Constraining Models of Shallow Fault Slip with Remote Sensing Data

Margaret Glasscoe, Andrea Donnellan, Gregory Lyzenga, Jay Parker

NASA Jet Propulsion Laboratory, California Institute of Technology

Christopher Milliner

University of Southern California

Margaret.T.Glasscoe@jpl.nasa.gov

21 April 2016

2016 Seismological Society of America Annual Meeting – The Role of Shallow Slip on Faults

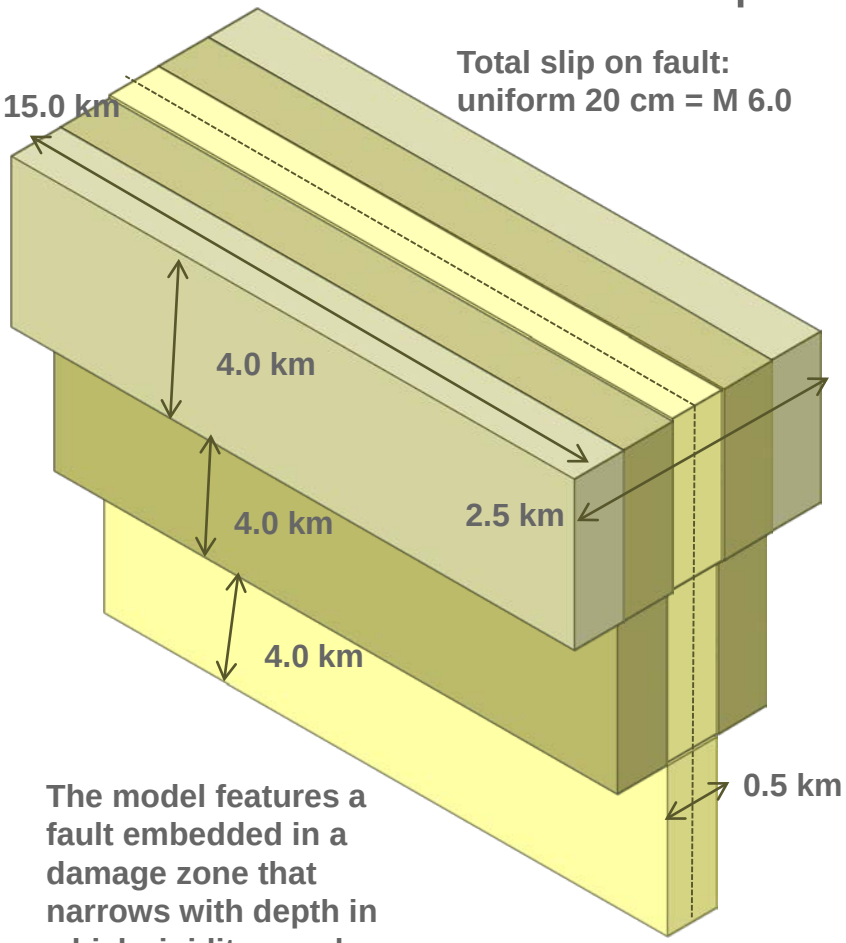
Copyright 2016 California Institute of Technology.
U.S. Government sponsorship acknowledged.

