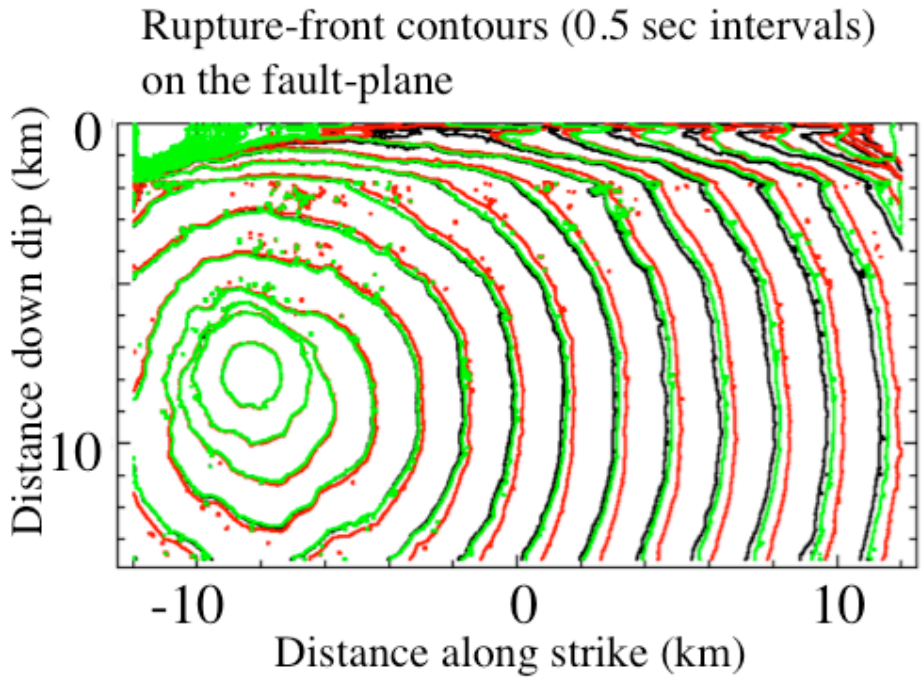
Outstanding questions

- We never know:
  - Exact fault plane geometry
  - Crustal rigidity structure
  - Characteristics of noise (exact)
  - Contribution from other deformation sources

- How important are the above issues?
- How do we present the family of slip models that are consistent with the data (and our knowledge of the above?)
- How does this vary in regions where we know almost nothing (e.g., Tibet) vs. something (e.g., SoCal)

Previous community/group activities

- Rupture dynamics code validation (Ruth Harris)
  - http://scecdata.usc.edu/cvws
  - Harris et al., SRL 2009
  - Testing codes that simulate spontaneous rupture

