Interactions among climate, hydrology, surface processes and tectonics:

Challenges across timescales

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Scientific themes

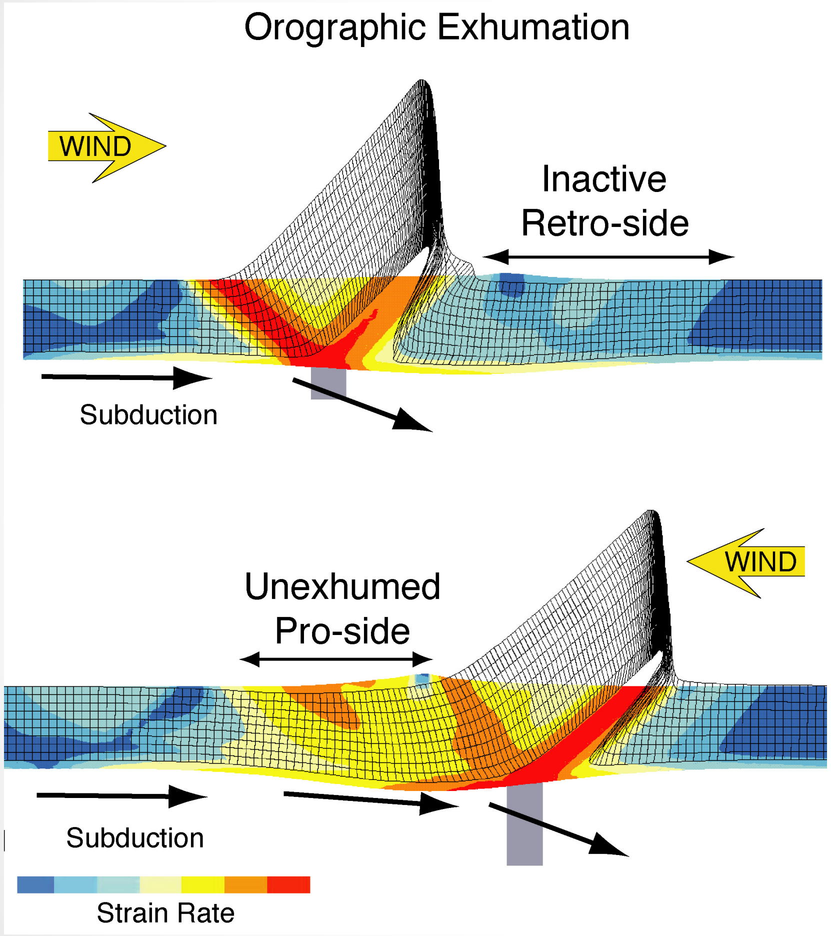
- Feedbacks among climate, erosion and orogen evolution
- Influence of mantle flow and dynamic topography on surface

- Response of surface fluxes (ice, water, sediment) to natural and anthropogenic forcing
- Response of solid earth to changes in surface loads

Although each theme has specific technical and scientific challenges, all share the need for close coordination with broader geoscience communities

‘Geologic’ timescales

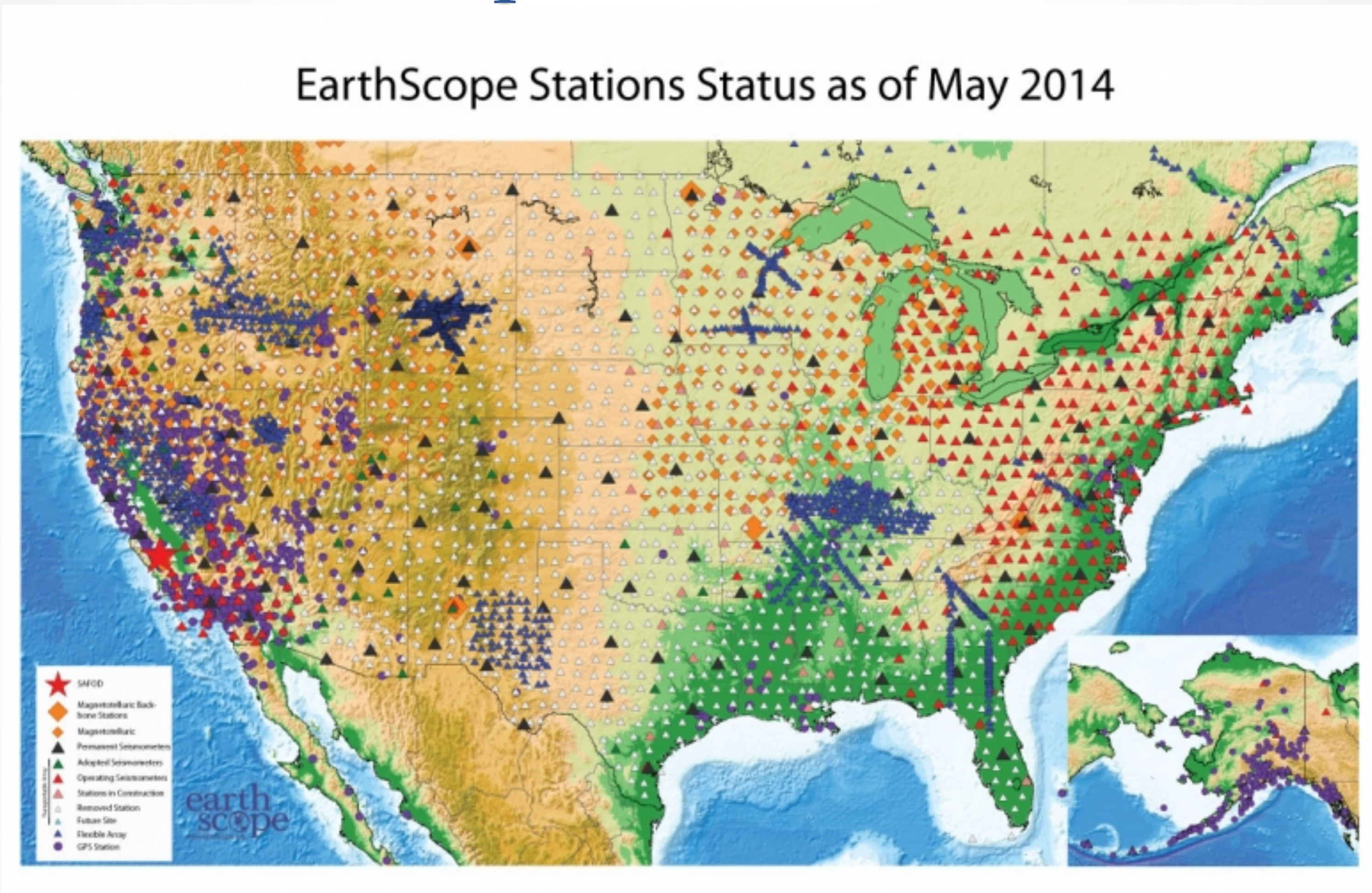
Evolution of orogenic wedges in response to climate