Motivation

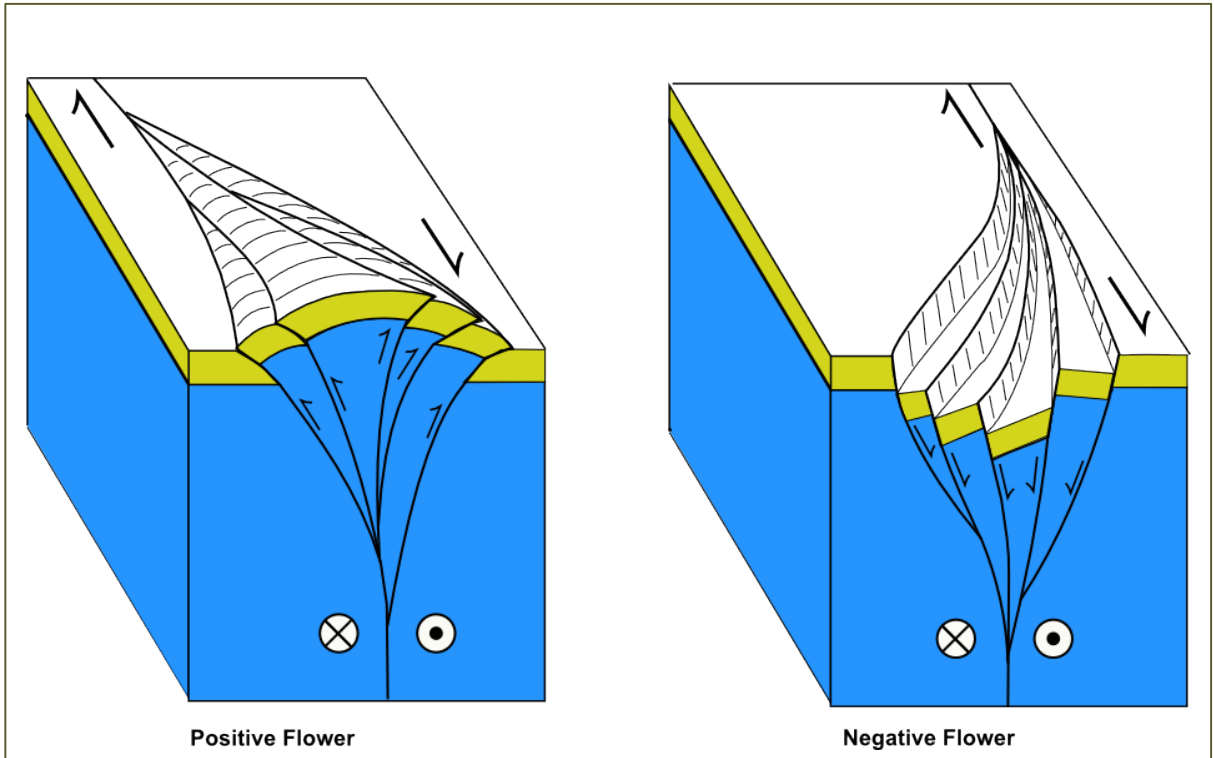
- Determining the distribution of slip and behavior of fault interactions is a complex problem
- Field and remotely sensed data often lack the necessary coverage to resolve fault behavior
- Realistic physical models may be used to more accurately characterize the complex behavior of faults
- Observed data such as InSAR, high resolution topography, and GPS may be used to constrain models
- Goal: improve the utility of using combined models and data to estimate earthquake potential

Model

We model a fault embedded within a damage zone of reduced elastic rigidity that narrows with depth and forward model the shallow slip and resulting surface deformation.

