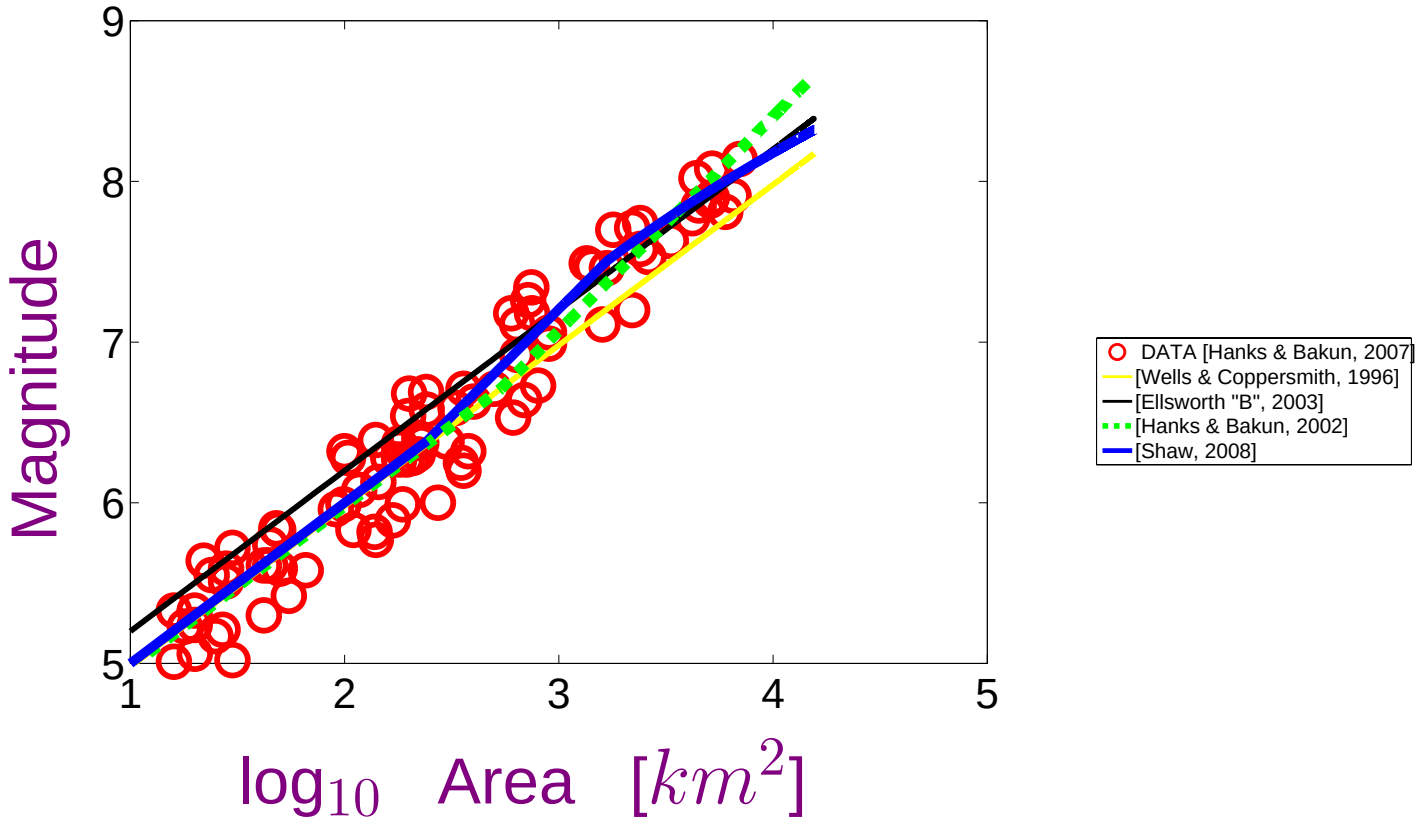
Task R2: Evaluate Magnitude-Scaling Relationships and Depth of Rupture