Willett, 1999 - *JGR*

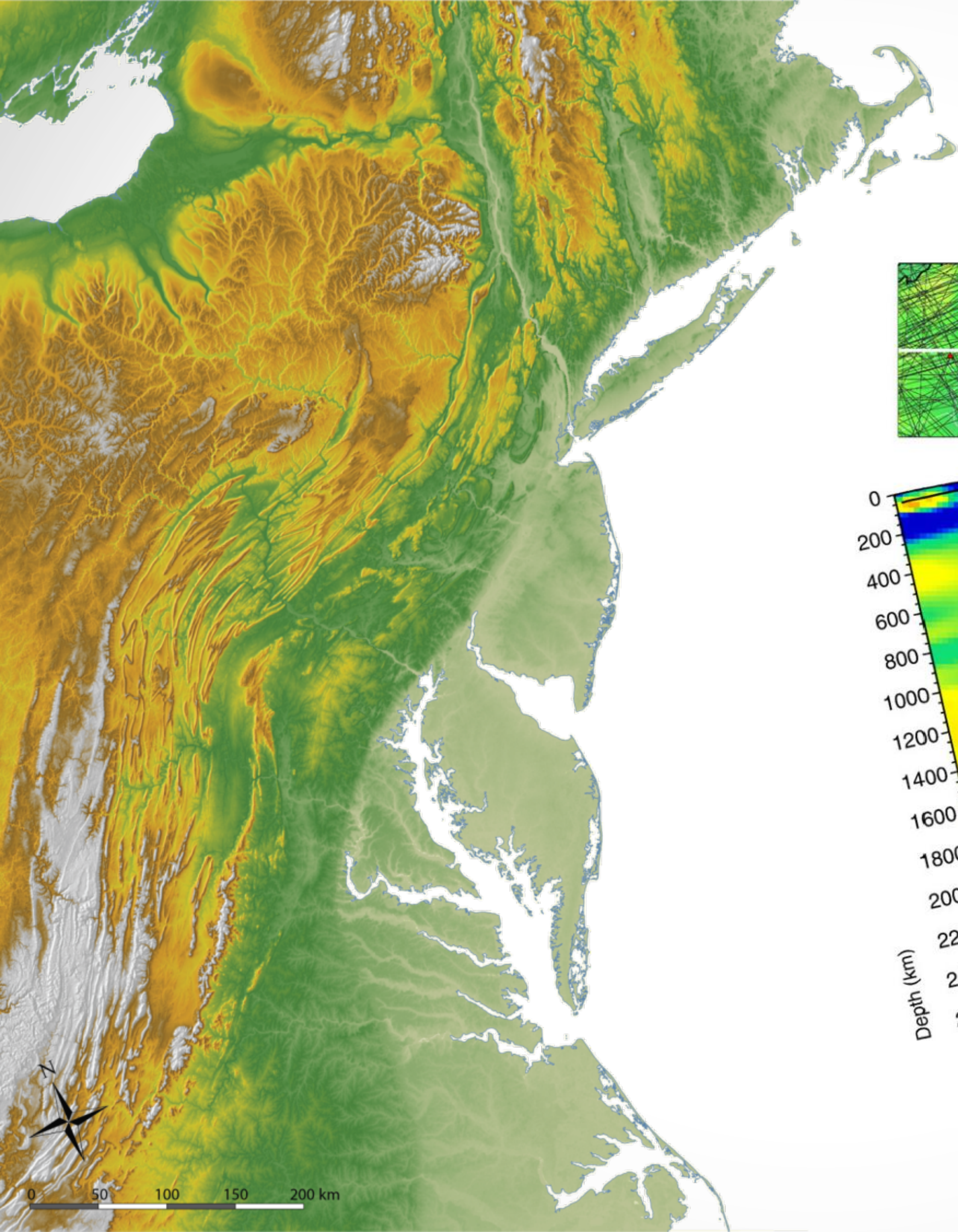
- Challenge:
  - Long response time
    - ~1-5 Ma (Whipple, 2009)
  - Link between climate and erosional efficiency uncertain
  - Requires known change in state across steady tectonic forcing

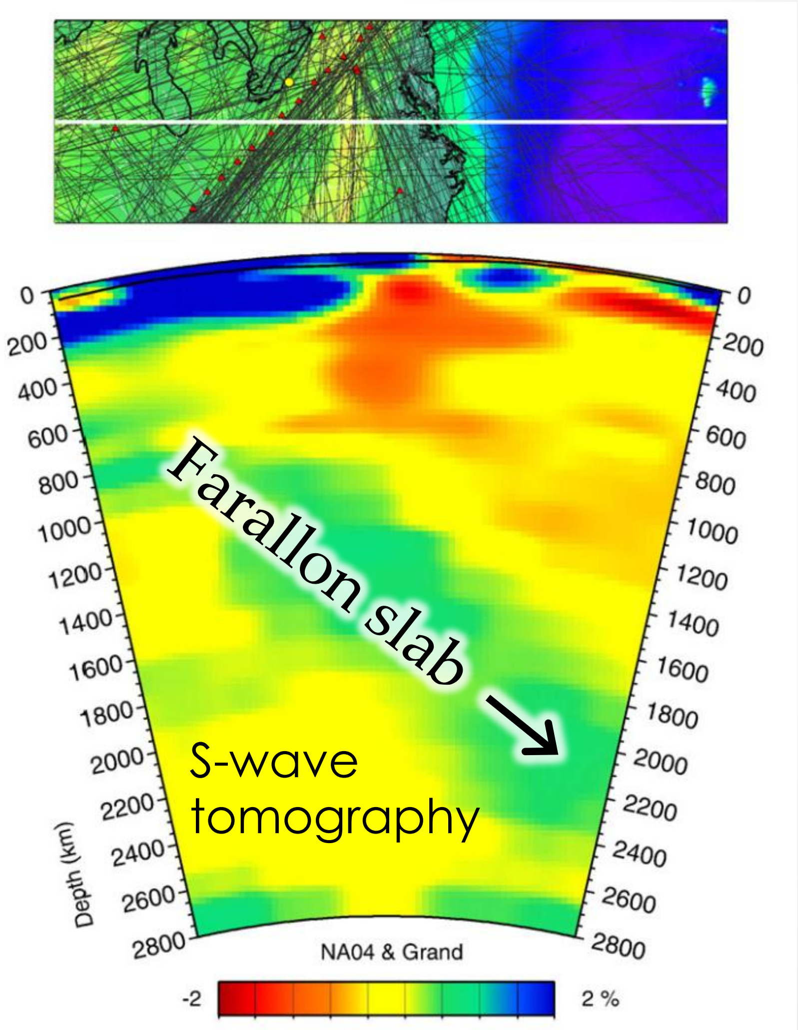
Surface response to mantle flow



- Emerging results from:
  - Eastern North America
  - Sierra, Rockies, CO Plateau

Topography along eastern seaboard?

