

UMassAmherst

Slip rates and distributed deformation  
in and around San Geronio Pass:

*Michele Cooke*



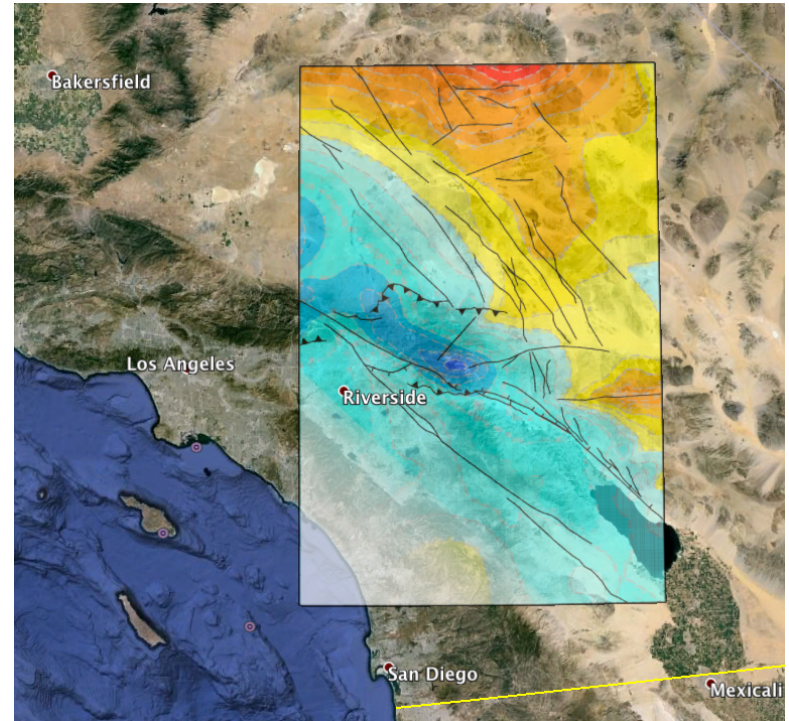
Slip rates and distributed deformation  
in and around San Geronio Pass:  
*insights from quasi-static  
long-term deformation models*

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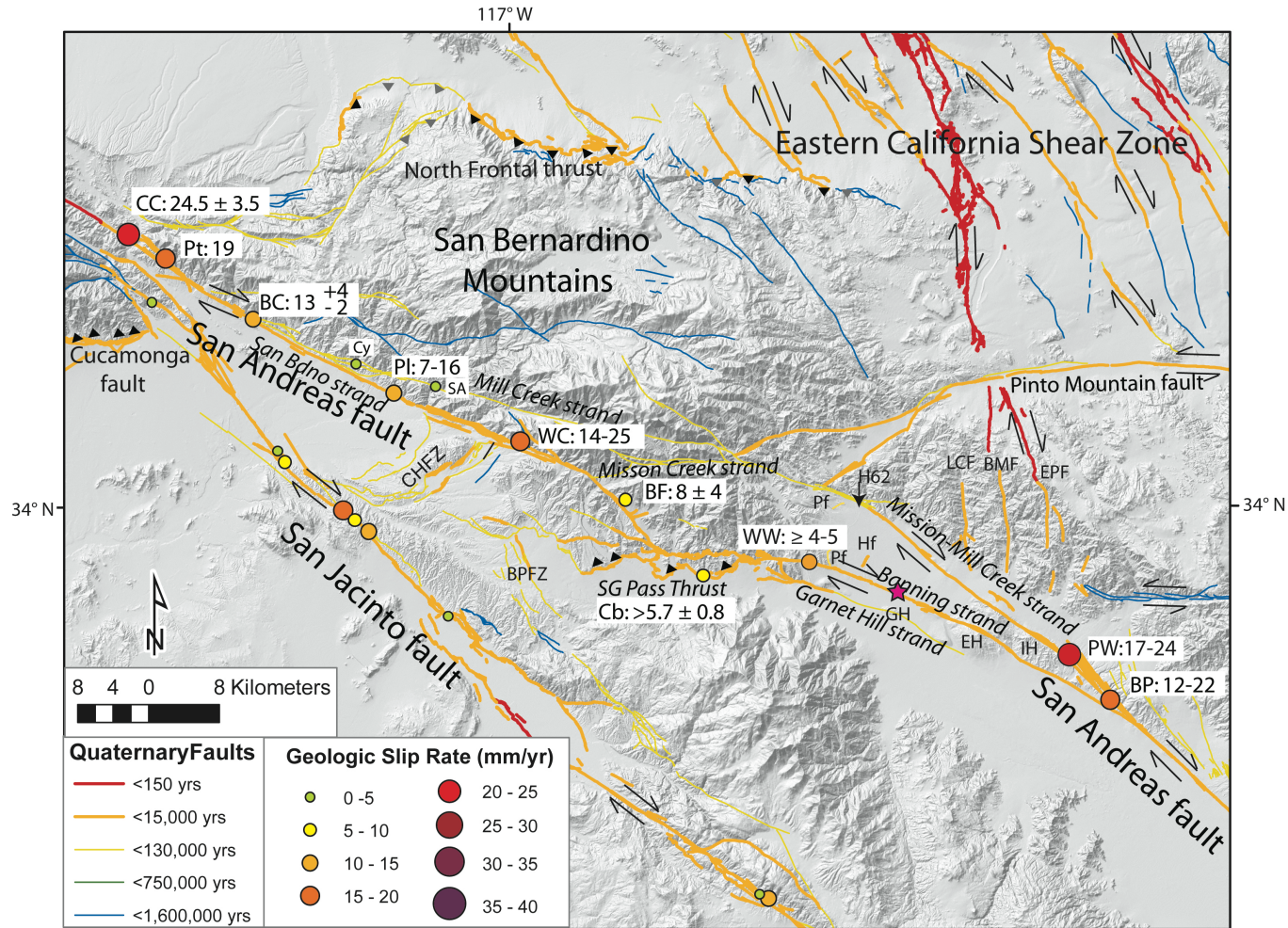


# Models might be useful

1. If slip rates decrease within the San Gorgonio Pass, where is the missing slip going?
2. How might alternative active fault configurations impact deformation?
  - Is the Mill Creek strand active?