Bruce Shaw
Columbia University

Magnitude-Area Scaling Laws

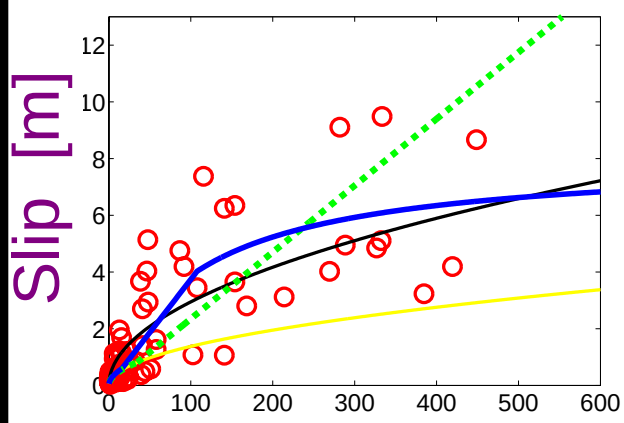


UCERF2 Magnitude-area scalings used two ways:

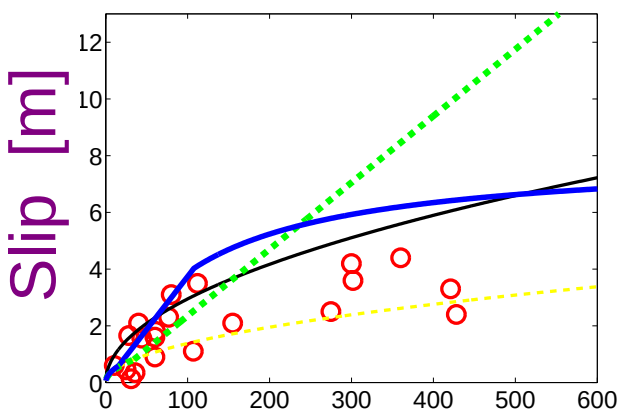
- Magnitude of event for given area
- Slip per event for event rate budgeting

$\longrightarrow$ Use Slip-Length scaling for event rate budgeting instead!