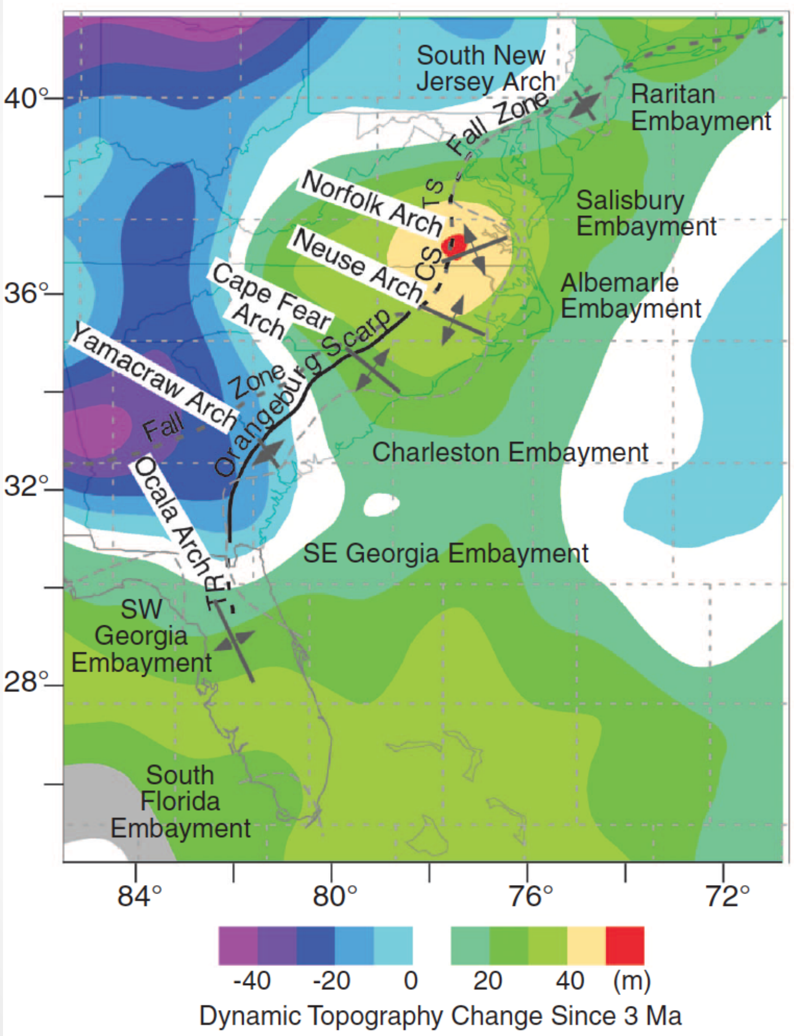




Van der Lee et al., 2008, EPSL

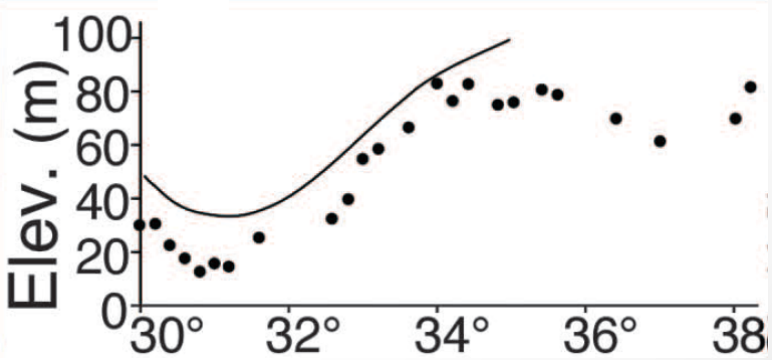
What record is in the landscape?

Surface response to mantle flow



Rowley et al, 2013 - *Science*

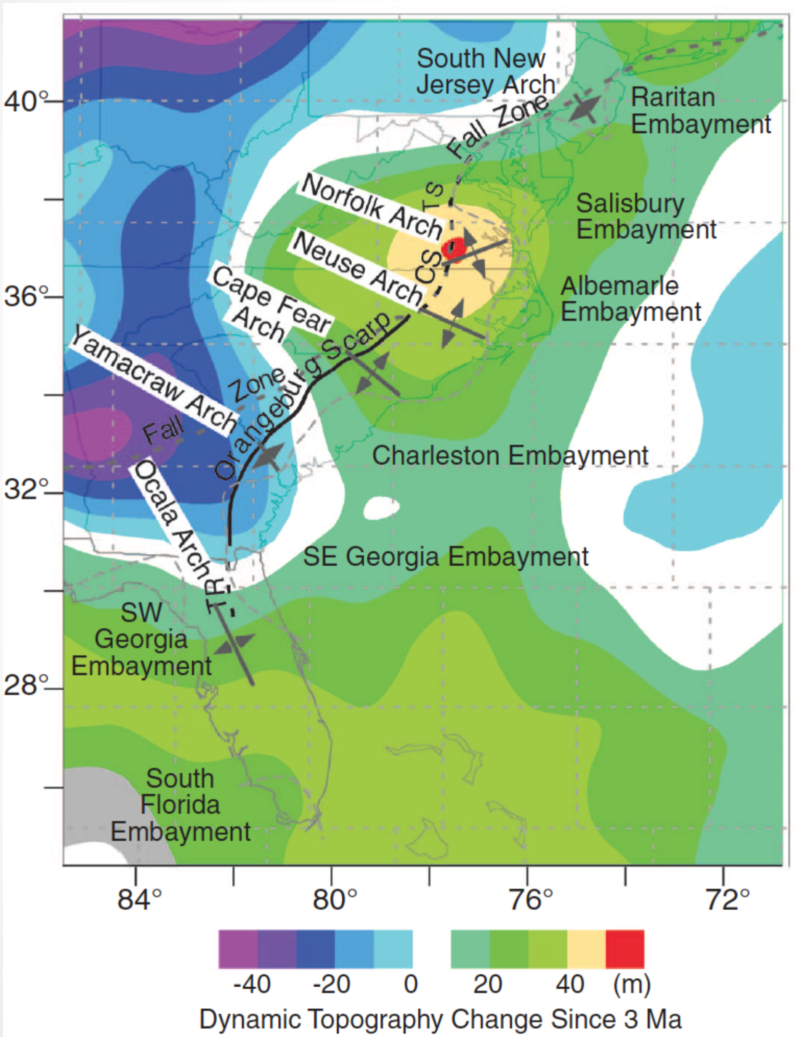
- Pliocene shoreline varies by ~60 m
- Appears to correspond to change in dynamic topography since ~3 Ma



Elevation of Pliocene shoreline

What record is in the landscape?