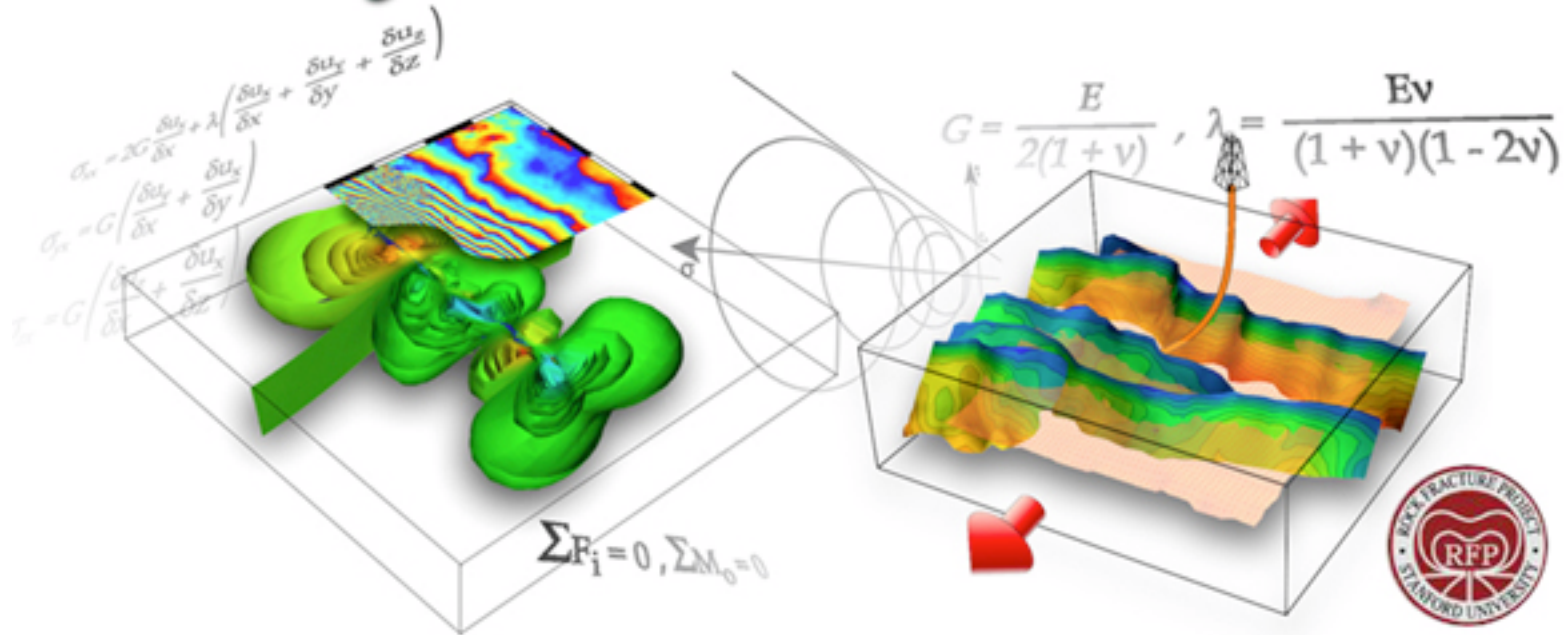


# Strike-slip rates decrease within the SGP



(from McGill et al., GSA Bull. 2013)

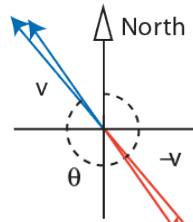
# *Poly3D and Poly3DGUI*



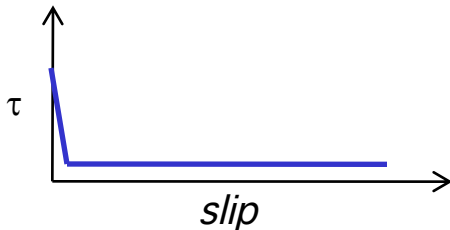
- Three-dimensional Boundary Element Method code
  - Discretize boundaries and faults into triangular displacement discontinuity elements
  - Solve for stresses/strains throughout the model

## Model Set Up

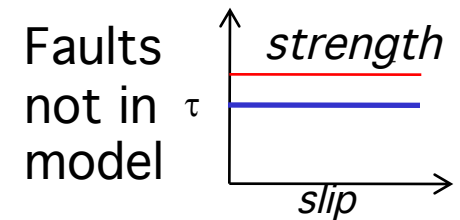
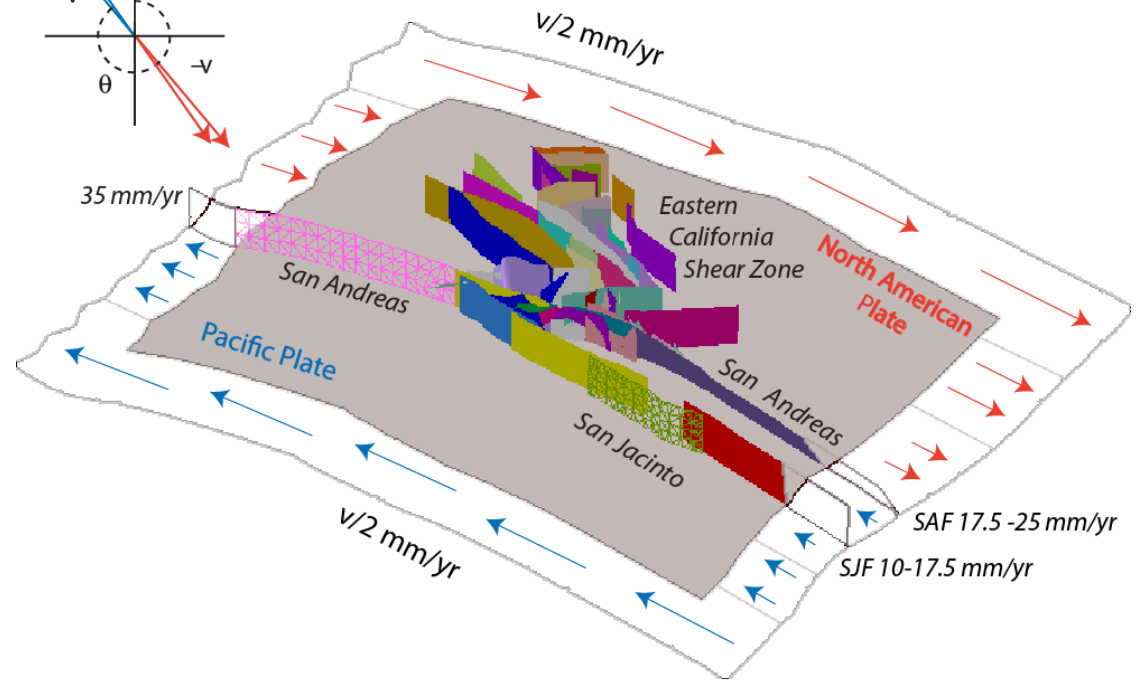
- Plate velocities applied to the boundaries capture tectonic loading uncertainty.