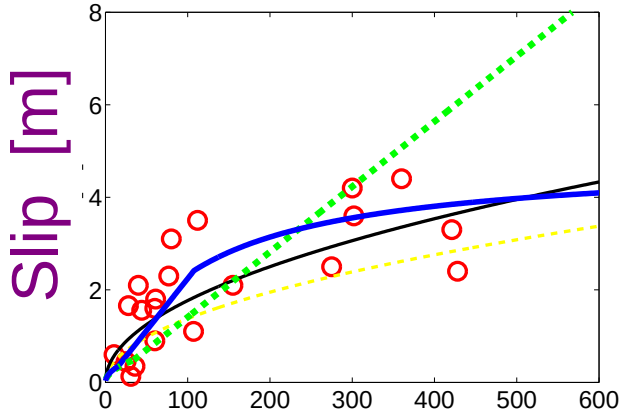
Slip vs Length Scaling and Hazard



From mag-area data



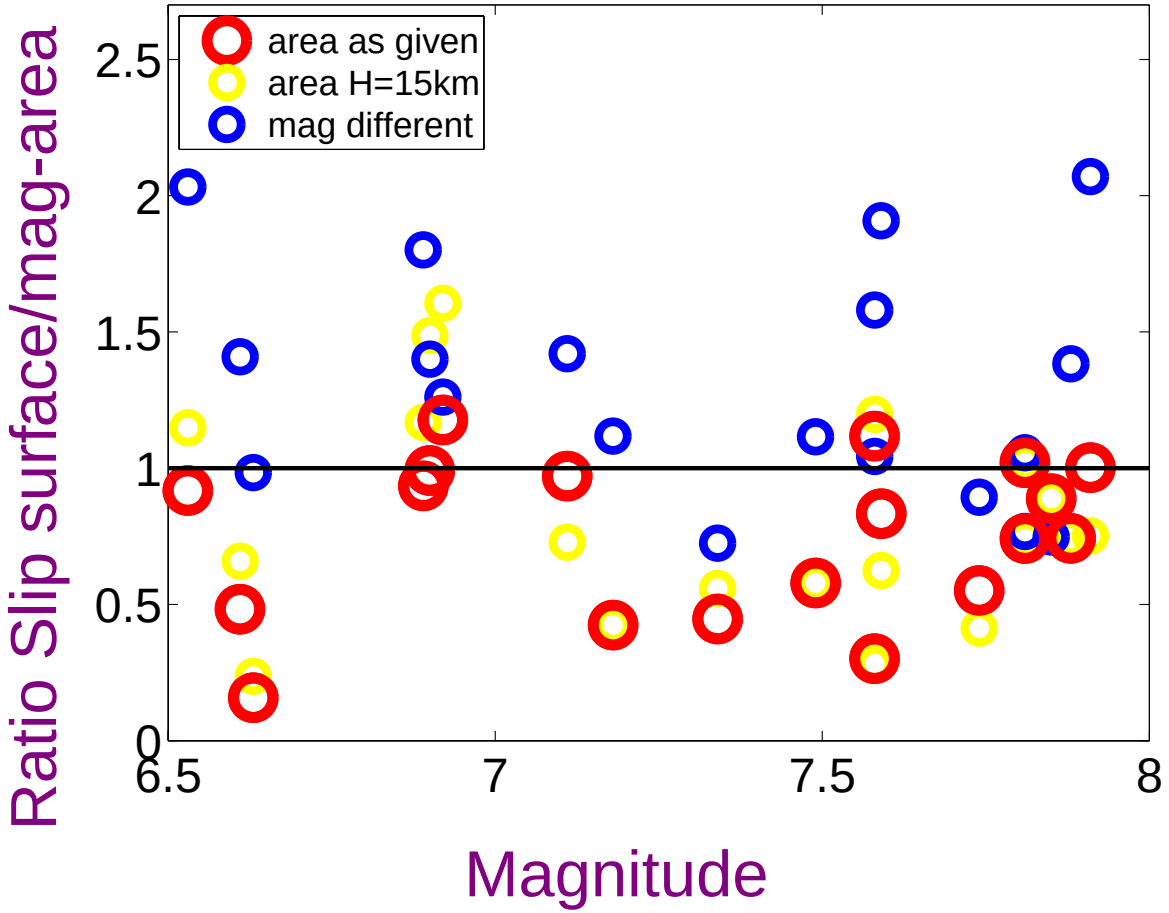
Slip-length data



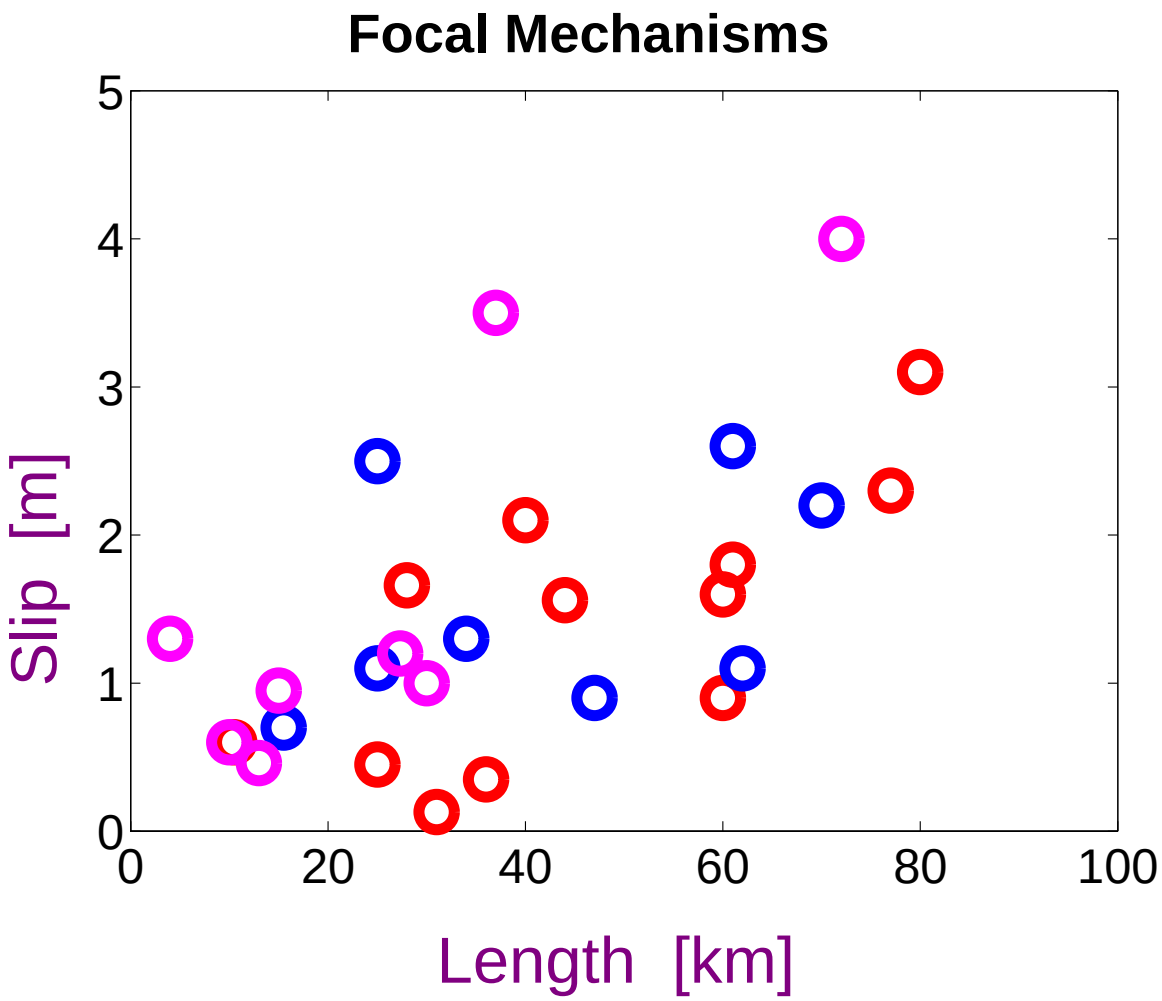
Rescaled fit by .6

- Magnitude-area scalings used in hazard overpredict surface slip
- New pathway for doing hazard estimates
- Hanks-Bakun (and Jackson proposed) linear fit inconsistent with slip data

Estimating Average Slip from Scaling Laws



- mean: 25% reduction $M > 7$; 35% reduction last 50 years
- Magnitude differences bigger effect than width uncertainty
- Lack of obvious magnitude dependence in difference



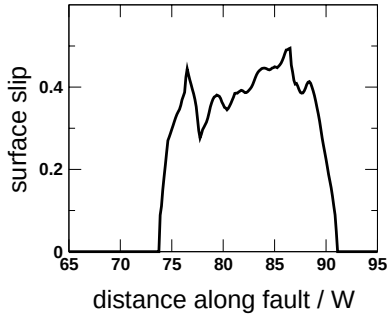
- Focal mechanism corrections?
- Thrust faults have more slip?

Recommendations

- Use Magnitude-Area to calculate size
- Use Slip-Length to calculate slip rate balancing
- Add one parameter for fraction of surface slip missing relative to seismogenic slip (values say 0% – 30%)
- For Magnitude-Area use two relations:
  Ellsworth-B Linear $M \sim \log_{10} A$
  Replace Hanks-Bakun with generalization Shaw [2009]
- Use only downdip width correction for focal mechanism
- Hold workshop to pin down largest dozen or two events

