The influence of topographic stresses on faulting, emphasizing the 2008 Wenchuan, China earthquake rupture

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If you want to leave now...

- Topographic stresses on the Wenchuan earthquake faults are large, heterogeneous, and persistent through the earthquake cycle
- Topographic stresses are mostly opposed to tectonic stress
  - Can give us constraints on tectonic stress
- Topographic stresses locally suppress coseismic slip
  - confusing implications for slip vs stress drop

Precursory thoughts

- Mountains are really big, heavy, irregular
- They must create large stresses in their supporting crust
  - Isotropic and anisotropic
- How may this affect faulting?
- Topography and rock density known with relative accuracy; this allows us to quantify stress

‘Hypotheses’

- Stresses from topography may inhibit or promote rupture or slip on faults

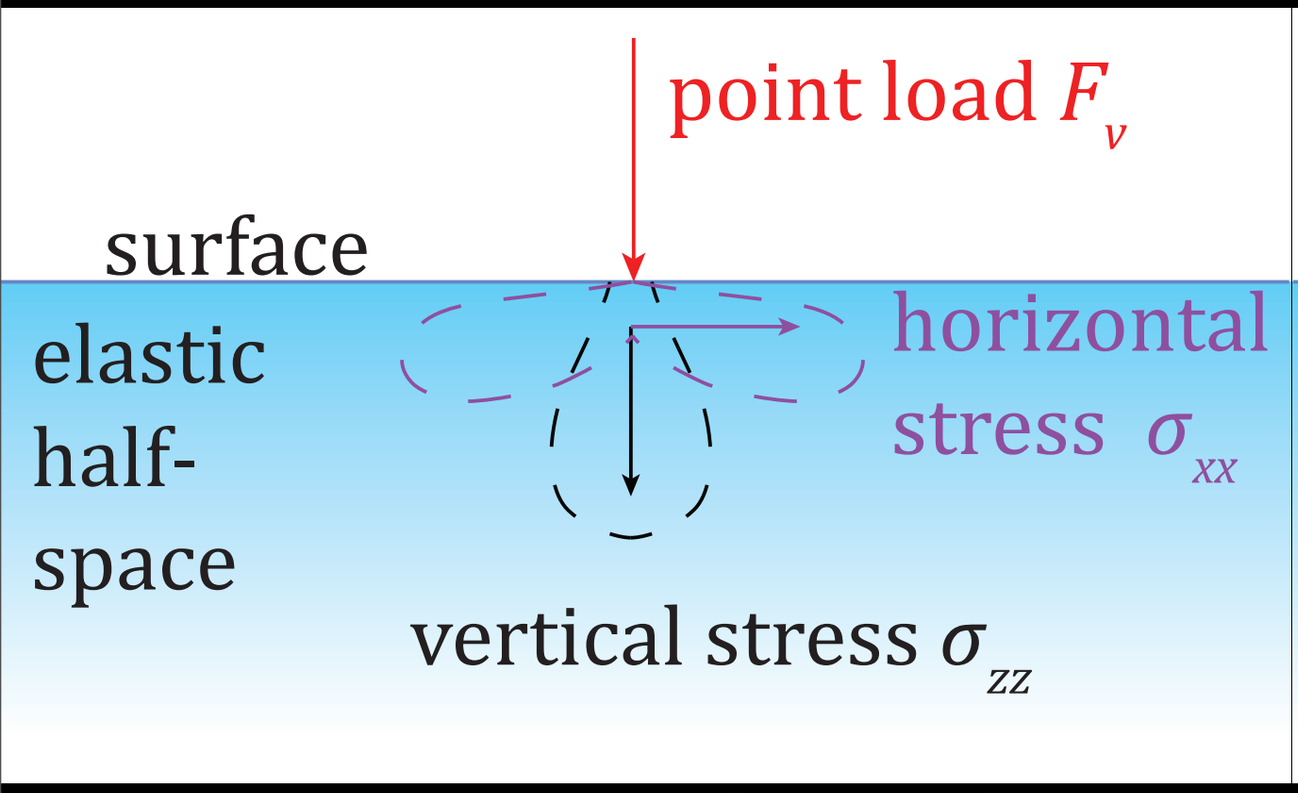
- Type of interaction should depend on relative orientations of faults, topographic and tectonic stresses

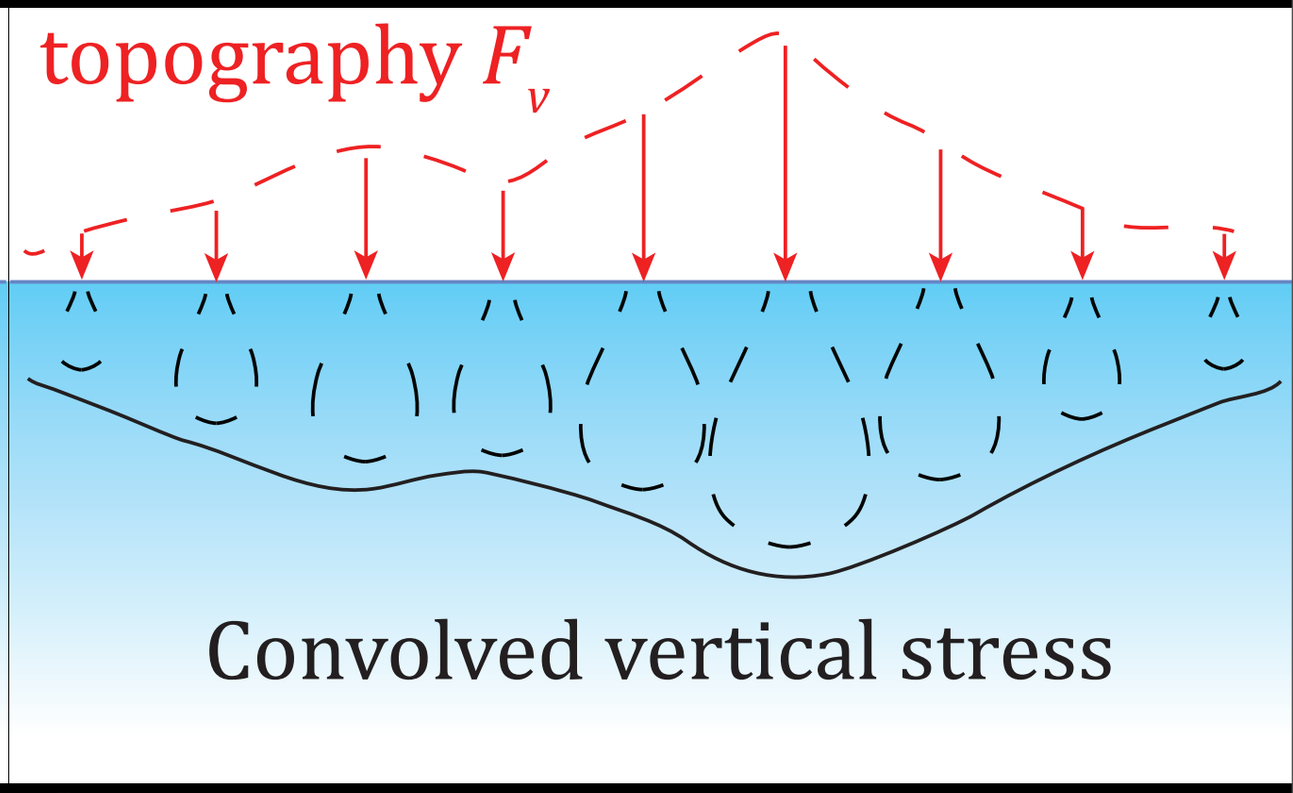
Previous work

- Liu and Zoback (1992, JGR) developed methods we used, and looked at stresses on the Cajon Pass segment of the SAF

- Bollinger et al (2004, JGR) looked at how Himalayan massifs influenced microseismicity on Main Himalayan thrust

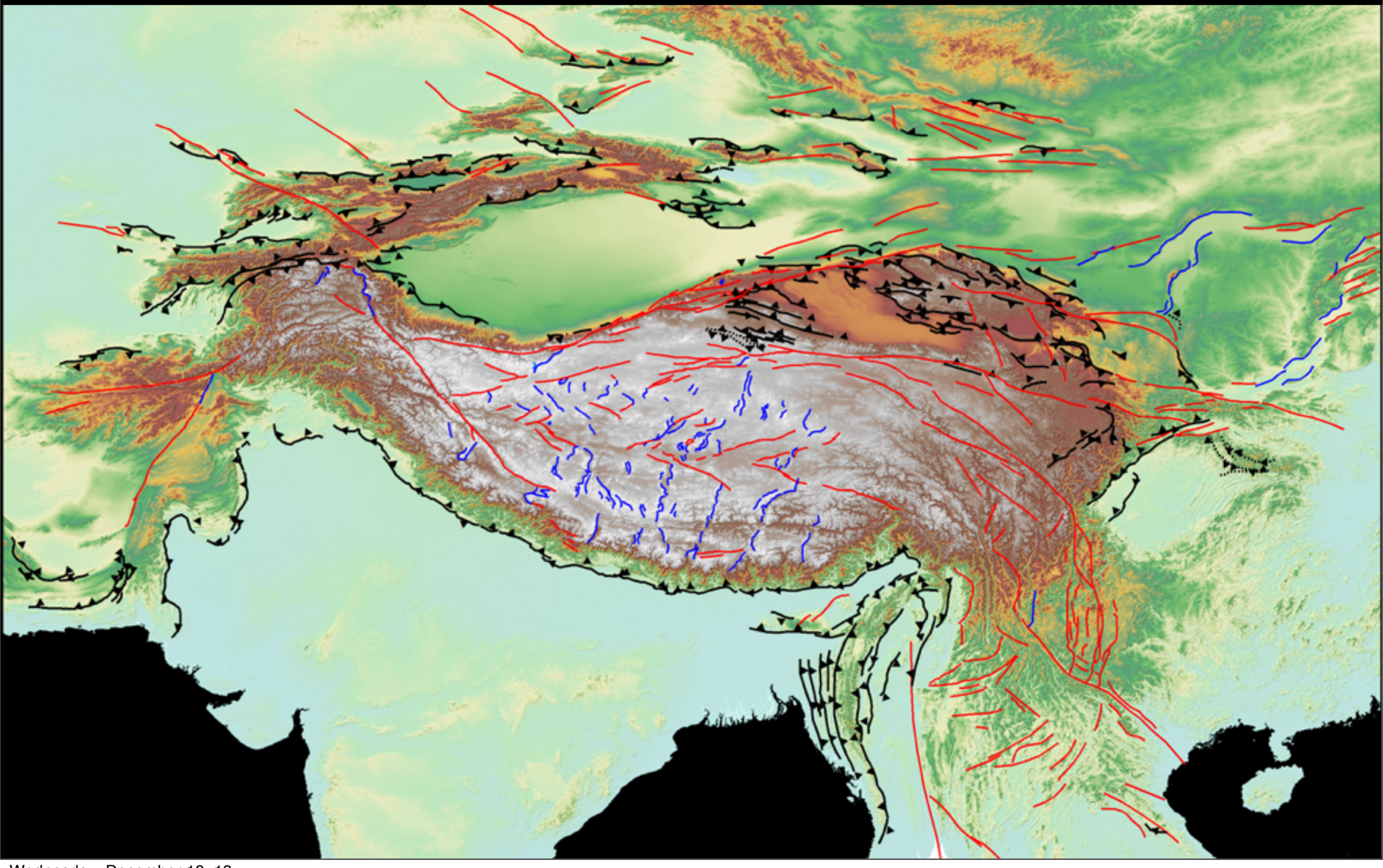
Calculating topographic stress fields





- Convolve solutions for point-source stresses with DEM
- Correct for effects of slope, irregular surface boundary condition

where to look?