- Frictionless faults simulate the low dynamic strength during slip accumulation

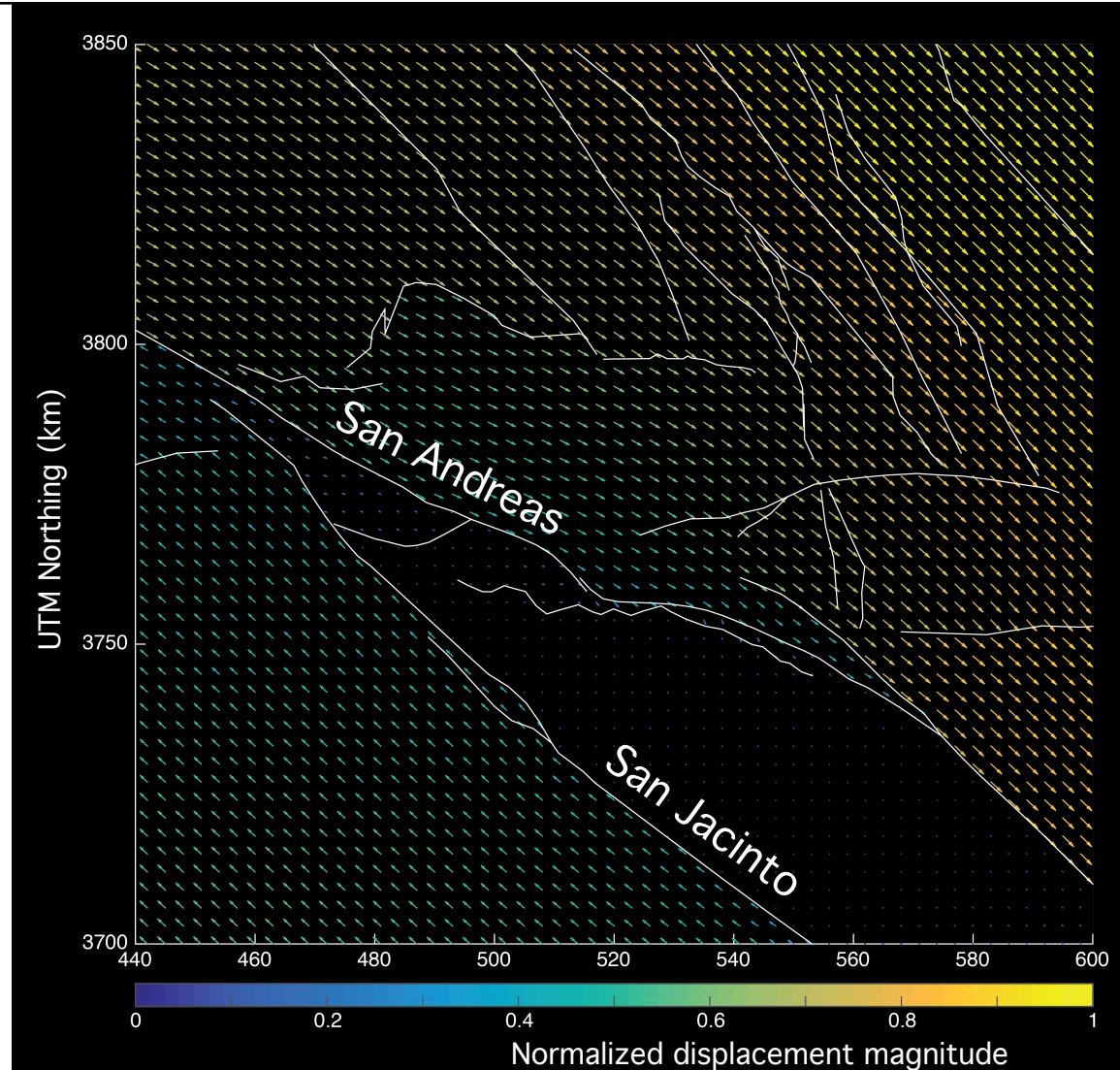


- Faults slip freely and interact



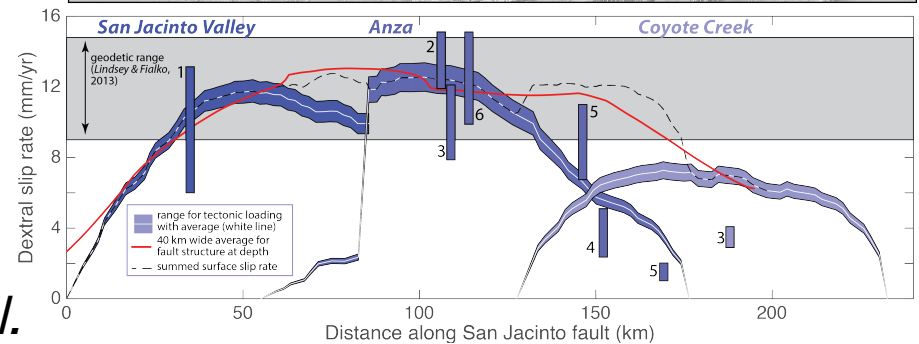
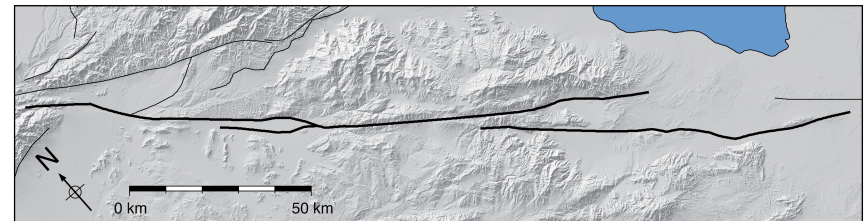
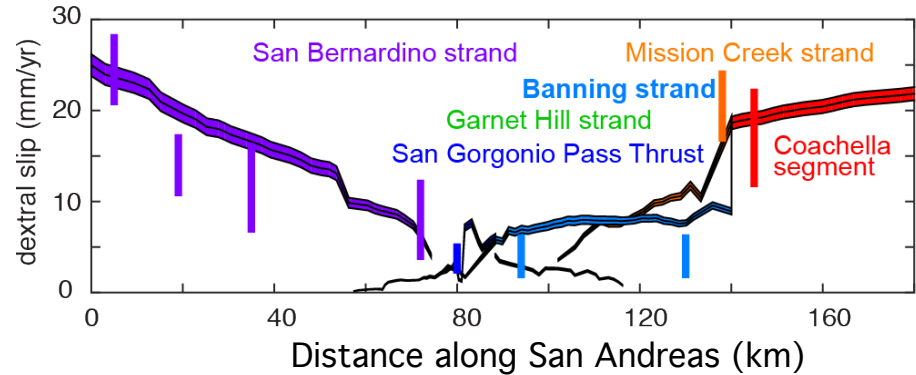
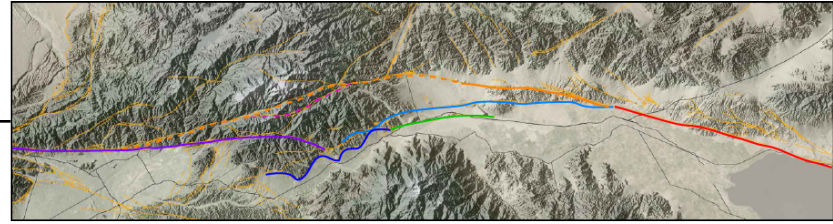
# Kinematically and Mechanically consistent

- The far field displacements reflect tectonic loading.
- Largest displacement gradients are across the faults.



# Slip rate distribution

- Along the San Andreas and San Jacinto faults, the modeled slip rates for range of tectonic loading uncertainty overlap many geologic rates.
- Where slip rates are low on the San Andreas fault, they are highest along the San Jacinto fault.

