Understanding Weak Low-Latitude SST Gradients and the Ocean Warm Pool Expansion in the Early Pliocene

Alexey Fedorov & Chris Brierley (Yale)

PP11G-08, AGU fall meeting 2009

YALE UNIVERSITY
GEOLOGY AND GEOPHYSICS

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Fedorov, A.V., P. Dekens, A. C. Ravelo, P. deMenocal, R. Pacanowski and S. G. Philander, (2006). The Pliocene paradox (mechanisms for a permanent El Niño). *Science* 312, 1437-1443.

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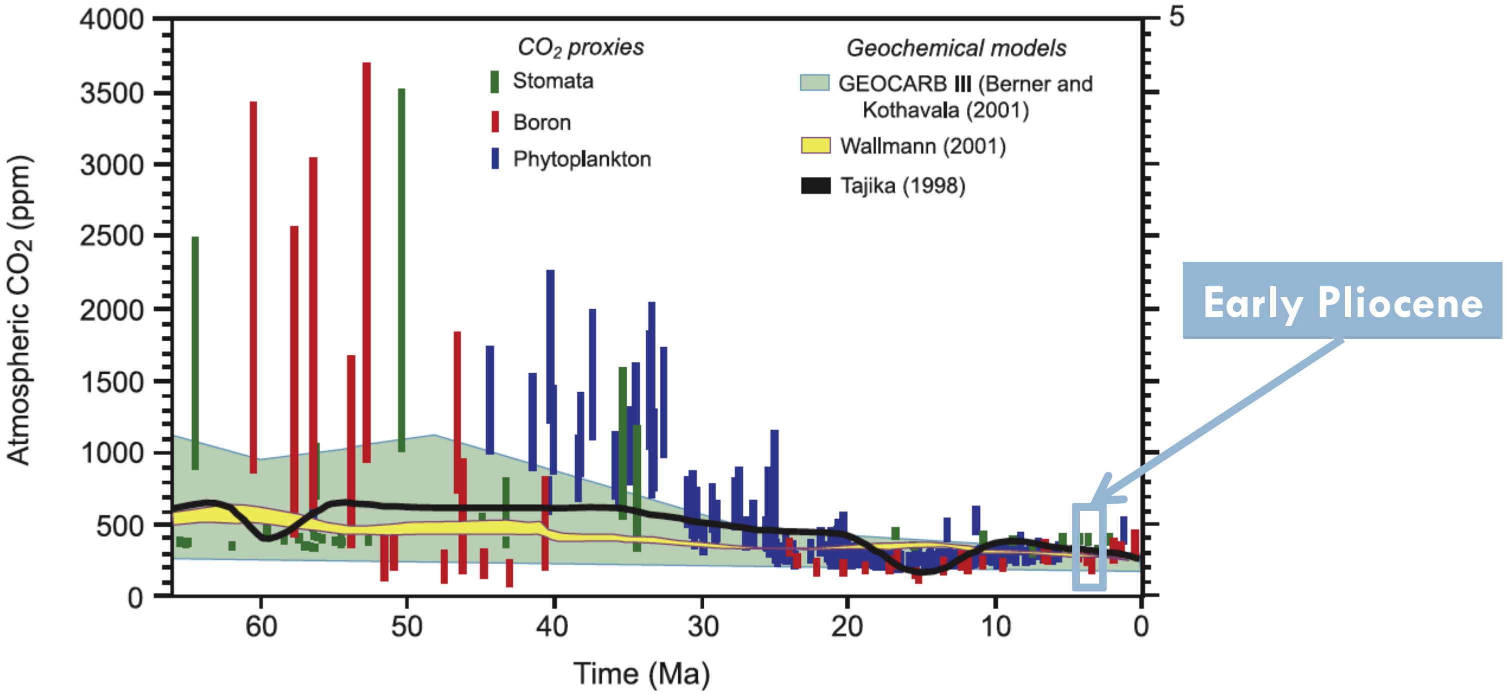
Outline

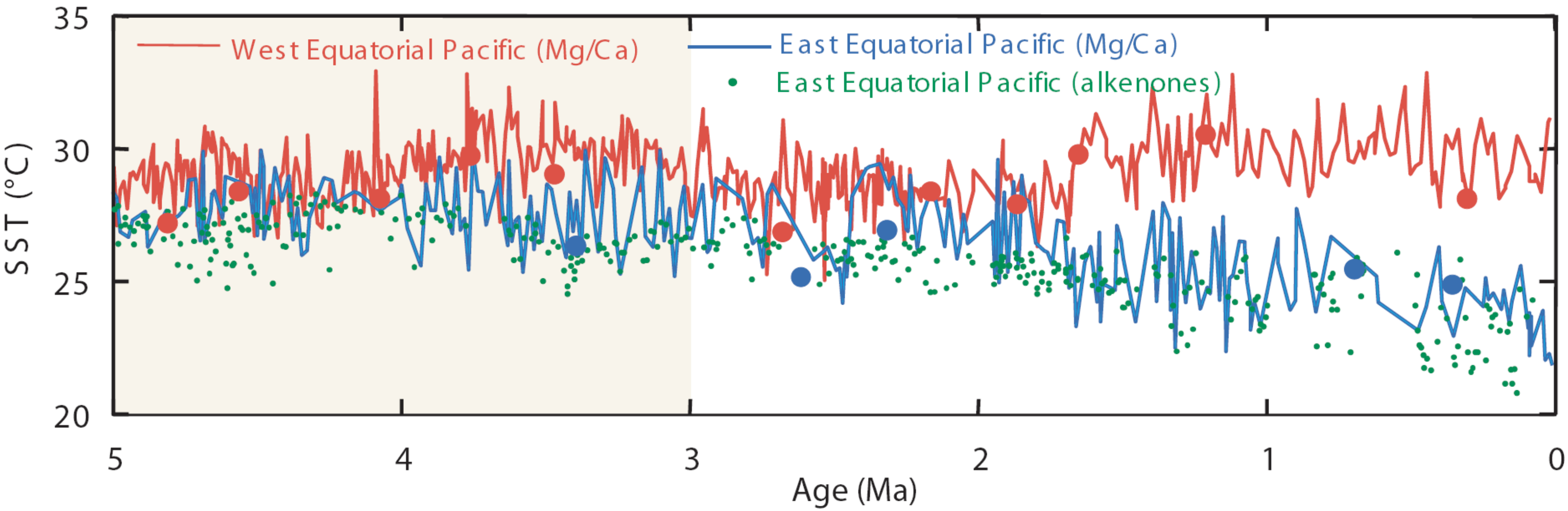
- Introduction to the early Pliocene climate
  - When & why should we care?
  - Tropical SST patterns
- Pliocene Paradox and missing heat transport?
- A tropical cyclone feedback?
  - The subtropical ocean circulation
  - Warming of the cold tongue
- Does this feedback explain the Pliocene warm pool?