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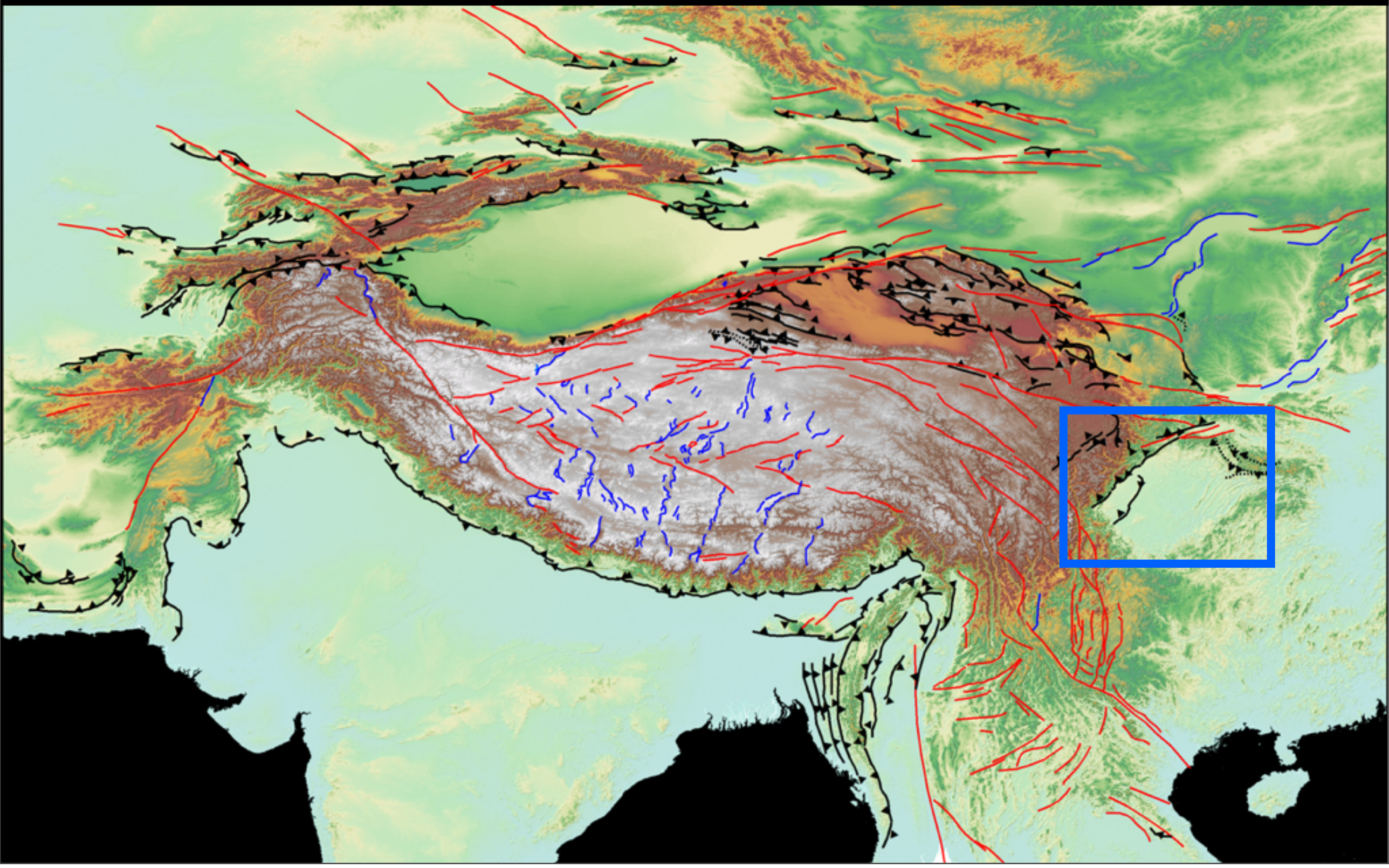
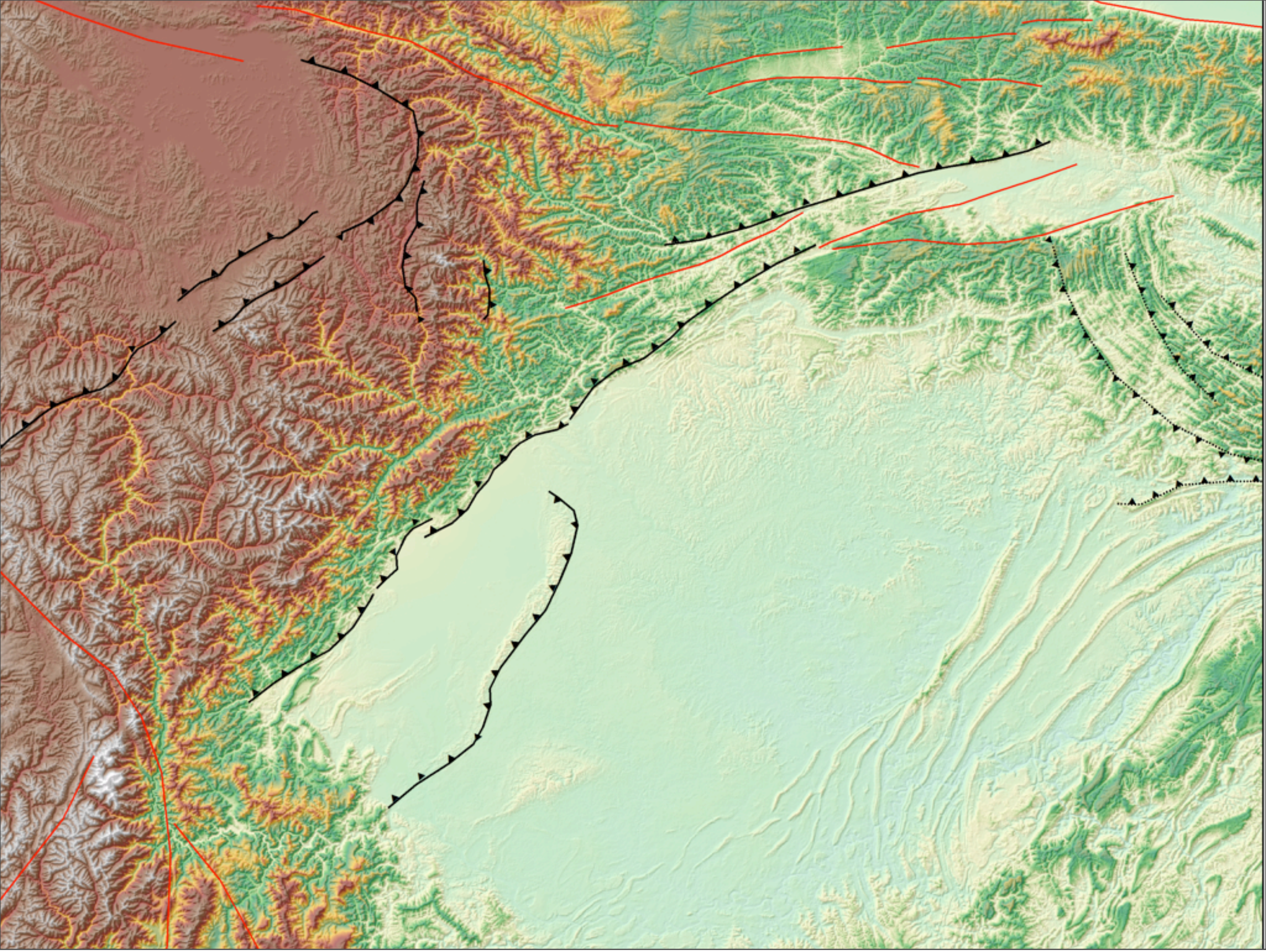
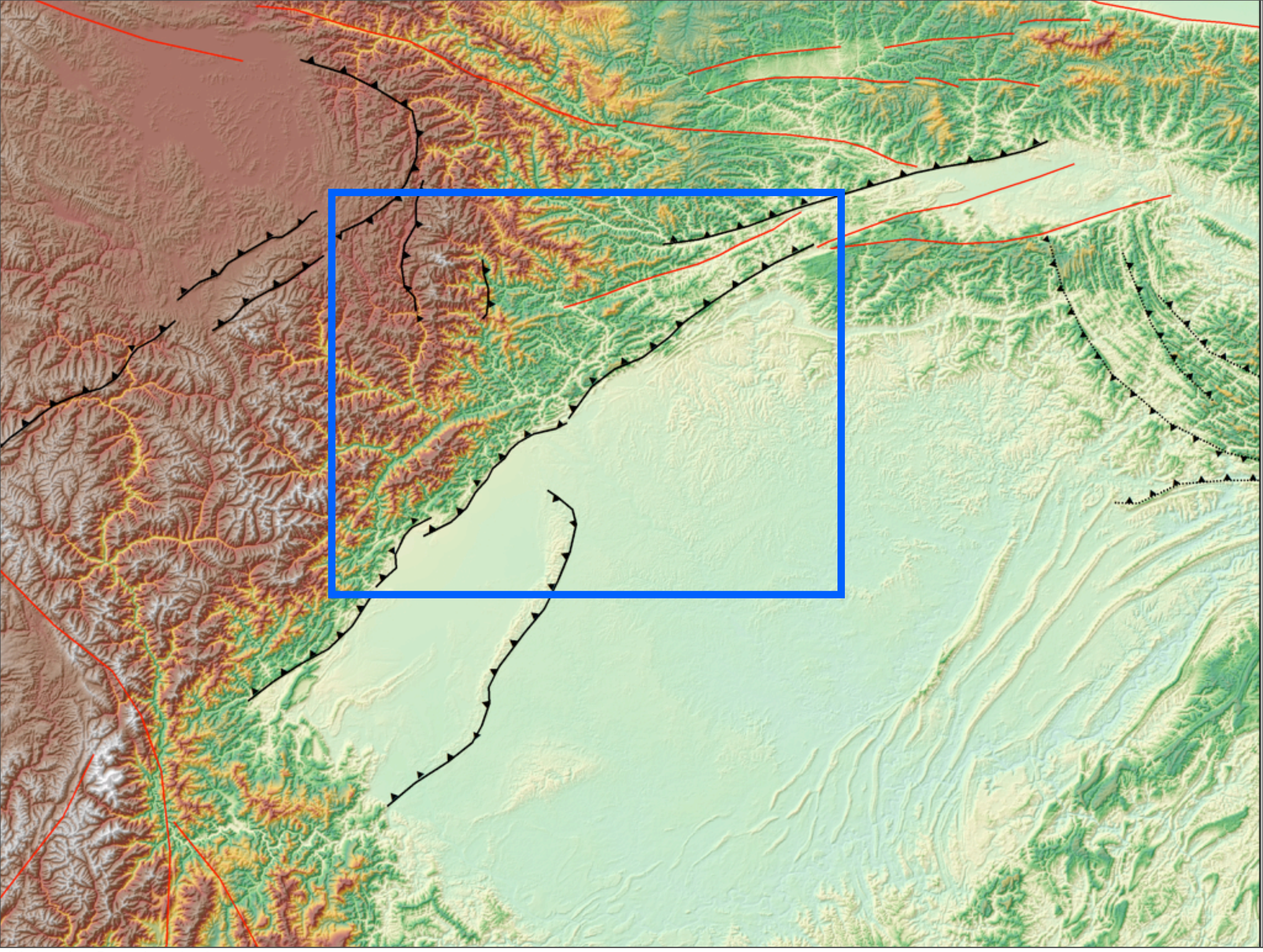