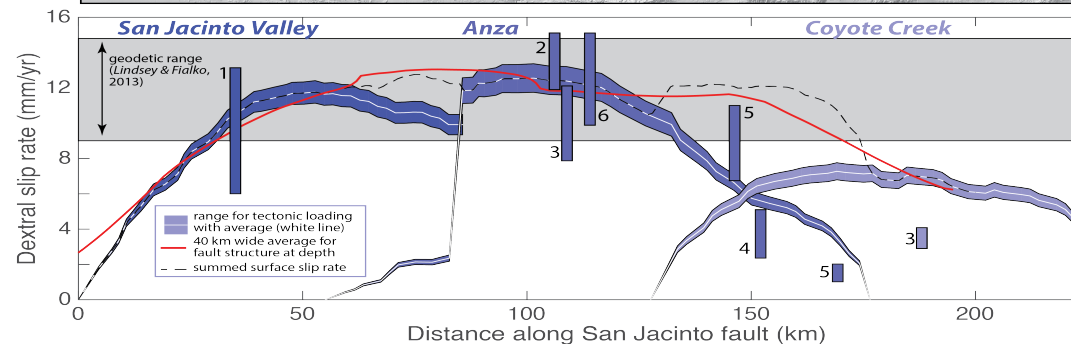
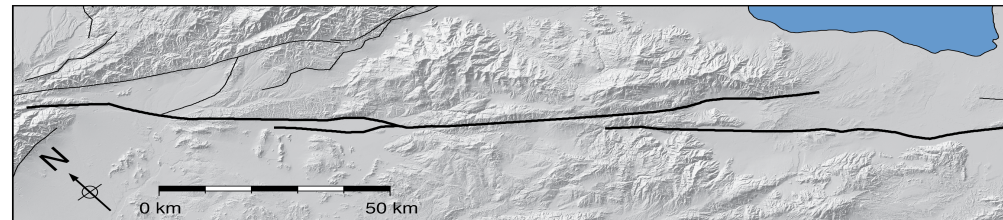
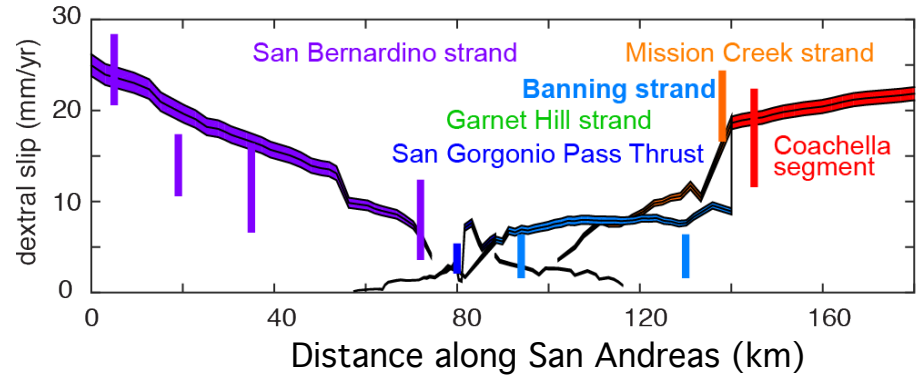
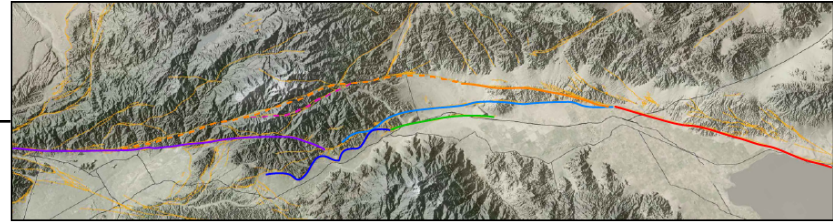


Poster 15 Resor et al.



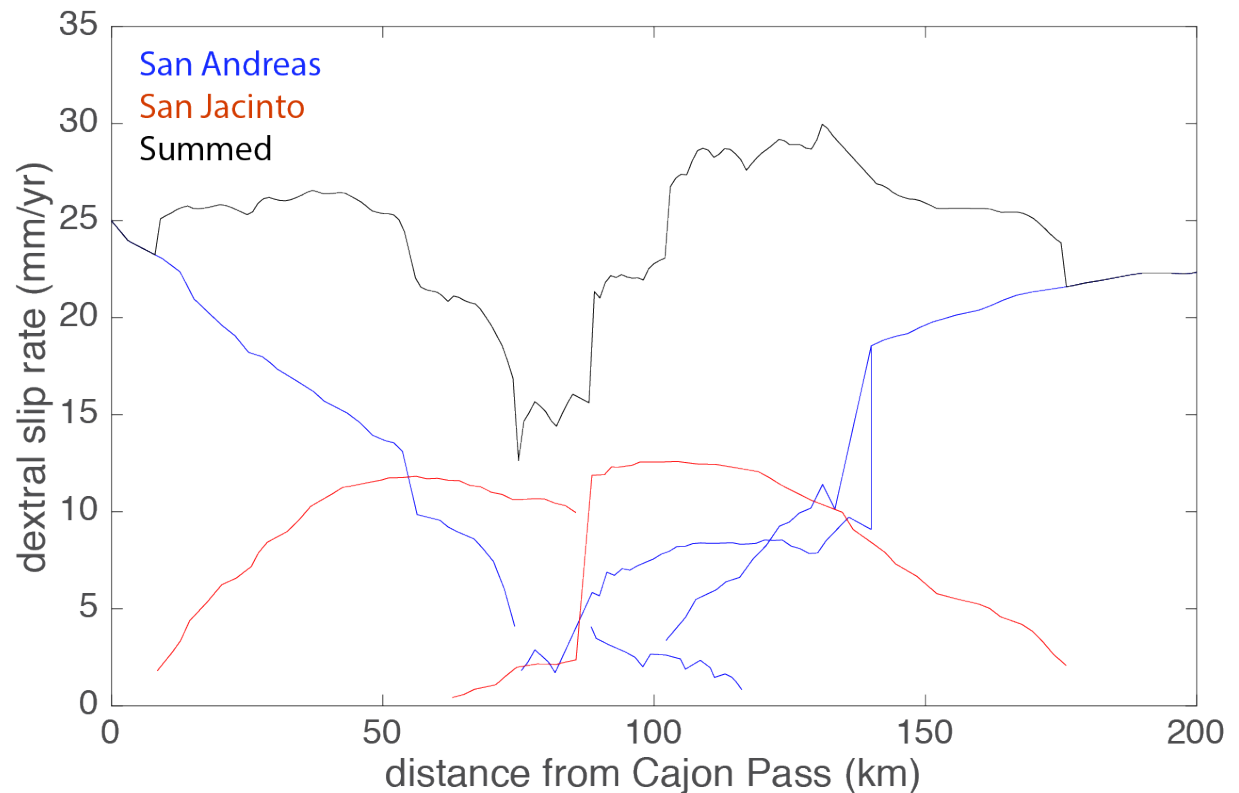
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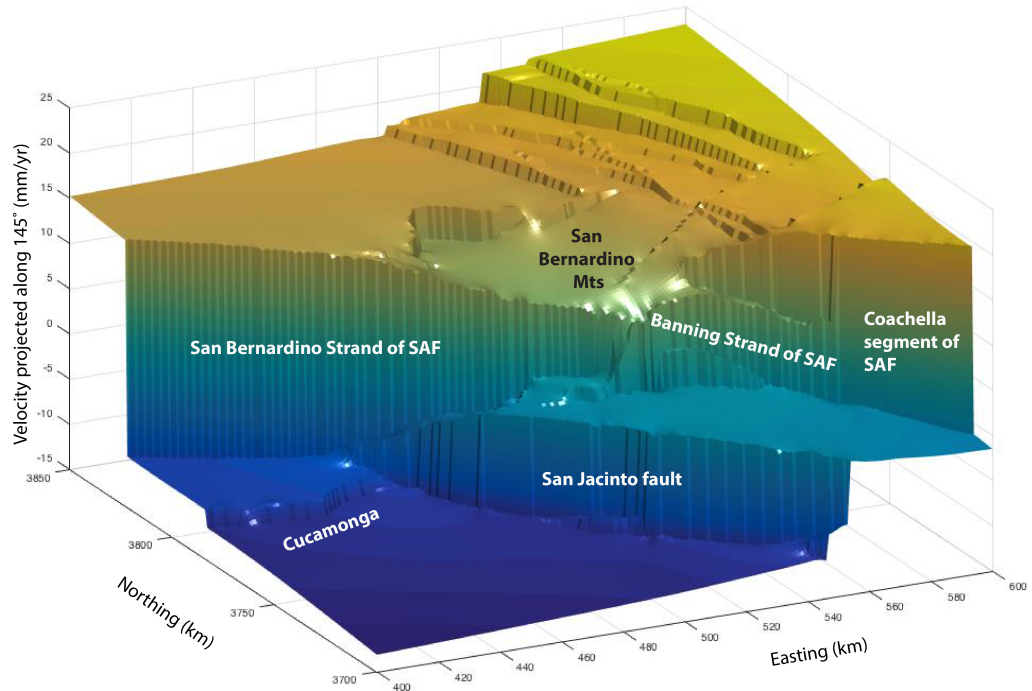
# Slip Rate Distribution