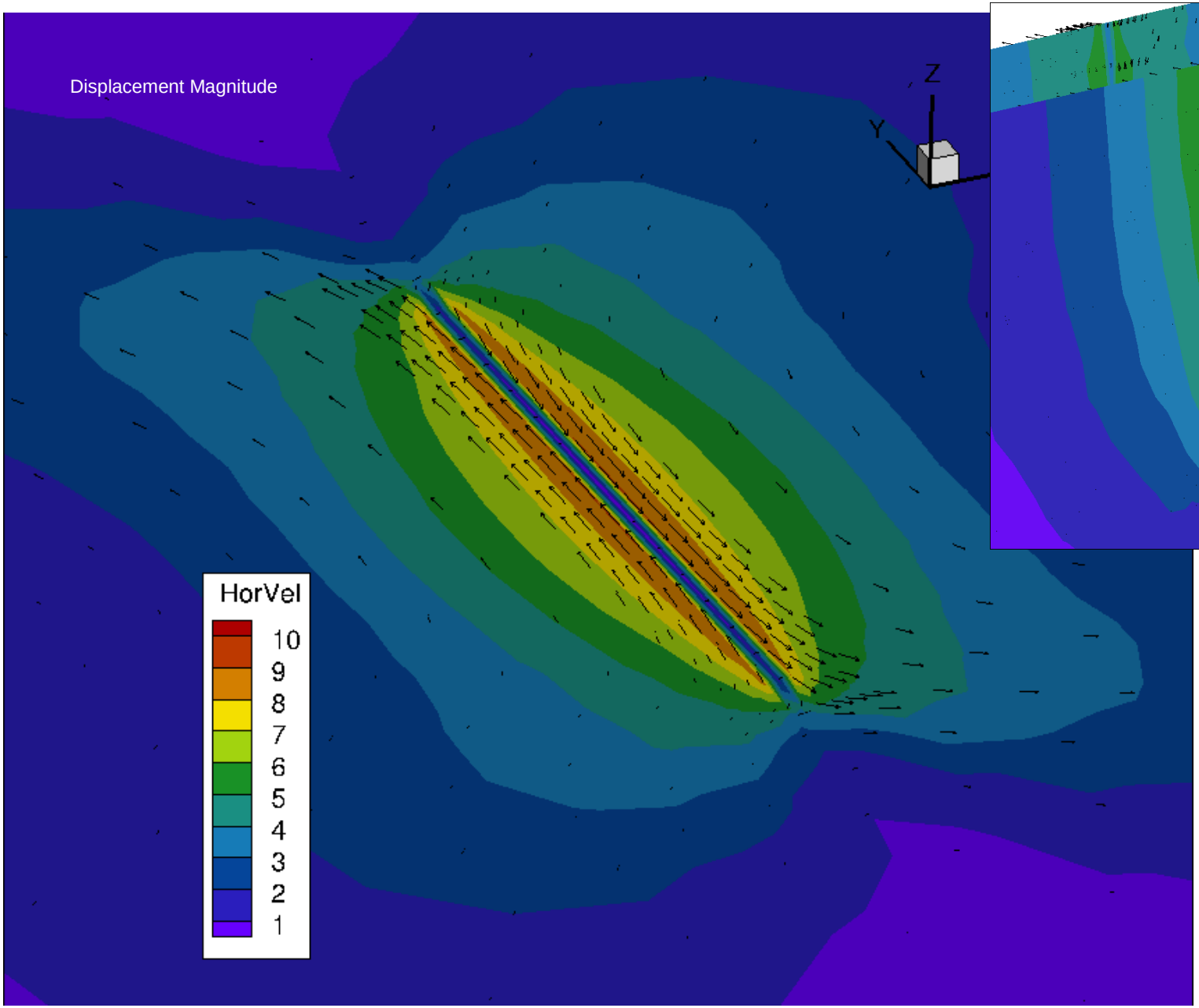


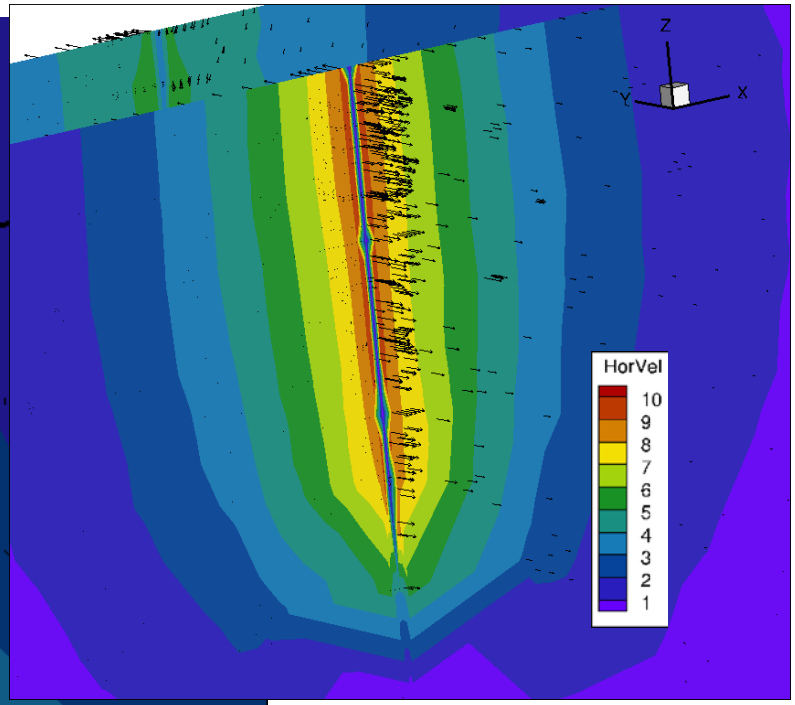
The model features a fault embedded in a damage zone that narrows with depth in which rigidity may be varied laterally