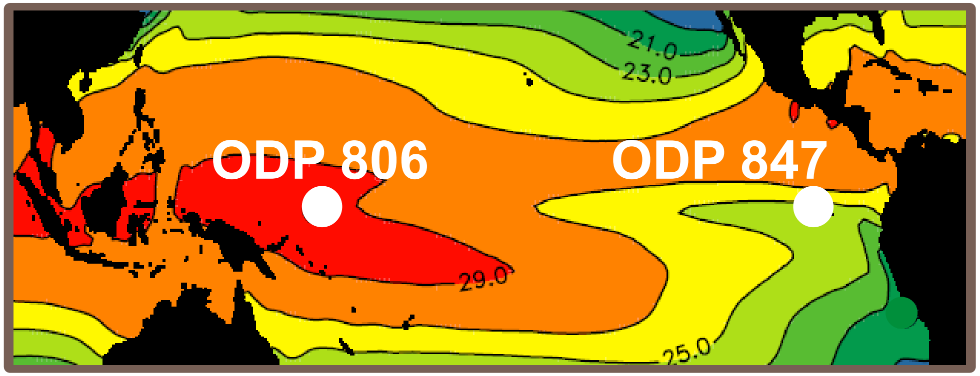
Why care about the early Pliocene?

- Natural global warming stabilization experiment
  - Pliocene CO_2 was 300 – 400 ppm
  - Continental configuration & orbital forcings similar



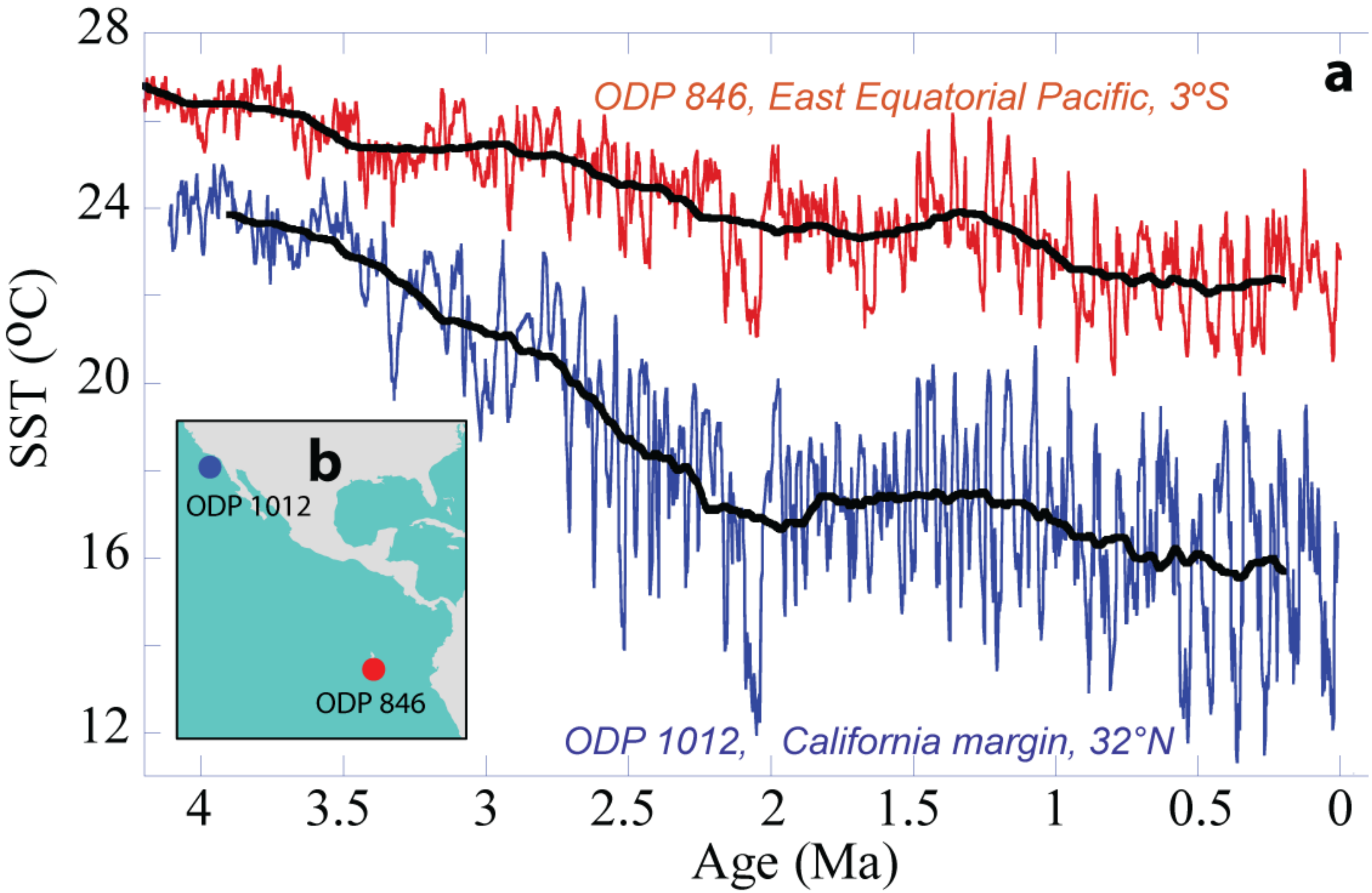
Permanent El Niño (No Zonal SST Grad.)