Wednesday, December 18, 13



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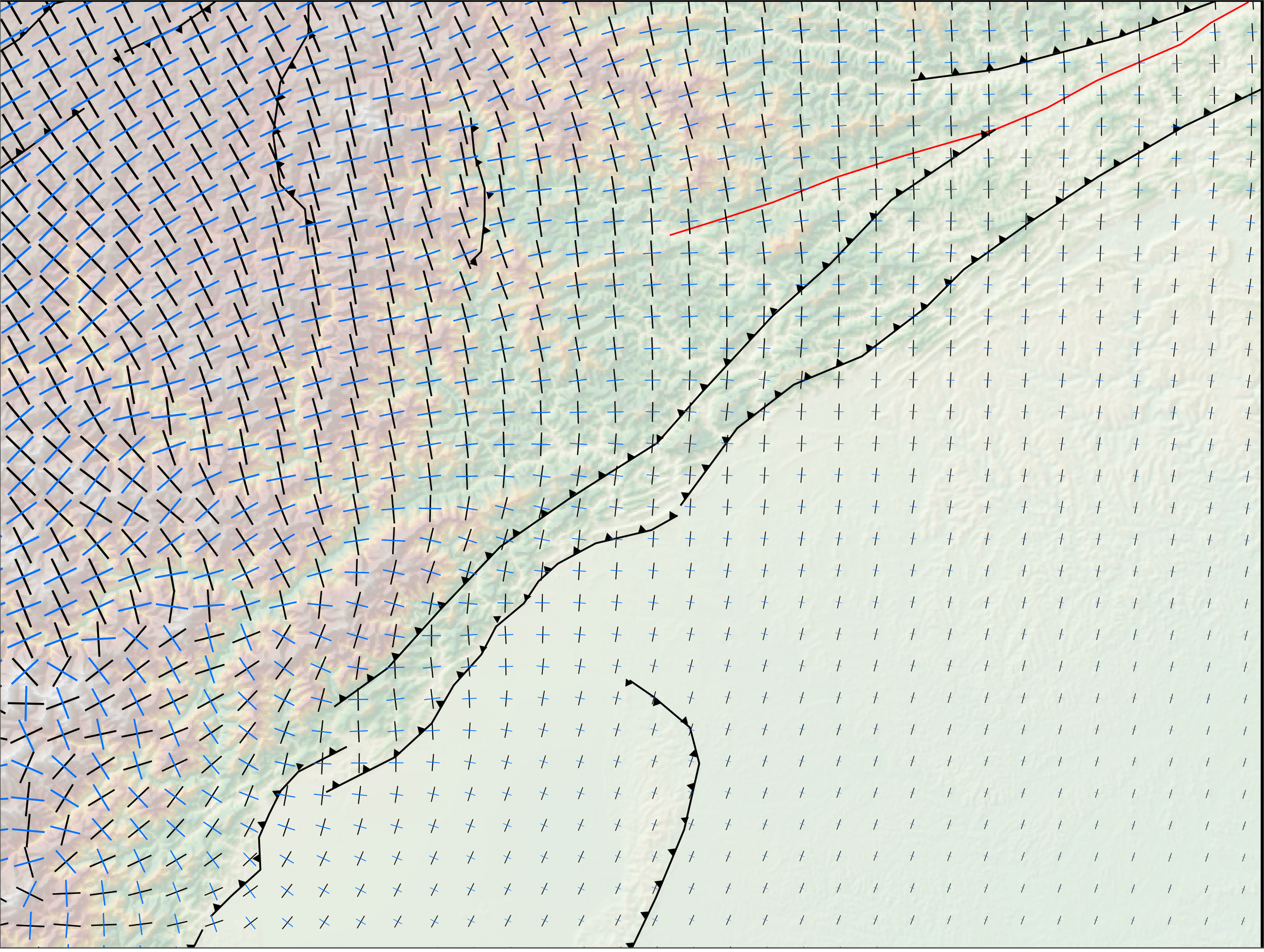

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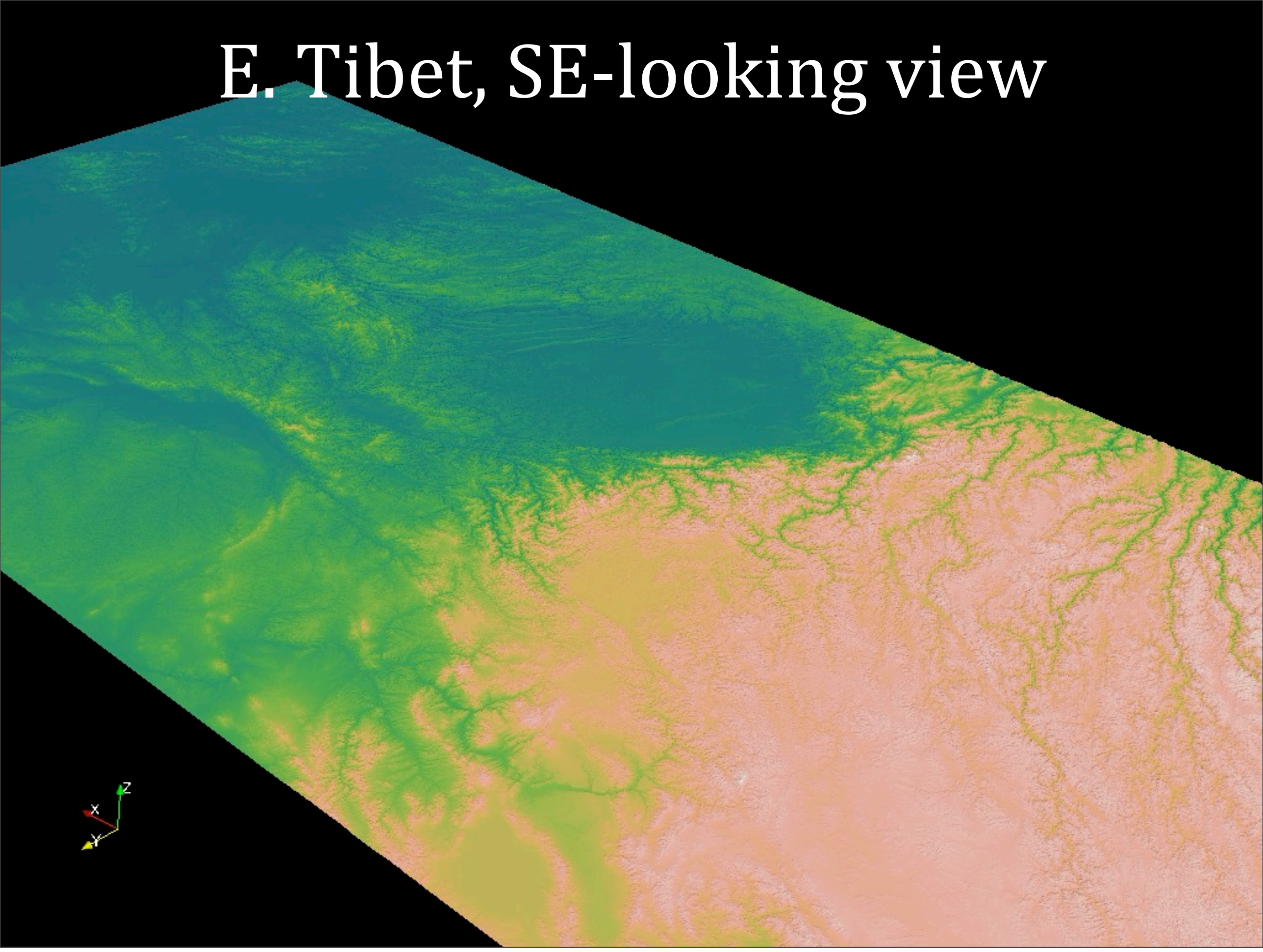
E. Tibet, SE-looking view



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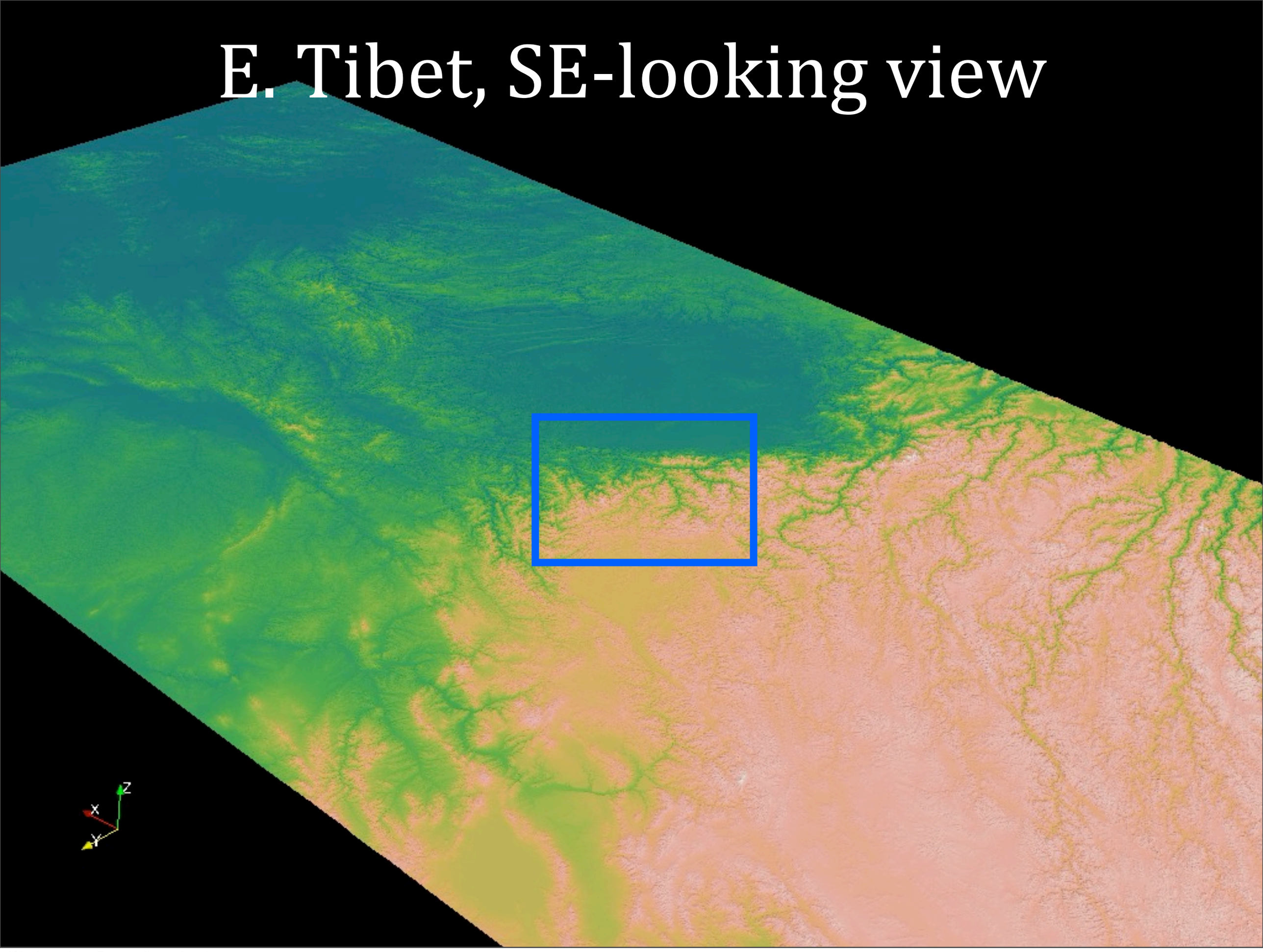

