Geodetic Source Inversion Validation

Forward model

Inversion for slip

Data

Massonnet et al., 1993
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://scecdatasc.edu/cvws](http://scecdatasc.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, $f_{\text{max}} \sim 3$ Hz)
  - **Known**: seismic moment: $1.43 \times 10^{19}$ 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

Deformation: Half Space
Deformation: Cross-Fault Contrast
Best-Fit Dipping Fault: Half Space

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
• 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 inversion
• Upper level undergrad class project?
• Verification of your own approaches?

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