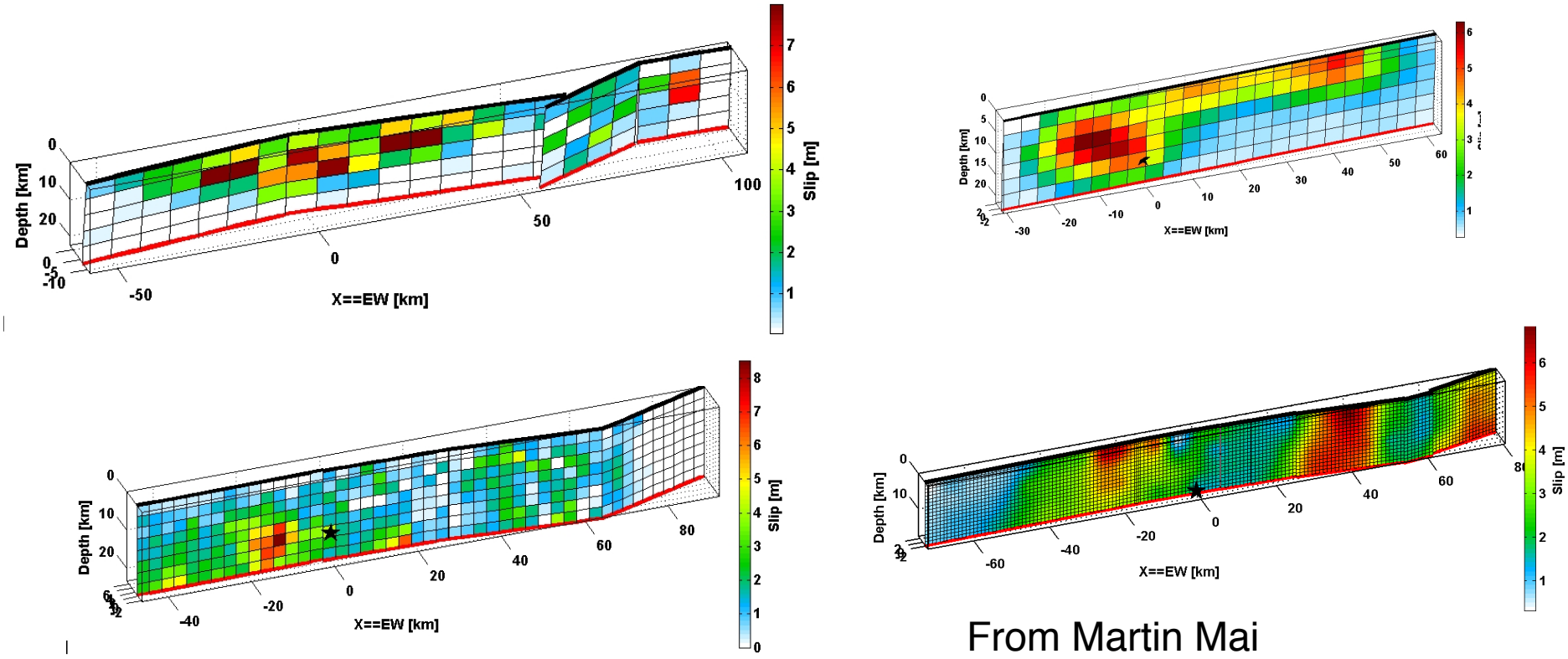


From Feb,2011 workshop

Previous community/group activities

- Source Inversion Validation (Mai, Page, Schorlemmer)

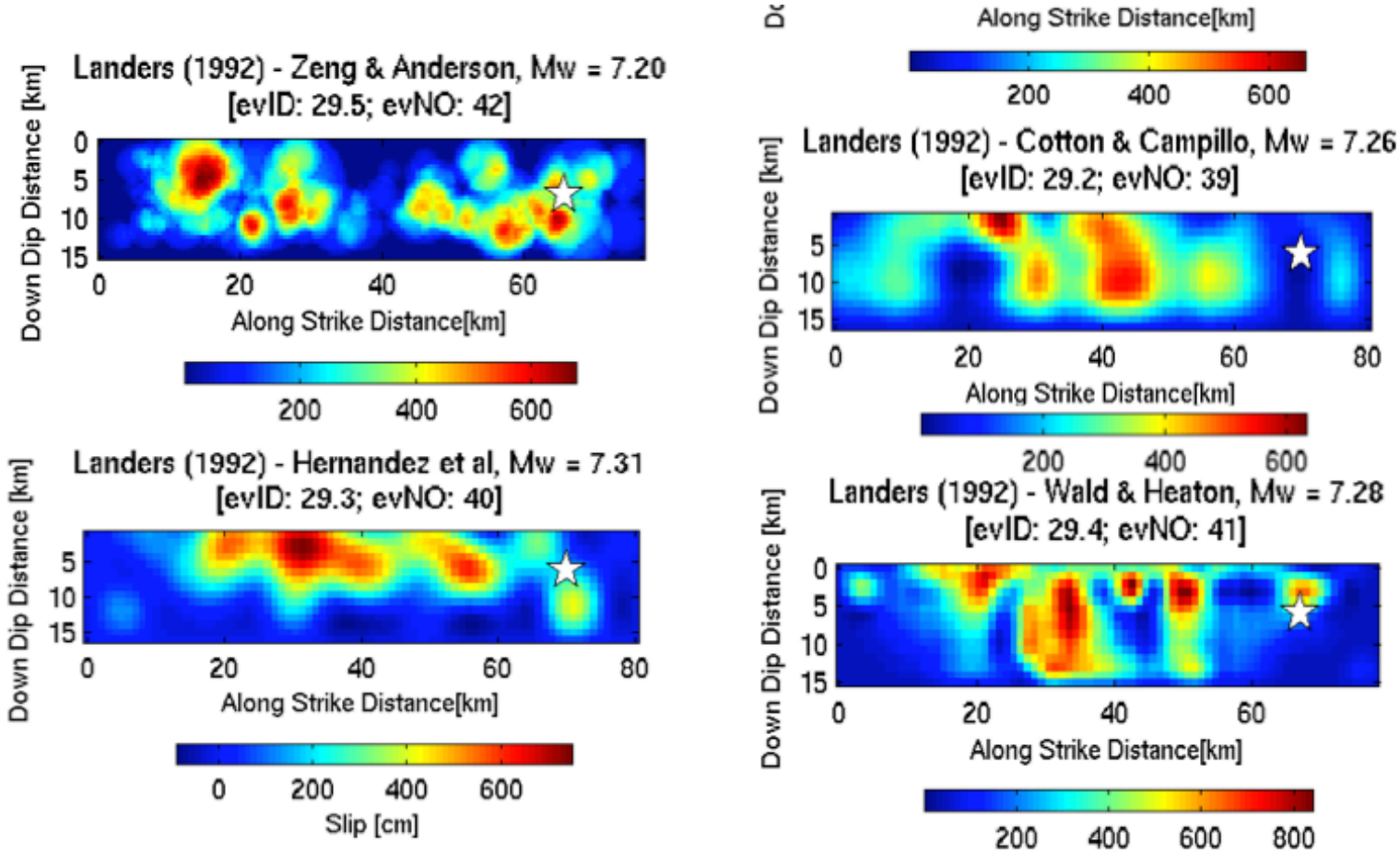
A suite of models for the 1999 Izmit (M 7.5) earthquake