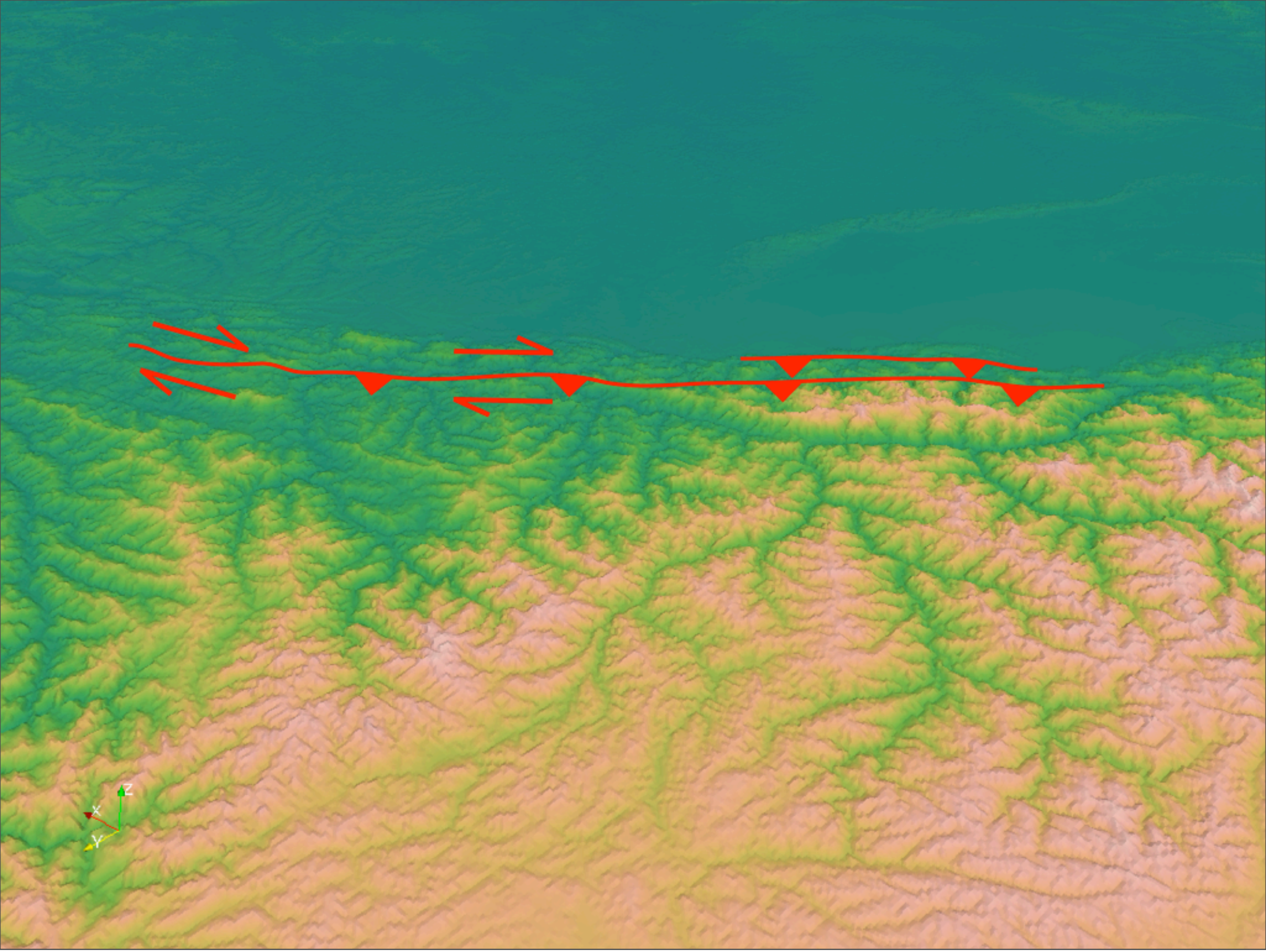

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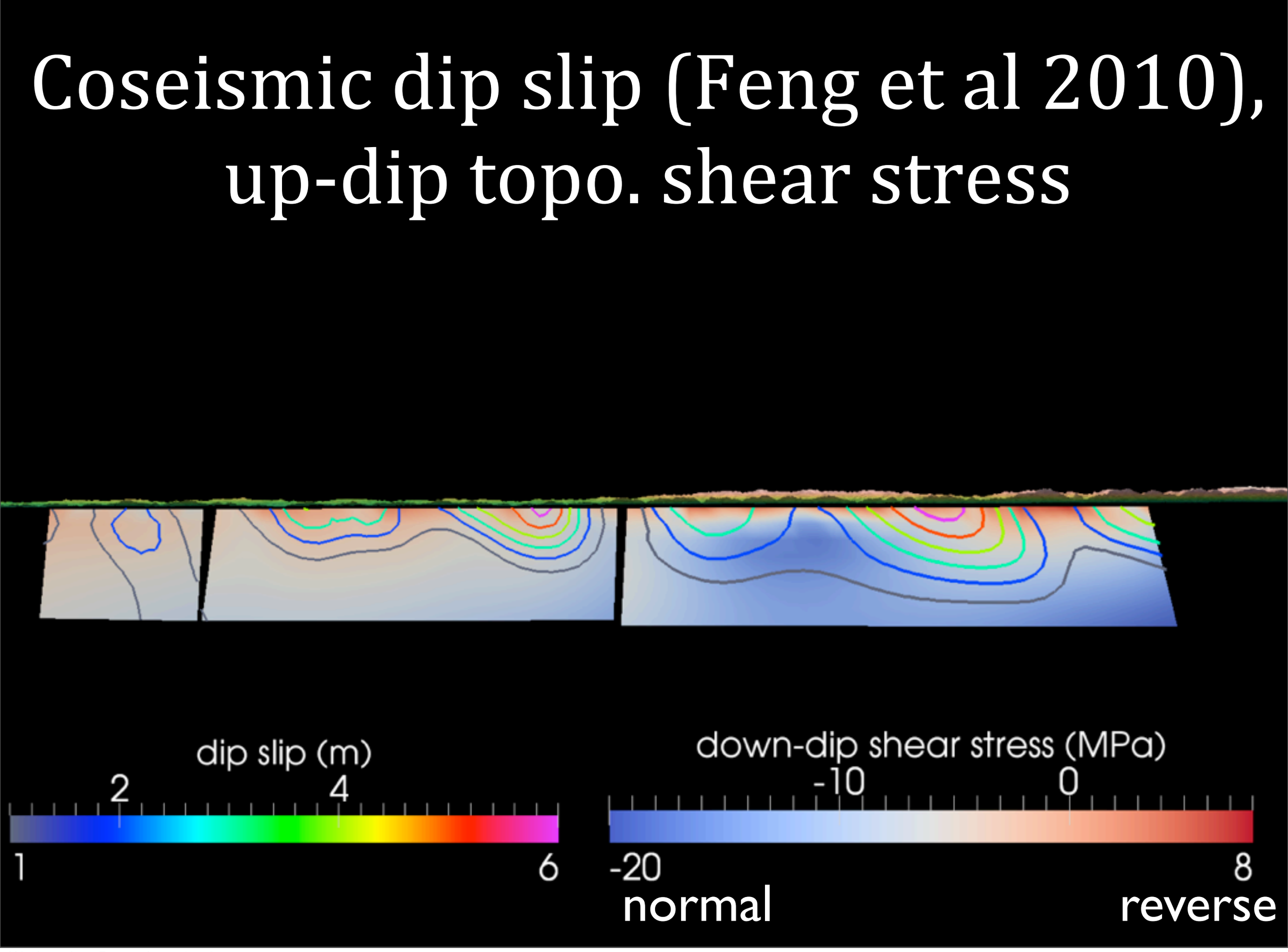
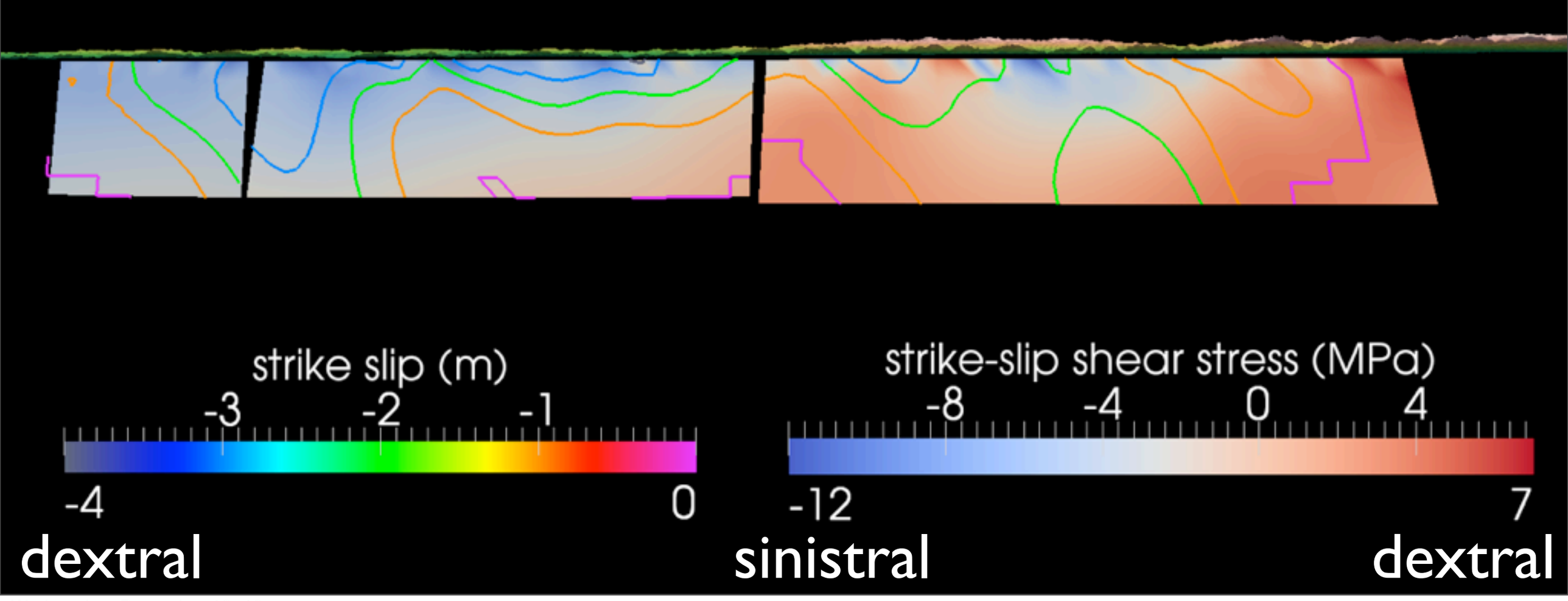
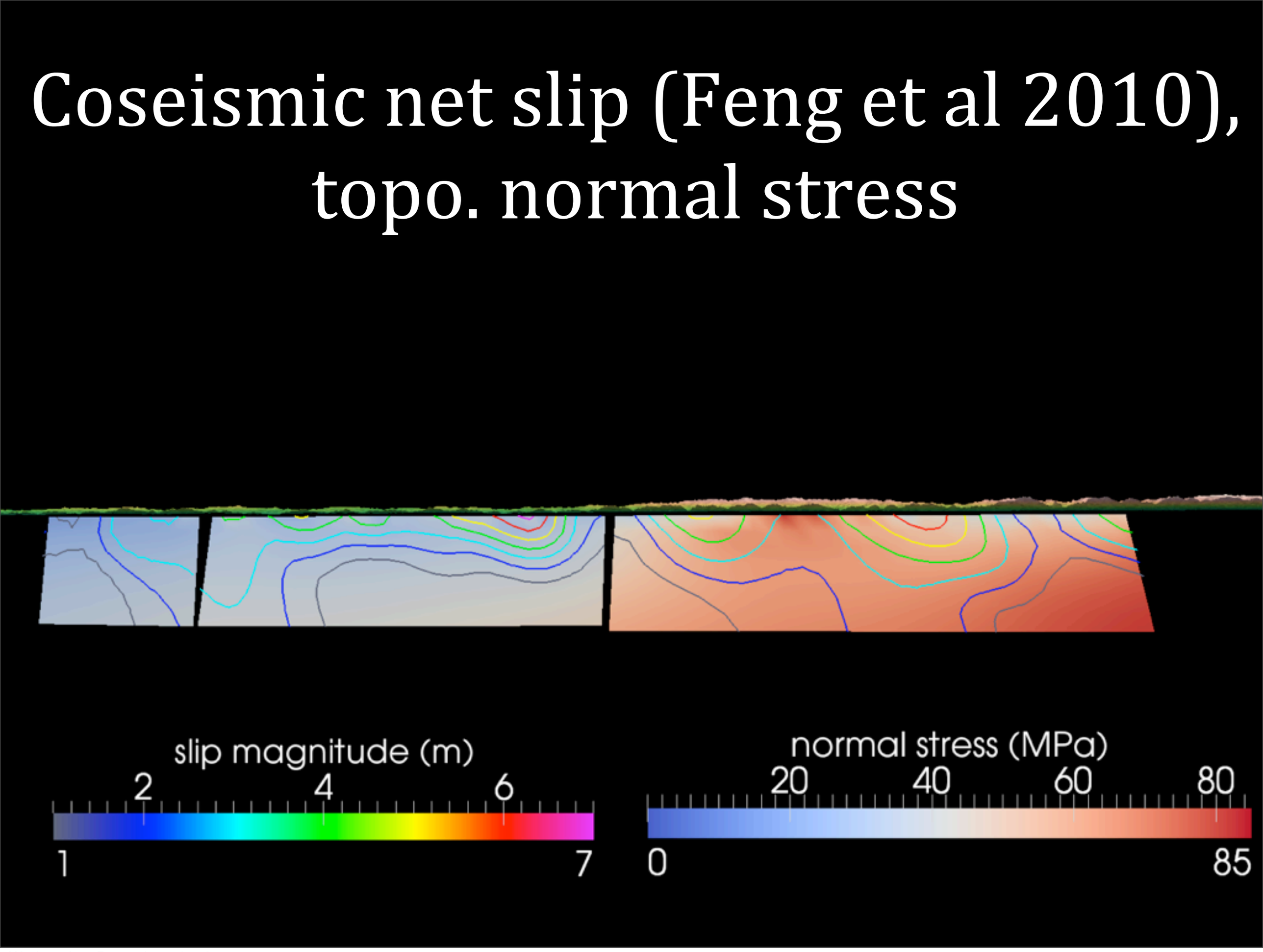
Coseismic dip slip (Feng et al 2010), up-dip topo. shear stress