- The slip on the San Jacinto fault doesn't completely 'fill' the gap' along the San Andreas



# Displacements along $145^\circ$

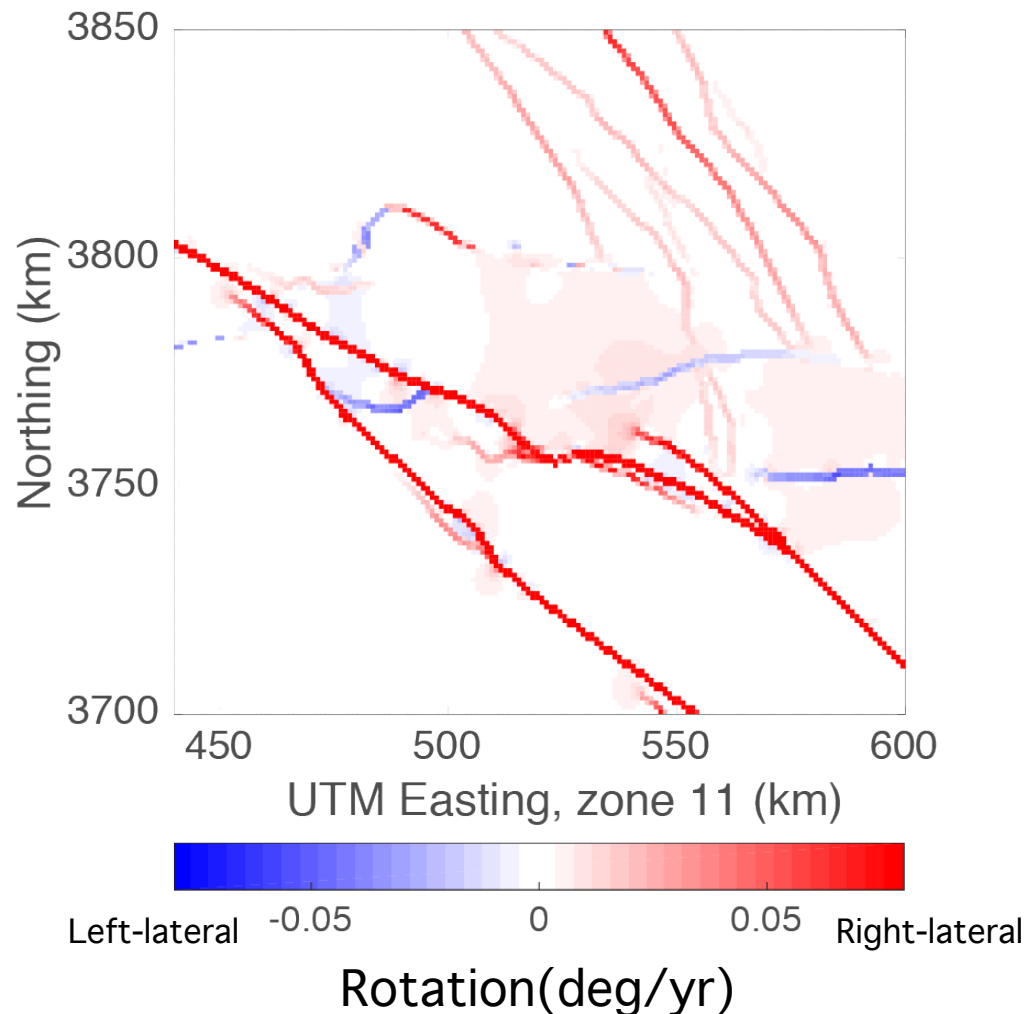
- “risers” indicate localized slip
- Horizontal “steps” indicates zero off-fault deformation.
- Warped and tilted surfaces indicate off-fault deformation.
- Significant off-fault deformation within the eastern San Bernardino Mountains.
- This strain is **not** released in earthquakes. The model shows strain left-over **after** the faults have slipped.