From Martin Mai

Previous community/group activities

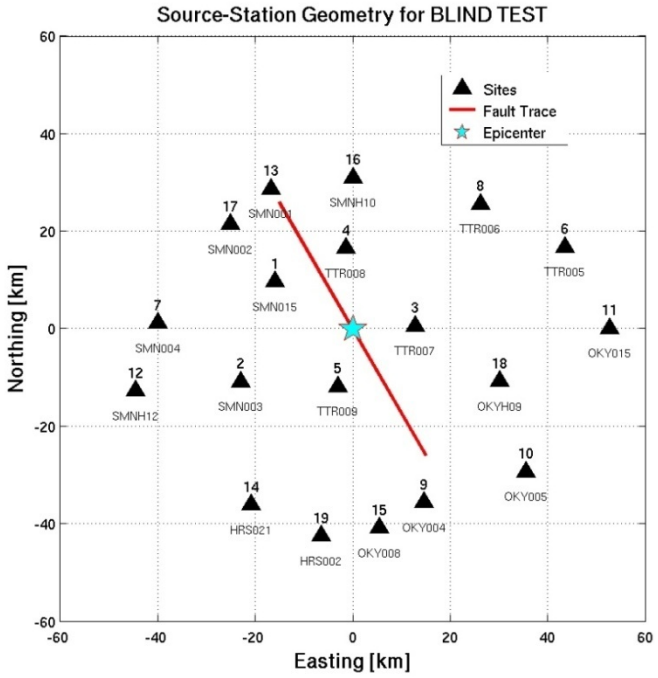
- Source Inversion Validation (Mai, Page, Schorlemmer)