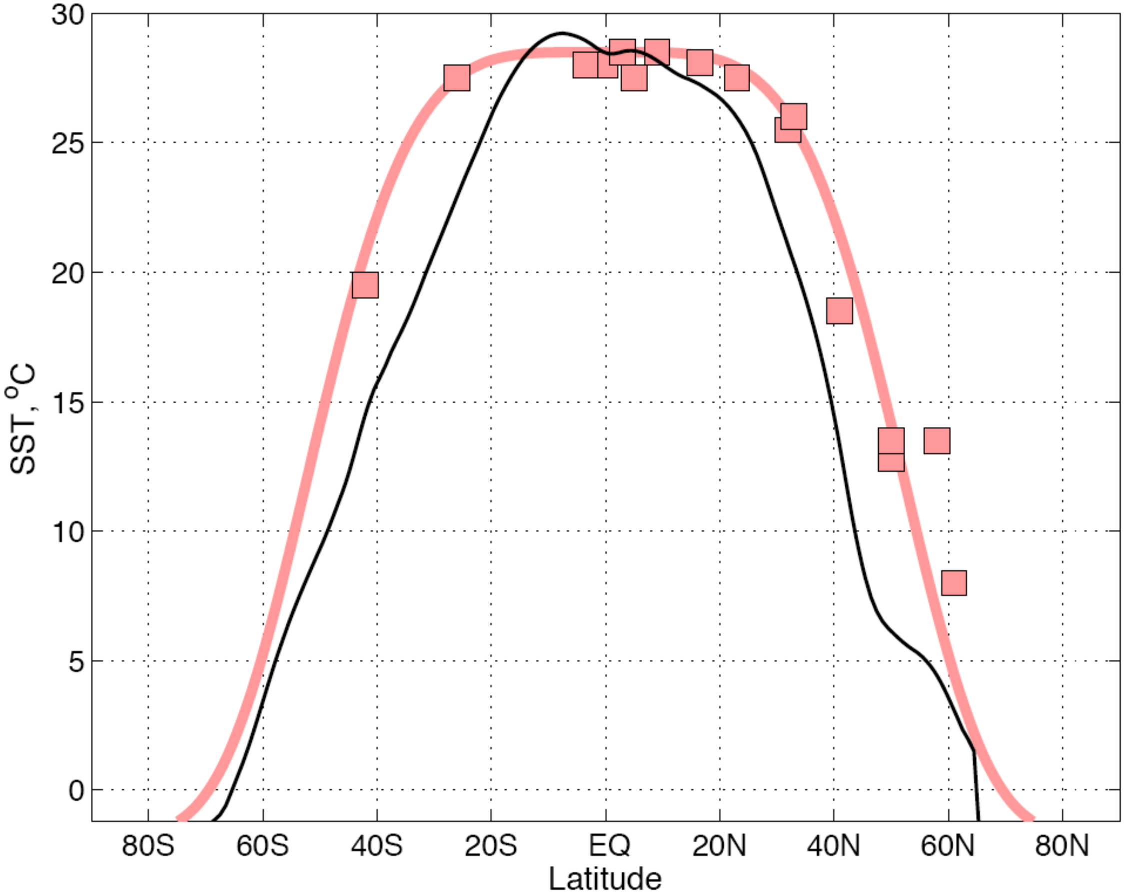
Fedorov *et al.* 2006. The Pliocene Paradox (Mechanisms for a permanent El Niño)

Reduced Meridional SST Gradient



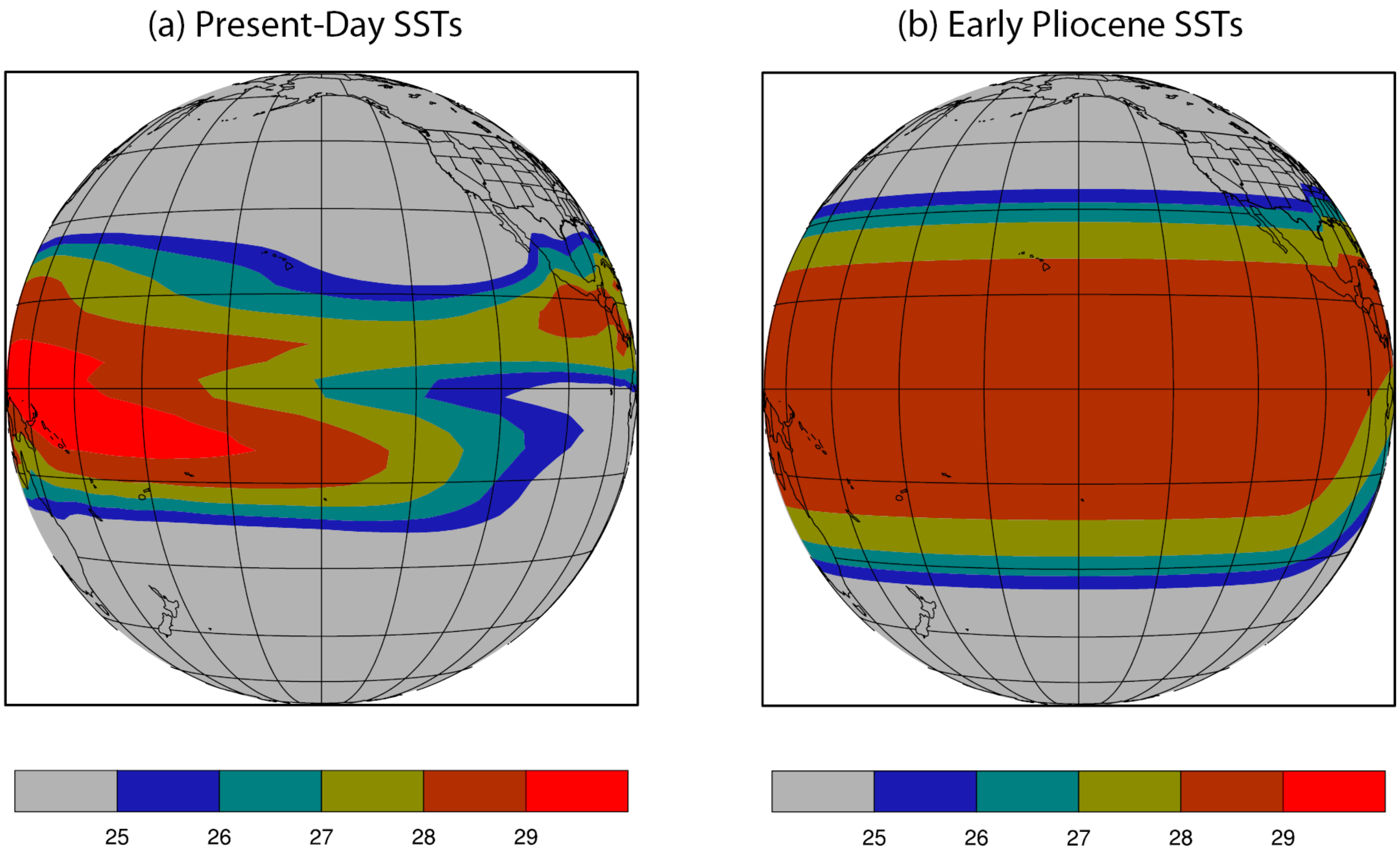
Brierley et al., Science. 2009

Reconstructed Pacific SST profile



- Extend zonally across Pacific
- Shift meridionally to replicate the seasonal cycle

