

# Fossil coral records of tropical Pacific climate over the last millennium: relationship to external forcing

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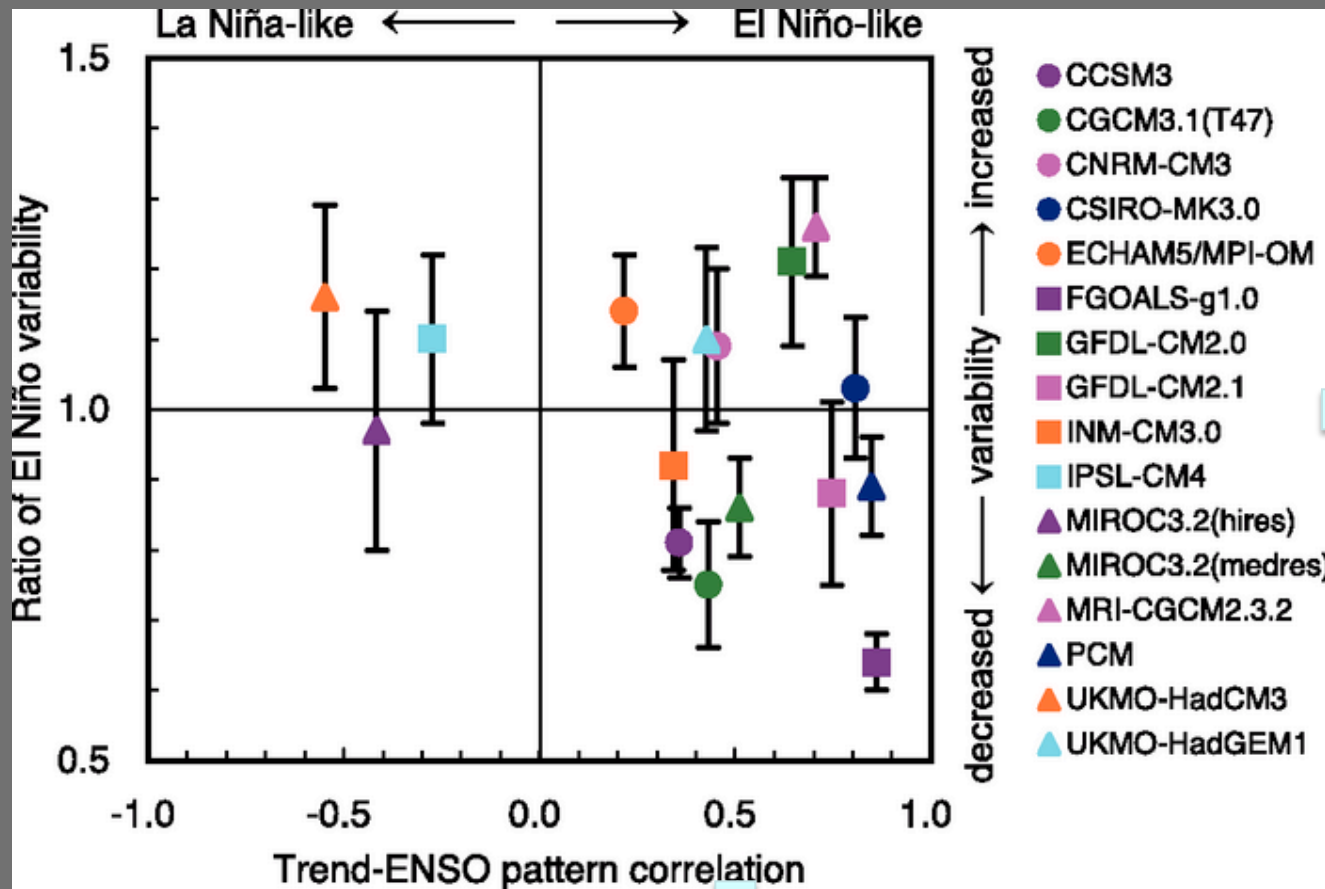
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with thanks to NSF, NOAA, ACS-PRF,  
NCL, PARC, NGS-WAITT,  
Cobb lab undergrads