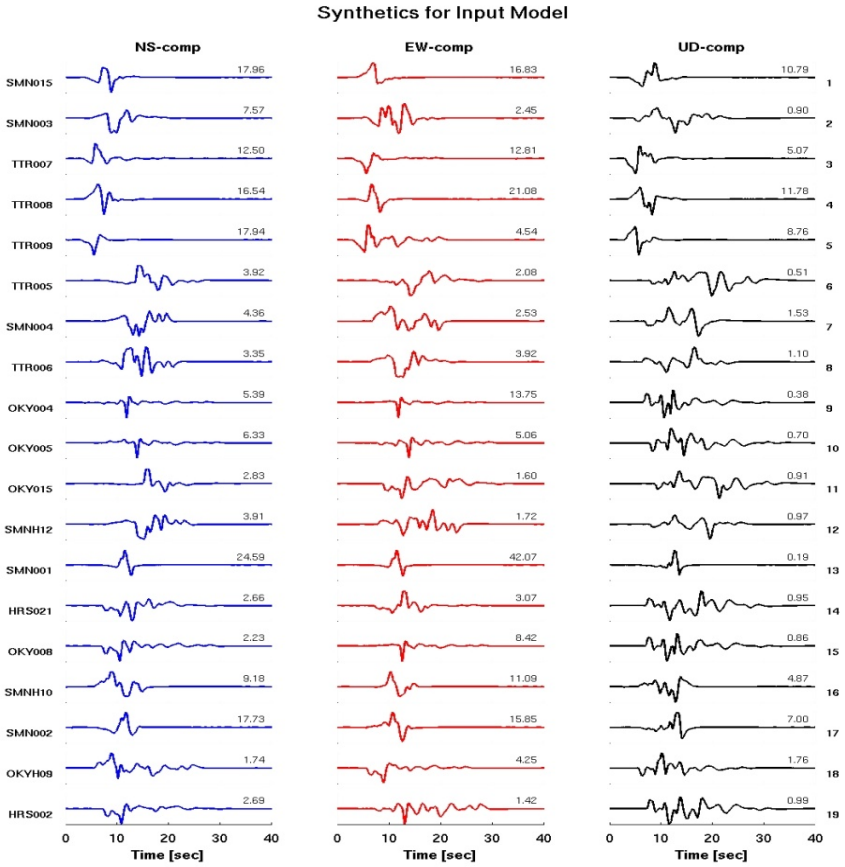


From Martin Mai

SPICE: Blind Test on Source Inversion

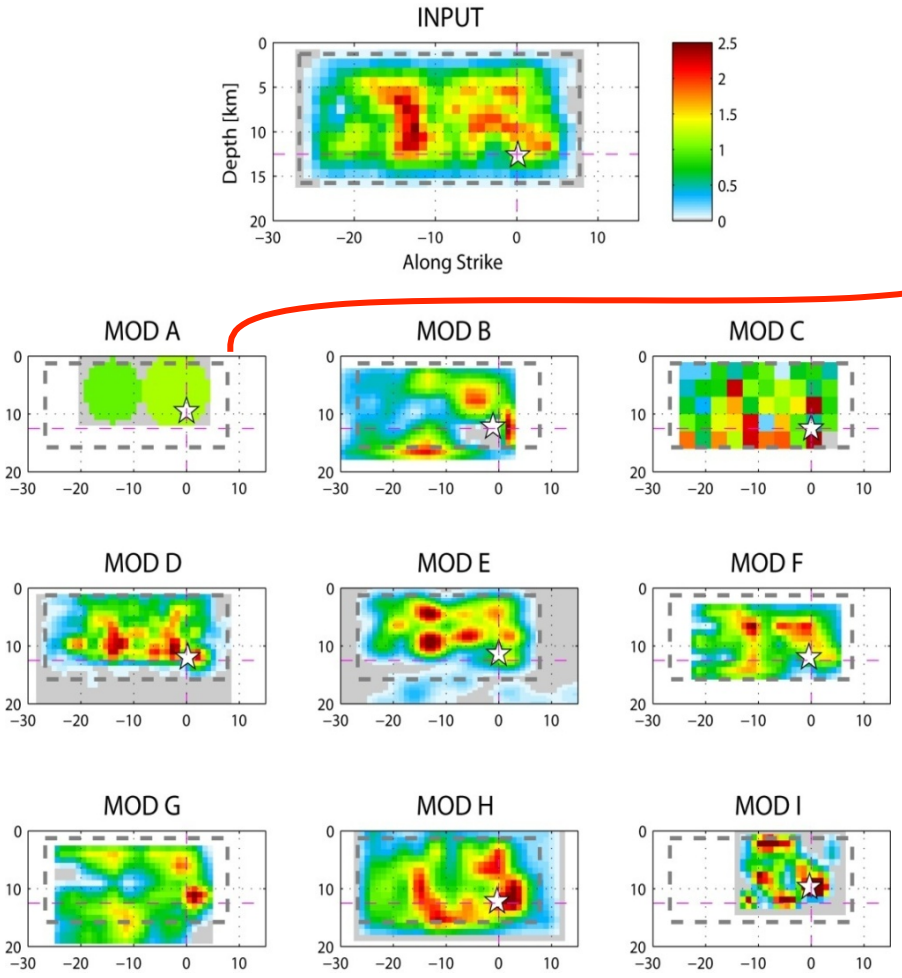
- Source geometry and station distribution similar to the 2000 Tottori earthquake
- Synthetic seismograms for 19 (33) near-fault sites (COMPSYN, f_{max} ~ 3 Hz)
- Known: seismic moment: 1.43 x 10^{19} Nm, geometry (strike, dip, rake: 150°, 90°, 180°), hypocentral location and depth (Z= 12.5 km), velocity-density structure
- Unknown: slip on fault plane, rupture velocity & rise time (both constant)