Surface response to mantle flow

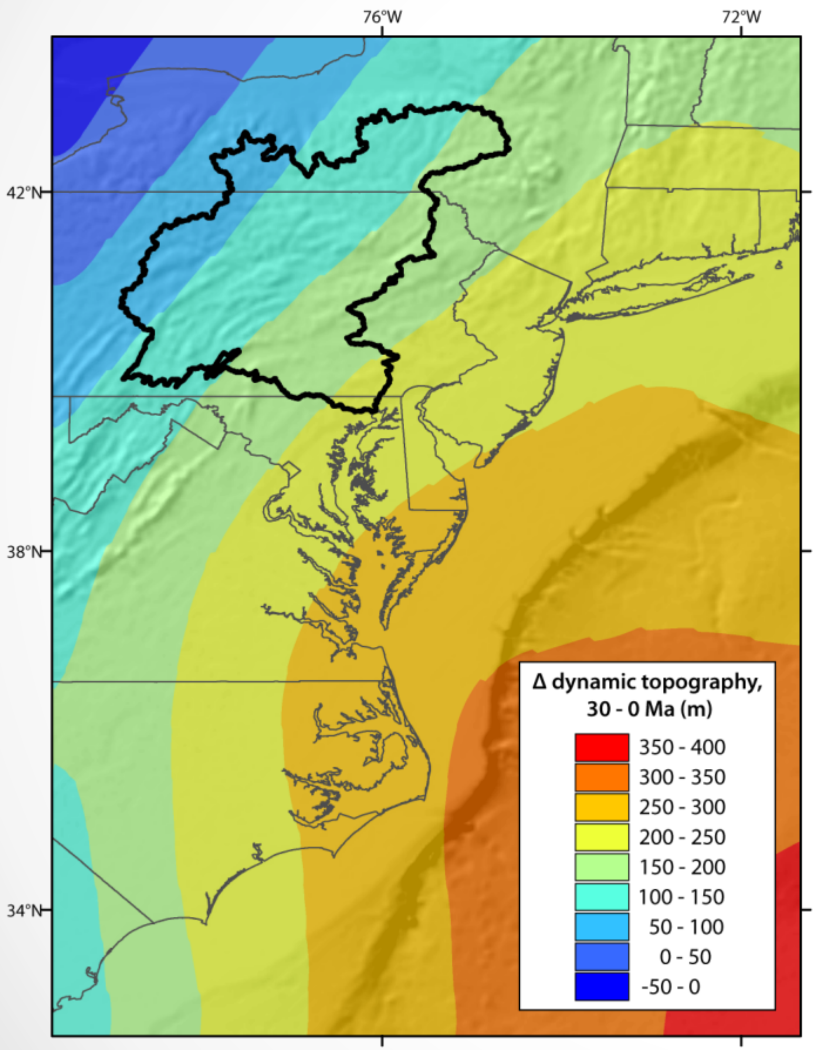


Rowley et al, 2013 - *Science*

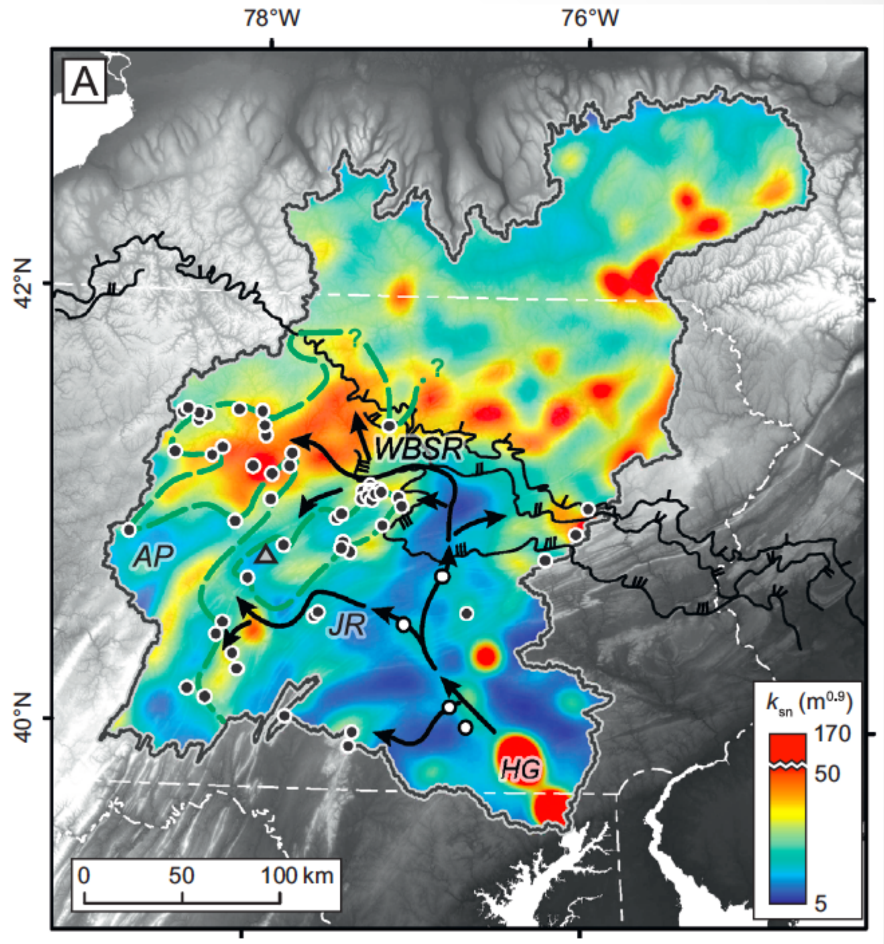
- Challenges:
  - Improving mantle flow models
    - Resolution of fine earth structure
    - Translation from seismic velocity to density
    - Mantle viscosity structure
    - GIA
  - Surface response
    - complicated by climate, lithology, uncertainty in process

Peering back in time

Surface response to mantle flow since Miocene?