# Towards accurate Tropical Pacific climate projections

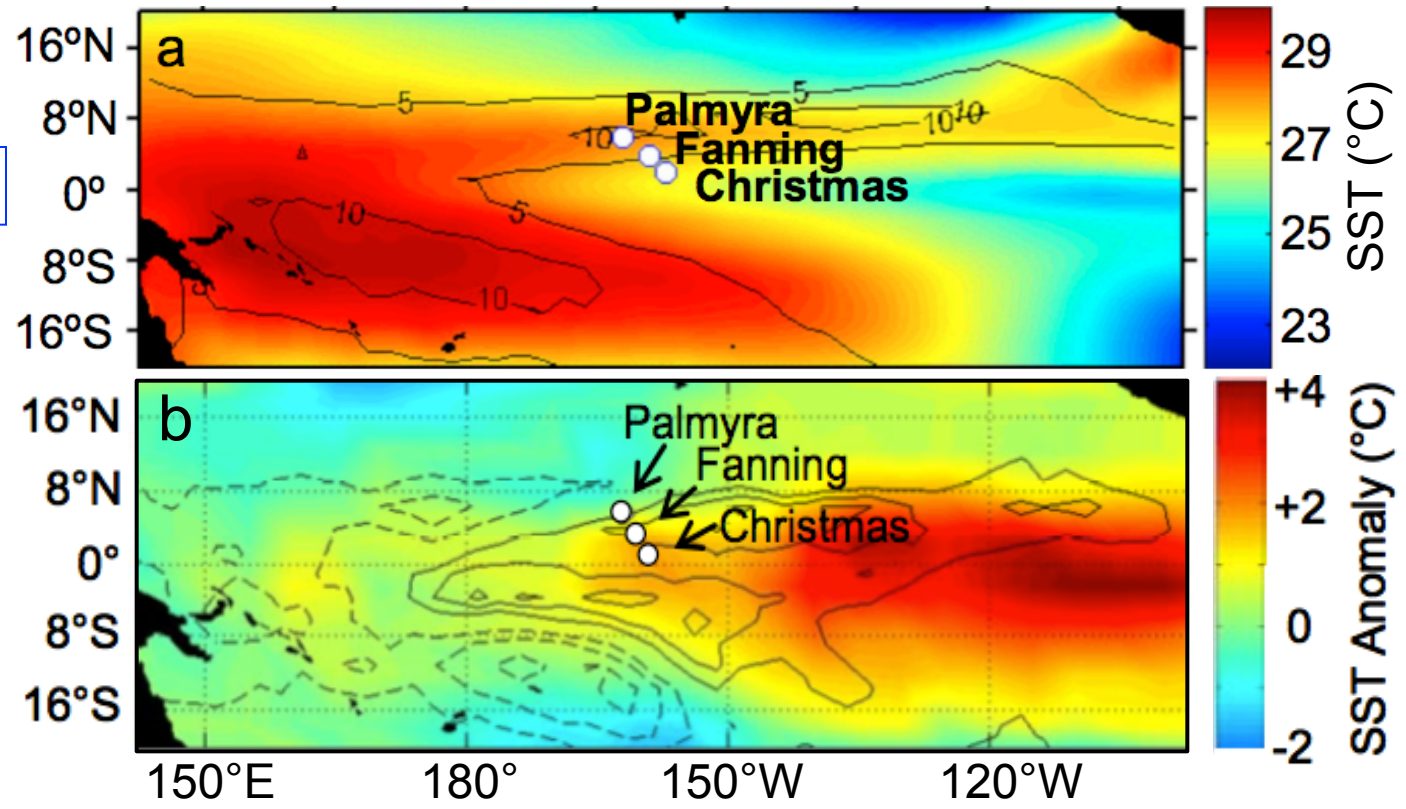


How sensitive is ENSO to external forcing?