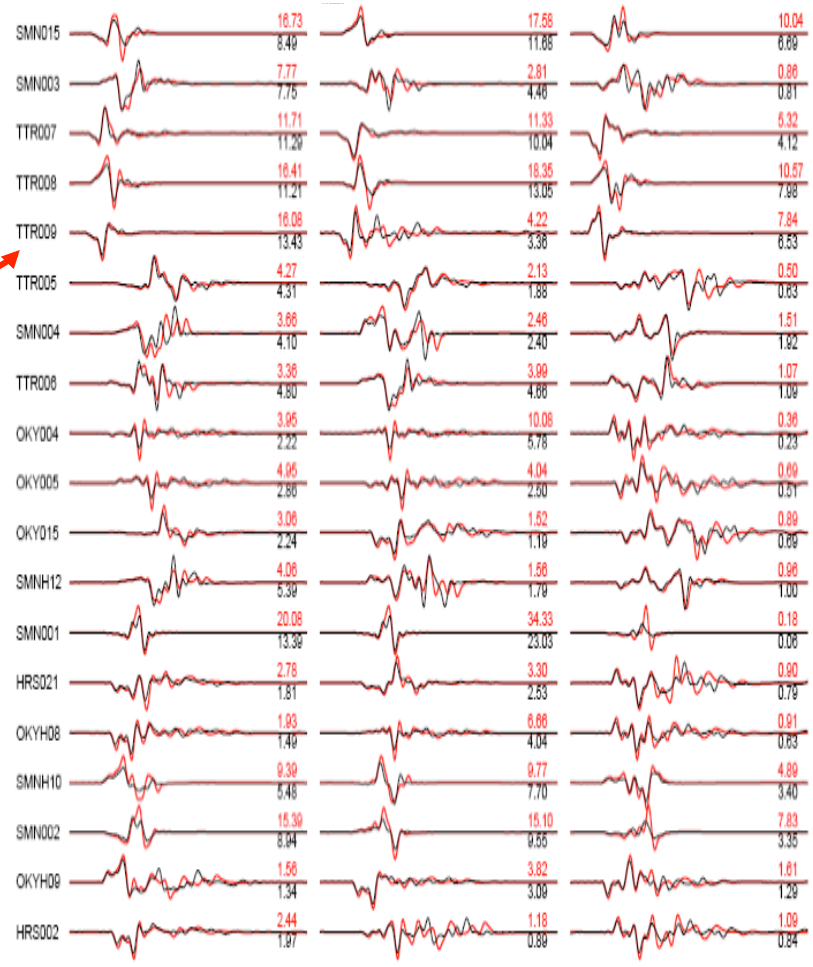




SPICE: Blind Test on Source Inversion

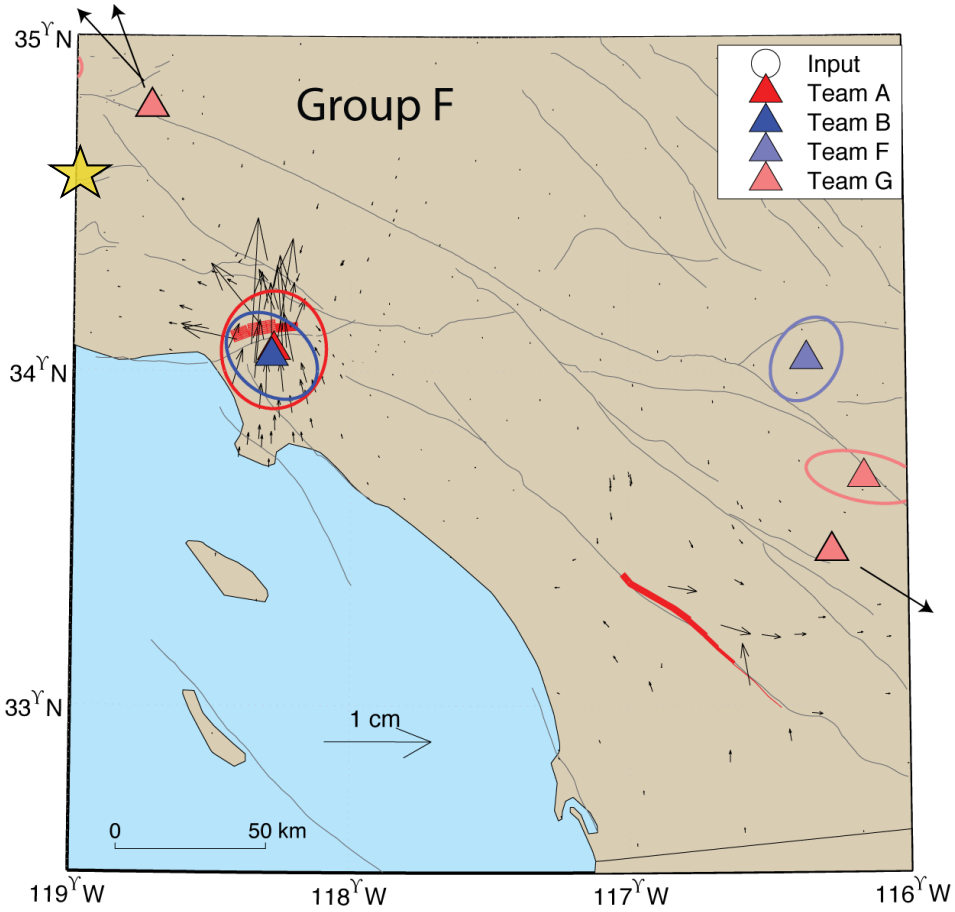
- 9 groups; the slip models from 5 groups are "visually" similar to the input model
- waveform fits in all cases implied visually a "very good fit" ….





Previous community/group activities

- Aseismic Transient Blind test (Murray, Lohman)
  - Synthetic (and real) data
  - Wide range of approaches
    - Manual search
    - Signal-based
    - Fault model-based
  - Goal: automated daily
  - Don't miss next event!



Previous community/group activities

- Compilations:
  - Ferreira et al., 2011, Weston et al., 2011, Devlin et al., 2012
  - Compare InSAR source models, seismic models

- Seismic locations show significant bias in some areas
  - Effects of unmodeled structure
  - But how much can we trust the InSAR/GPS?

Previous community/group activities

- Lessons learned
  - From Ruth Harris: Start simply
  - Then go simpler

  - Verifying that the forward models are correct
    - Conventions for defining fault, representing slip, reading in data!

  - Require consistent format (and deadlines) for submitting results
    (or else organizers go insane)

  - Online portals (Mai), immediate plots, seem most successful

Proposed exercise

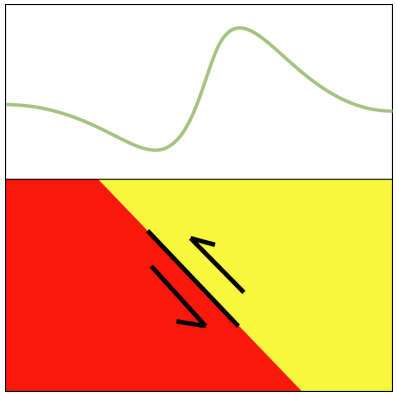
- Geodetic source inversion
  - We provide fake data, you (your students, I expect) invert it.
  - Phased complexity
    - Single fault patch, uniform slip, known geometry, no noise
    - Progressively add:
      - Geometry not known to participants
      - Spatially variable slip
      - Random, spatially correlated, topographically correlated noise
      - Non-stationary noise
      - Non-planar faults
      - Effects of 3D-varying elastic structure