https://commons.wikimedia.org/wiki/File:Flowerstructure1.png

Examining differences in damage zone rigidity

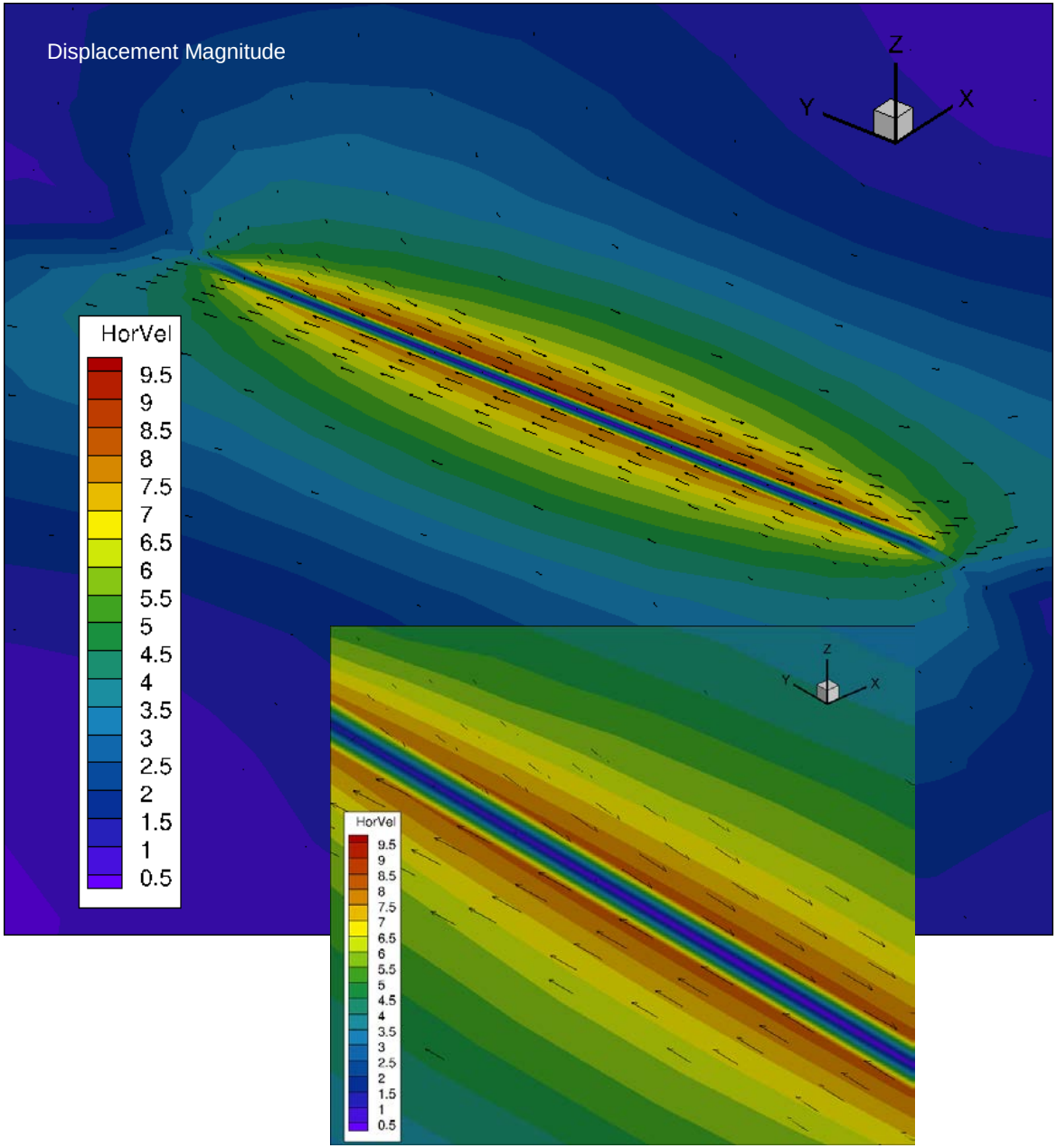




Observe zone of distributed deformation with concentrated high deformation near fault zone