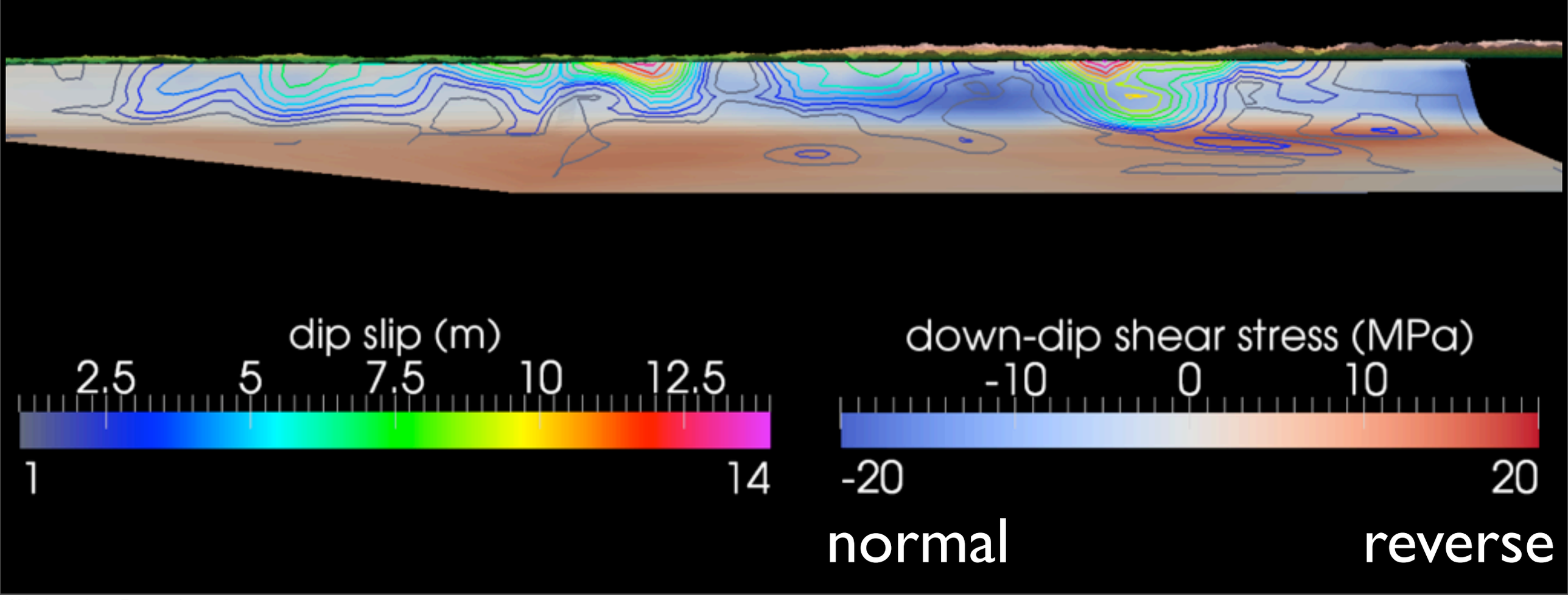


Coseismic strike slip (Feng et al 2010),
along-strike topo. shear stress

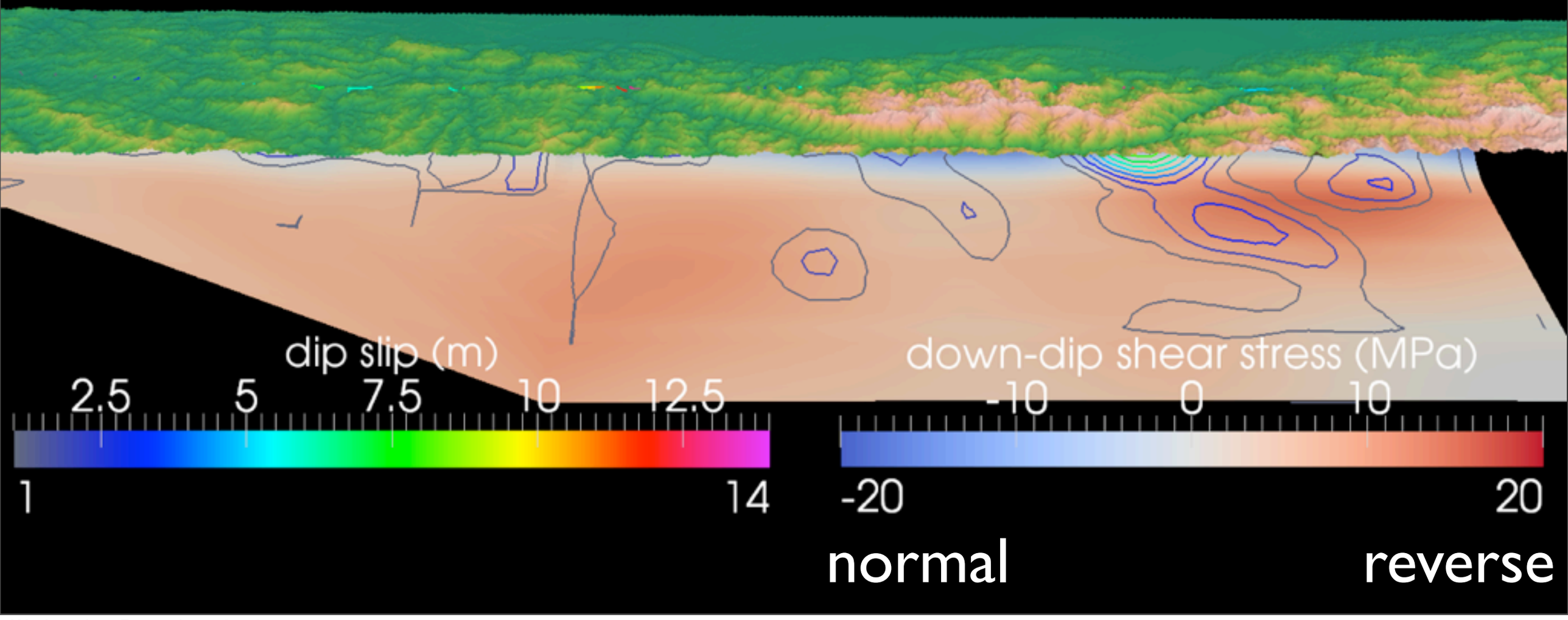


Coseismic net slip (Feng et al 2010), topo. normal stress

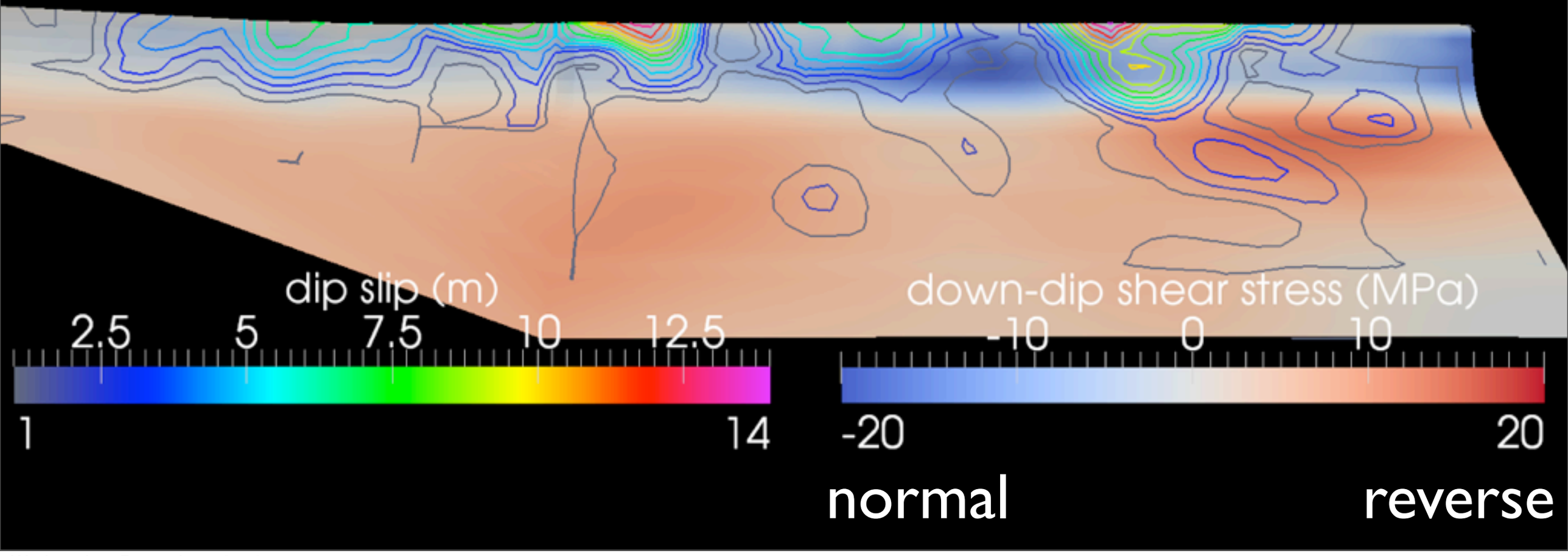



dip slip (m)
2.5
5
7.5
10
12.5
1
14
down-dip shear stress (MPa)
-10
0
10
-20
20
normal
reverse