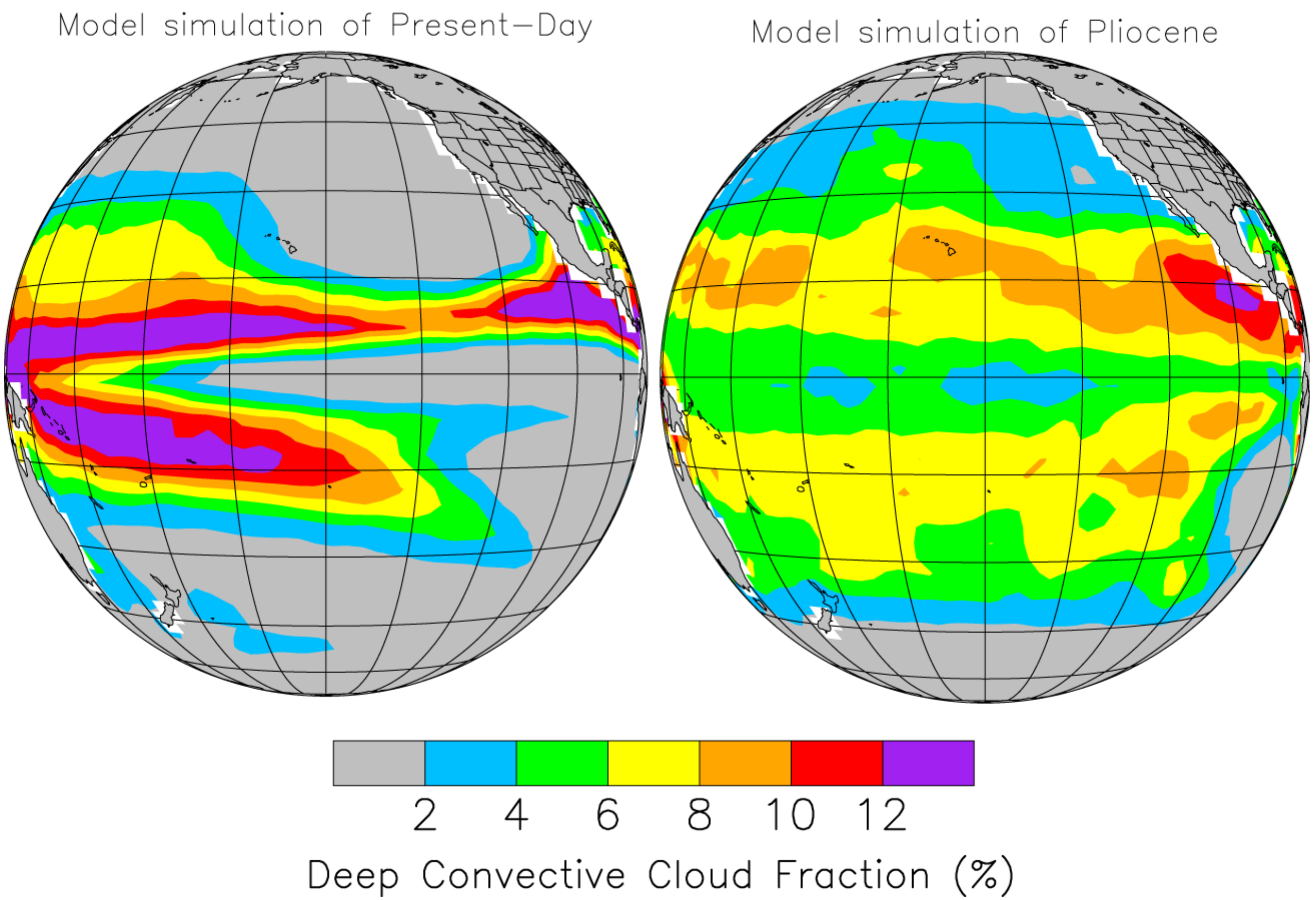
Expansion of Warm Pool



Expansion of Convection

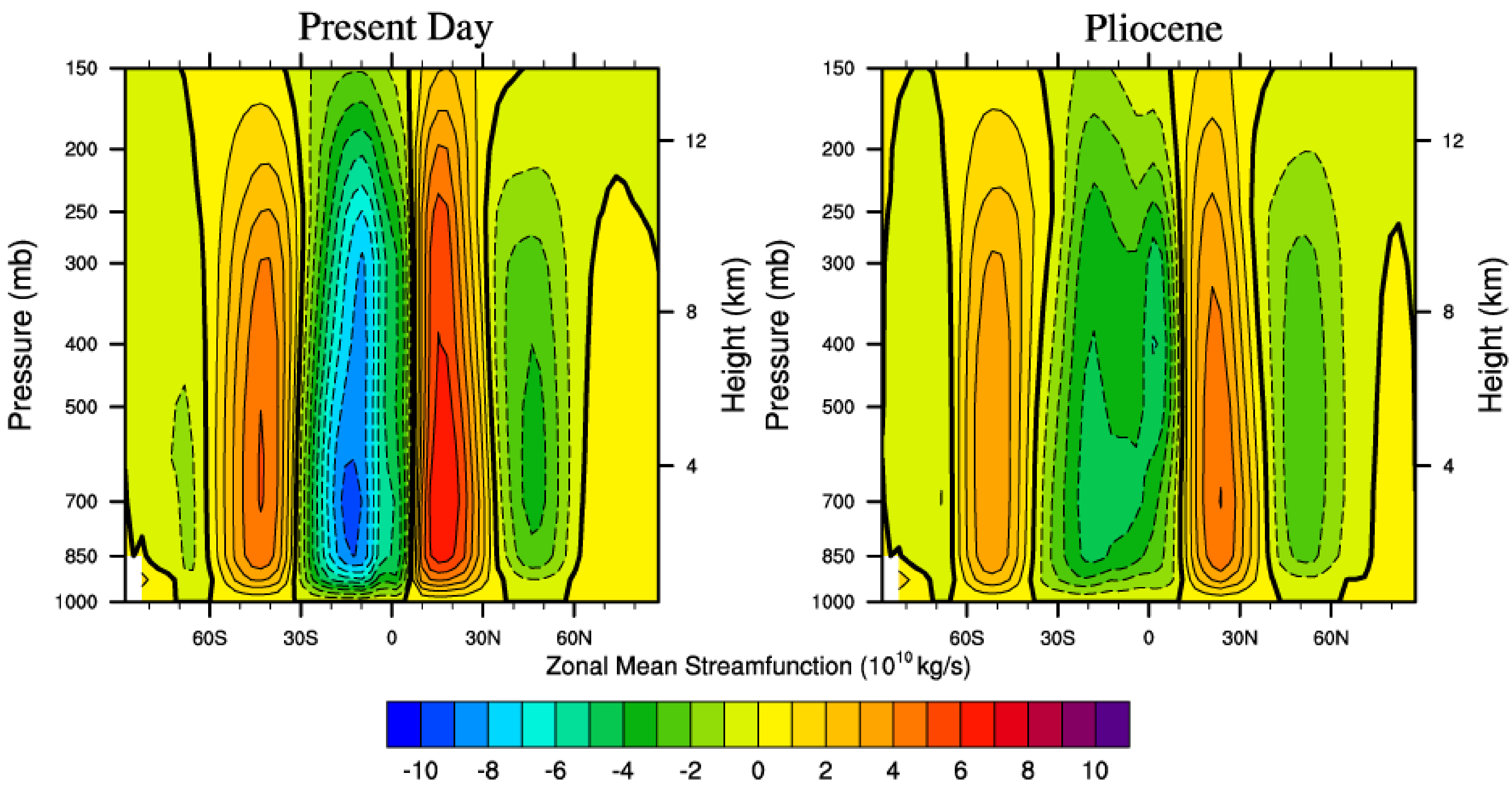
Use AGCM (CAM3 T85) with fixed SSTs to find impacts of warm pool

