Intensification of tropical circulation documented by Neogene terrestrial $\delta^{18}O$ records of the western U.S.
What might this area look like in the past?

Neogene (~23 - 2.6 Ma)
extension and subsidence

55 – 28 Ma
Stable isotope (O$^{18}$) compositions

- Stable isotope (O$^{18}$) compositions of authigenic minerals and organic materials
- Mineral O$^{18}$ composition
  - proxies for the surface water and precipitation O$^{18}$

δ notation:

- $\delta = (R - R_{std})/R_{std} \times 1000$, $R = O^{18}/O^{16}$
How do we interpret elevations from proxy $\delta^{18}O$?

- Decreasing $\delta^{18}O$ with increasing elevation.
Surprising enrichment pattern of Neogene isotope records

Horton et al., 2006

~5 – 8 ‰

δ¹⁸O equivalent

~7-8 ‰
Neogene Environmental changes

– Increasing equator-to-pole temperature gradient
  • lowering CO₂ level (2 x PI CO₂ to PI CO₂) (Zhang et al., 2014)
  • high latitude glaciation (early Neogene reconstructions from Herold et al., 2008)
    • increasing meridional SST gradient (Goldner et al., 2014)
– Increasing tropical Pacific zonal SST gradient (Zhang et al., 2014)
– Grassland expansion (Strömberg, 2011)
– Geographic and topographic changes (outside the western U.S.) (Herold et al., 2008)
Experiment setup

- ECHAM5-JSBACH-wiso: isotope tracking in both atmosphere and land model (Werner et al., 2011; Haese et al., 2013)
  - T63 resolution (~2°)

- Boundary conditions designed to test regional responses to four different aspects of Neogene climate changes (ΔC):
  - $\Delta C = C((\Delta T_{\text{meridional}})_{\text{mod}}, (\Delta T_{\text{zonal}}, Gc, Vc)_{\text{mod}}, R)$
    - $C((\Delta T_{\text{meridional}})_{\text{early Neogene}}, (\Delta T_{\text{zonal}}, Gc, Vc)_{\text{mod}}, R)$;
  $\Delta T_{\text{meridional}}$: meridional SST gradient, $CO_2$, icesheets
  $\Delta T_{\text{zonal}}$: zonal Pacific SST gradient
  Gc: geographic and topographic changes
  Vc: vegetation changes (Grassland expansion)
• Enrichment pattern in response to increasing equator-to-pole temperature gradient matches the proxy enrichment pattern at most locations.
The proxy enrichment across the central Rockies and northern Great Basin can mostly be explained as $\delta^{18}O$ responses to Neogene strengthening of the equator-to-pole temperature gradient.
Global responses of soil water $\delta^{18}O$

Responses of geopotential height and vertical pressure velocity  700 hPa

$t$ changes (m)

Enhanced subsidence
Strengthened Hadley circulation

• Strengthen of the Hadley circulation by increasing equator-to-pole temperature gradient through enhanced tropical convergence and moist convection
Conclusions and implications

- Neogene terrestrial $\delta^{18}O$ records from the Sierra Nevada and Central Rockies may have recorded long-term intensification of Hadley circulation.
- Stable isotope records have the potential to be used to reconstruct past circulation changes with the help of isotope-enabled climate models.
Megalodon
15.9 – 2.6 Ma

Questions?

Karencarr.com