TEMPERATURE GRADIENTS AND GLACIATION

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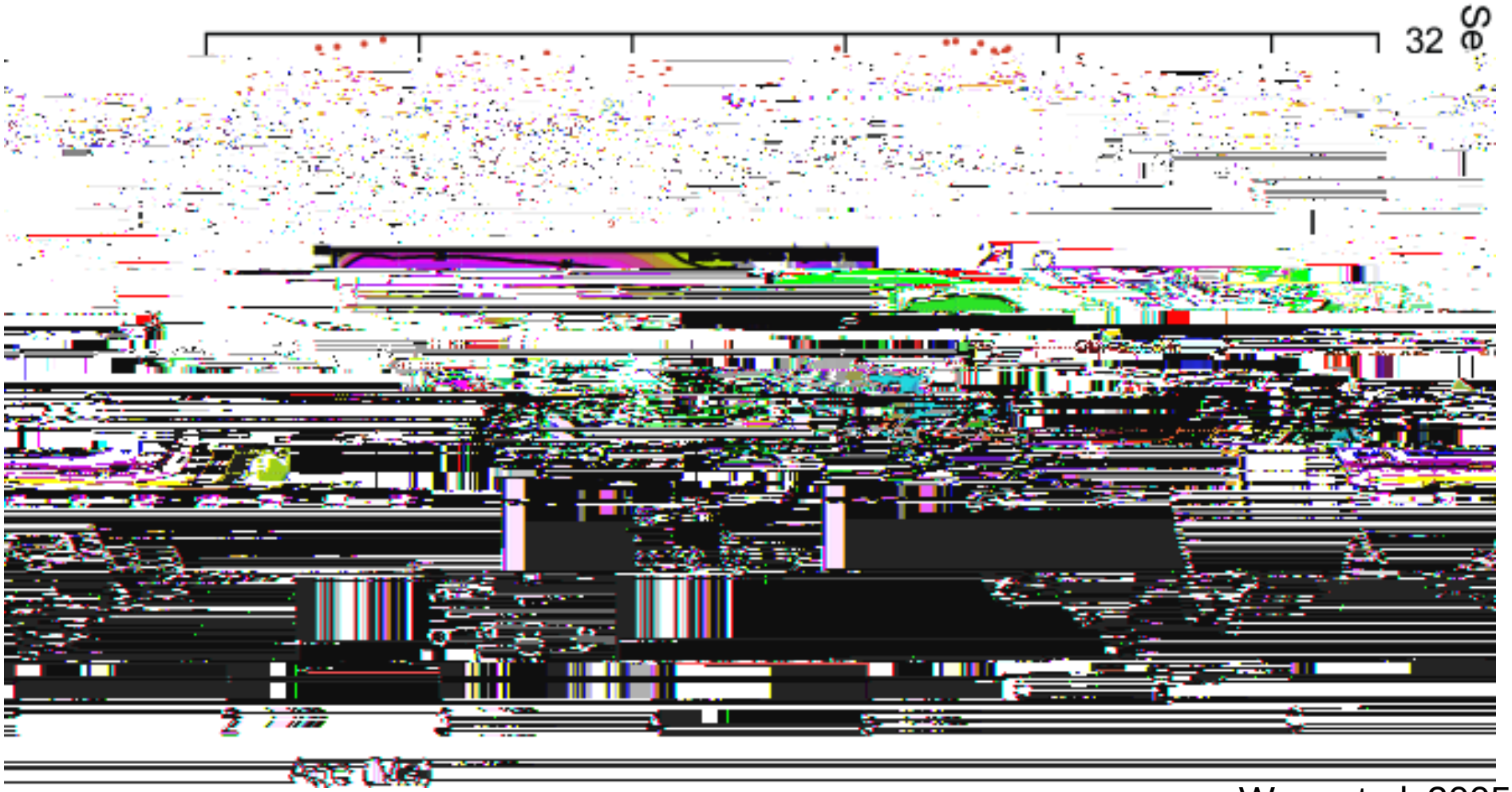
Outline

- Recap on the warm early Pliocene (as we have reconstructed it)
- Methodology to compare meridional SST gradient impacts and zonal SST gradient impacts
- Findings about the onset of Northern Hemisphere Glaciation
- Dominance in reconstructed climate
- Speculations on about Monsoon

Why care about the early Pliocene?