Models pose clear tests for paleoclimate data

# SST, hydrology, and coral $\delta^{18}\text{O}$ in the Line Islands

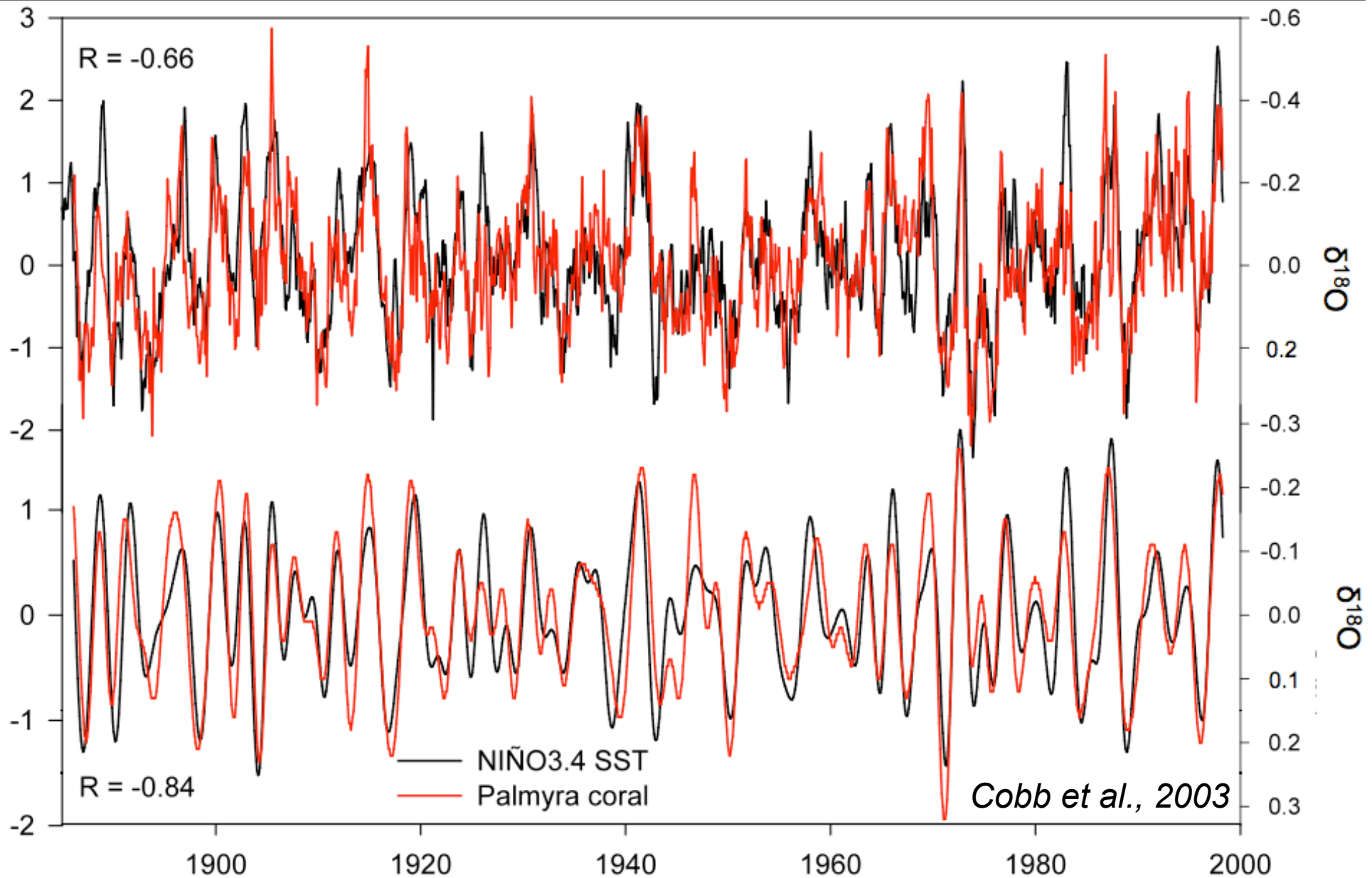
CLIMATOLOGY



EL NIÑO

Coral  $\delta^{18}\text{O}$  decreases when SST warm (thermodynamics)  
Coral  $\delta^{18}\text{O}$  decreases when rainy (lower seawater  $\delta^{18}\text{O}$ )  
→ great for resolving paleo-ENSO extremes