Coseismic dip slip (Qi et al 2011), up-dip topo. shear stress



Coseismic dip slip (Qi et al 2011), up-dip topo. shear stress



Coseismic strike slip (Feng et al 2010),
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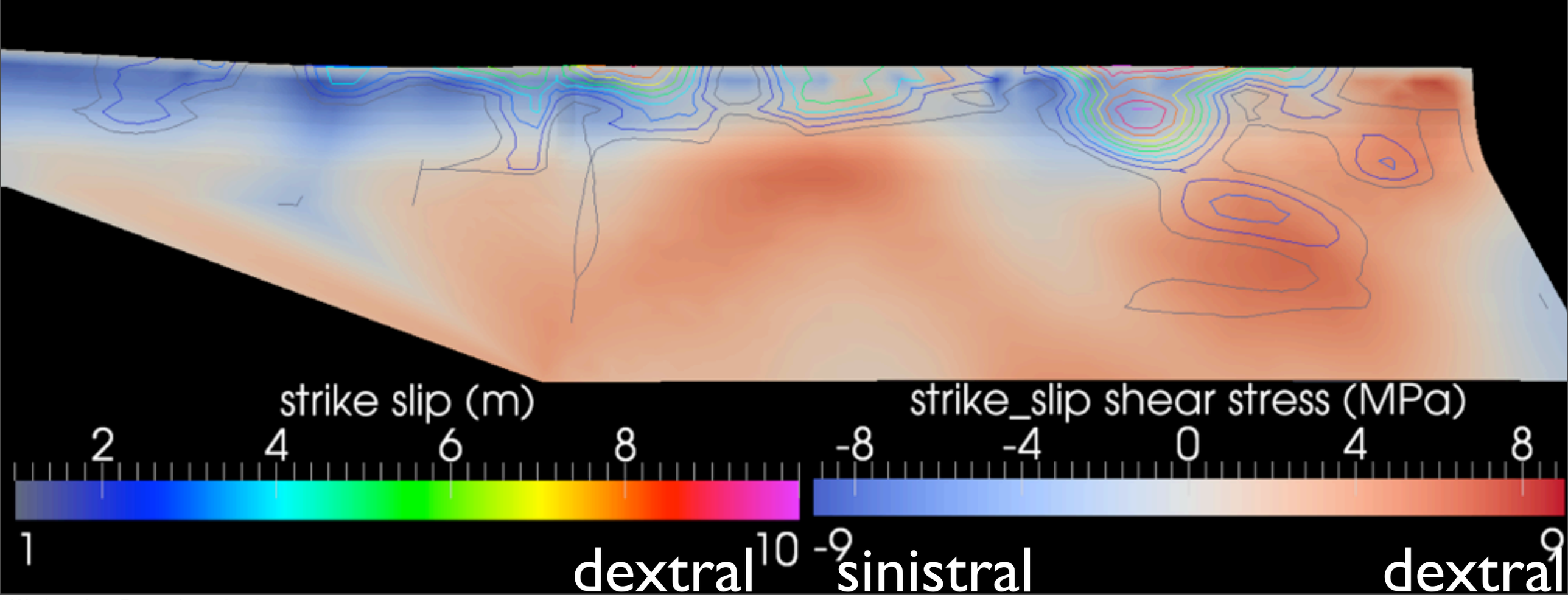
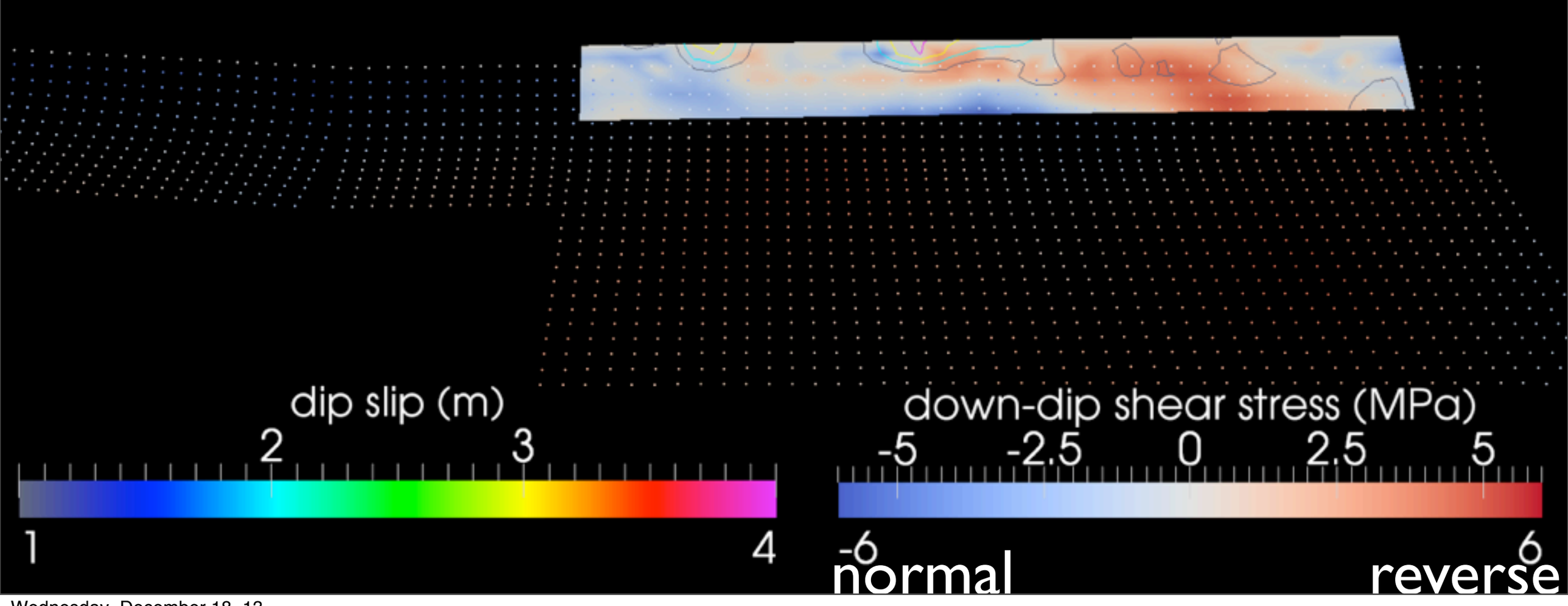
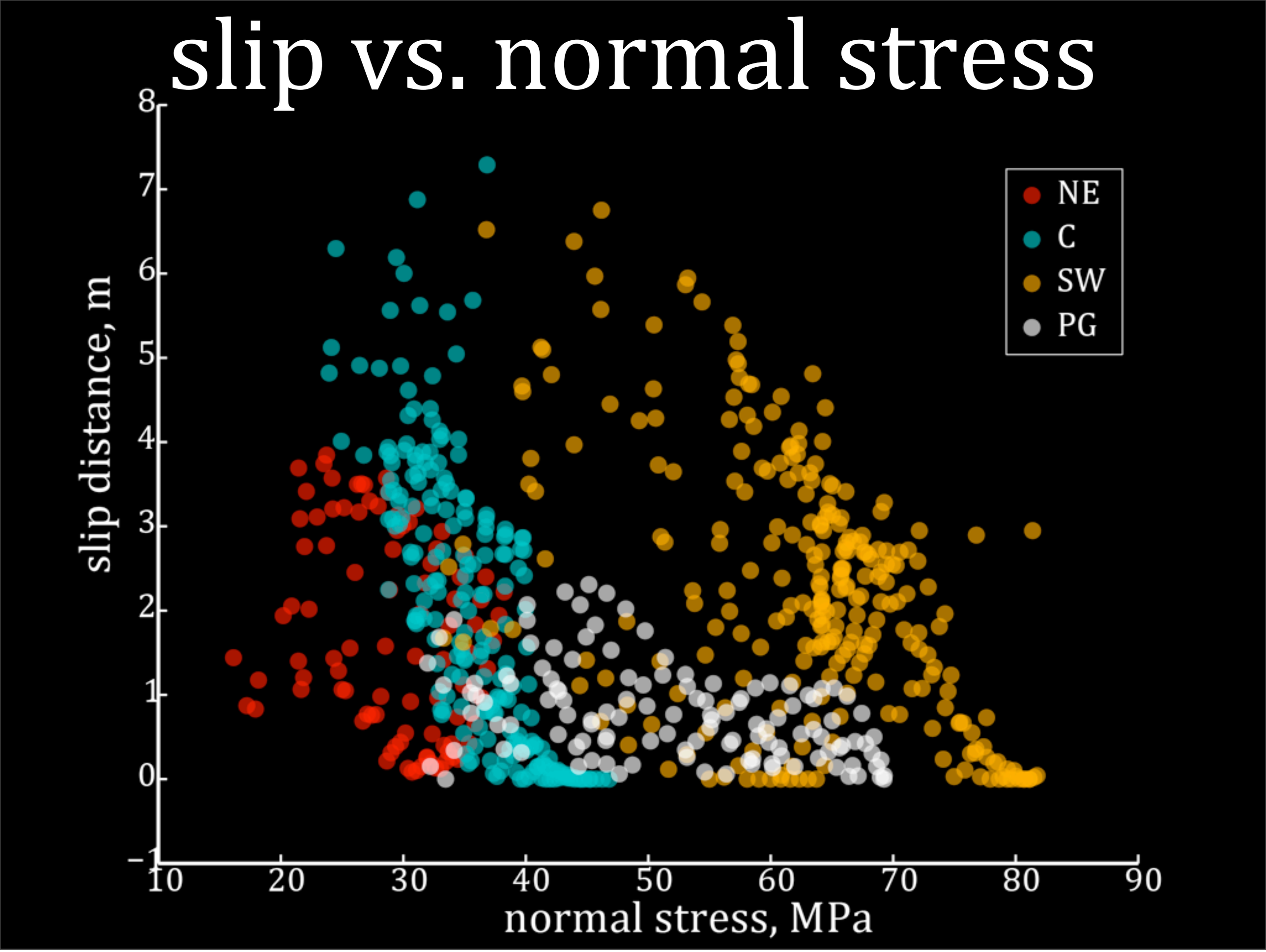


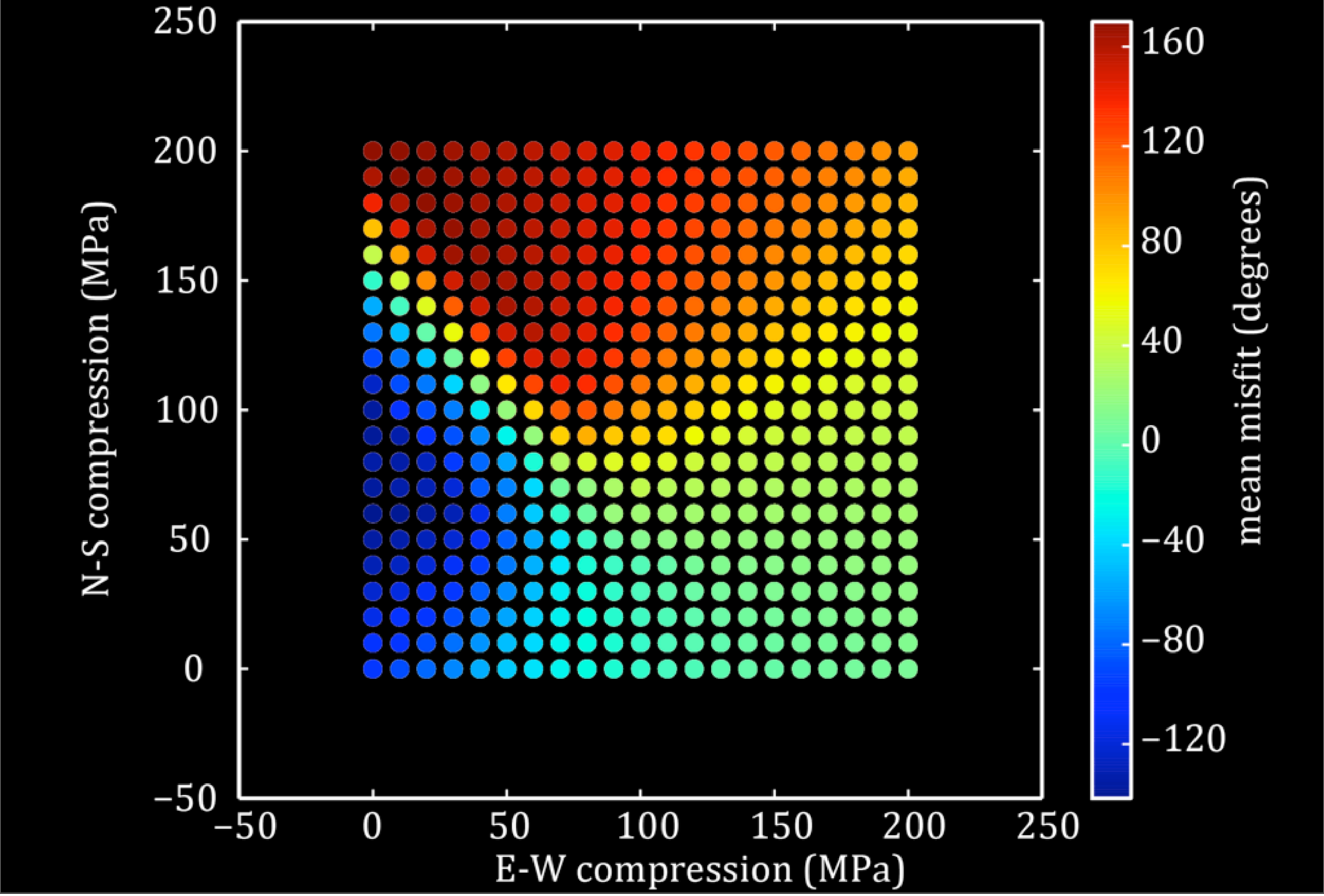
Coseismic dip slip (Qi et al 2011), up-dip topo. shear stress



slip vs. normal stress



Tectonic stresses



Summary of results

- Topographic stresses on the Wenchuan earthquake faults are large, heterogeneous, and persistent through the earthquake cycle
- Topographic stresses are mostly opposed to tectonic stress
  - Can give us constraints on tectonic stress
- Topographic stresses locally suppress coseismic slip