1990 CO_2 levels, modern orography, only SST (and sea ice) diff.



Brierley et al., Science. 2009

Weak Hadley Cell

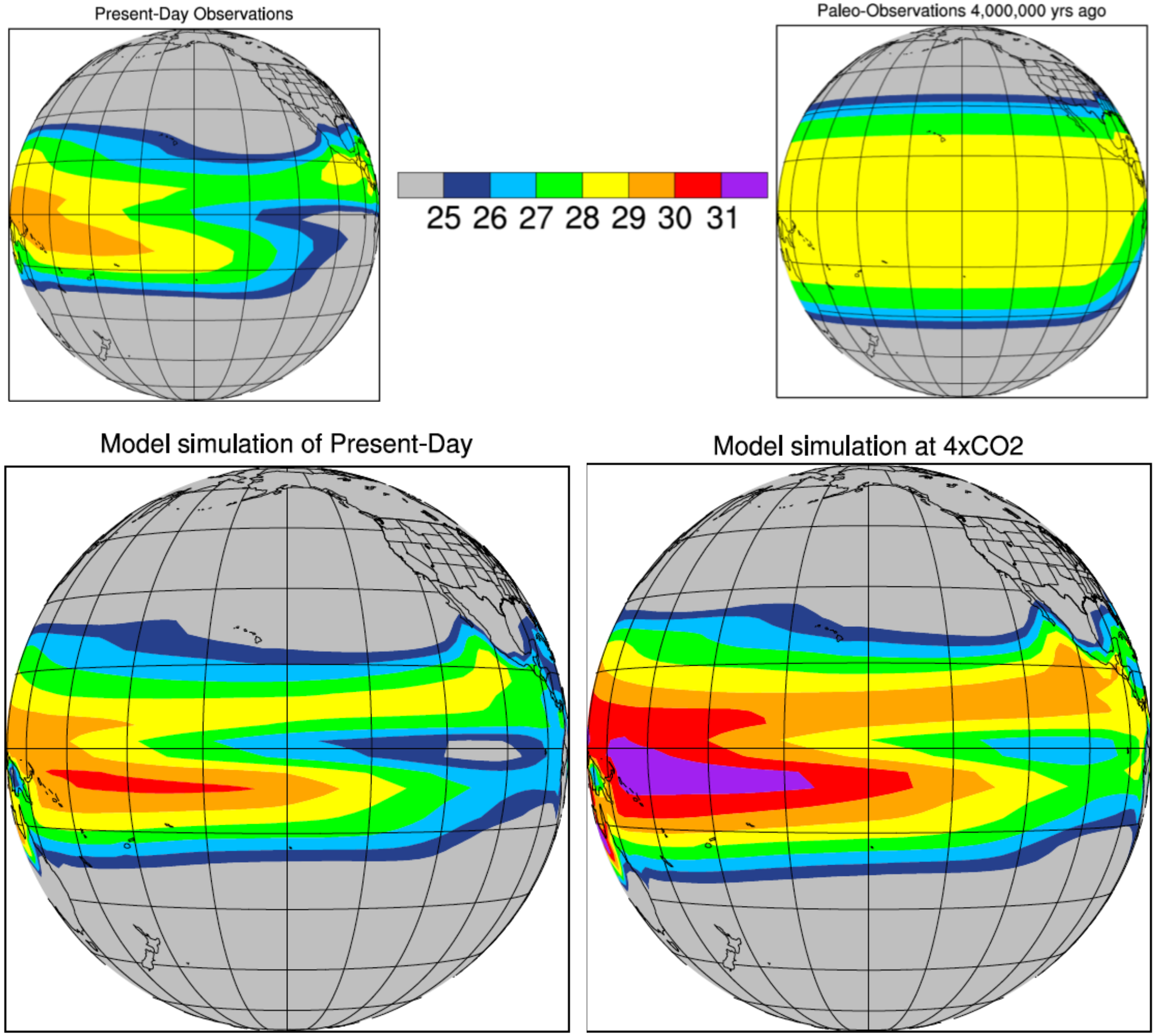


Brierley et al., Science. 2009, Fedorov et al, Science. 2006

The Pliocene Paradox

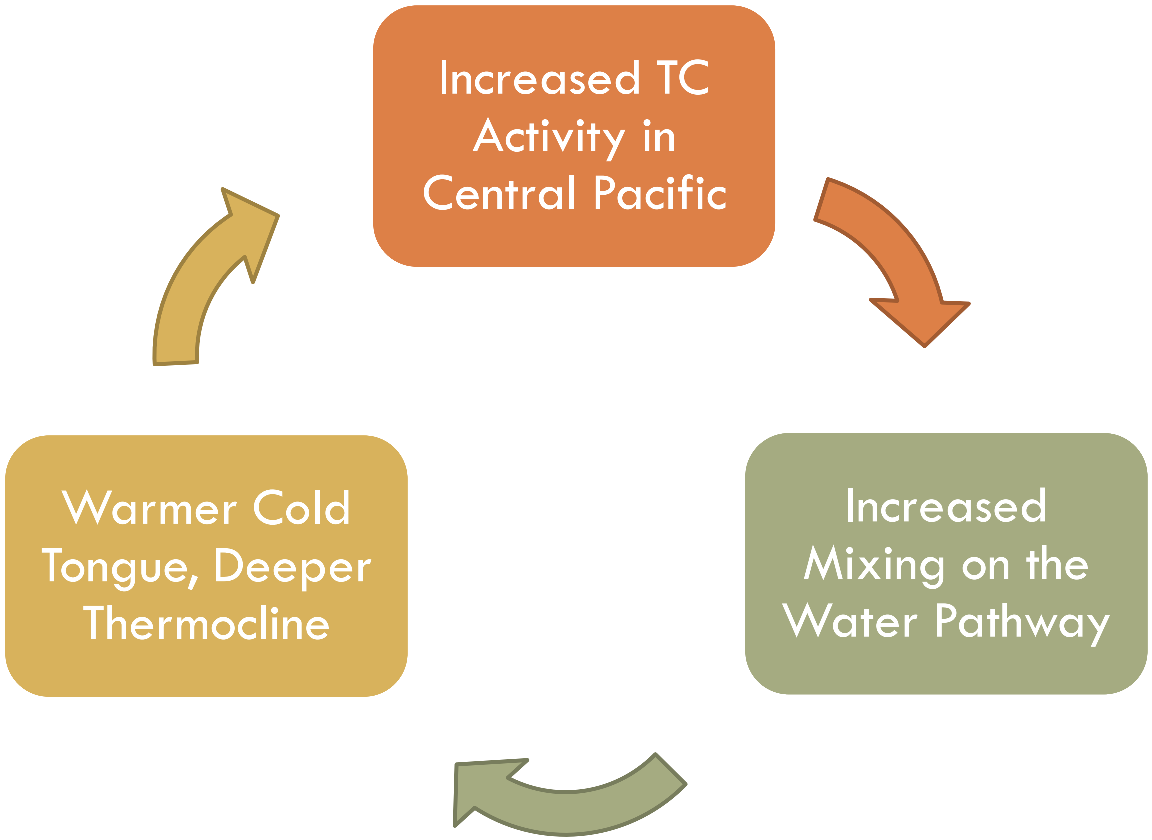
Pliocene warm pool unlike predicted response to added CO_2

Maybe Earth has heat transport mechanisms not included in coupled GCMs?