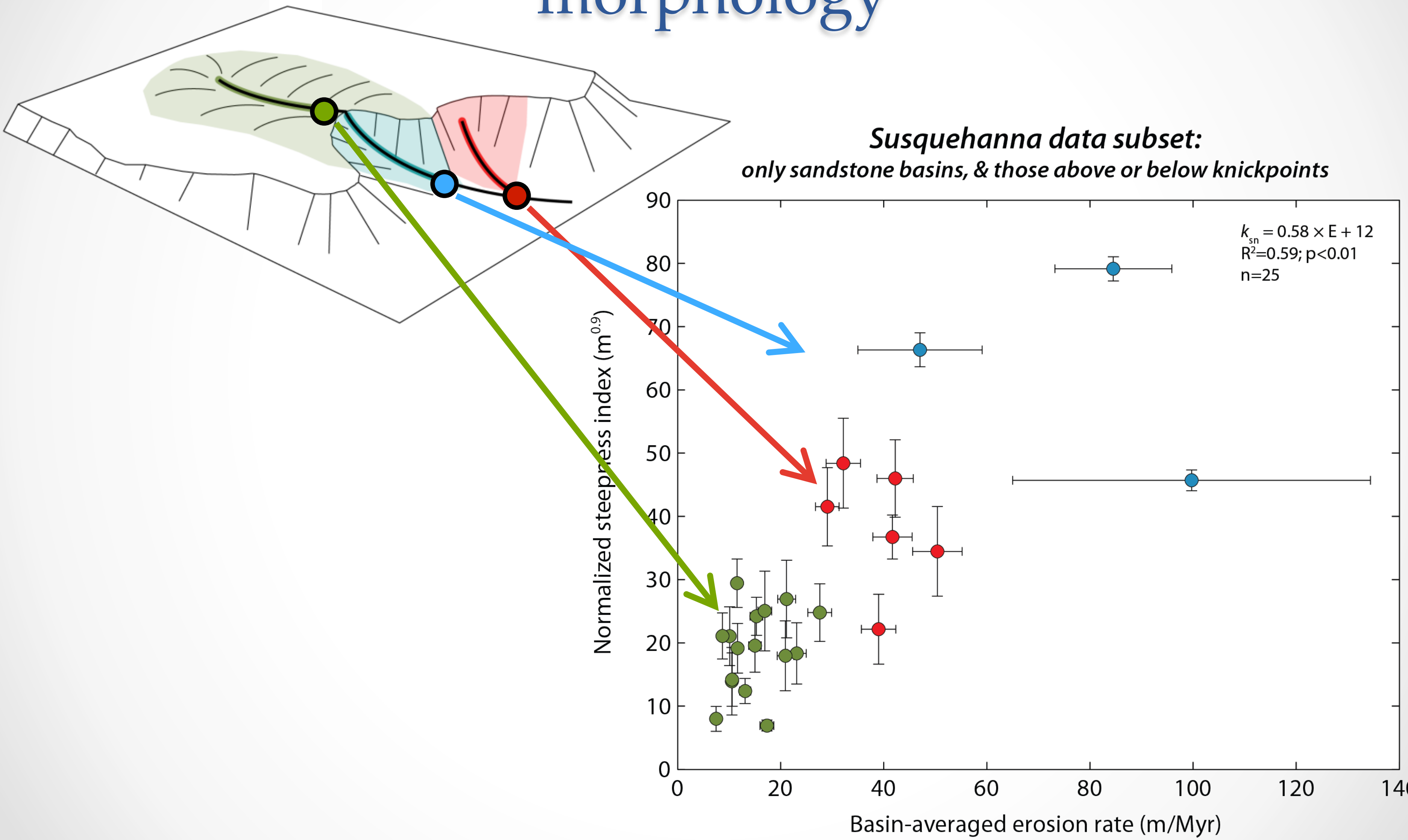


(adapted from Moucha et al., 2008, EPSL)



Miller et al, 2013 - *EPSL*

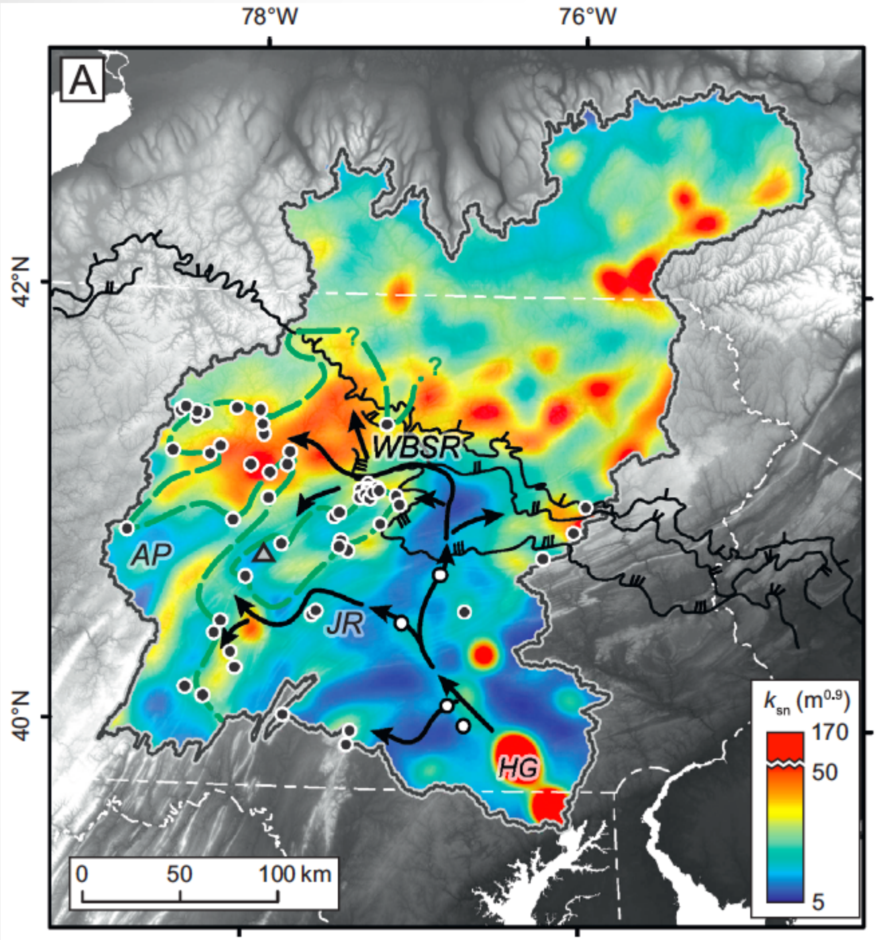
Erosion rates are tied to channel morphology