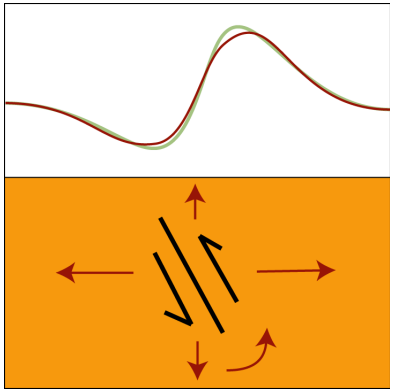
Easy

Harder (Pylith)

Role of 3D structure

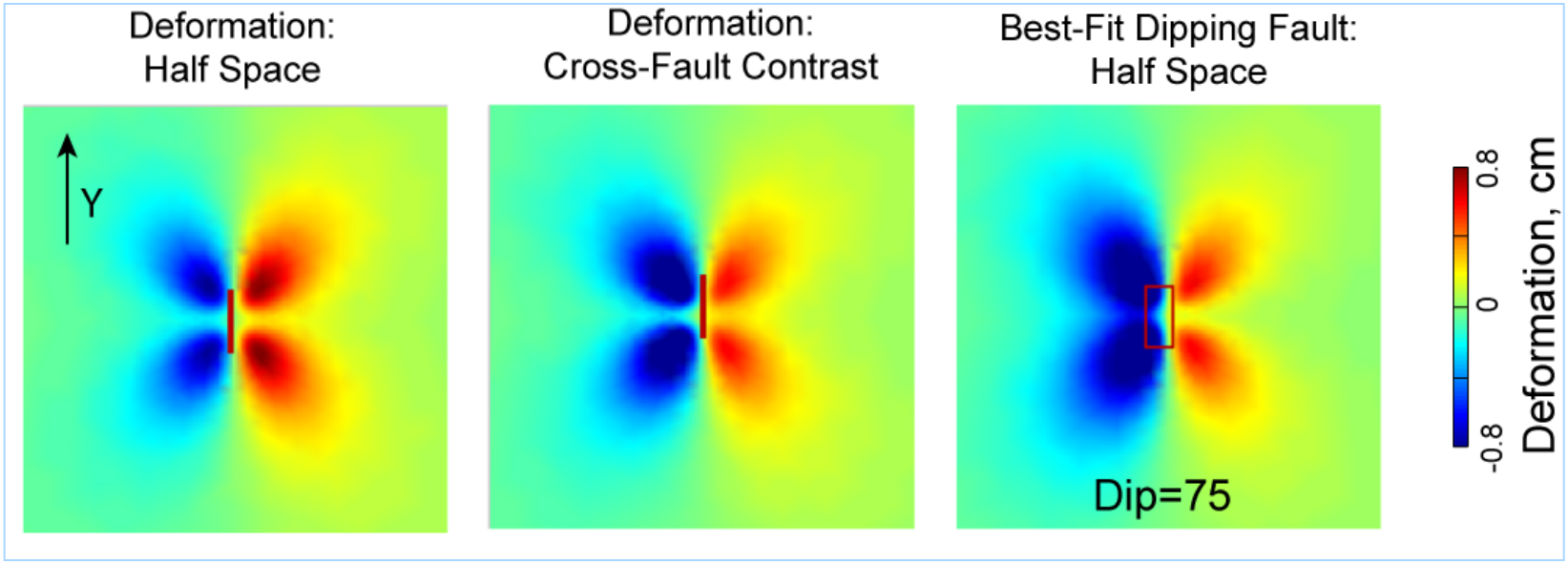
- Goal: What is inversion sensitivity to unknown structure?
  - Generate synthetic data using cross-fault contrast (slow)
  - Invert using elastic half space (fast)
  - Assess potential bias: Inferred fault dip