# 20<sup>th</sup> century calibration

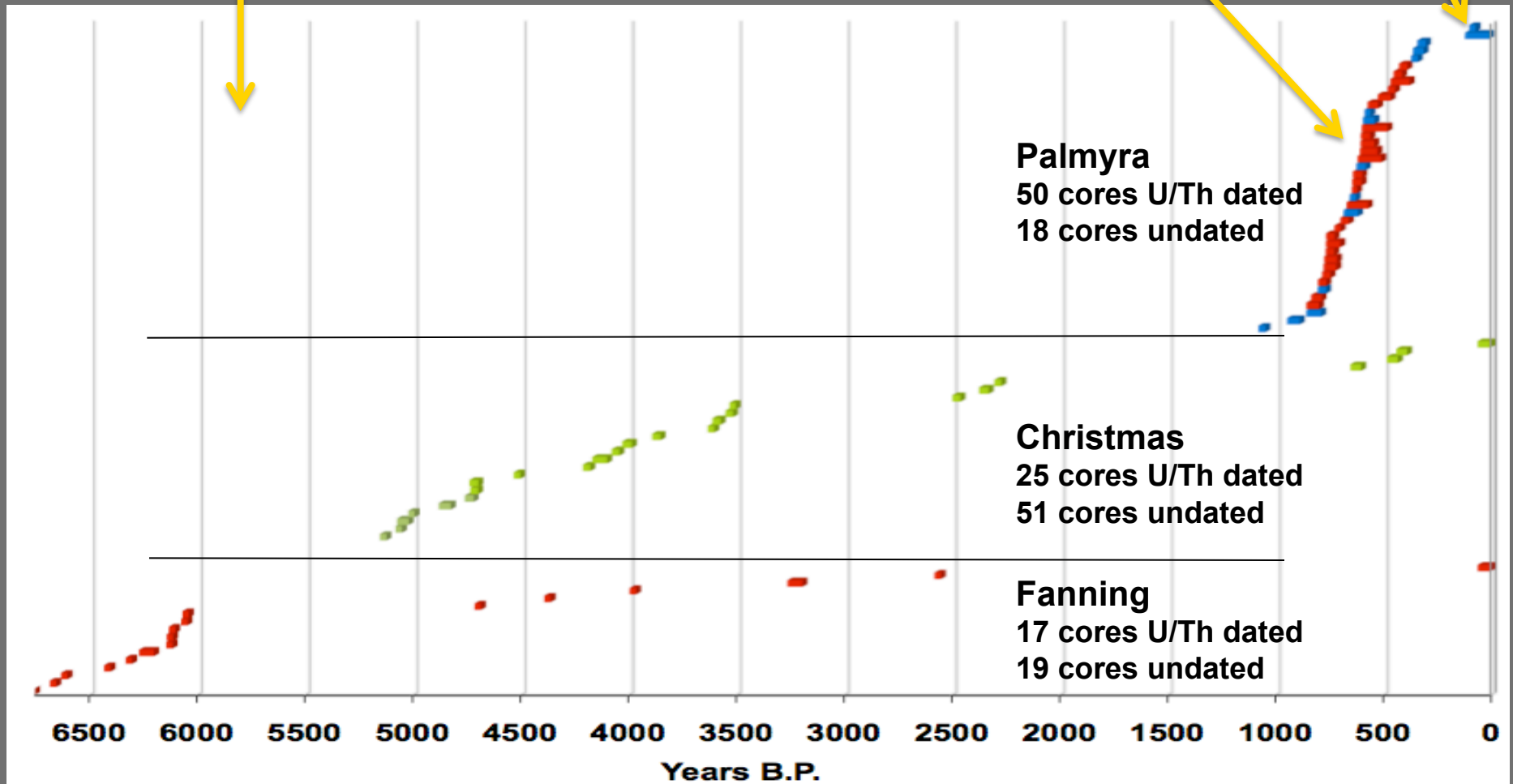


# The Line Islands Coral Collection

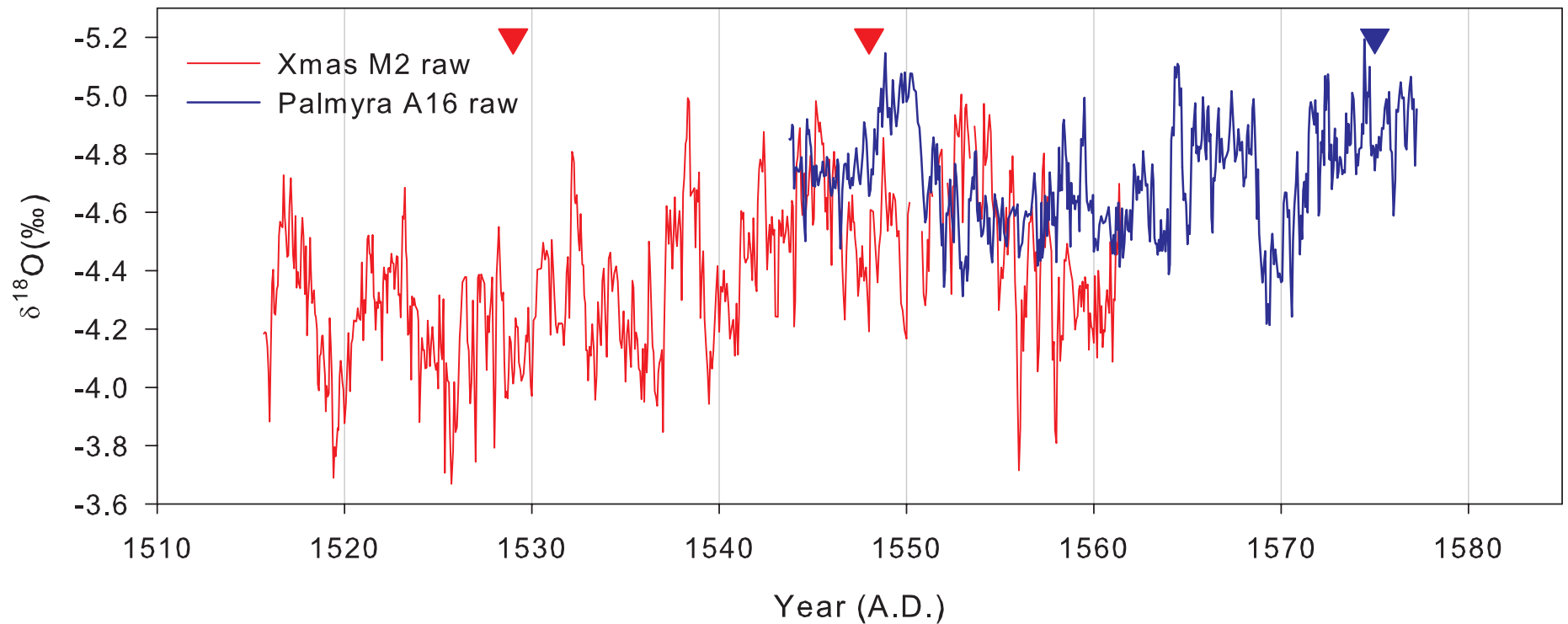
many cores  
in mid-Holocene

splice  
overlapping  
cores in last  