The sum of fault slip rates need not equal the plate velocity

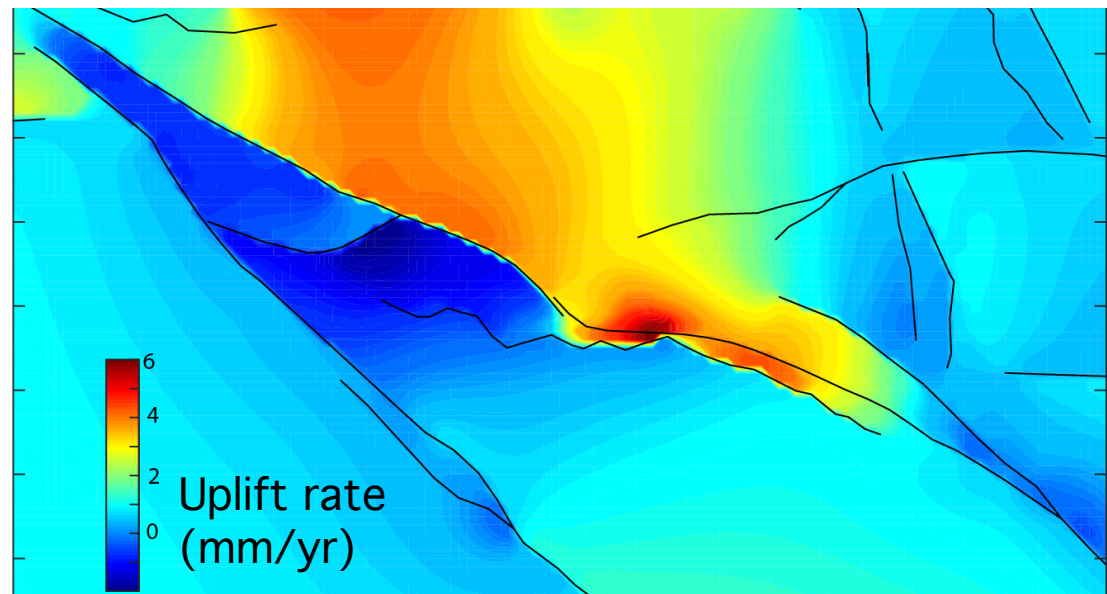
# shear strain distribution

- $\nabla \times \mathbf{U} = \text{curl } \mathbf{U}$
- San Andreas and San Jacinto major contributors
- No direct slip transfer from northern Coachella Valley to ECSV
- Zone of distributed shear in the eastern San Bernardino Mountains.



## Uplift pattern

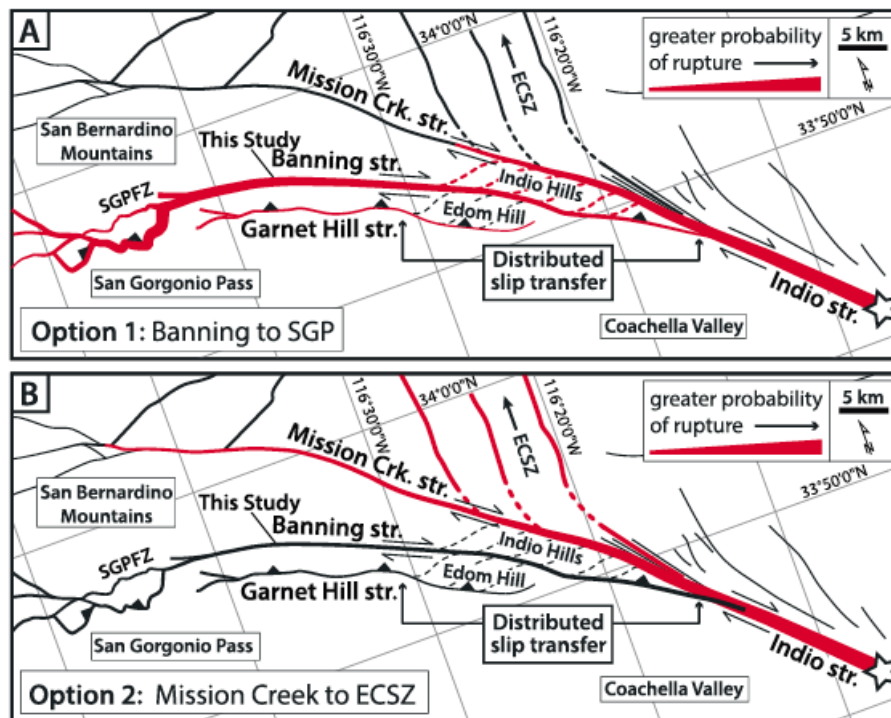
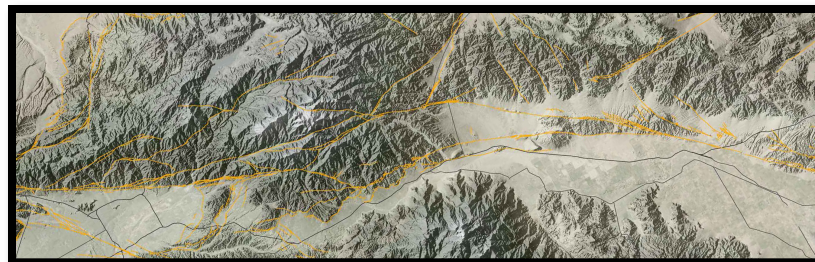
- Regions of strike-slip gradient, such as along the San Bernardino strand produce local uplift/downdrop.



*Not yet corrected for isostatic adjustment*

# What about different active fault configurations?

- If the active fault geometry is wrong, the model results are not so useful.
- How would an active Mill Creek strand impact the deformation?

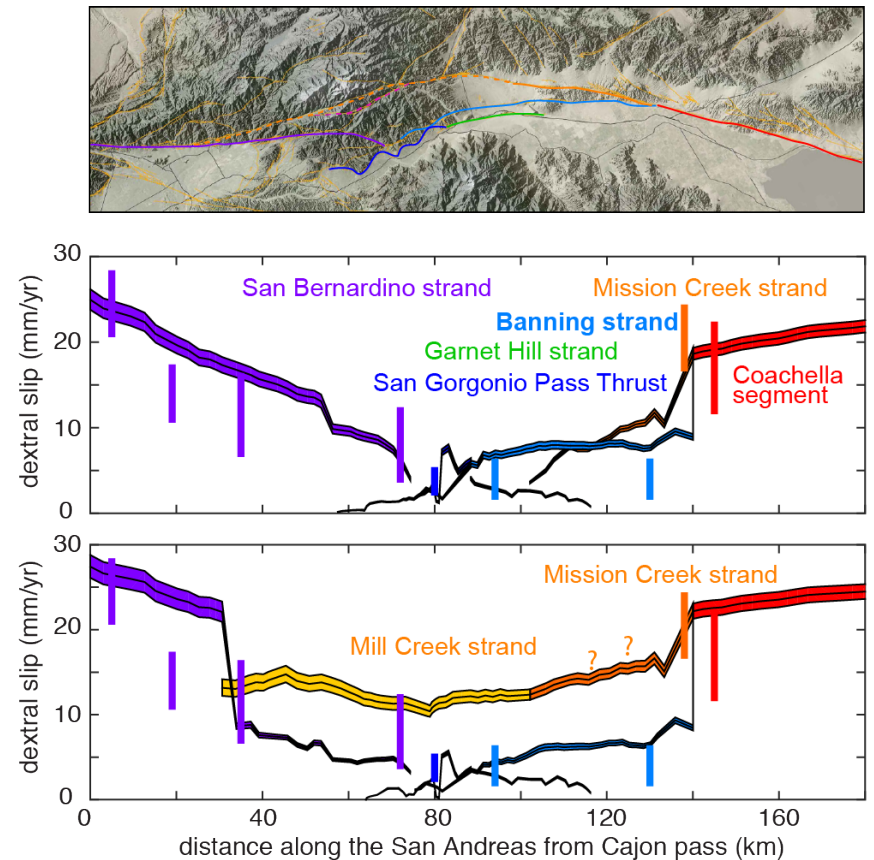


(Gold, Behr et al., JGR 2015)