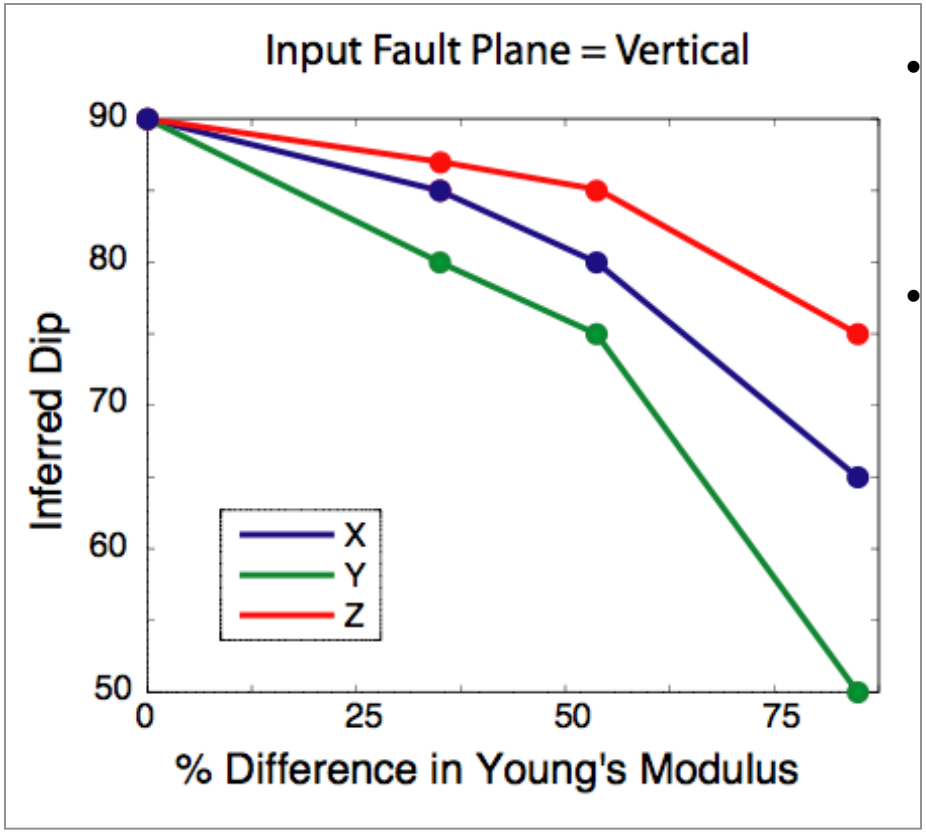
FE calculations using Pylith: http://geodynamics.org