millennium

modern cores  
from three  
islands

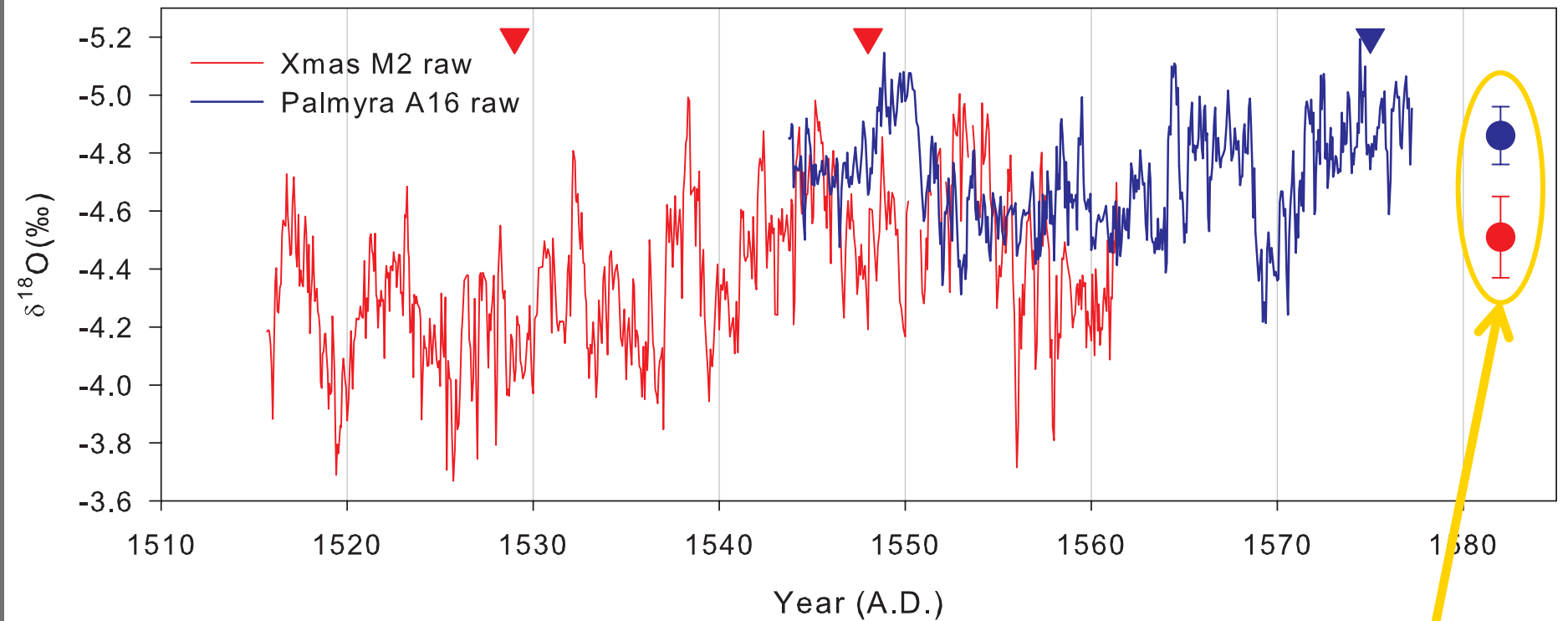


## Incorporating other Line Islands corals into reconstruction: a 16<sup>th</sup> century example



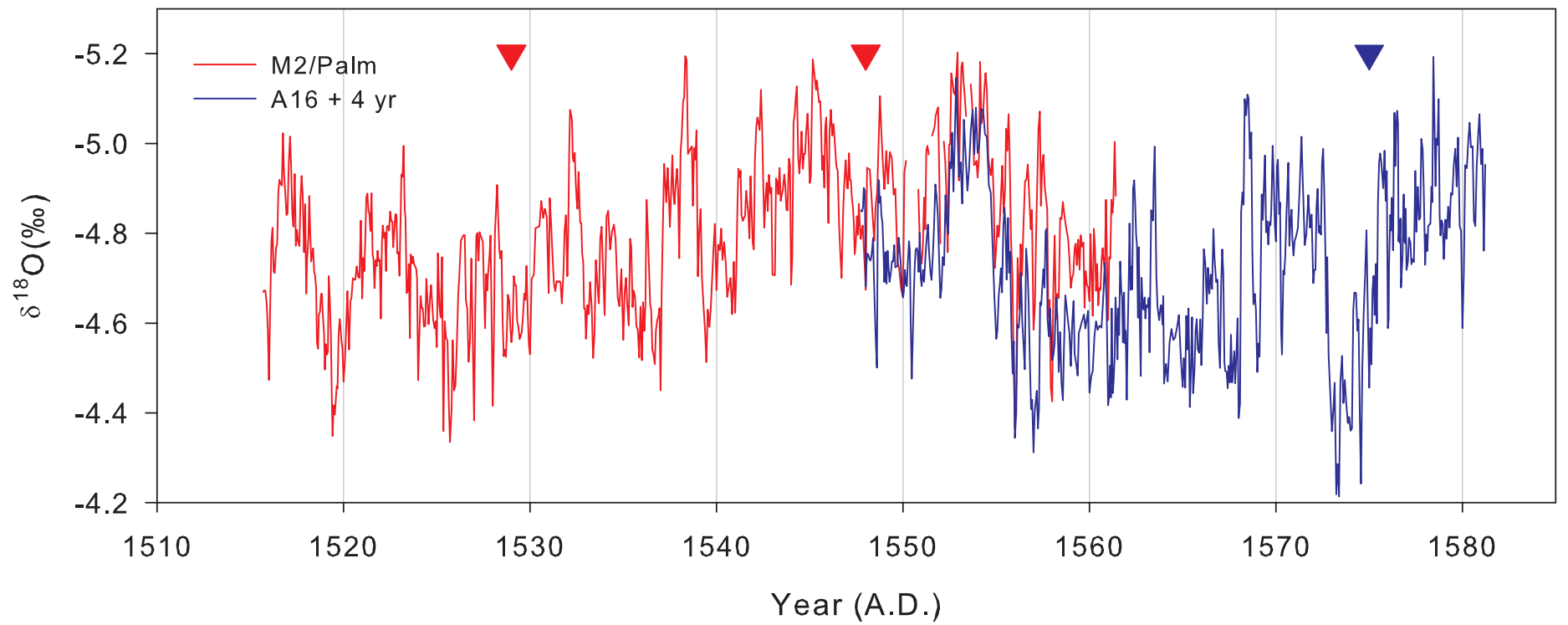
- U/Th dating errors of  $\pm 2$ -4 yrs analytical + 0-4 yrs  $^{230}\text{Th}$  unidirectional correction
- Christmas fossil coral  $\delta^{18}\text{O}$  heavier and more variable than Palmyra fossil coral  $\delta^{18}\text{O}$