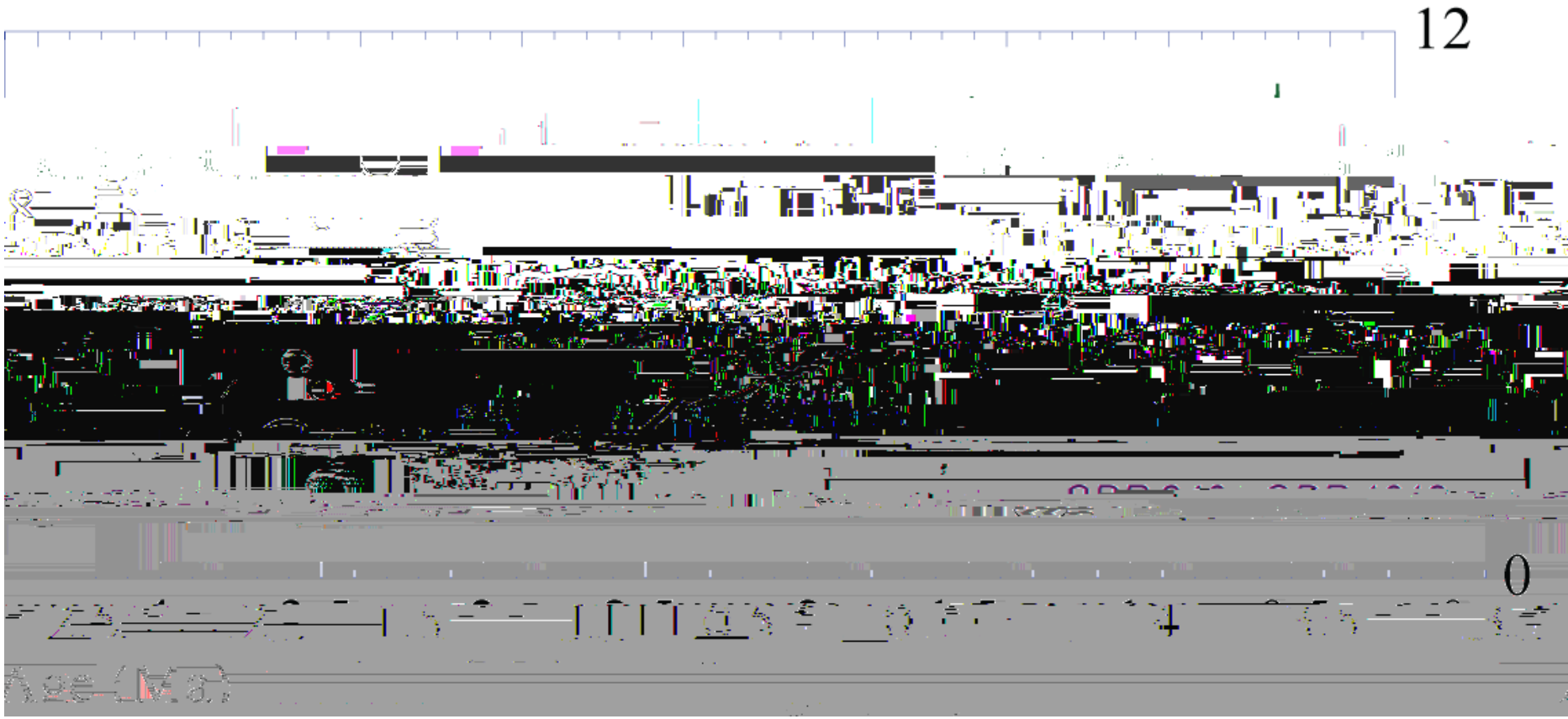
Wara's Permanent El Niño



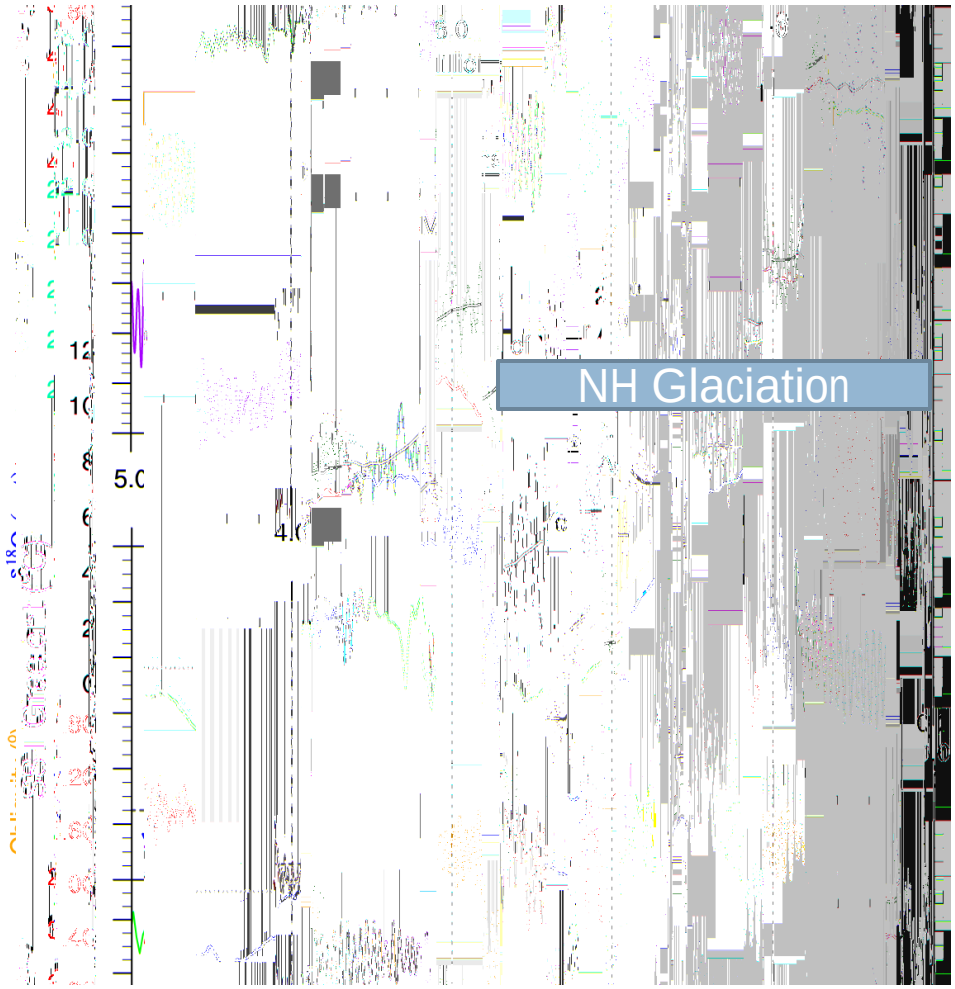
Wara et al. 2005

California Margin

Reduced Difference between Equator and Californian Margin

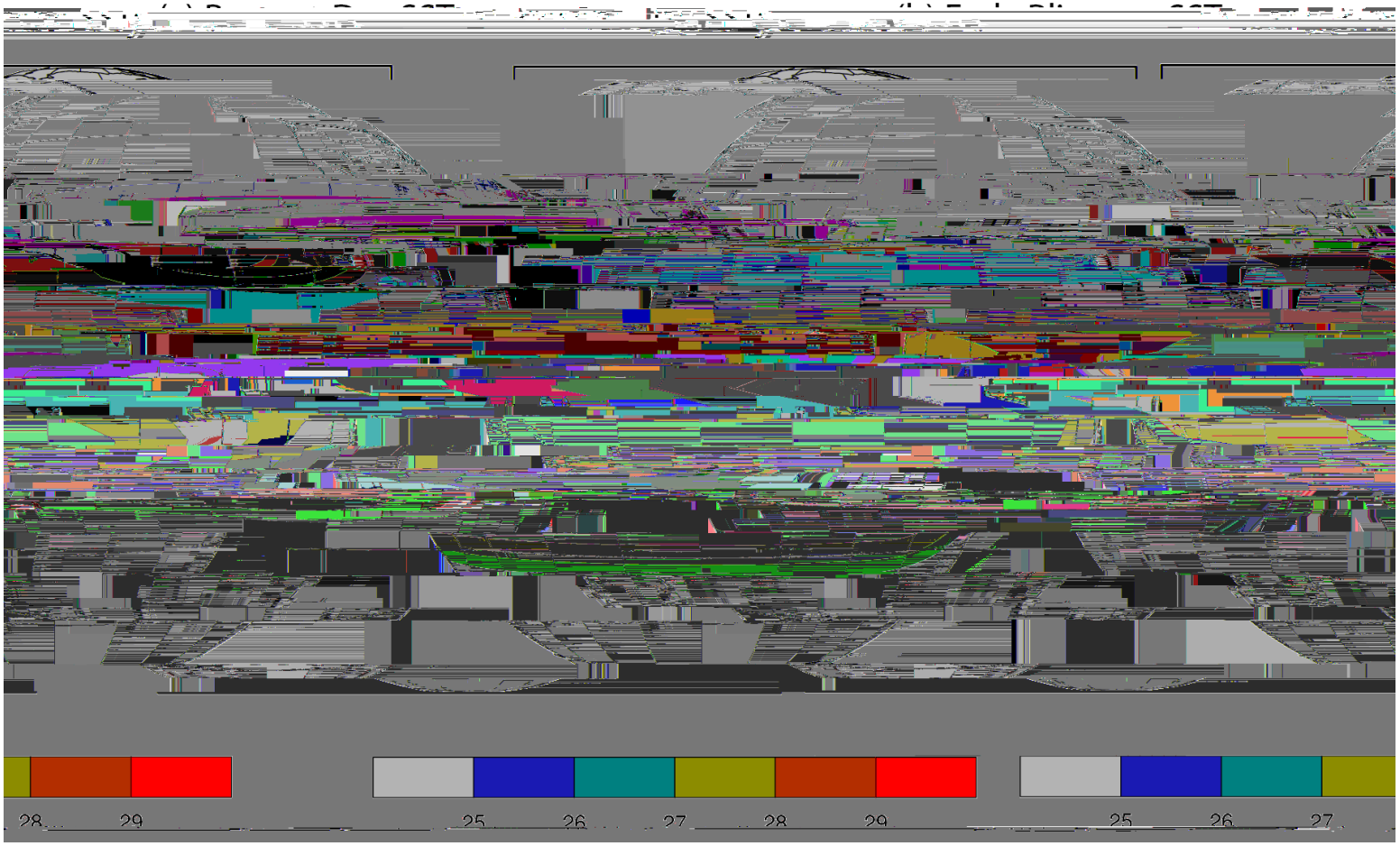


How do these SST gradients compare?