Crustal Elastic Structure

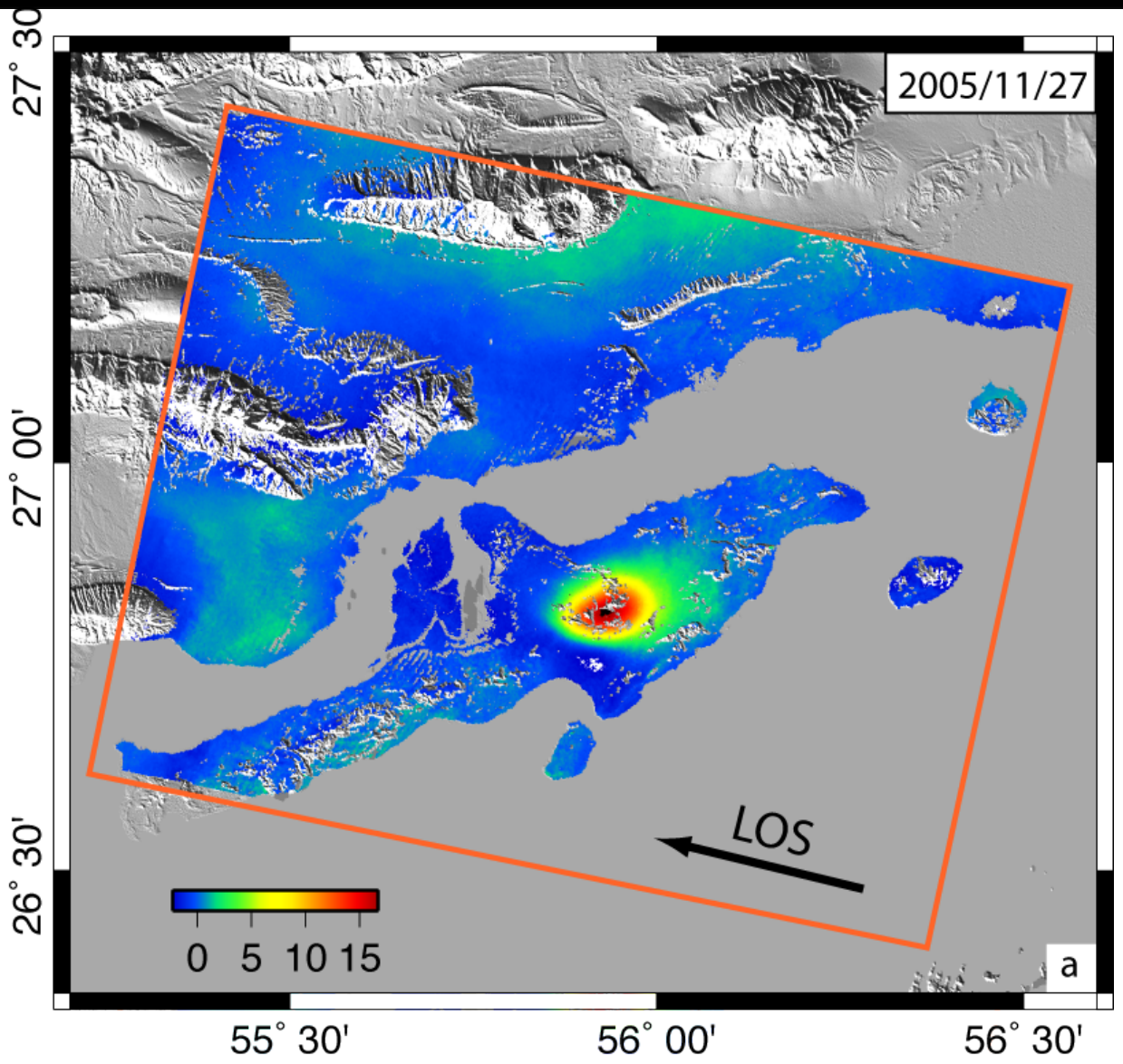


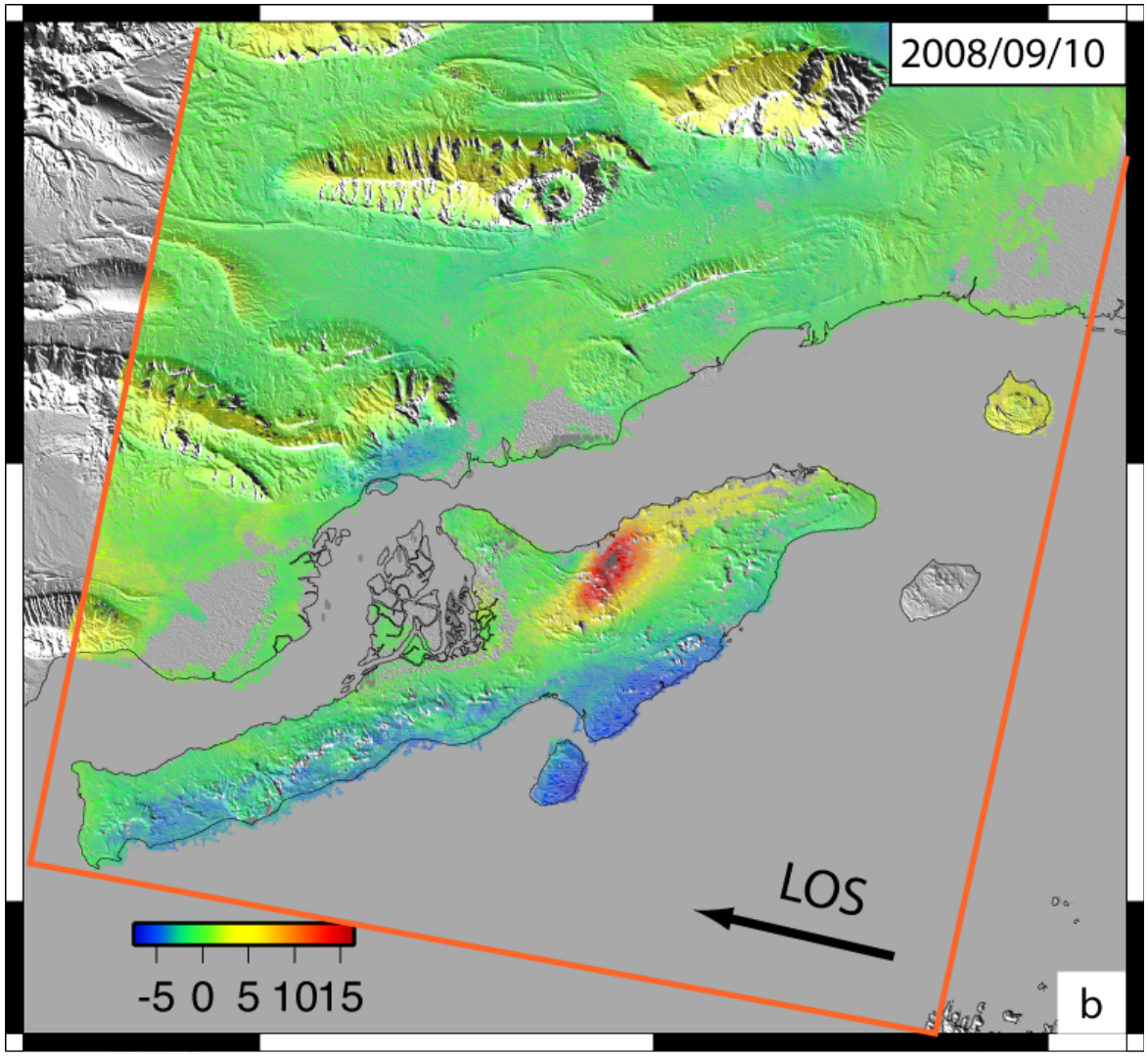
Can't fit asymmetric deformation with vertical fault

Cross-Fault Contrast Results



- Retrieve input geometry when contrast=0
- Sensitivity depends on viewing and earthquake geometry


2005/11/27
LOS
0 5 10 15
a
27° 30'
27° 00'
26° 30'
55° 30'
56° 00'
56° 30'


2008/09/10
LOS
-5 0 5 1015
b
55°30'
56°00'
56°30'

- Goal: get started this fall!
- Kickoff at SCEC annual meeting
  - Any interested participants please contact me regardless

rbl62@cornell.edu

- Graduate student training exercise?
  - Definitely help “intuition” about slip inversionse
- Upper level undergrad class project?
- Verification of your own approaches?

- Carrot: previous exercises (including aseismic transients) often result in publication for the participants