# Incorporating other Line Islands corals into reconstruction: a 16<sup>th</sup> century example



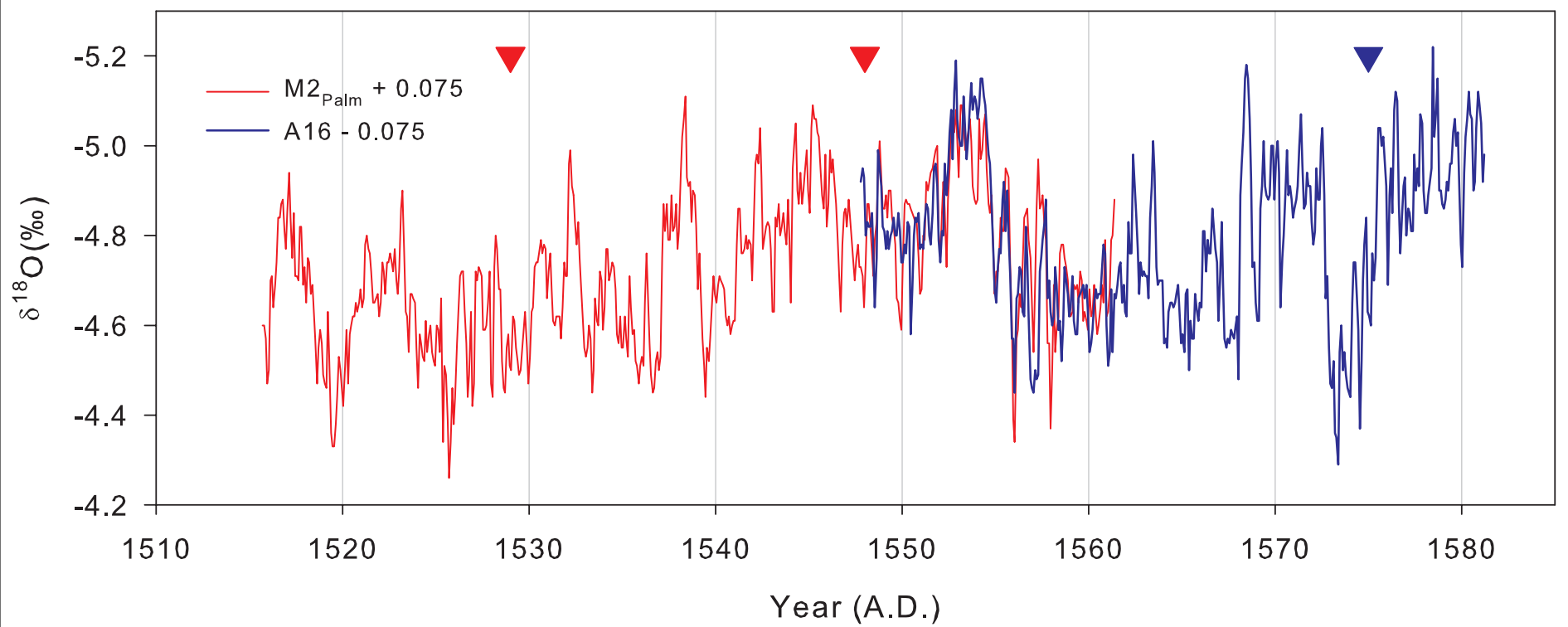
- Use modern coral  $\delta^{18}\text{O}$  scalings to make Christmas coral into a “Palmyra” coral