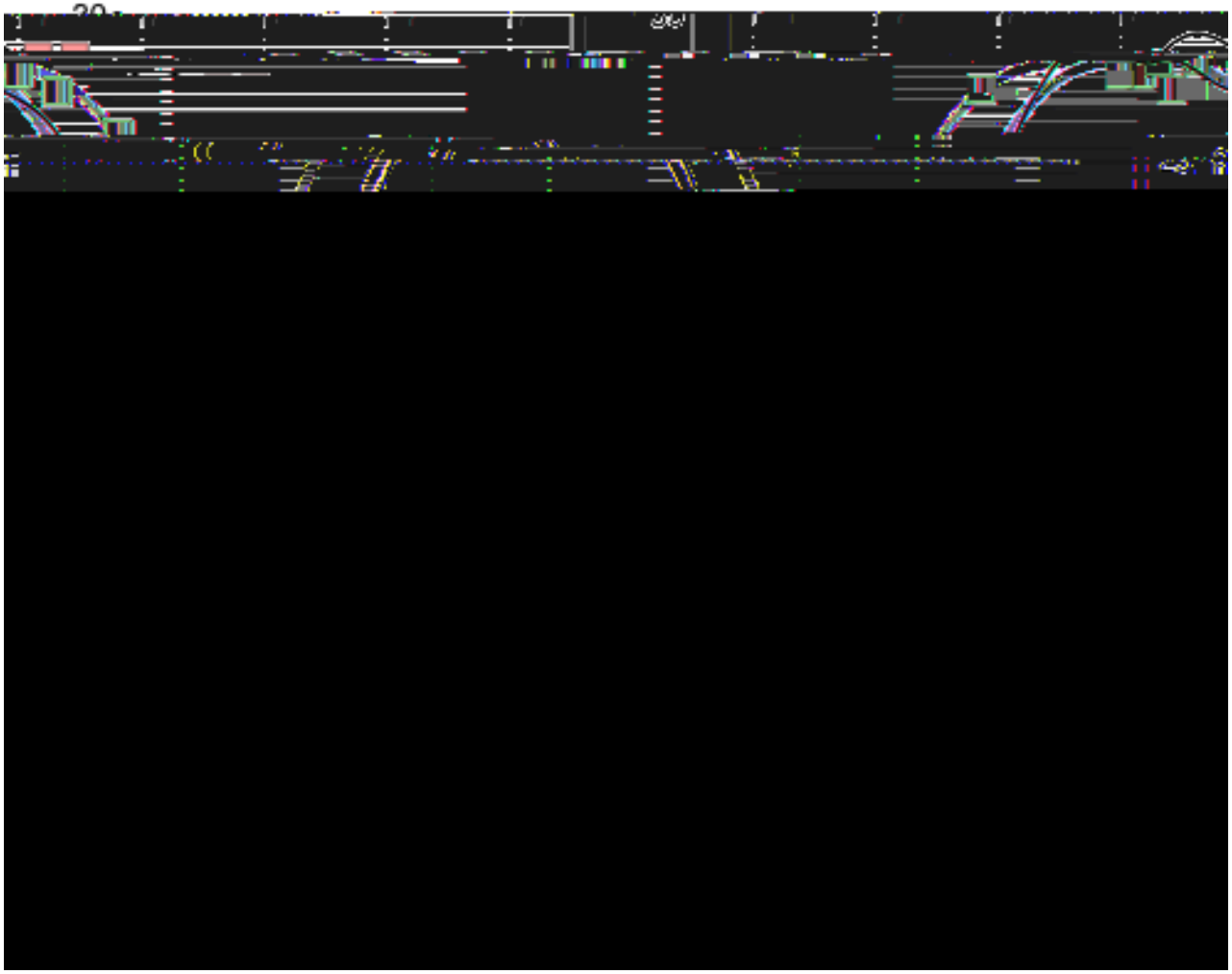


Reconstructing early Pliocene SSTs

Expansion of Warmpool



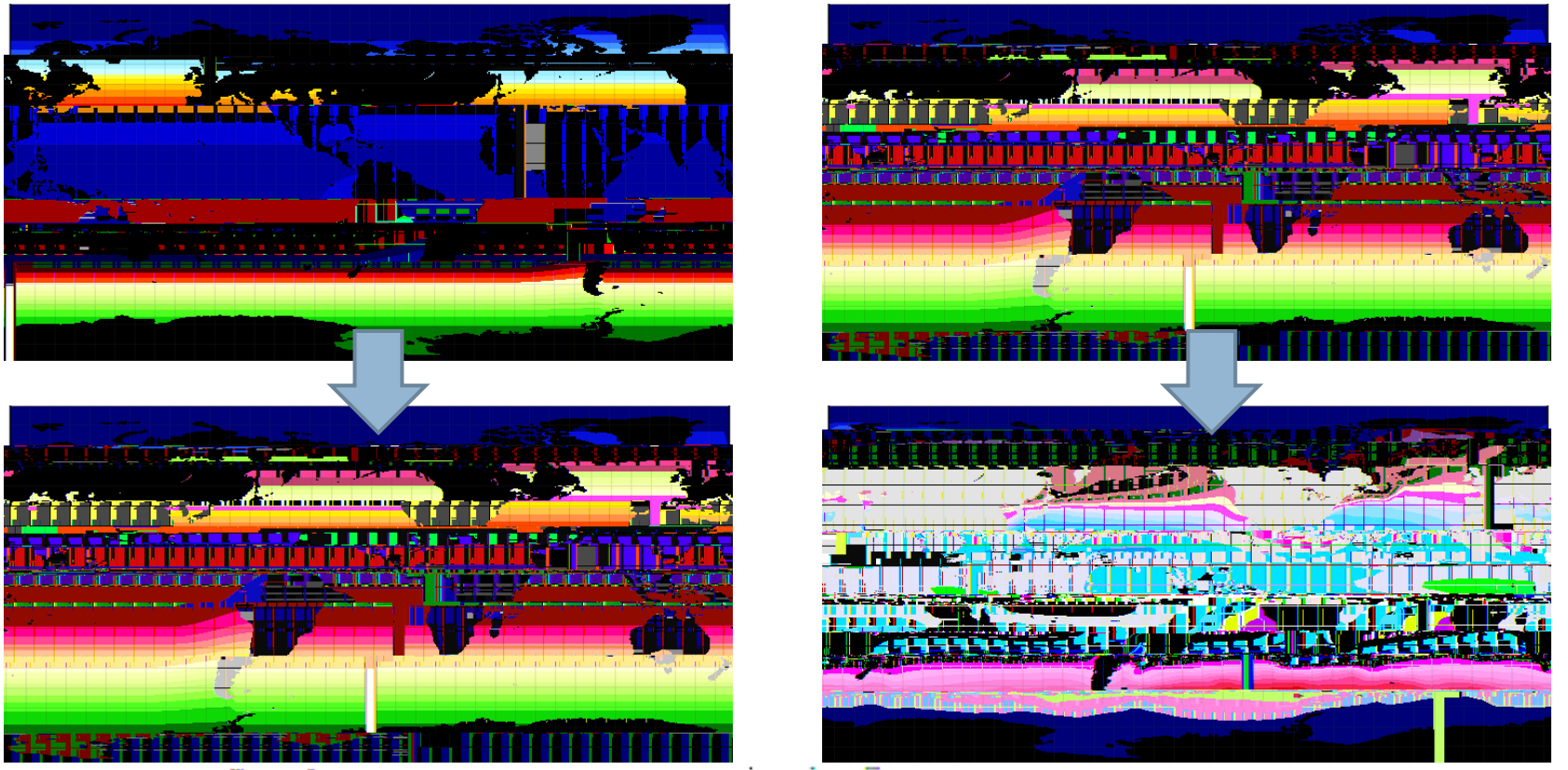
SST profiles for this work



Community Atmospheric Model, v3

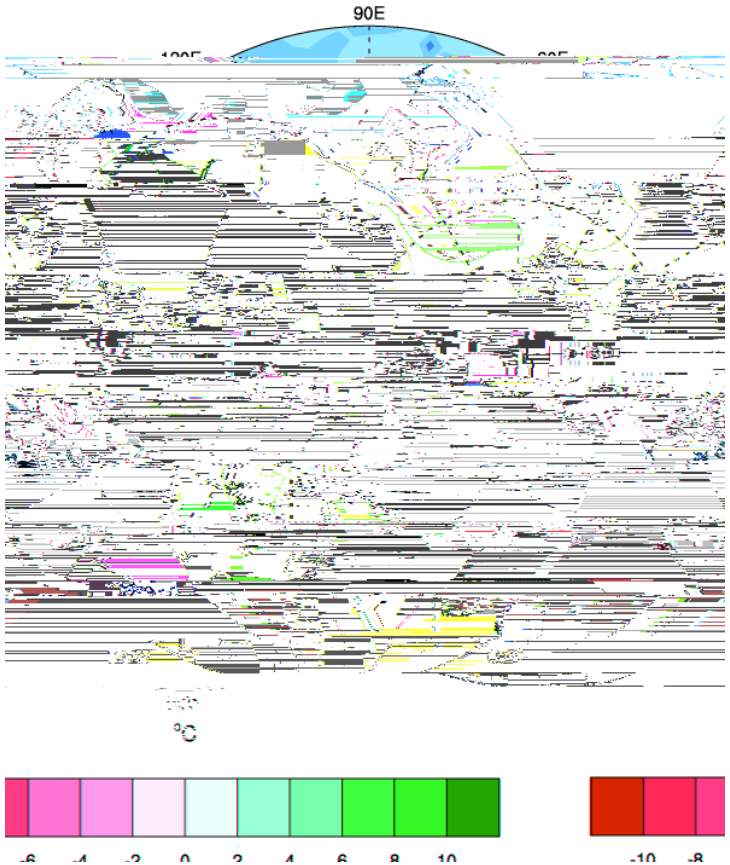
- Developed at National Center for Atmospheric Research in Colorado
- Part of coupled model used in most recent IPCC
- Has a resolution of T42 ~ 2.8 x 2.8 degrees latitude-longitude
- Modern Boundary conditions (Land, CO_2, Solar etc)