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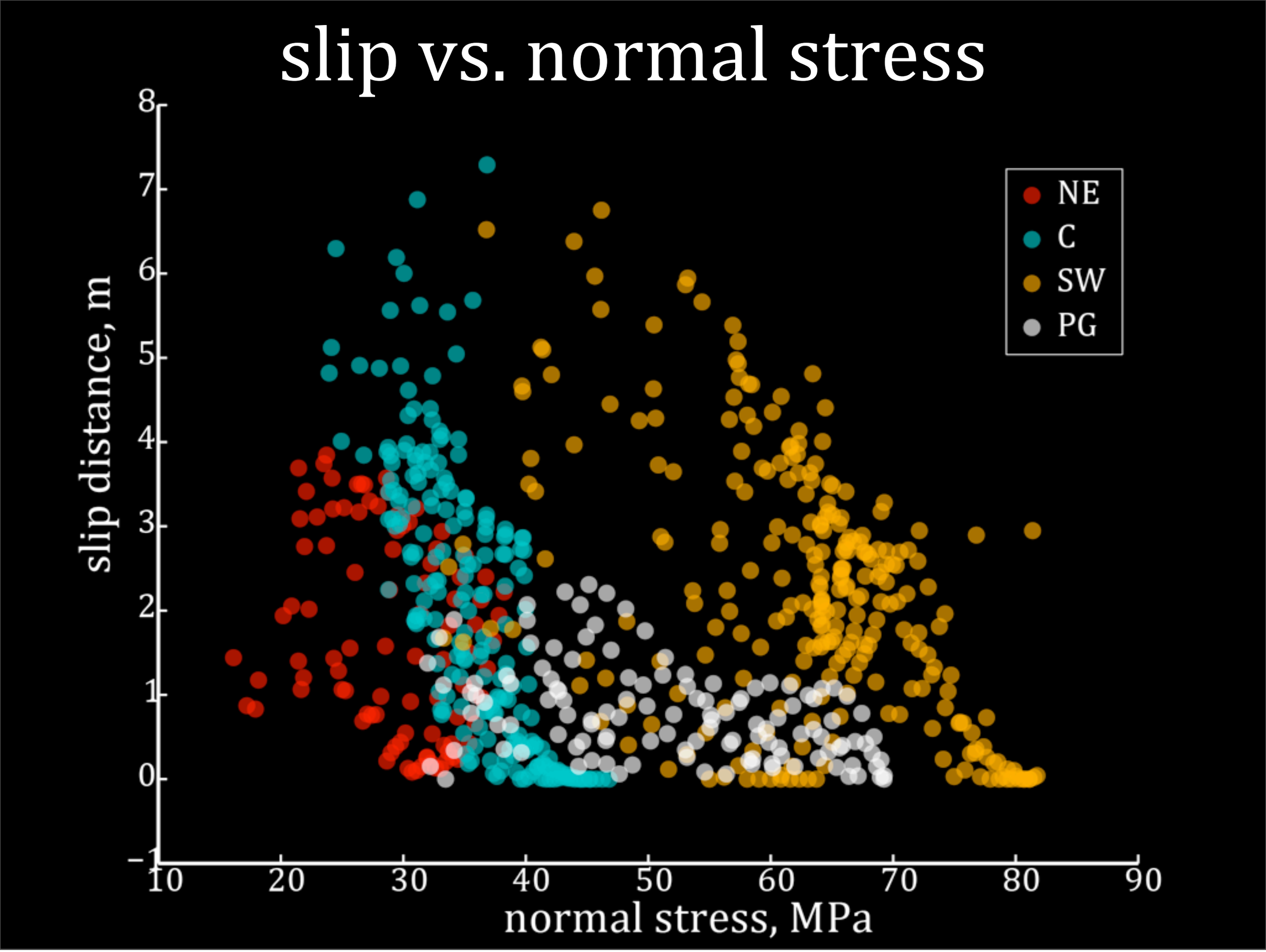
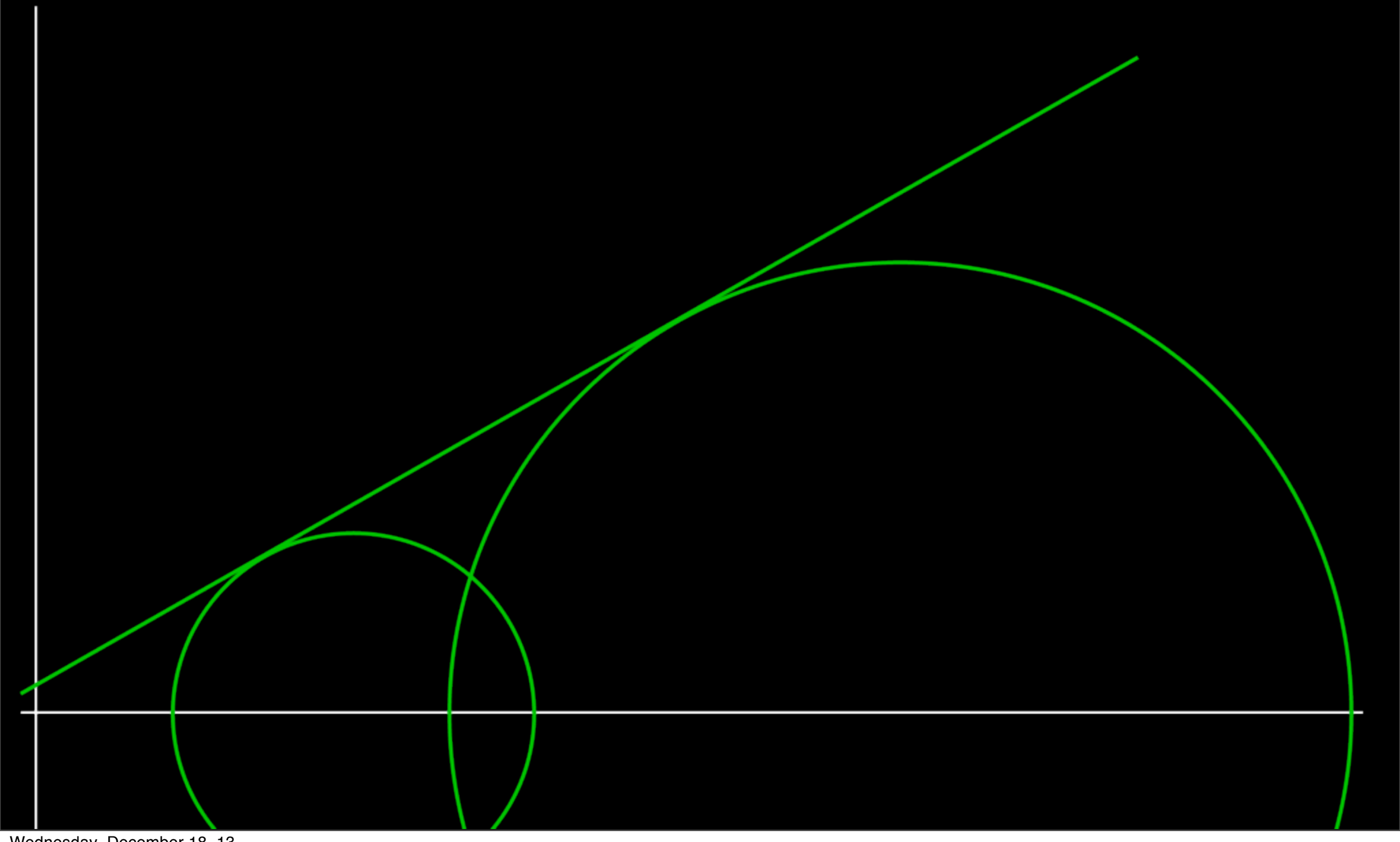


