Crustal stress and deformation in southern California from seismic anisotropy

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CSM-0.1 vs. WSM: what did we learn?

Comparison of different orientational fields

Orientation misfit
(blue: second field CCW, green: CW from first field)

Major compressive axes
(of the horizontal stress tensor components)

Baseline for comparison between stress models

Histogram of misfit in sampled regions

Mean (~same azimuth), STD ~ 0.38 (~21°)
CSM-0.1 vs. WSM – no FM

Major compressive axis

Limited scope for “validation”  CCW deviation with non FM WSM
Seismic: Michael vs. Kostrov

Major compressive axis

same mean, STD ~ 0.37 (~ 21°)
(comparable to match with WSM)
Seismic: shallow vs. deep Kostrov

Major extensional axis

same mean, STD ~ 0.4 (≈ 23°)
No meaningful patterns?
Multi-scale, fault-less models

- Should use Corne Kreemer's compilation + PBO and Tape et al.'s (2009) wavelet dependent analysis
- compare with stress models

Tape et al. (2009)
**S anisotropy vs. Michael stress**

Major compressional axis

Splits more fault aligned, stress more N-S

*cf. Yang et al. (2011)*

Assumption: S splits see upper crustal, SPO anisotropy via alignment of cracks in stress field
CSM-0.1 does not work

WSM no FM comparison

S splitting comparison
Shear Wave Anisotropy Along the San Jacinto Fault (Li et al., in prep; Yang et al., in revision)
Variations of fast direction (b), and crack densities (b) measured at dense arrays across the San Jacinto Fault. The right two panels show the along-strike variations of the fast direction rose diagrams and mean crack densities.

Li et al./Yang et al.
Variations of fast direction (b), and crack densities (b) measured at dense arrays across the San Jacinto Fault. The right two panels show the along-strike variations of the fast direction rose diagrams and mean crack densities.

Li et al./Yang et al. Yang et al. (2011)
Automatic Measurements of Shear-Wave Anisotropy in Southern Calif.

Number of stations retrieved: 683
S anisotropy vs. crustal anisotropy

“Fast axes”

Noise surface wave imaging (completely different signal)

cf. Lin et al. (2011)
crustal anisotropy vs. GPS stretch

Major extensional axes

Good match in Big Bend region!
Origin of crustal anisotropy unclear, but alignment with finite extension common?

Endrun et al. (2011)
crustal anisotropy vs. Michael stress

Major extensional axes

Good match in Big Bend region
(again, same for GPS and Kostrov)
crustal vs. mantle anisotropy

crust and mantle anisotropy from SW imaging

Lin et al. (2011)
$Pn$ vs. mantle anisotropy

Lin et al. (2011); Buehler and Shearer (2010)
Deep:
mantle anisotropy vs. SKS anisotropy

Very good alignment,
SKS trends more W-E in central region
Shallow: mantle anisotropy vs. GPS stretch

Very good alignment, GPS trends more W-E in central region
Mantle flow model predictions
CStrainModel

GPS

lower crustal anisotropy

uppermost mantle anisotropy

upper mantle anisotropy
Conclusions

- Need more borehole data, S split compilations (and more modeling, cf. RFP)
- Interesting coherence in terms of finite deformation between surface (GPS), lower crust (SW), uppermost mantle (SW) and upper mantle (SKS)
- Can build deformation model
- Fault zone interactions important for merging S splits with Michael stress models