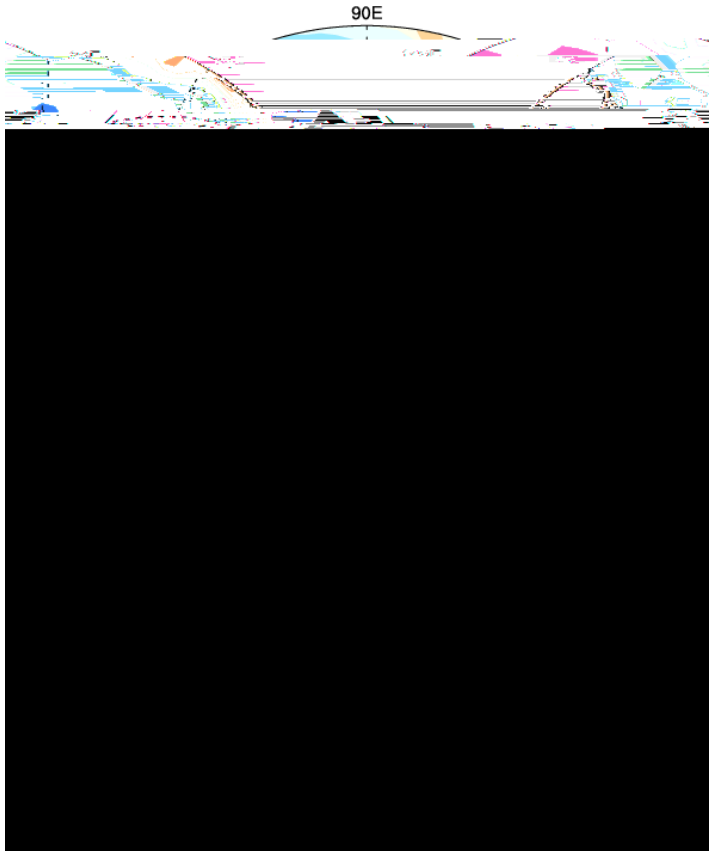
Meridional or Zonal SST dominate?



Impacts of Meridional SST Grad.

Colder North America





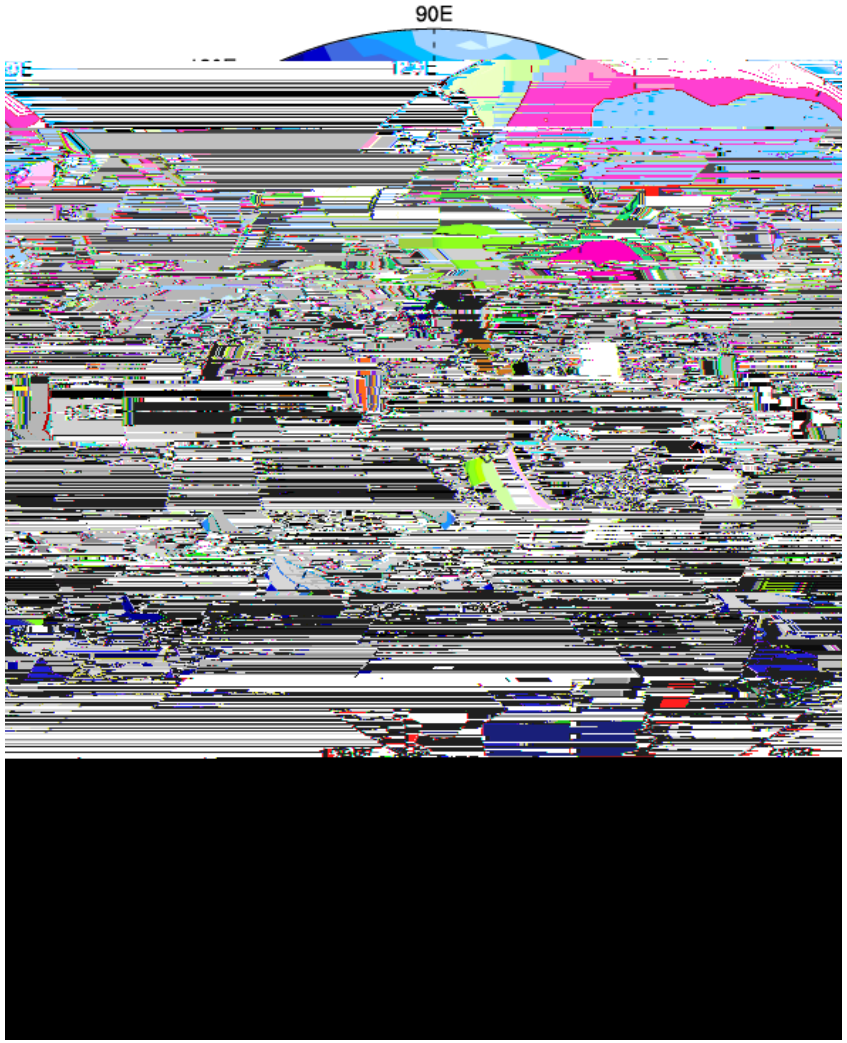
Colder North America - 2

Change in Mass Balance

Combine above two diagnostics:

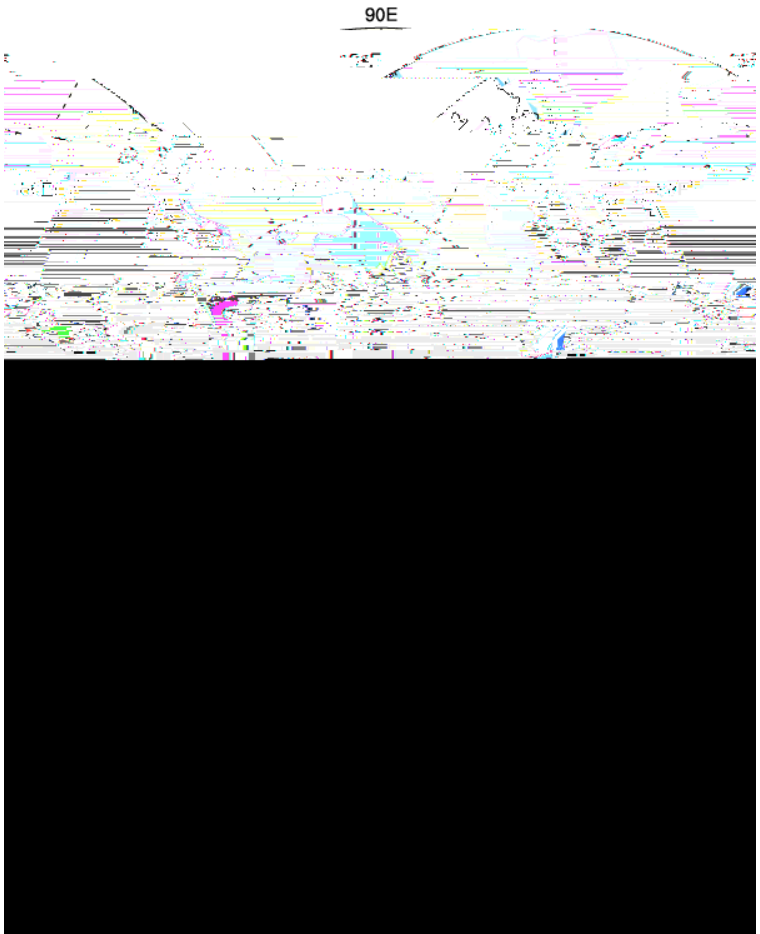
$dm/dt = Acc - \beta_* pdd$

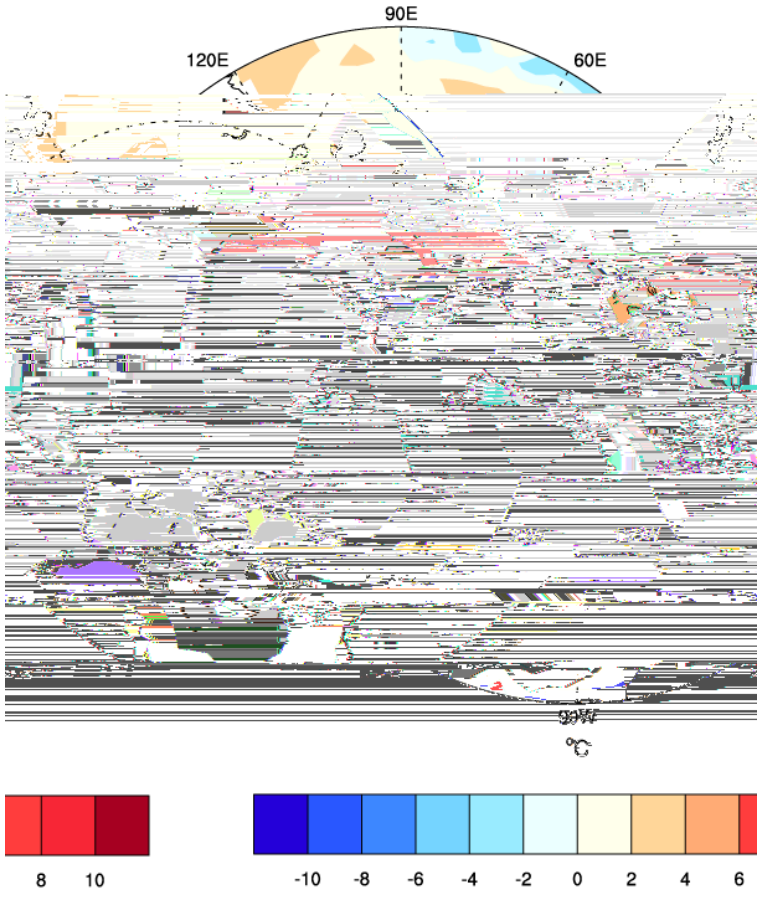
Observed changes in meridional SST grad from 3.5 - 2 Ma cause strong reduction in snow melt in N. H.



Impacts of Zonal SST Grad.

Changes in North America



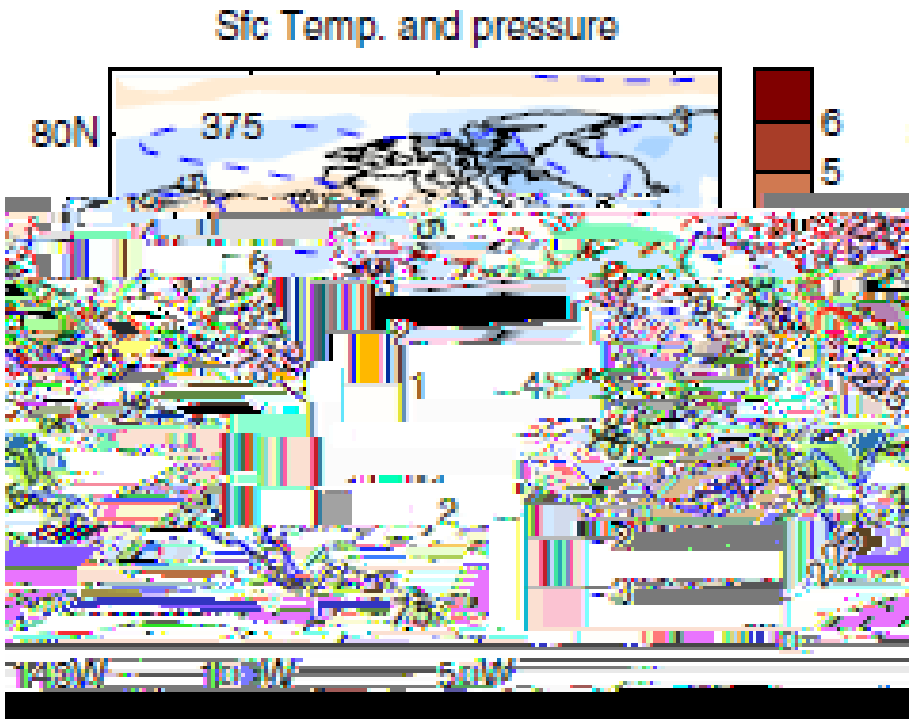


Previous Findings – Pt 1

Barriero et al (06) performed an AGCM experiment to look at permanent El Niño.

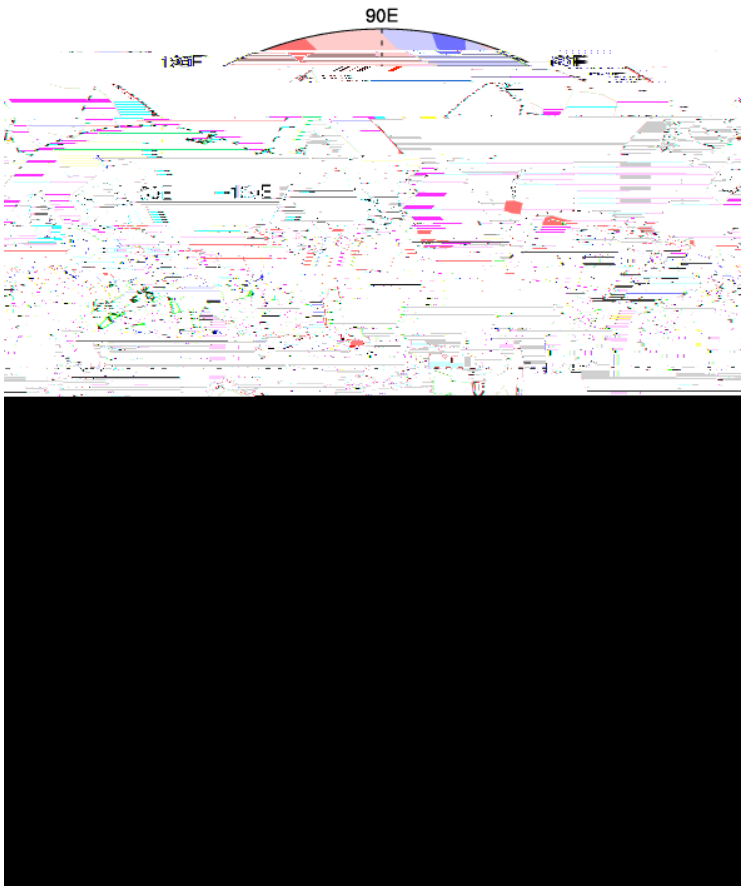
They showed the annual mean temp.

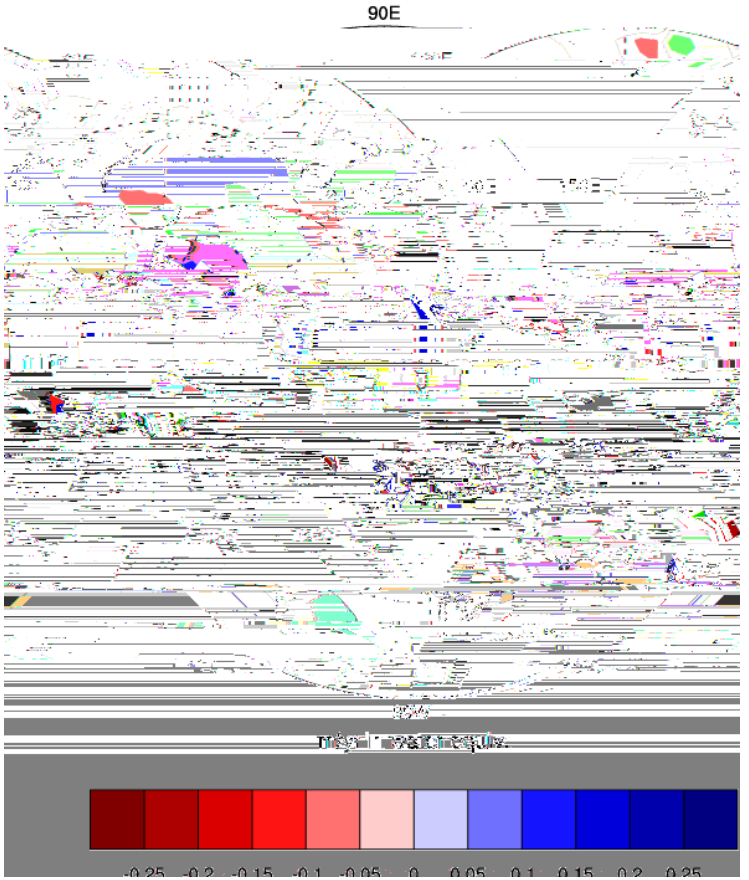
Concluded that permanent El Niño could prevent glaciation



This is the anomaly caused by a permanent El Niño, so positive is reversed from my previous figure.