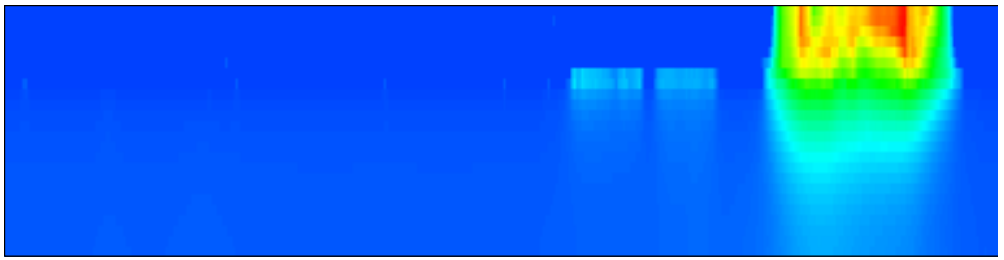
3D Model

surface slip



vertical exaggeration 8:1

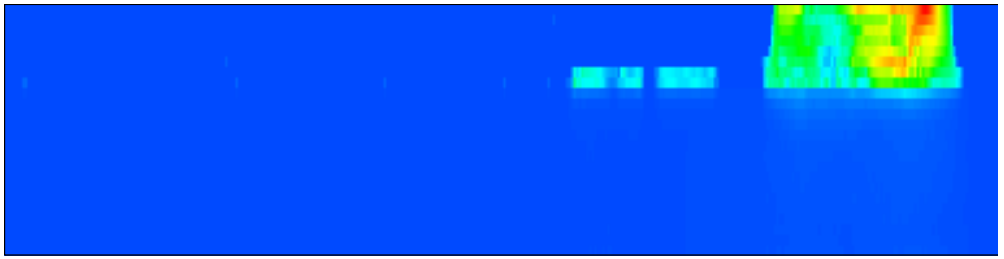
slip



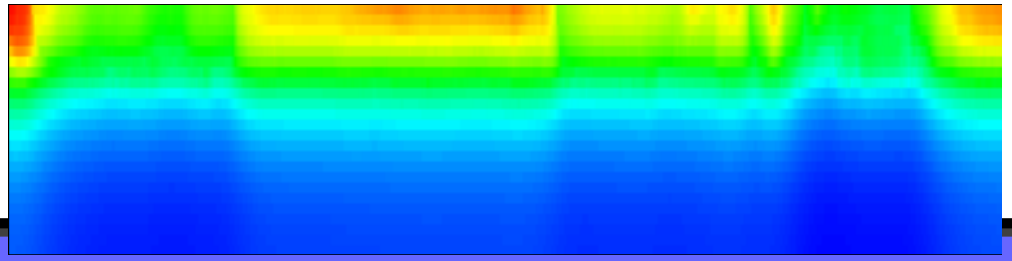
unstable sliding

stable sliding

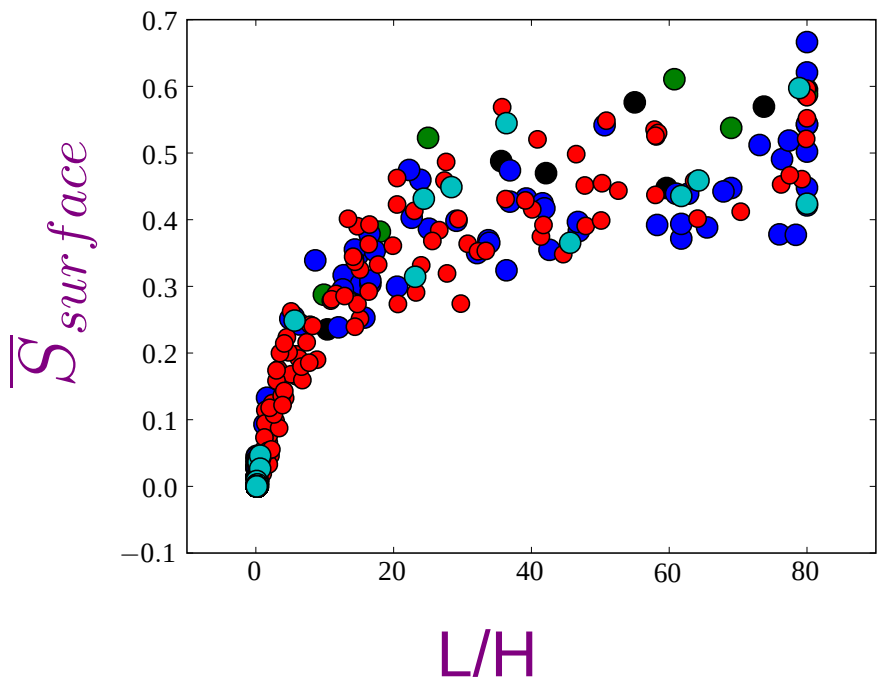
peak velocity

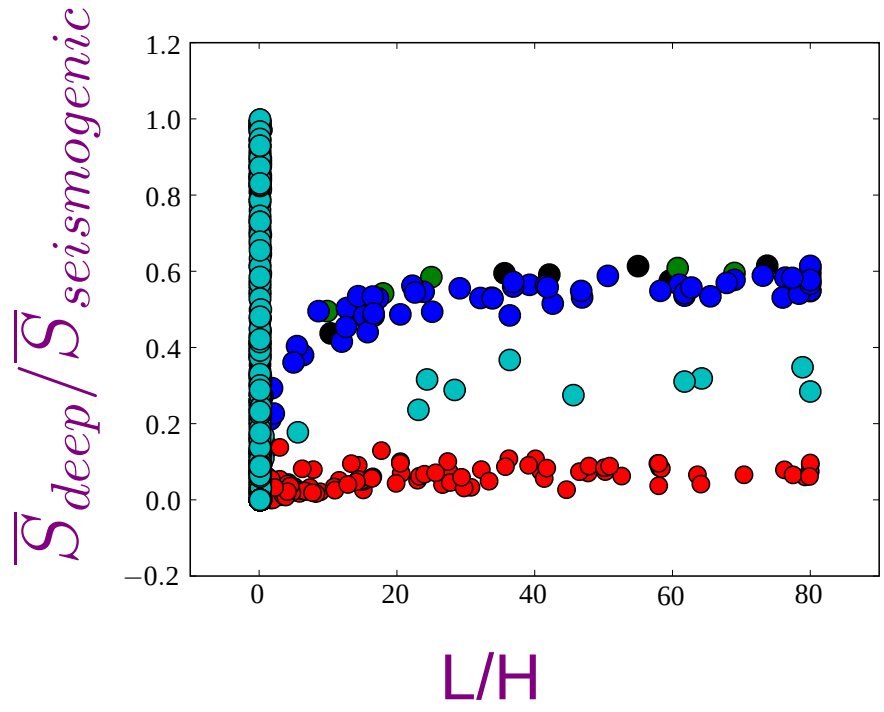


initial displacement



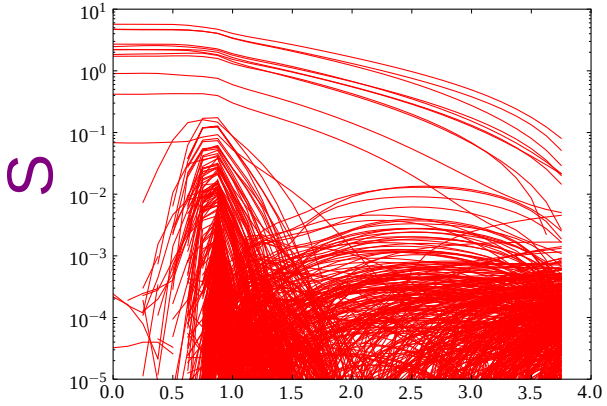
Relationship of Surface Behavior to Depth





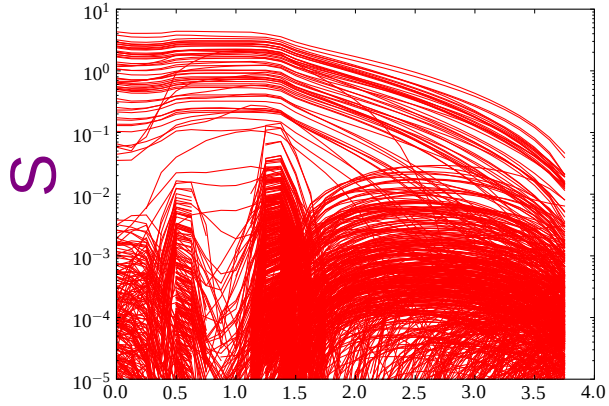
- Average surface slip insensitive to different properties at depth, though deep slip is affected