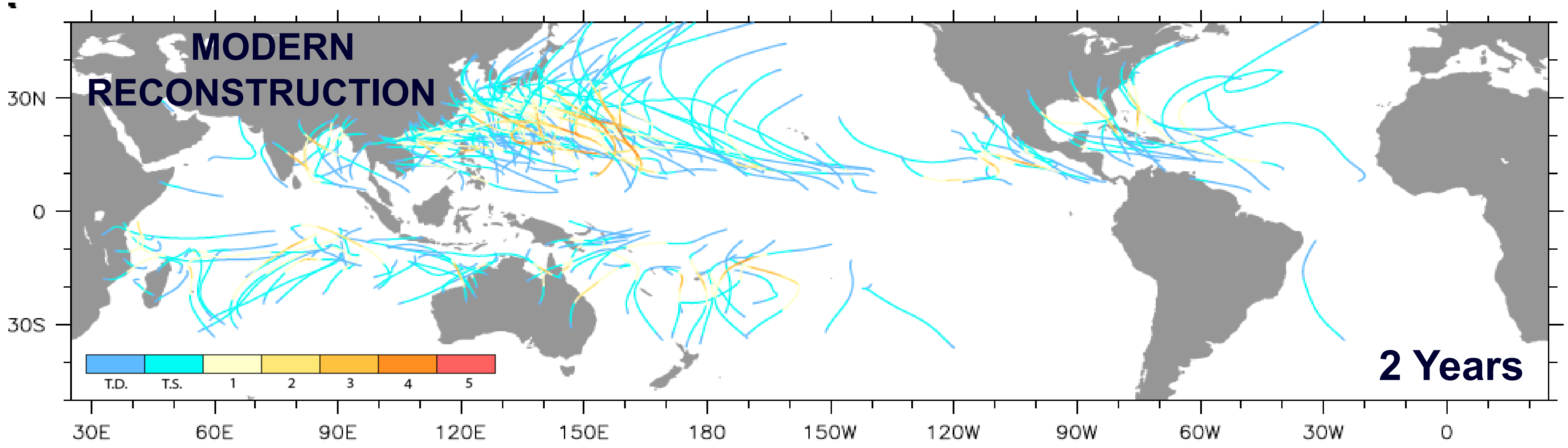
Fedorov et al, Science. 2006

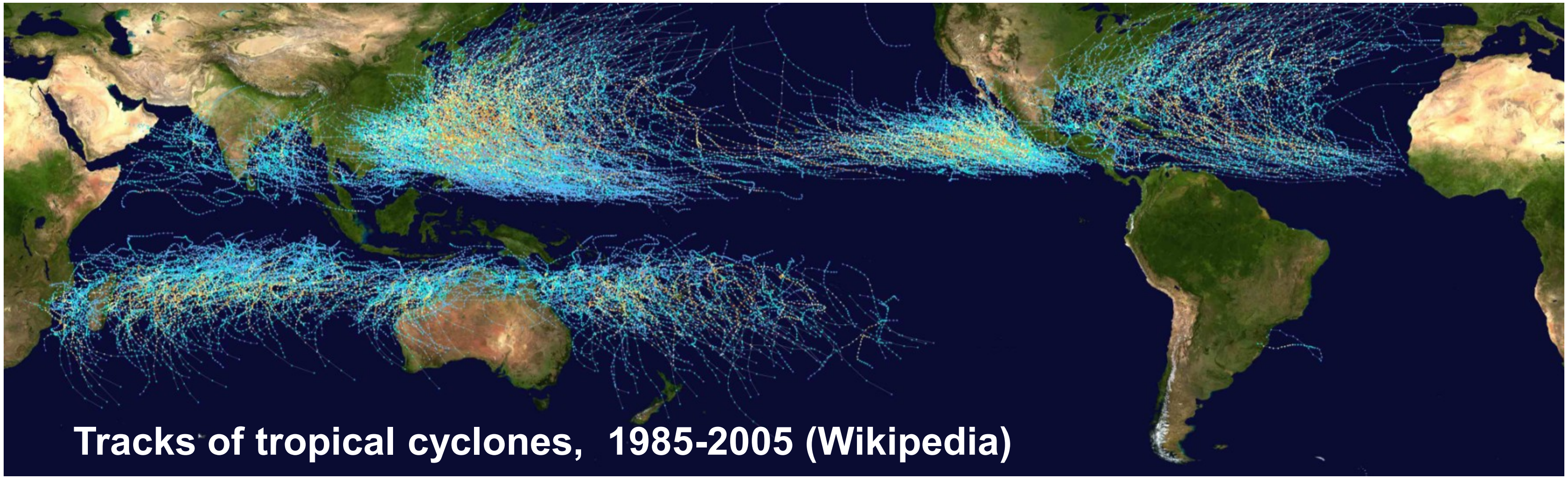
Tropical Cyclone Feedback



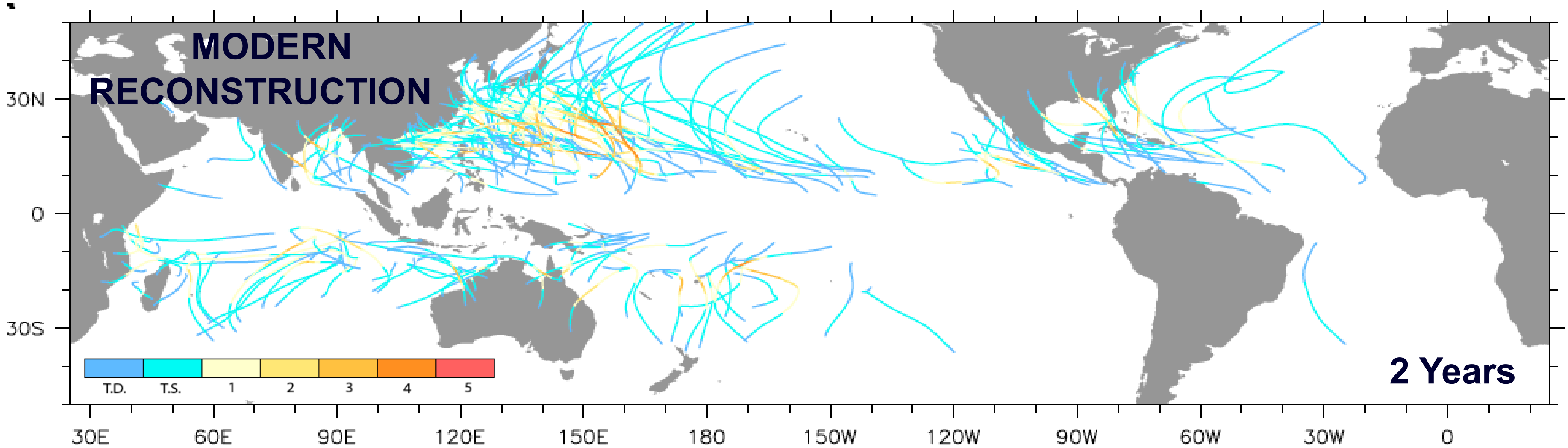
Fedorov et al., Nature. 2010

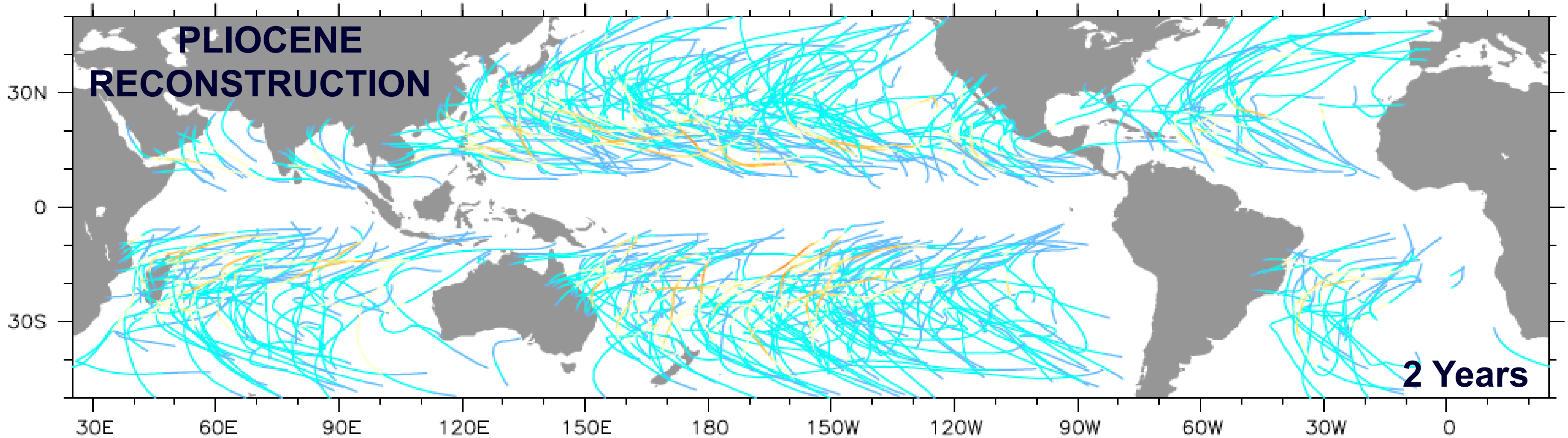
Synthetic Tracks for Present-day





Synthetic Tracks for Pliocene

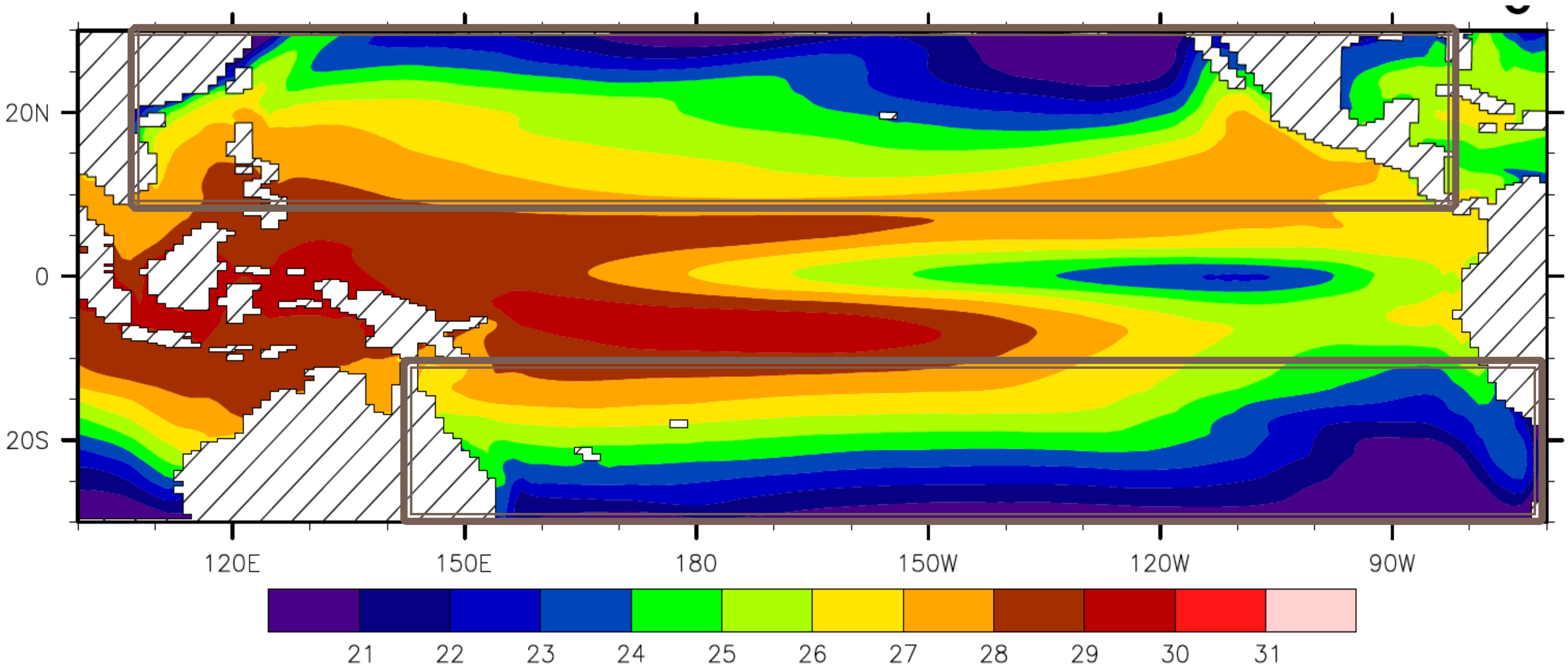