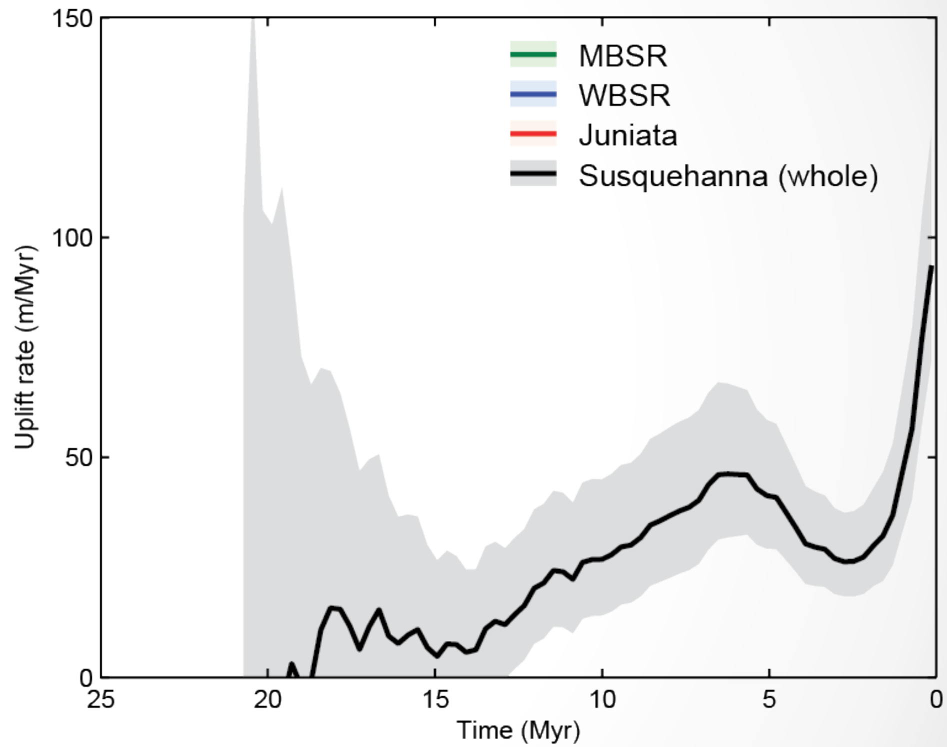
- Miller et al., 2013 - EPSL

Timing and magnitude of uplift

~150 – 200 m since 15 Ma

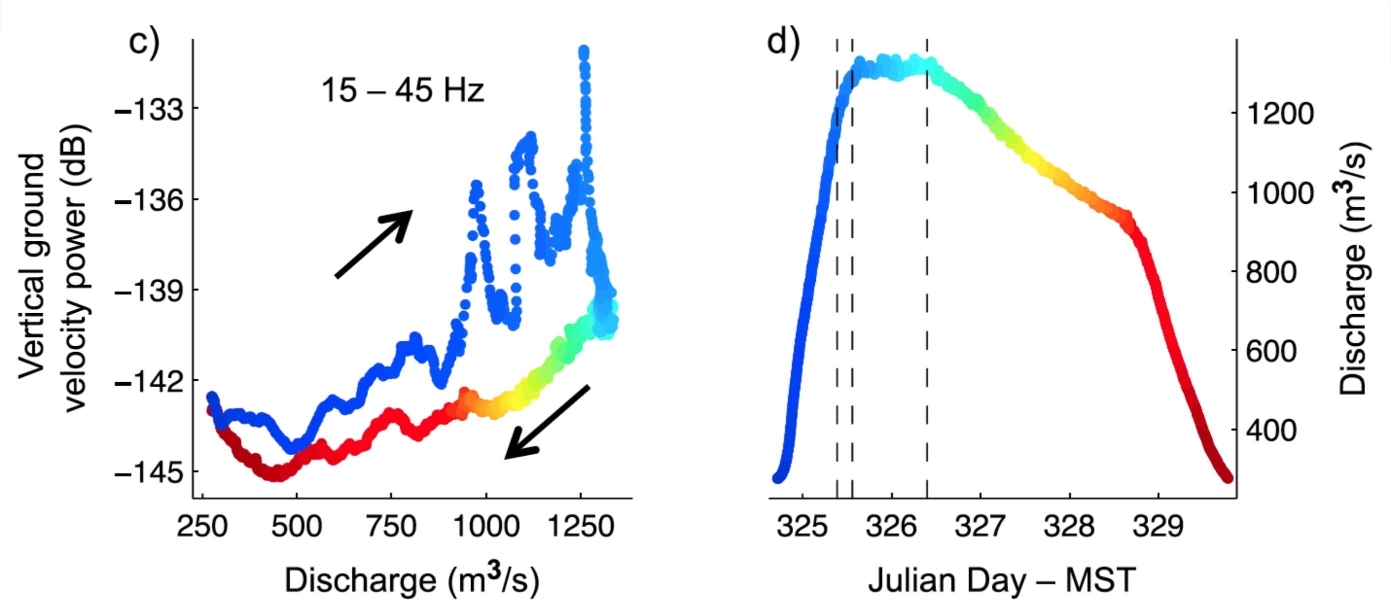


Miller et al, 2013 - *EPSL*



‘Anthropogenic’ timescales

Direct monitoring of surface fluxes (ice, water, sediment)

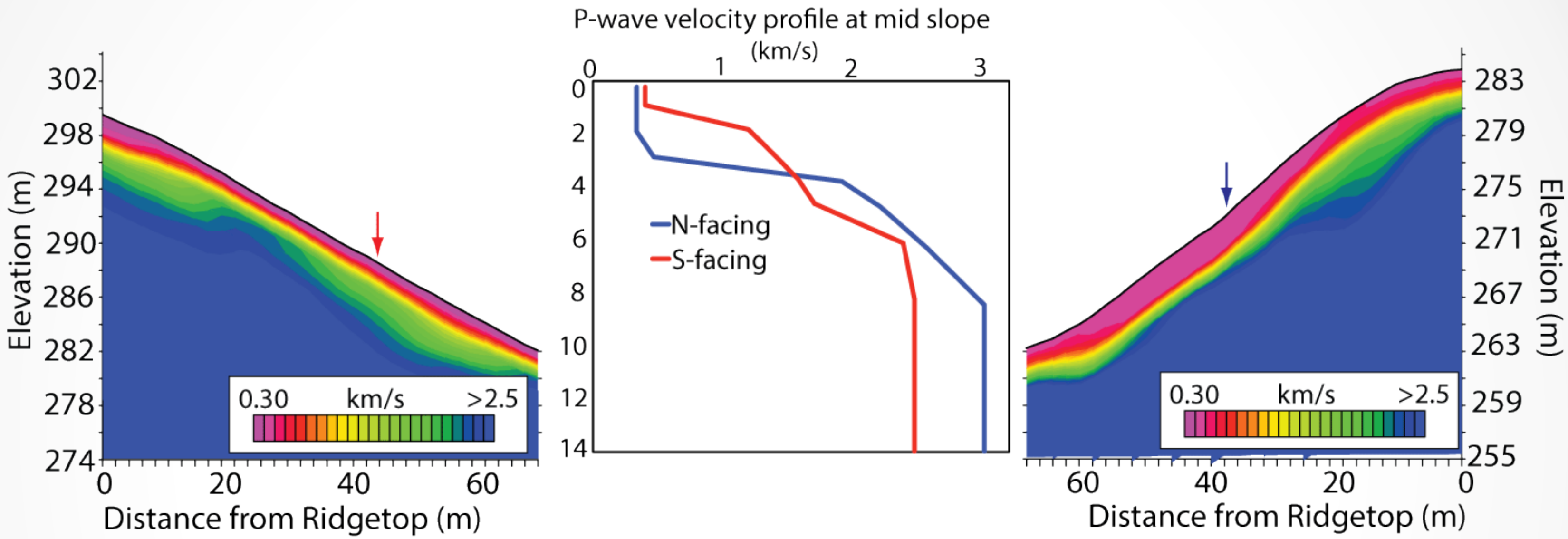


Schmandt et al, 2013 - *GRL*

- Challenges:
  - Quantitative relationship between frequency content and sediment flux
    - Sediment caliber, rock properties (Tsai et al., 2012)
    - Intermittency of sediment flux

