Estimating lithospheric stress tensors in southern California by 2.5-D Shells F-E modeling

Peter Bird
UCLA

2012.10.15
CSM workshop at SCEC, Los Angeles, CA
Thin-plate or thin-shell F-E modeling:

Long-term rheology of lithosphere (ignoring any transient elastic strain):

Two layers, each homogeneous & isotropic:
- feldspar-rich crust
- olivine-rich mantle

Two deformation mechanisms:
- frictional plasticity (Coulomb-Anderson-Navier, both on & off designated faults)
- thermally-activated dislocation-creep (with power-law exponent $n = 3$).

[Note: In my programs Shells, Plates, & Faults, the crust and mantle-lithosphere layers always move together; only Laramy allow independent tectonics. Hence, “2.5-D” modeling.]
The effective friction coefficient of the continuum (microplates) between the modeled faults is always 0.85, per “Byerlee’s Law” [Byerlee, 1978, Pageoph].

Effective friction of modeled master faults always needs to be lower for a good simulation; today I will show a model using effective friction of 0.15 on faults.
In *Bird & Baumgardner* [1984, *GSAB*] we calibrated the crustal creep strength by matching observed depths of seismicity in California, as a function of heat-flow:

Creep strength of the mantle-lithosphere is from olivine lab studies [*Kirby, 1983, Rev. GSP; Kirby, 1985; Tectonophysics*].
Long-term-average Surface Velocity
Model CSM2012007: fault friction 0.15, continuum friction 0.85
Change in Horizontal Velocity Across Faults
Model CSM2012007: fault friction 0.15, continuum friction 0.85

Horizontal part of slip rate

- normal
- thrust
- dextral
- sinistral
Long-term-average of Continuum Strain-rates (between faults); $\log_{10}$ scale

Model CSM2012007: fault friction 0.15, continuum friction 0.85
Long-term-average of Continuum Strain-rates (between faults); $\log_{10}$ scale

Model CSM2012007: fault friction 0.15, continuum friction 0.85

Strain-rate of continuum, as conjugate microfaults:

$E_3 - E_1 = 1 \times 10^{-13} \text{ s}^{-1}$
(Area is proportional to strain-rate.)
NOTE that stress & strain-rate are **anticorrelated** at regional scales!