slip and stress drop



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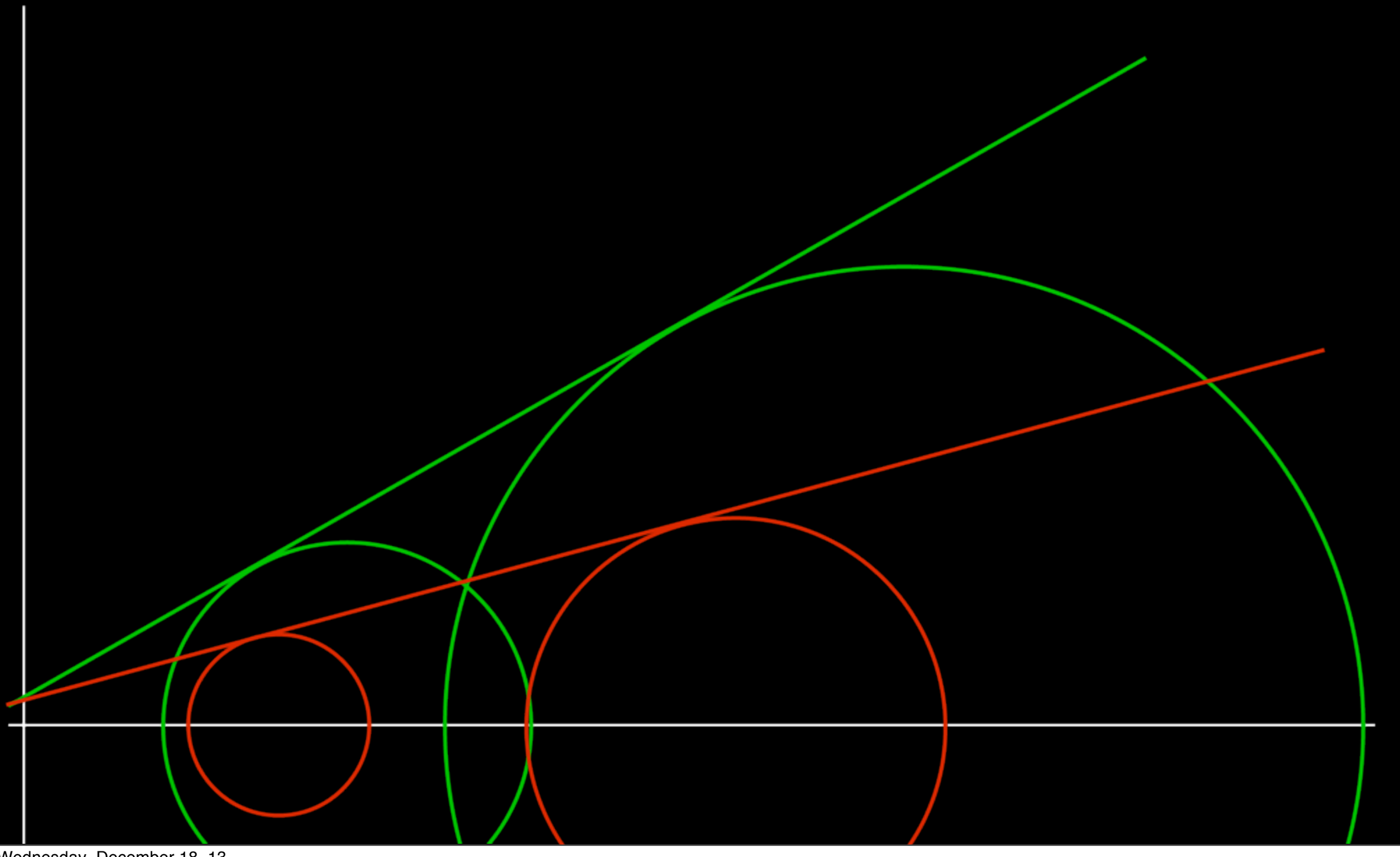
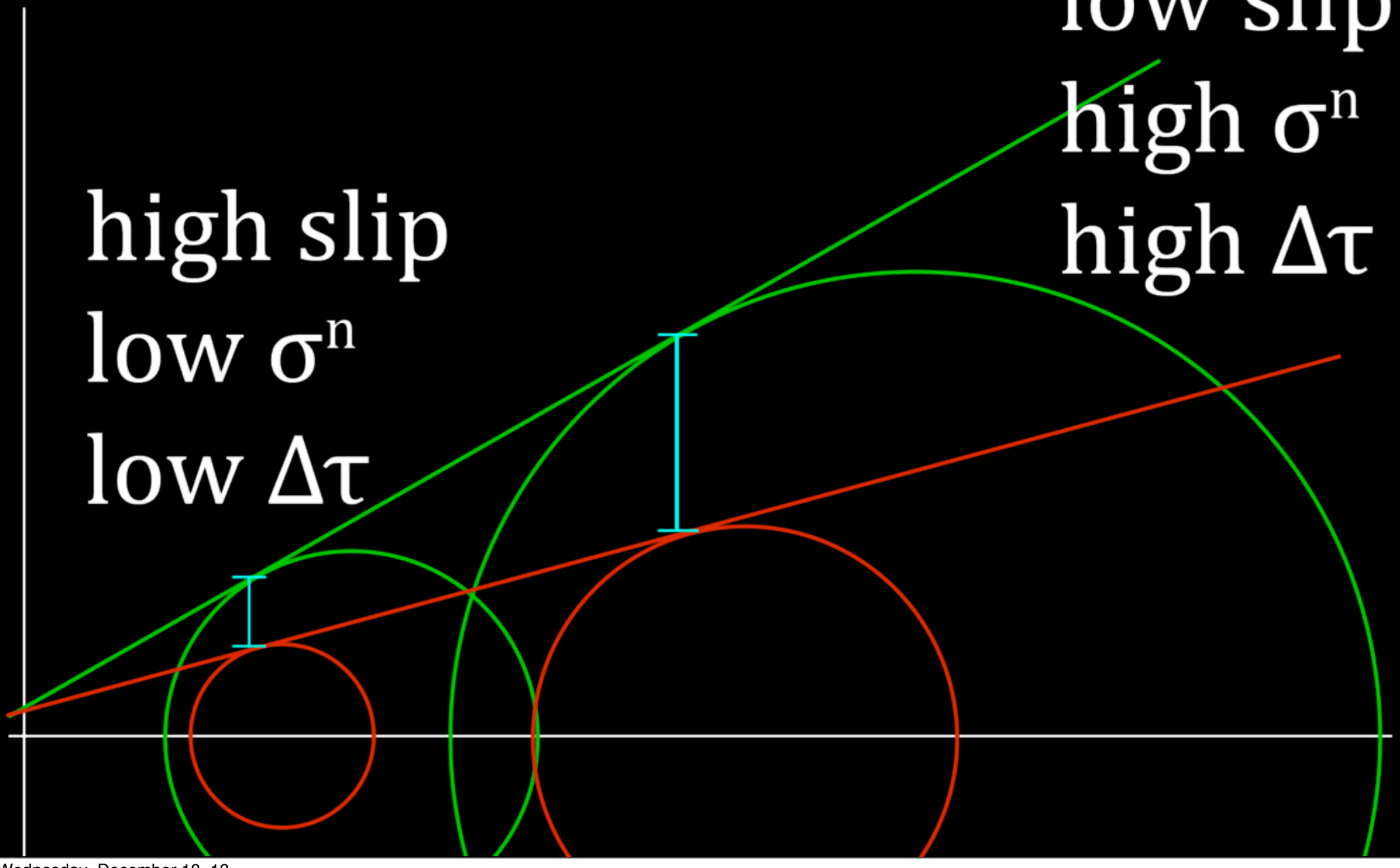


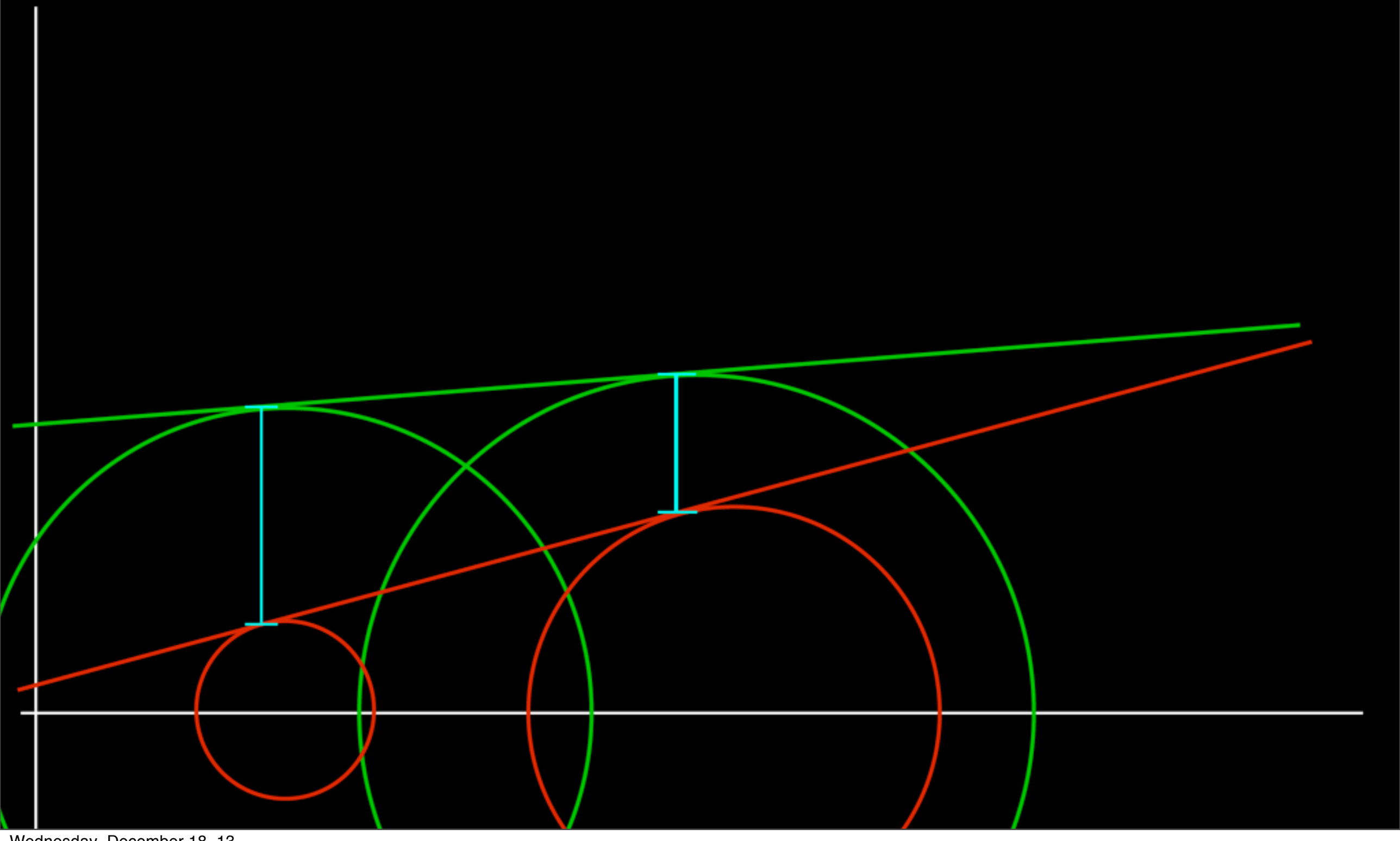
slip and stress drop

low slip
high σ^n
high $\Delta\tau$

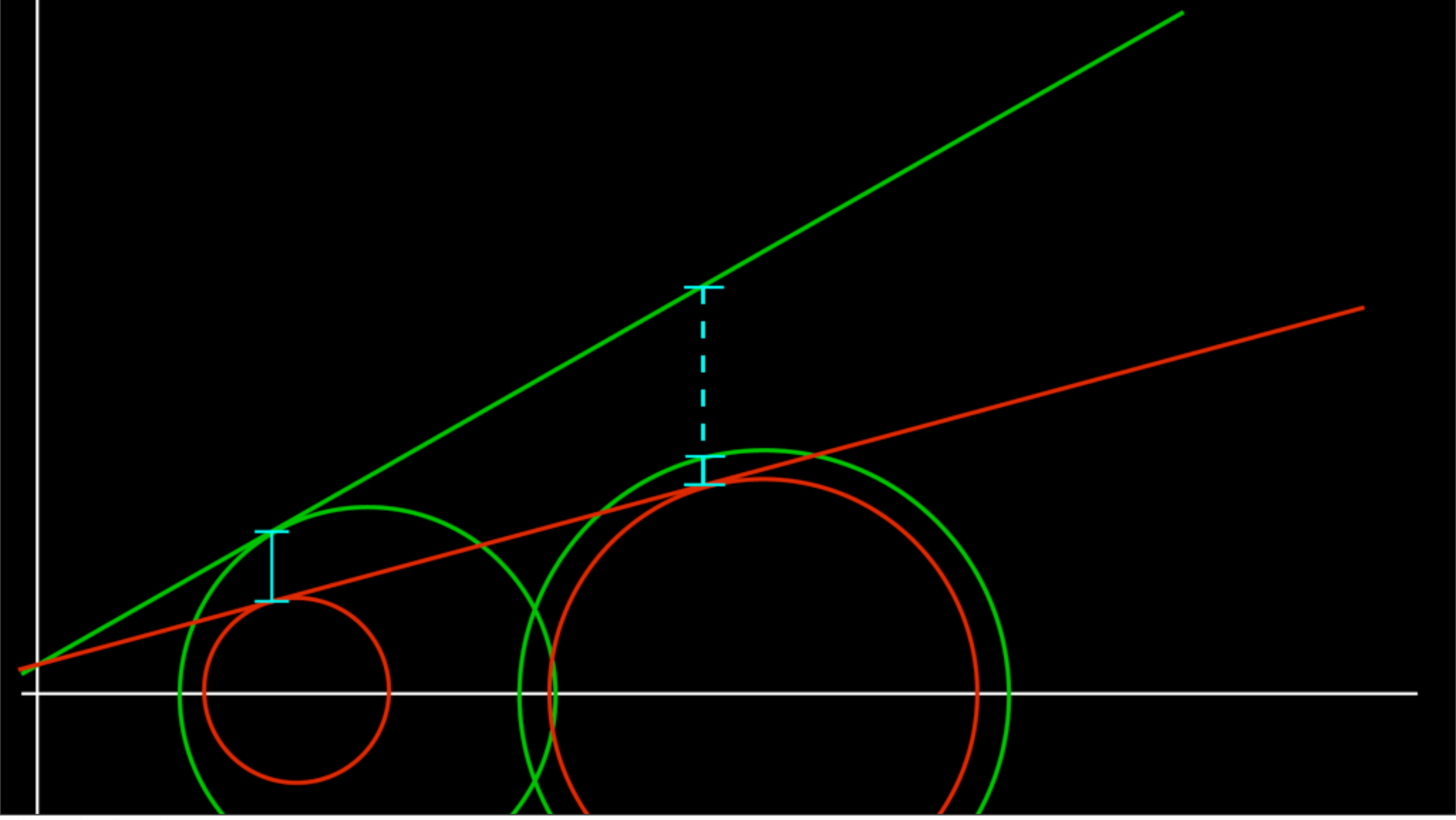
high slip
low σ^n
low $\Delta\tau$



high initial shear stress?



low initial shear stress, dynamically kicked to failure



different arrest frictions?