‘Anthropogenic’ timescales

Characterization of rock fracture

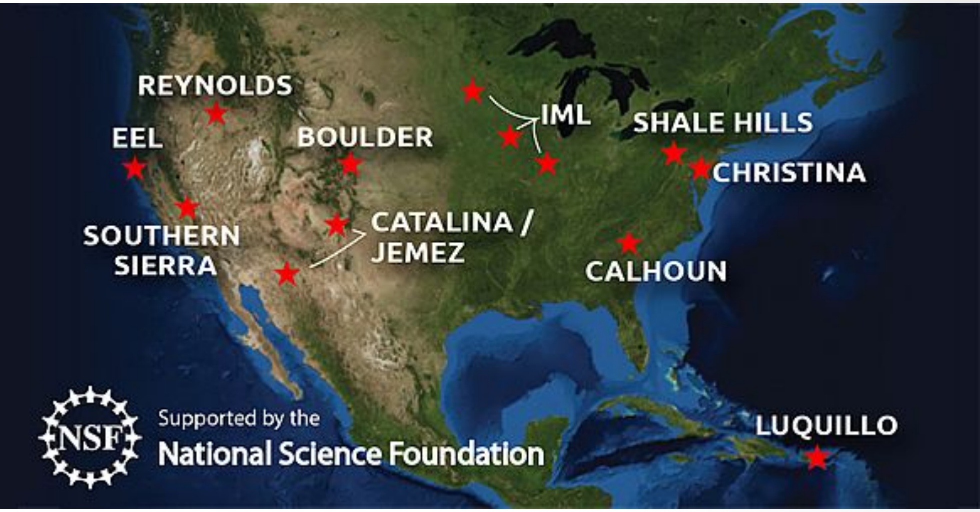


Clarke et al, unpublished

- Opportunity:
  - Rock fracture sets architecture of rock/regolith interface, influences grain size and susceptibility to weathering, dictates shallow hydrology
  - Prediction of fracture distribution is in infancy

‘Anthropogenic’ timescales

Better characterization of rock fracture



- Opportunities:
  - NSF Critical Zone Observatories
  - National Center for Earth Surface Dynamics (NCED)
  - Industry (hydrofracturing)

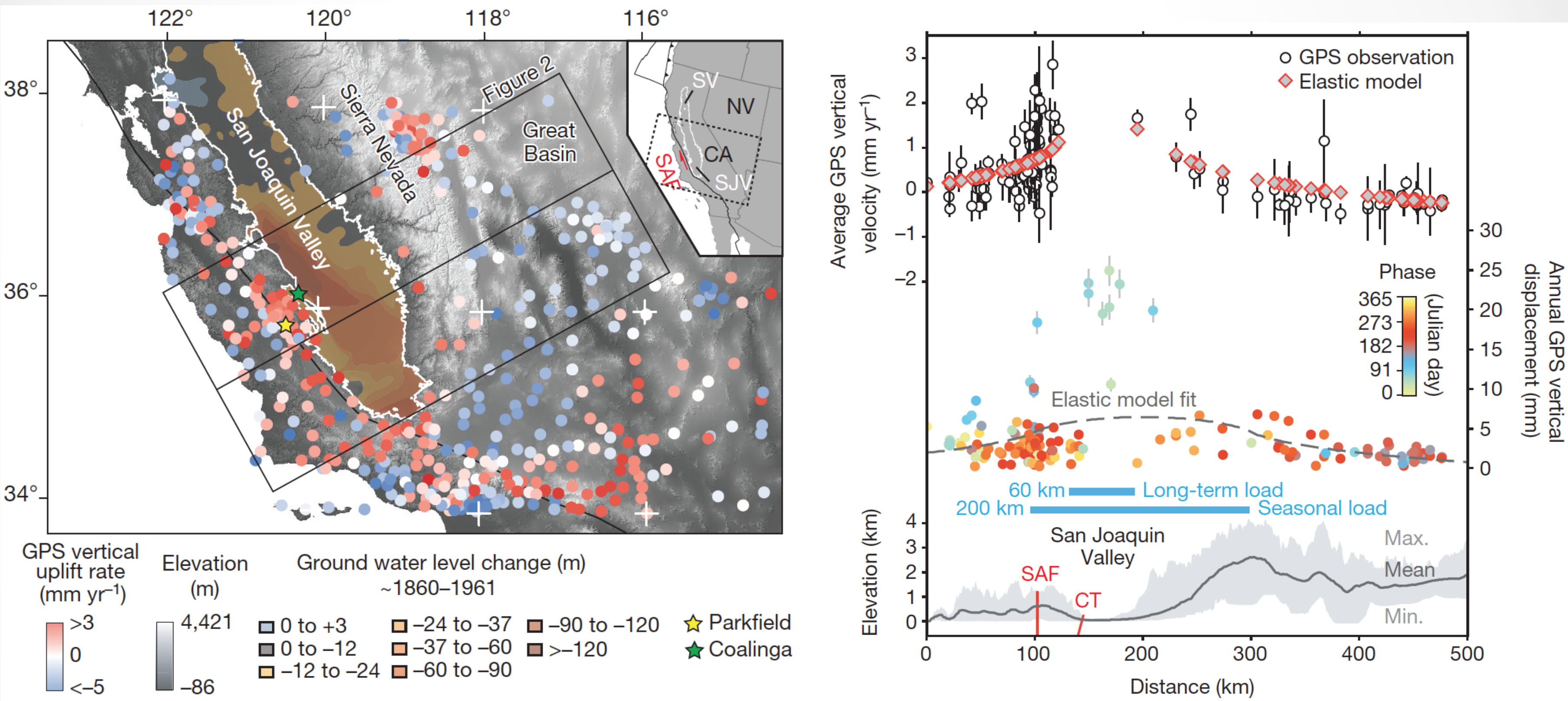
Looking forward

- ES deployment to Alaska (SAGE)
  - Cryosphere/tectonic interaction
  - Linkages between sediment and subduction zone behavior
- Emerging EarthScope science – surface to mantle connections
- Shallow rock properties – erosion, weathering, ecology
- Interface of seismology with other disciplines:
  - Close linkages with other facilities (UNAVCO), centers (NCED), programs (CZO), and modeling efforts (CIG, CSDMS)