# With addition of Mill Creek strand

# SAF

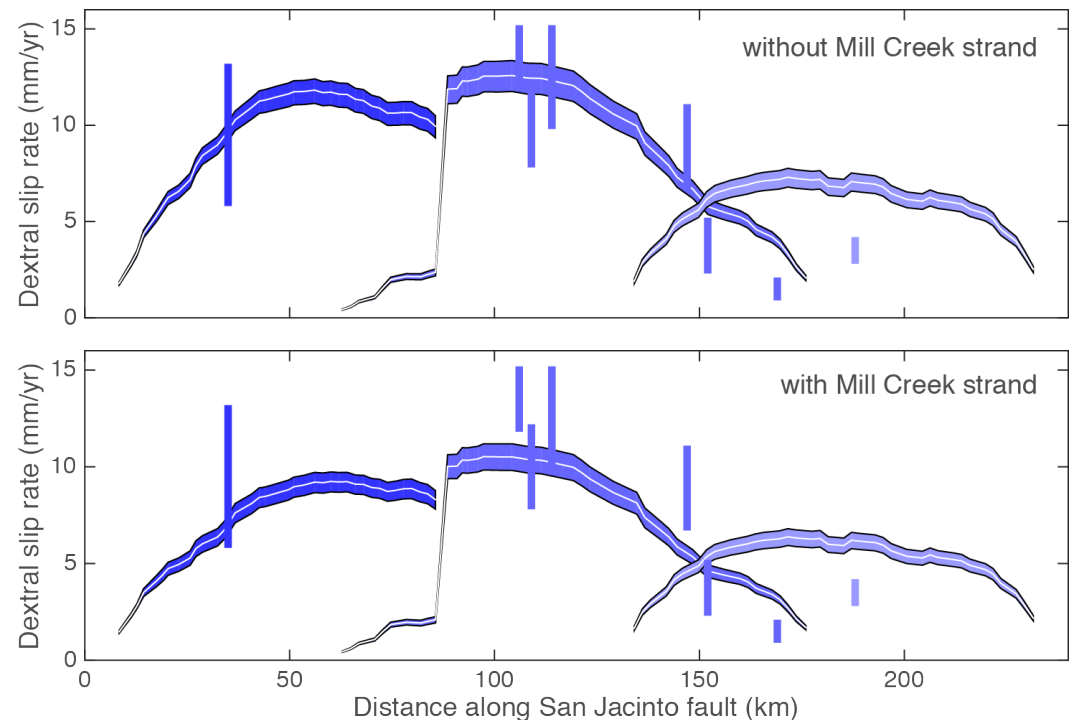
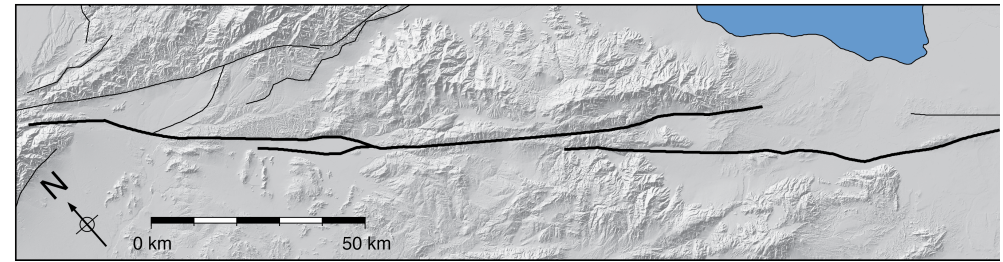
- Majority of dextral slip passes from Coachella to San Bernardino via the Mill Creek strand
- Dextral slip rates along the outboard strands decreases.



## With addition of Mill Creek strand

## SJF

- Increased dextral slip rates along the San Andreas reduces slip rates along the San Jacinto fault.

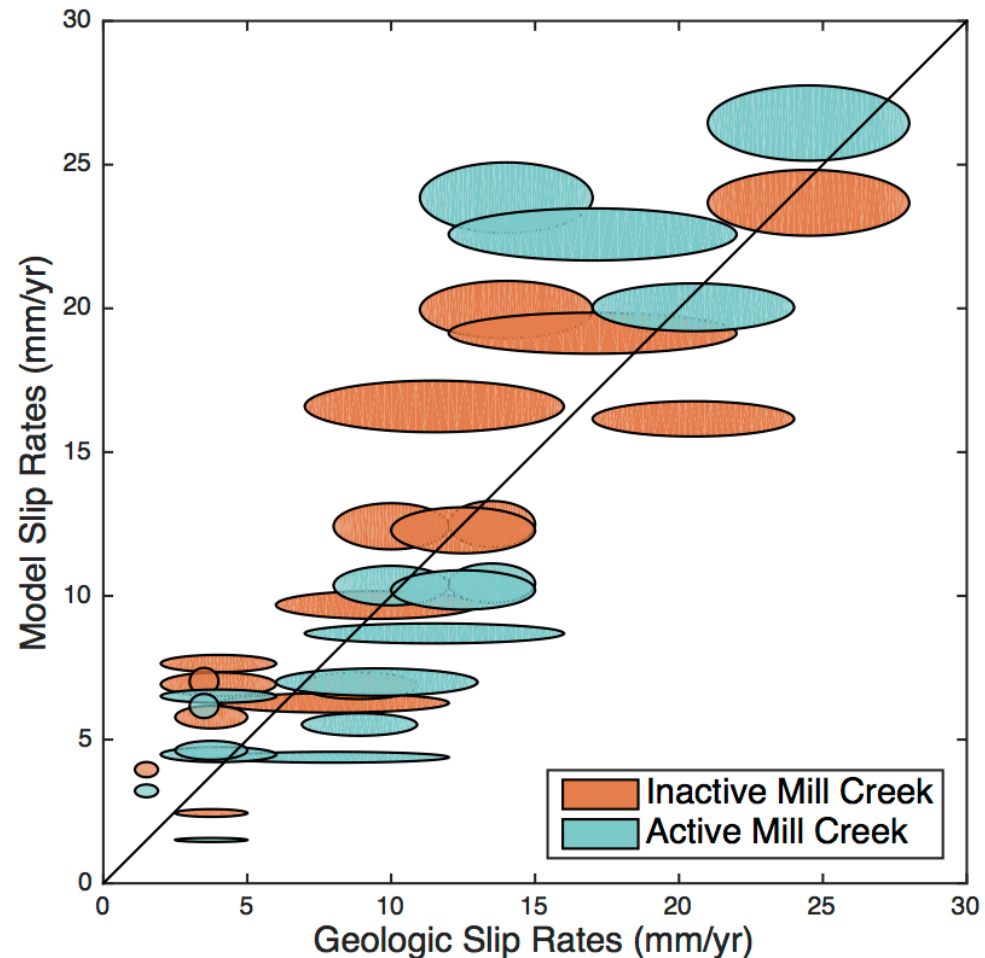


- Which model fits best overall?