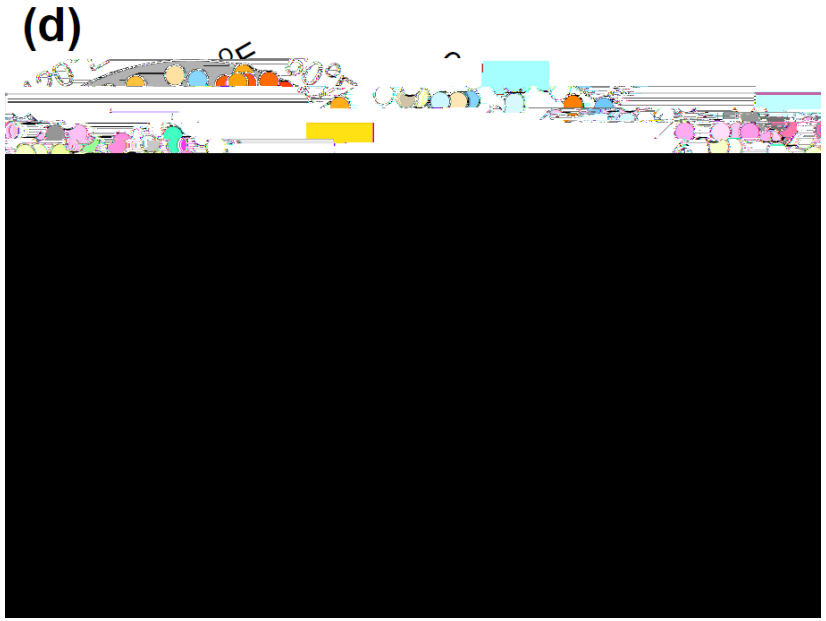
Changes in North America - 2





Previous Findings – pt 2

- Huybers & Molnar ’07
- Determined present-day El Niño impacts on North America.
- Opposite Response.
- Appear to only include winter temperature changes, not summer ones.



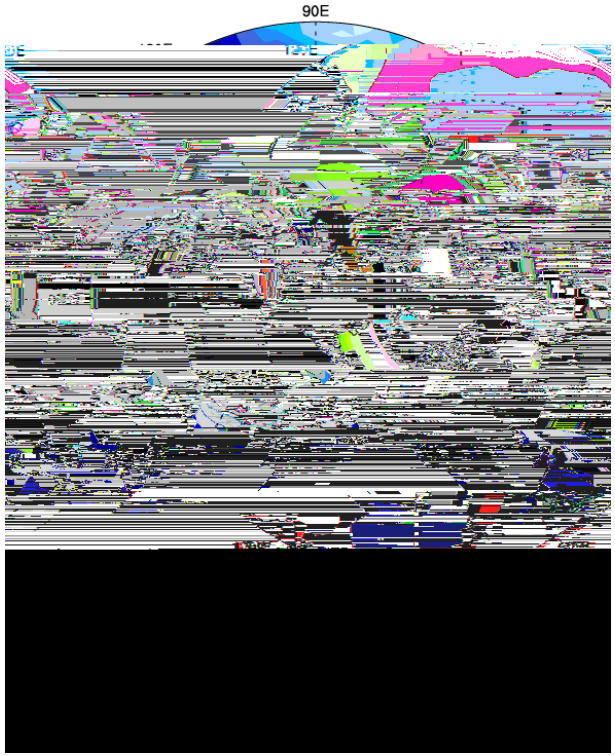
This is the anomaly caused by an El Niño, so positive is reversed from my previous figure.

Change in Mass Balance

Combine above two diagnostics:

$dm/dt = Acc - \beta$

Meridional SST changes dominate!



Does the Meridional SST gradient always dominate?

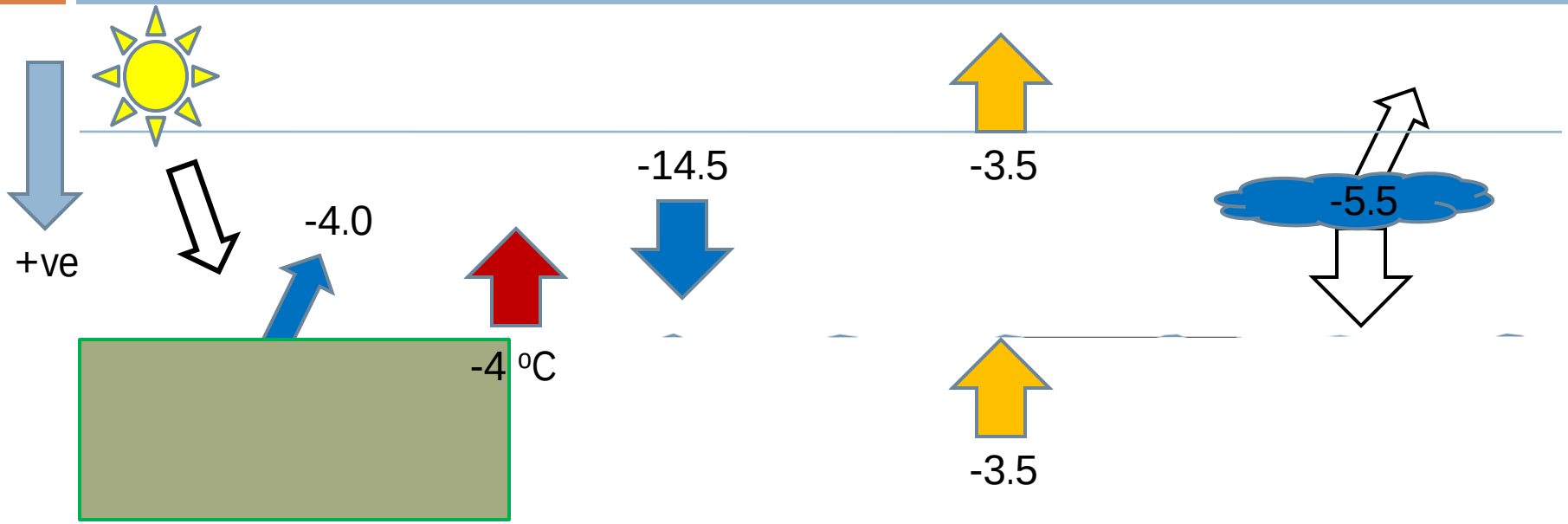
When we described our early Pliocene reconstruction, we looked at different properties that could help to sustain a warmer climate.

Are these similarly dominated by the changes in meridional SST gradient?