Fedorov et al., Nature. 2010

Modeling "tropical cyclone" mixing

Preindustrial SST

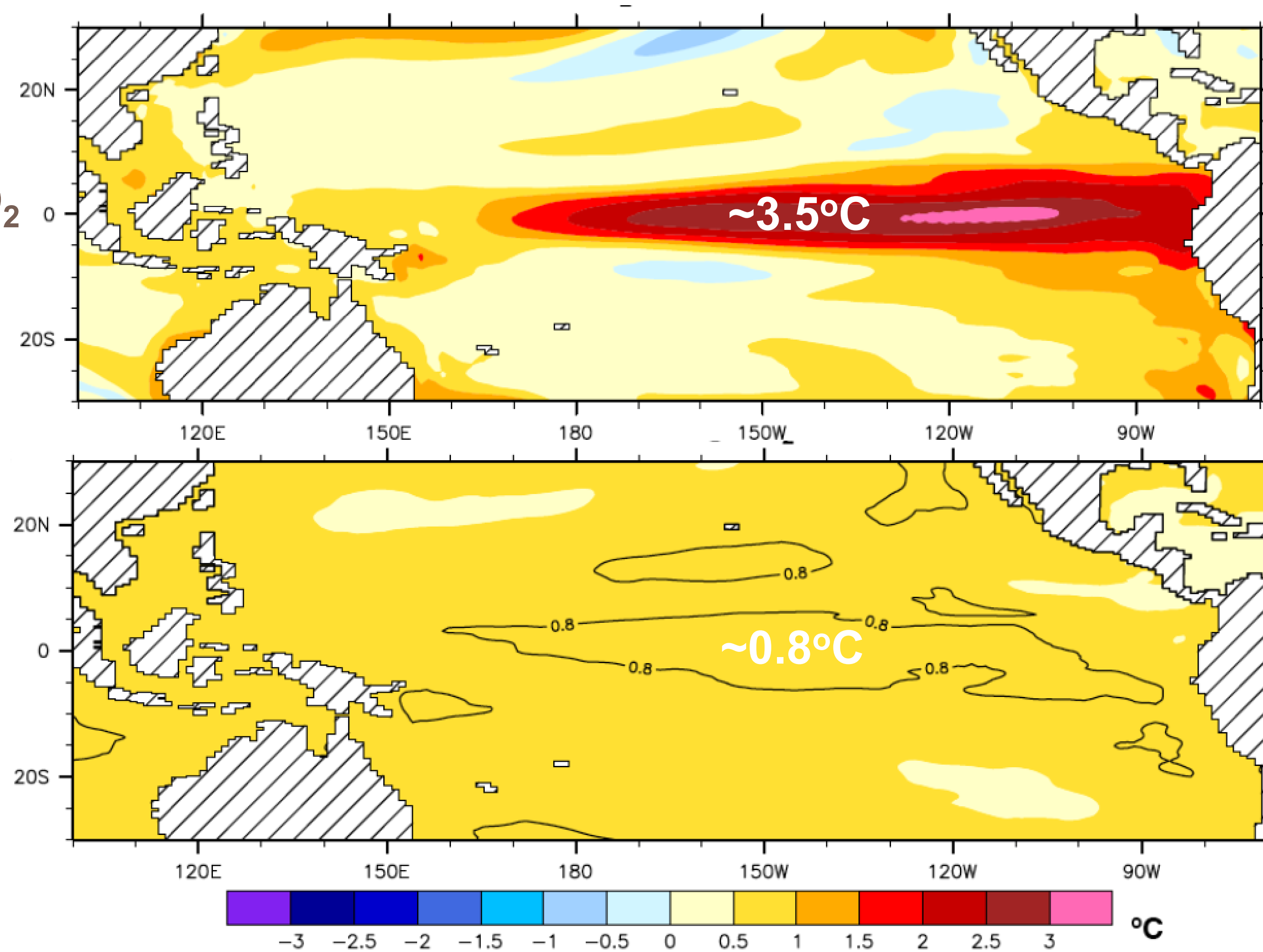


We impose enhanced ocean mixing between 8-40^o latitude (K_v=1cm^2/s)

Impact of "tropical cyclone" mixing

TC Mixing + increasing CO_2

Increasing CO_2 Only



Conclusions

- The Tropical Pacific had a different SST distribution in the early Pliocene than at Present
  - One vast warm pool stretching from Indonesia towards California
- This vast warm pool created a sluggish atmospheric circulation.
- Sustaining the warm pool needs an additional physical process included in climate models
- Tropical cyclone feedbacks could be that process
- This feedback could be important in future projections