Fault zone: 10 Gpa
Damage Zones: 20, 30 GPa

Modifying fault zone rigidity

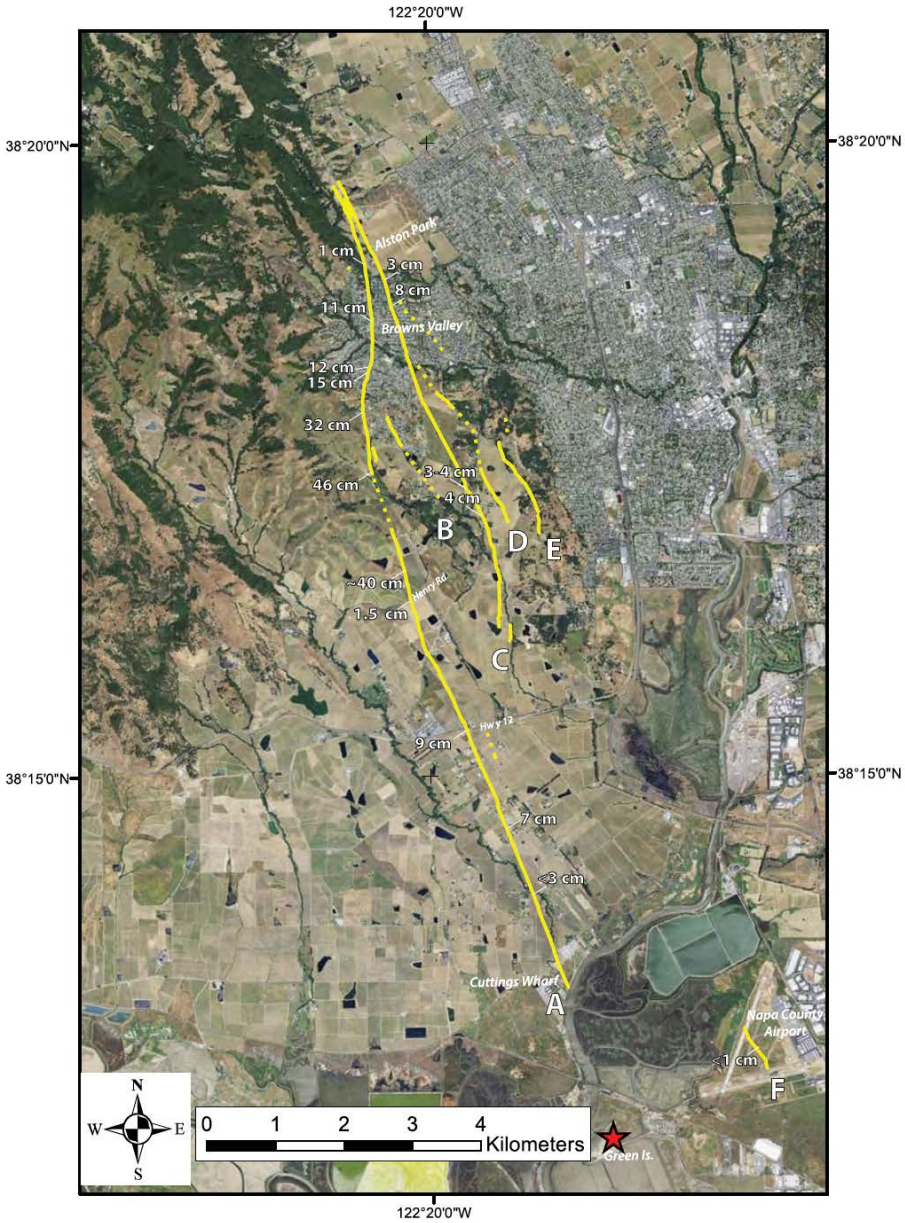


Fault zone: 5 Gpa
Damage Zones: 20, 30 GPa

Observe zone of distributed deformation with concentrated high deformation near fault zone

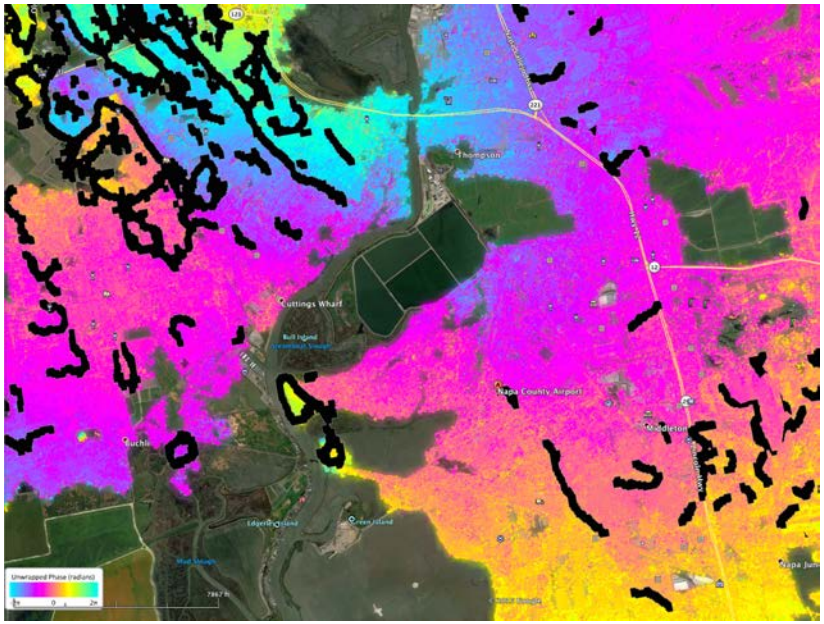
Reducing rigidity by half reduces magnitude of displacement, but not distribution