Global Mean Analysis

Surface Temperature	-4.0 °C

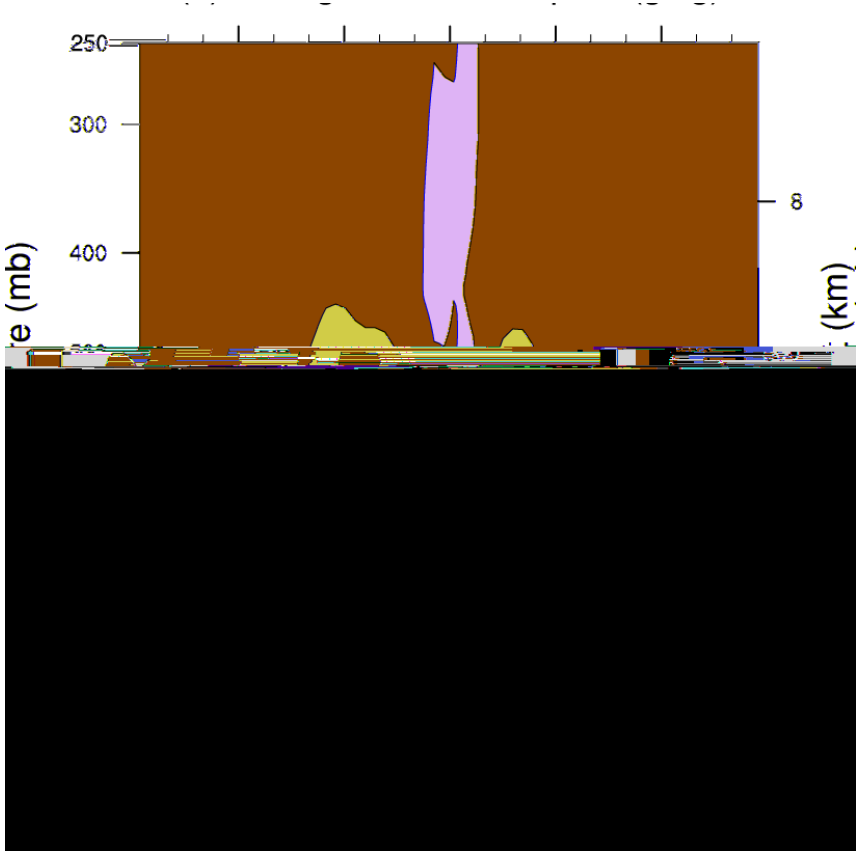
Components from SST gradients



Surface Temperature	-3.2 ºC	-0.8 ºC
Water Vapor/Lapse Rate	-11.0 Wm^{-2}	-3.7 Wm^{-2}
Cloud Feedbacks	-2.5 Wm^{-2}	-3.6 Wm^{-2}
Surface Albedo Changes	-1.9 Wm^{-2}	-1.6 Wm^{-2}
	Wm^{-2}	Wm^{-2}

Water Vapor Content

Difference between present-day conditions and early Pliocene reconstruction.



Water VaZ0 54044.0n BT.ntent

Cloud Cover

Difference between present-day conditions and early Pliocene reconstruction.

Increase in low level cloud

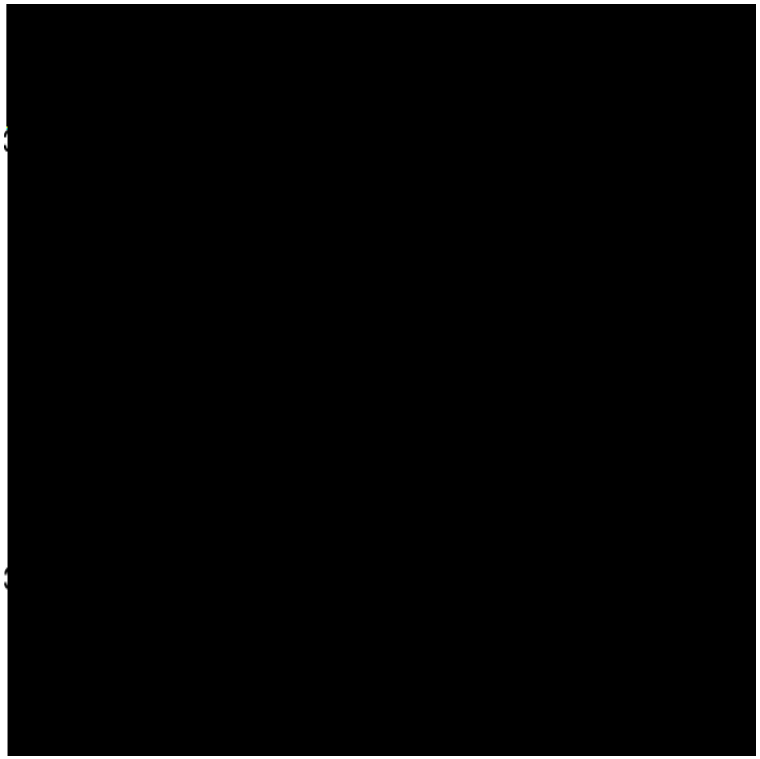
Increased in high cloud/convection in ITCZ, but strong reduction in high cloud in subtropics

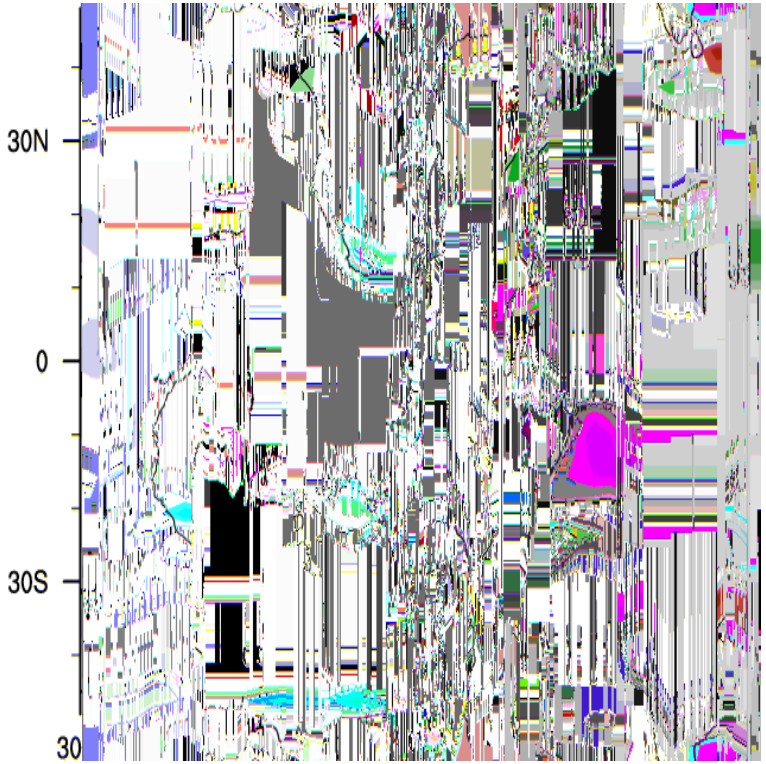
Impacts on African Rainfall

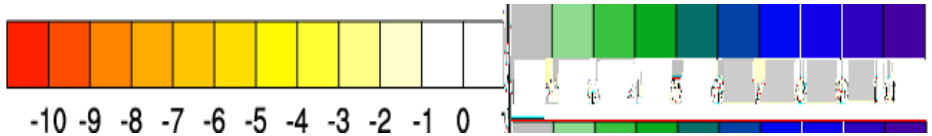
Hominid evolution

Time Line of Human Evolution

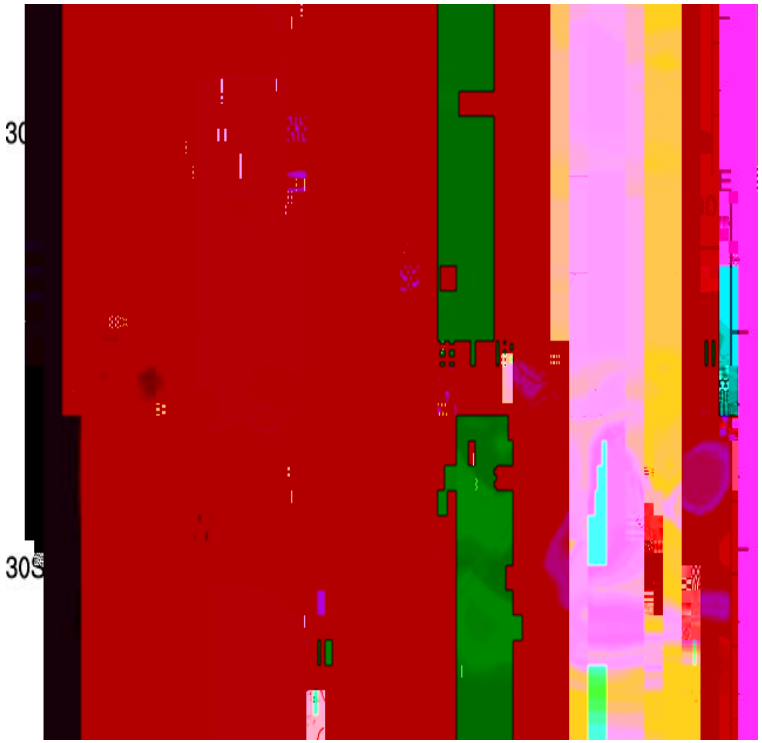
Meridional SST gradient impact on African rainfall (mm/day)