earth
scope
www.earthscope.org

'Anthropogenic' timescales

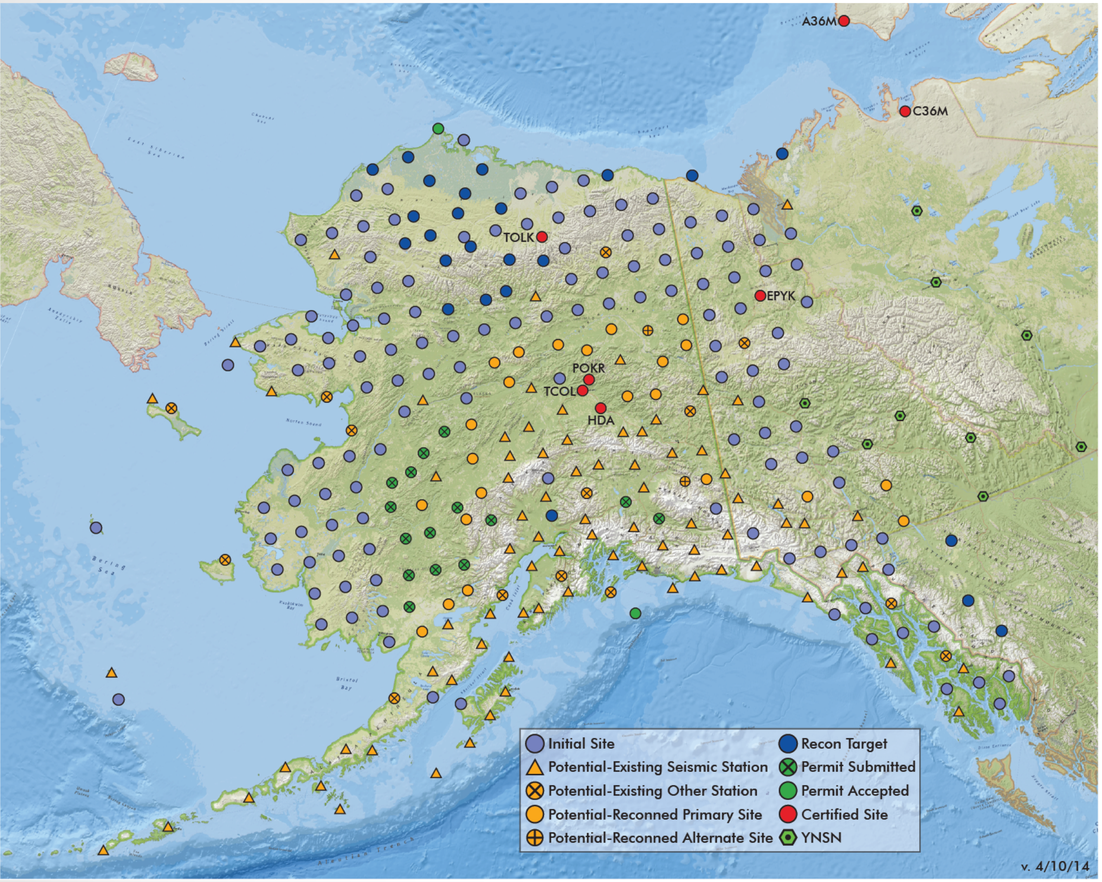
Impact of surface loads on fault behavior



Amos et al, 2014 - *Nature*

‘Geologic’ timescales

Evolution of orogenic wedges in response to climate



EarthScope deployment as of April 10, 2014

- Opportunity:
  - Cryosphere-tectonic interactions in Alaska

'Geologic' timescales

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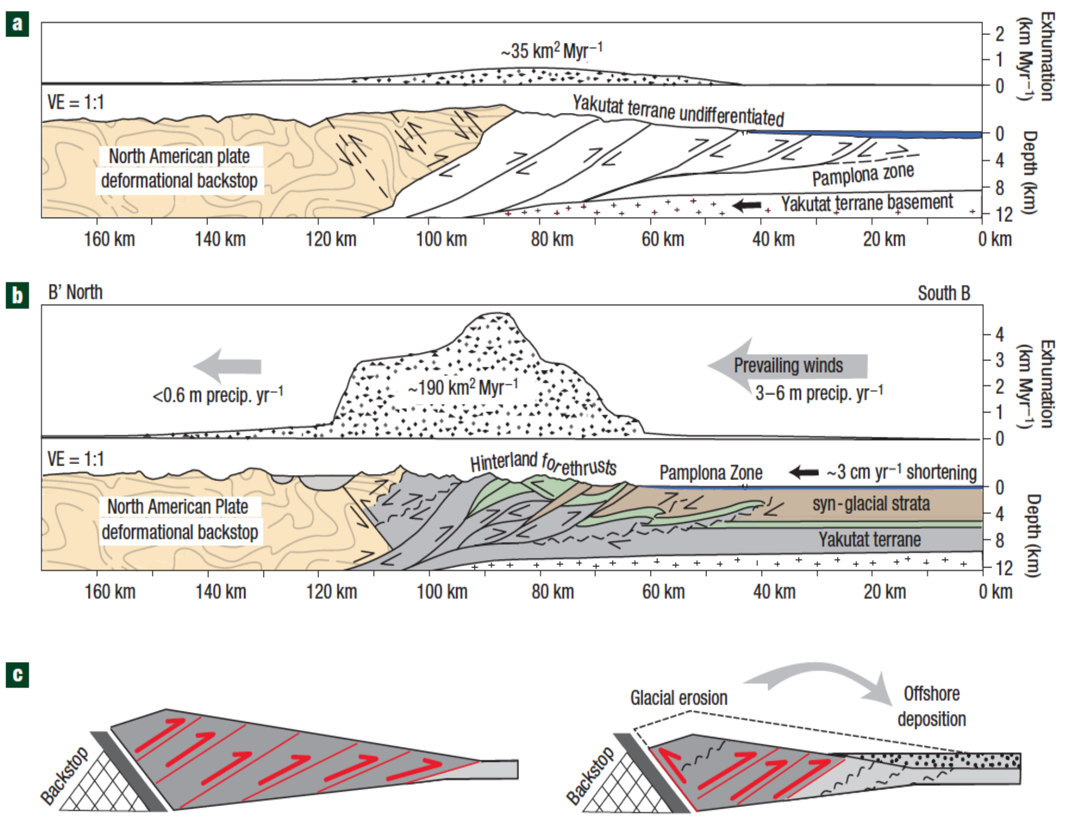

Berger et al., 2008 – *Nature Geoscience*

- Opportunity:
  - St. Elias Range, Alaska
  - Suggested to have undergone response to enhanced glaciation in mid-Pleistocene (Berger et al., 2008)