Comparison with observed behavior South Napa earthquake



Mapped tectonic surface rupture associated with the South Napa earthquake. From Brocher, et al., 2015, based on Hudnut, et al. 2014

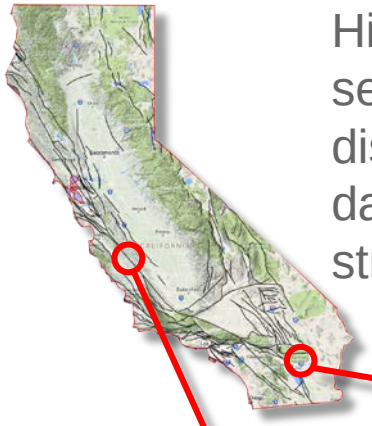
The South Napa rupture demonstrated distributed deformation that may indicate a wide damage zone or partitioning of slip onto a flower structure rooted into a main fault.

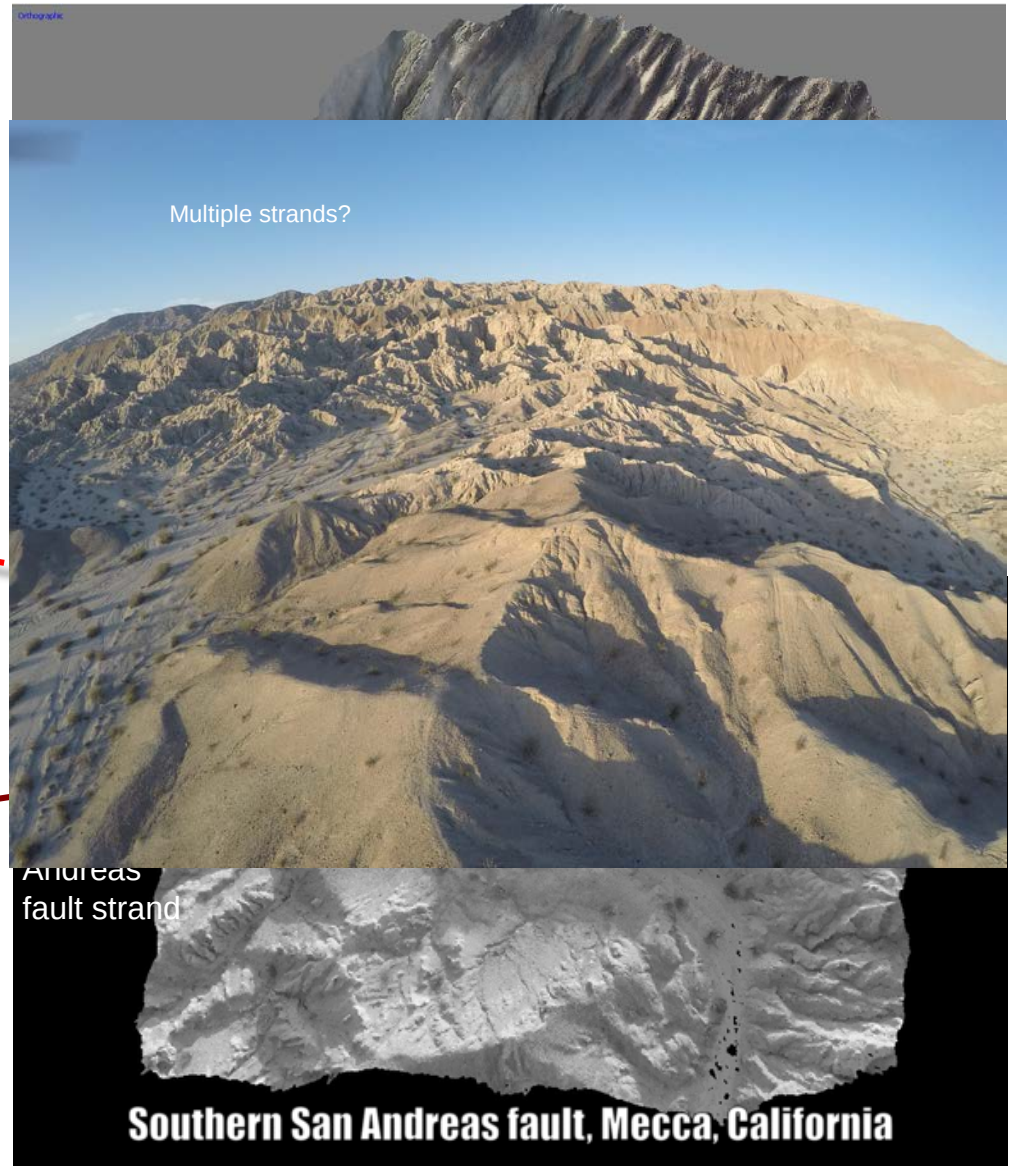


Edge detection of fractures associated with the South Napa earthquake in UAVSAR interferogram, courtesy Jay Parker

Comparison with observed behavior (2) San Andreas fault

The San Andreas fault has multiple strands in the Mecca Hills region and the creeping section which may indicate distributed deformation in a damaged zone or flower structure.