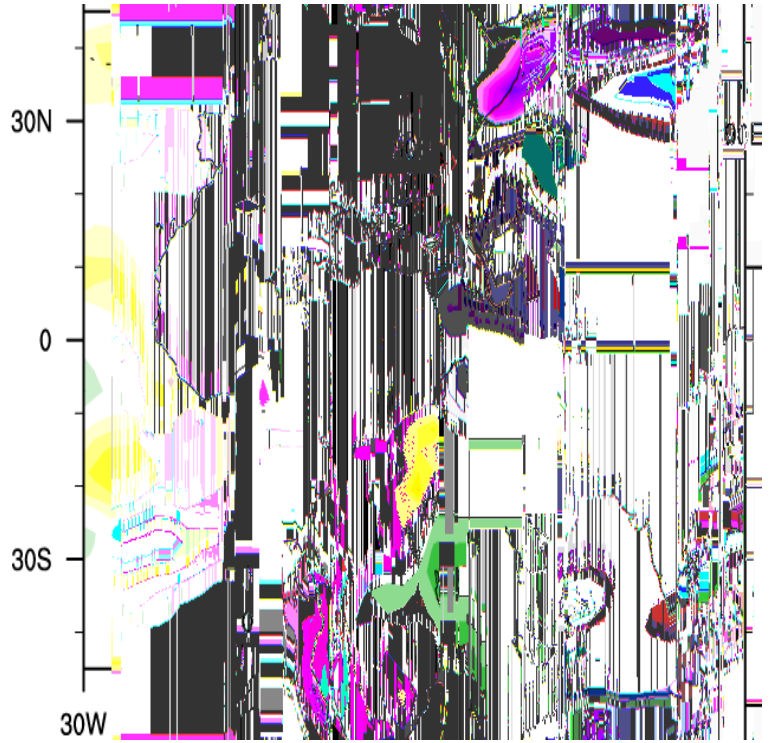


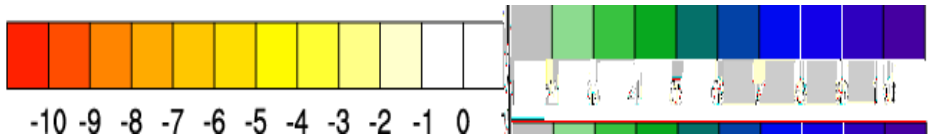




Zonal SST gradient impact on African rainfall (mm/day)







Existence of the Monsoon

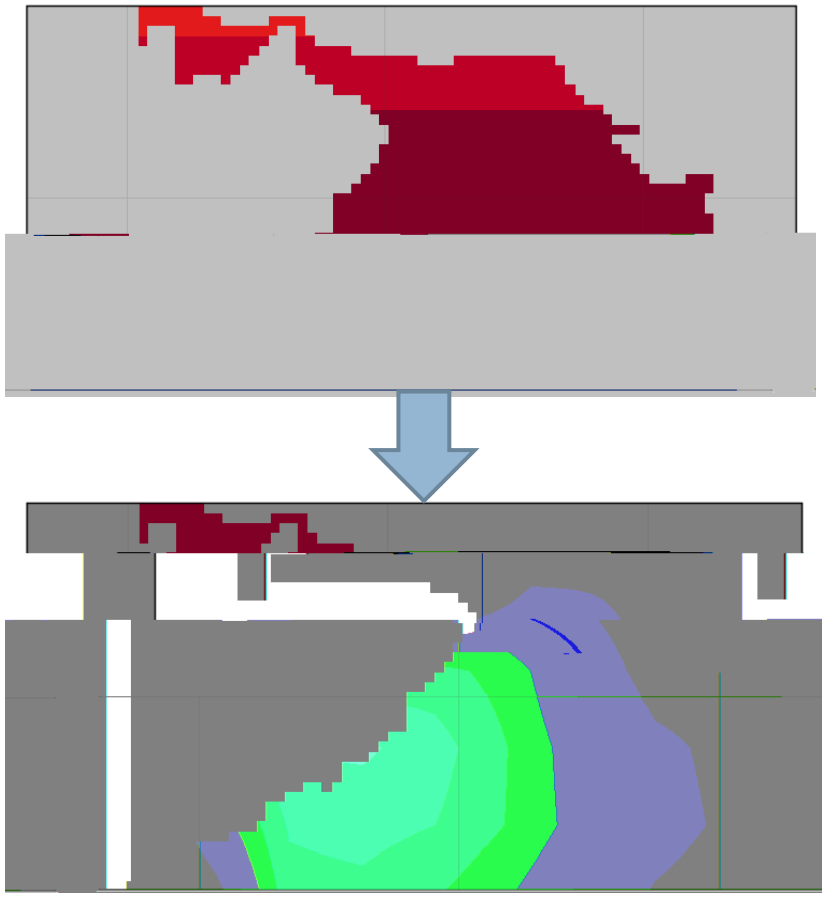
Traditionally the monsoon is thought to have started at ~9Ma.

Caused by uplift of the Tibetan Plateau providing heat source

Zonal SST Gradient Expt

So the traditional view is of a slowly developing upwelling system over ~9Myr

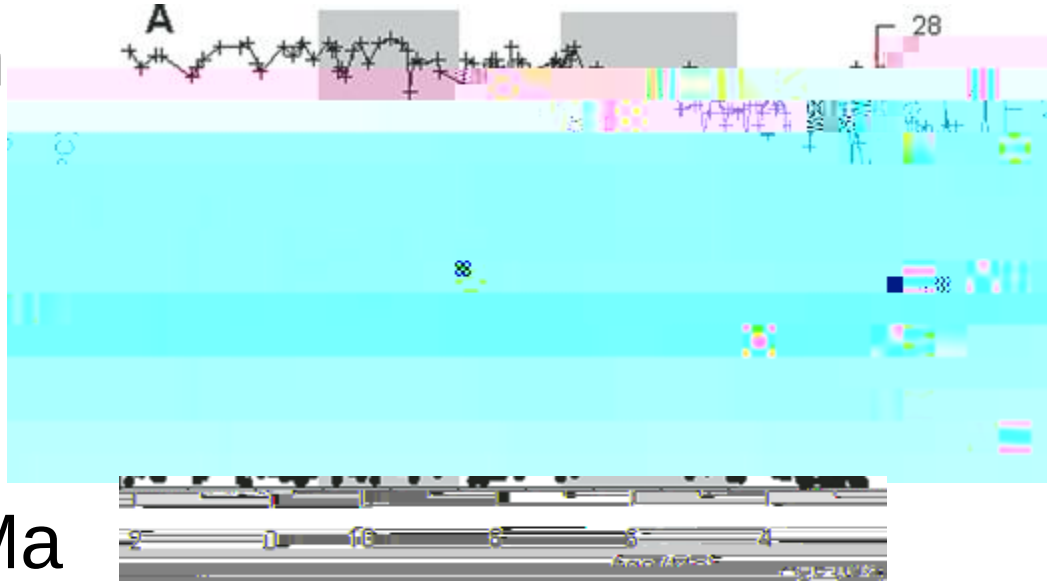
What am I imposing with my zonal SST gradient experiments?



So is that result relevant?

Recent SST data from ODP site 772 (near the previous one)

Implies that the upwelling zone only developed since 4.2Ma



If there is an alternate mechanism that controls SST then monsoon may not be controlled by tectonics.

Conclusions

The early Pliocene had a vast pool of warm water in the Pthe0 2/F1 29.04 th.8 BT/F2 17.4 Tf1 0 0 1 55.4