- Deep penetrating effect comparable to observational discrepancy average

Surface Slip Behavior and Subsurface Properties



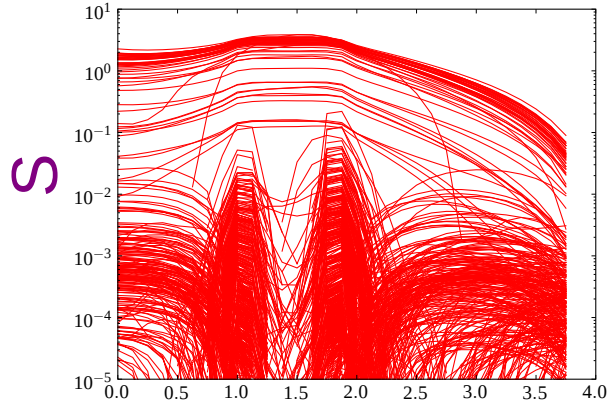
depth

Top layer=0



depth

Top layer=.5



depth

Top layer=1

- Surface slip in large events impacted by free surface
- Free surface effects penetrate significantly deep

Summary and Questions

- Mean surface slip = mean seismogenic slip?
- Focal mechanism effects?
- Discrepancy of slip from surface/mag-area due to deep slip? surface bias?
- Model surface slip relatively unaffected by deep behavior
- Free surface effects penetrating pretty deeply