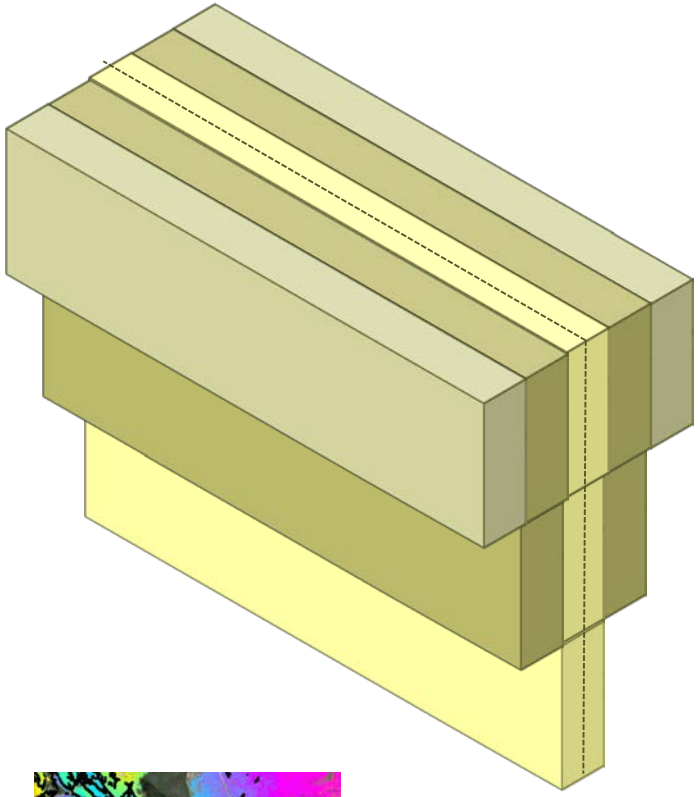


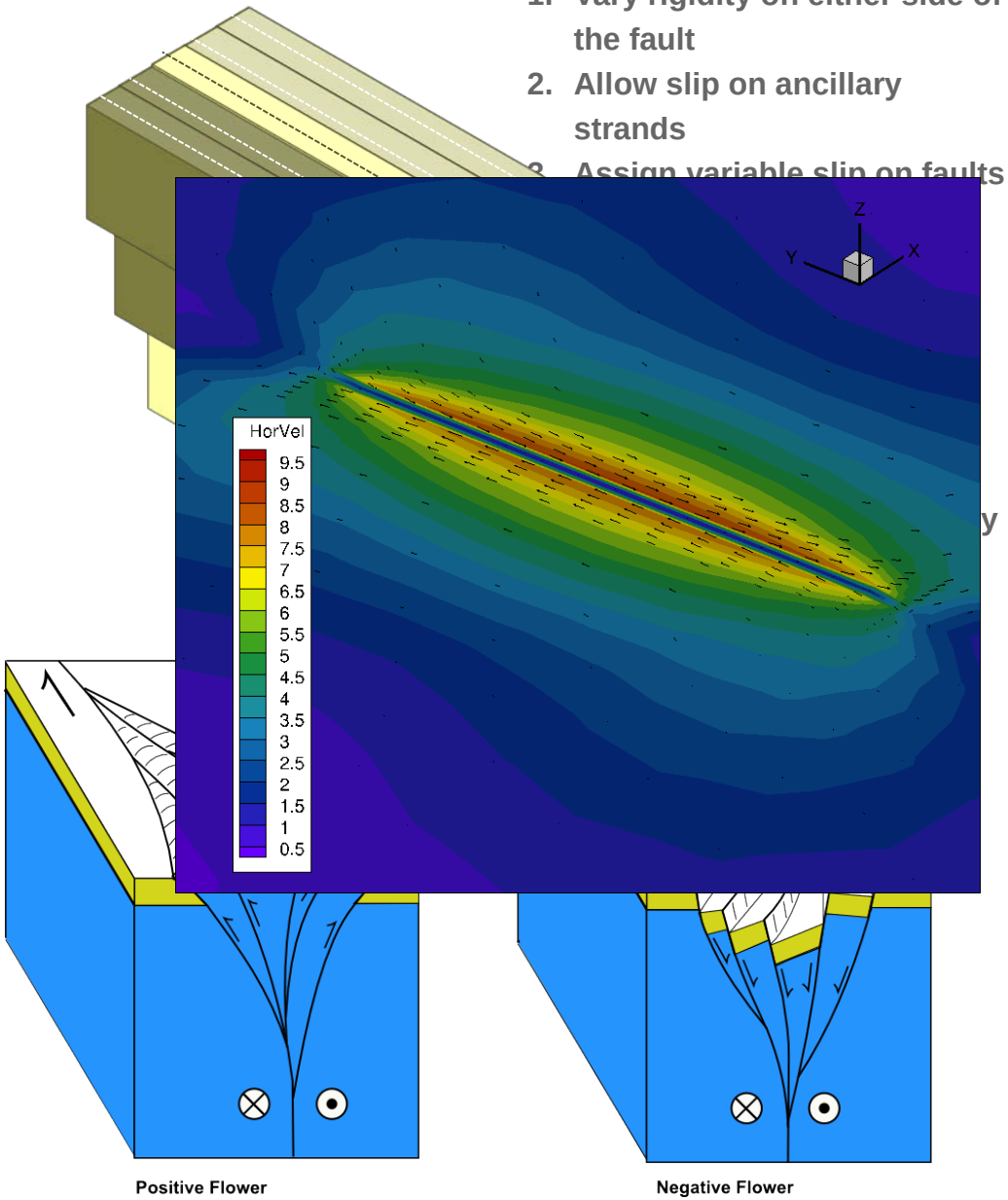


Next steps

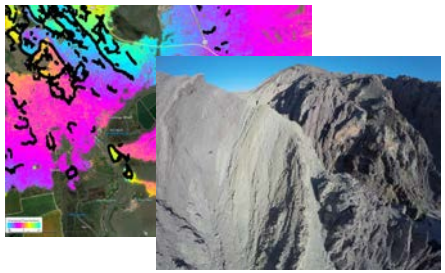
1. Vary rigidity on either side of the fault
2. Allow slip on ancillary strands
3. Assign variable slip on faults

Simple model with laterally varying rigidity in damage zone





https://commons.wikimedia.org/wiki/File:Flowerstructure1.png



Continue to validate with remote sensing data

Conclusions

- Question: how do faults root at depth and how is this reflected at the surface?
- Preliminary models show distributed deformation in the damage zone which could be related to observed deformation
- South Napa and San Andreas provide excellent field corollaries to test hypotheses
- Remotely sensed data, particularly high resolution topography data, is extremely helpful in constructing and constraining models
- Future modeling with more realistic geometry and additional tests of material behavior will aid in better understanding of complex fault mechanics

Thank you for your kind attention!

Questions?

Maggi Glasscoe

Margaret.T.Glasscoe@jpl.nasa.gov

Copyright 2016 California Institute of Technology.
U.S. Government sponsorship acknowledged.