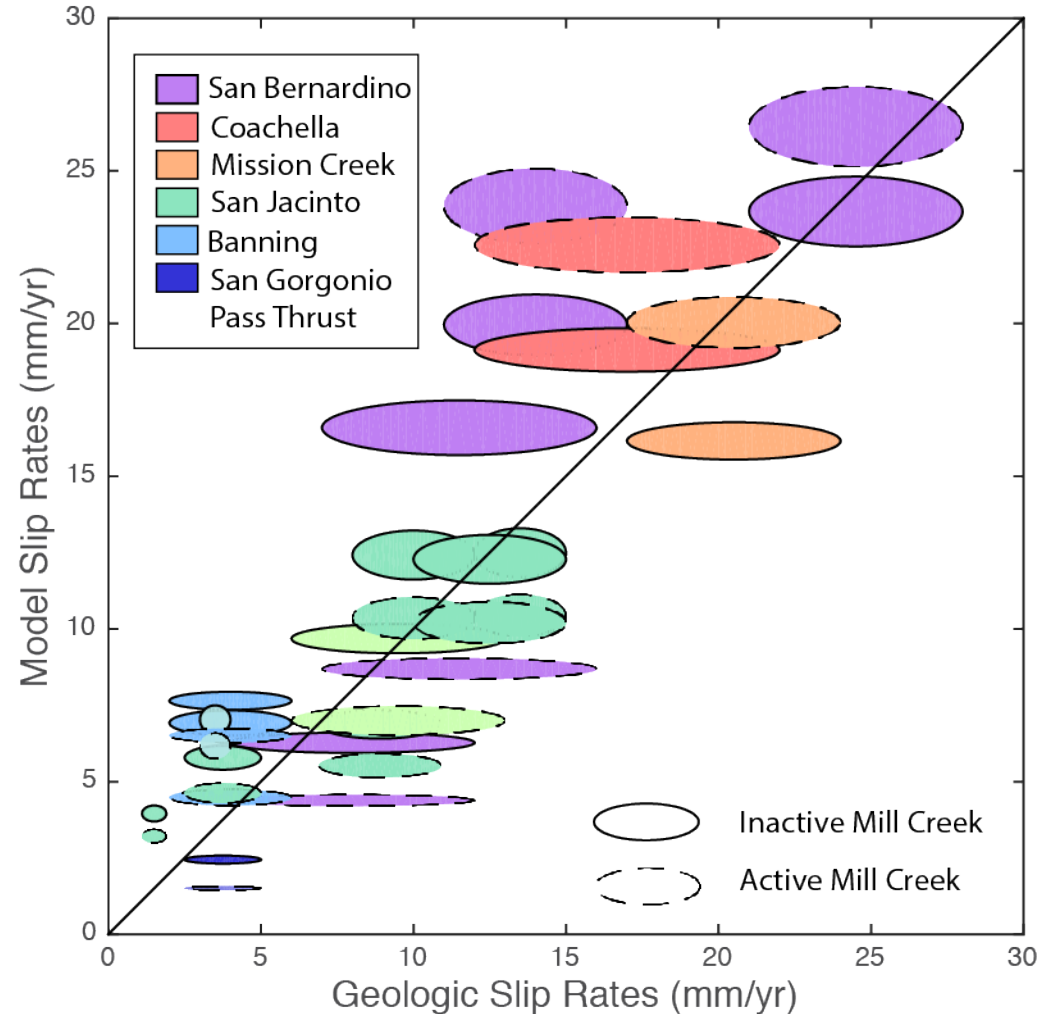


# Comparison of Model and Geologic Slip Rates

- Ellipses show model and geologic range of slip rates.
- Both models over- and under-estimate dextral slip rates
- Cumulative misfit to preferred rates
  - Inactive Mill Creek 41.8 mm/yr
  - Active Mill Creek 46.3 mm/yr
- Cumulative misfit to permissible rates
  - Inactive Mill Creek 13.3 mm/yr
  - Active Mill Creek 15.3 mm/yr

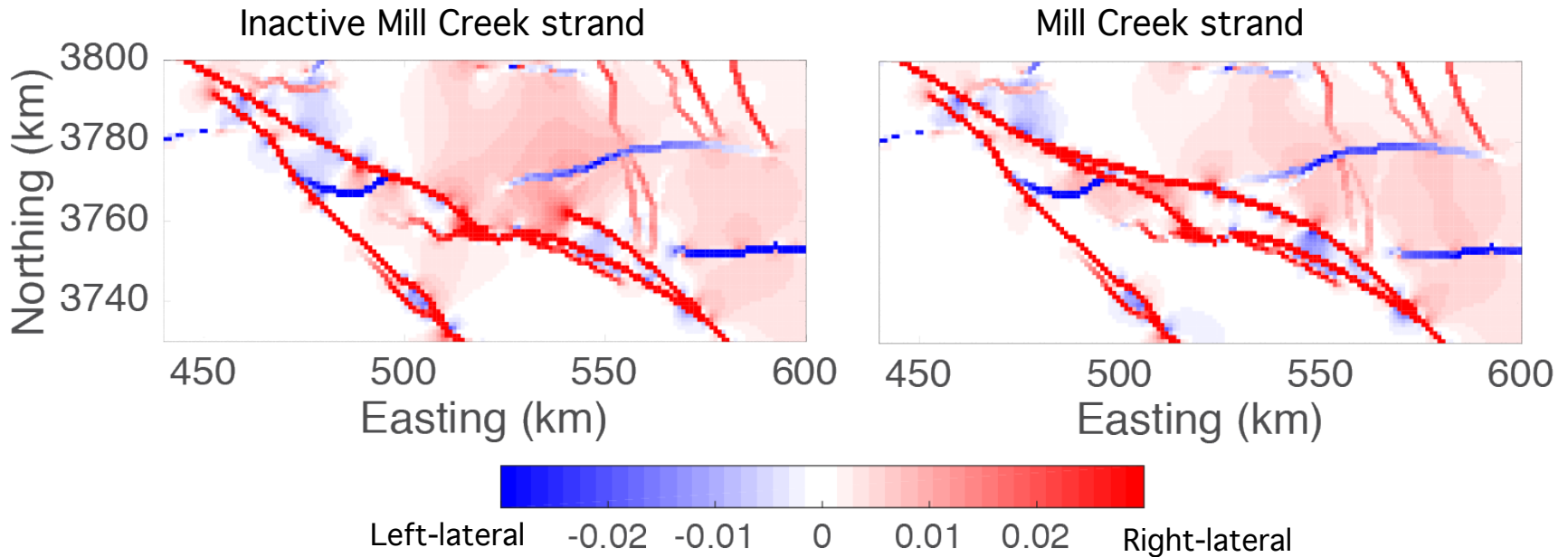


- Fast slipping sites (along the SAF outside of SGP) increase
- Slower slipping sites within SGP and along San Jacinto decrease



Poster 60 Beyer & Cooke

# Distributed shear strain



- Active Mill Creek strand has less distributed deformation.

- Slip rates in SGP-ECSZ transition zone
 

	noMill	Mill
• Blue Cut	2.8	1.9 mm/yr
• Burnt Mountain	0.8	0.4 mm/yr
• Eureka Pea	0.8	0.4 mm/yr

- San Jacinto dextral slip increases where San Andreas decreases.
- Model without activity along the Mill Creek strand has lower misfit to the available geologic slip rates than model with an active Mill Creek strand
- Slip gradients at the northern Coachella fault could be accommodated by:
  - increased slip rate along the Anza segment of SJF,
  - distributed shear strain in the eastern San Bernardino Mountains,
  - only modest increase in slip along Eureka Peak & Burnt Mountain

*Photo along the Mill  
Creek strand of the  
San Andreas fault*