Differences in mean coral  $\delta^{18}\text{O}$  and std(ENSO) for Palmyra and Xmas modern corals



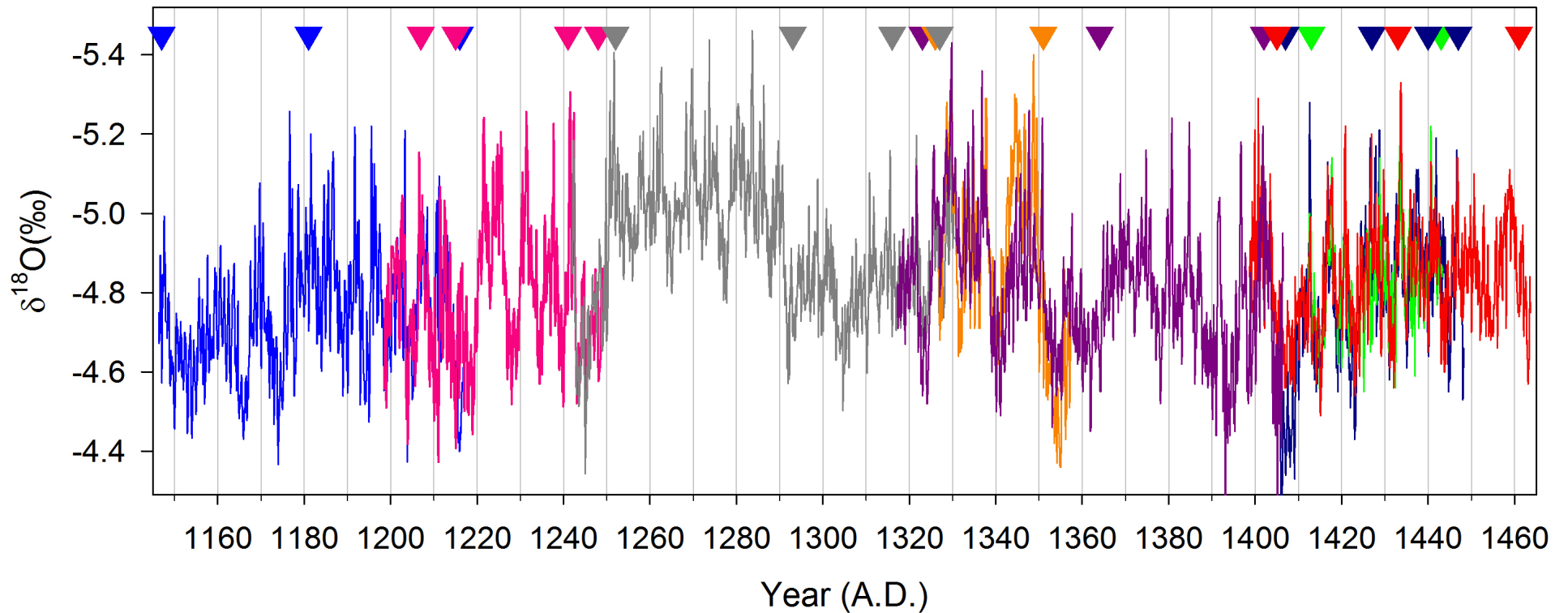
Result yields surprisingly good overlap between fossil corals (both in mean and variance); supports “modern-like” configuration of CTP climate





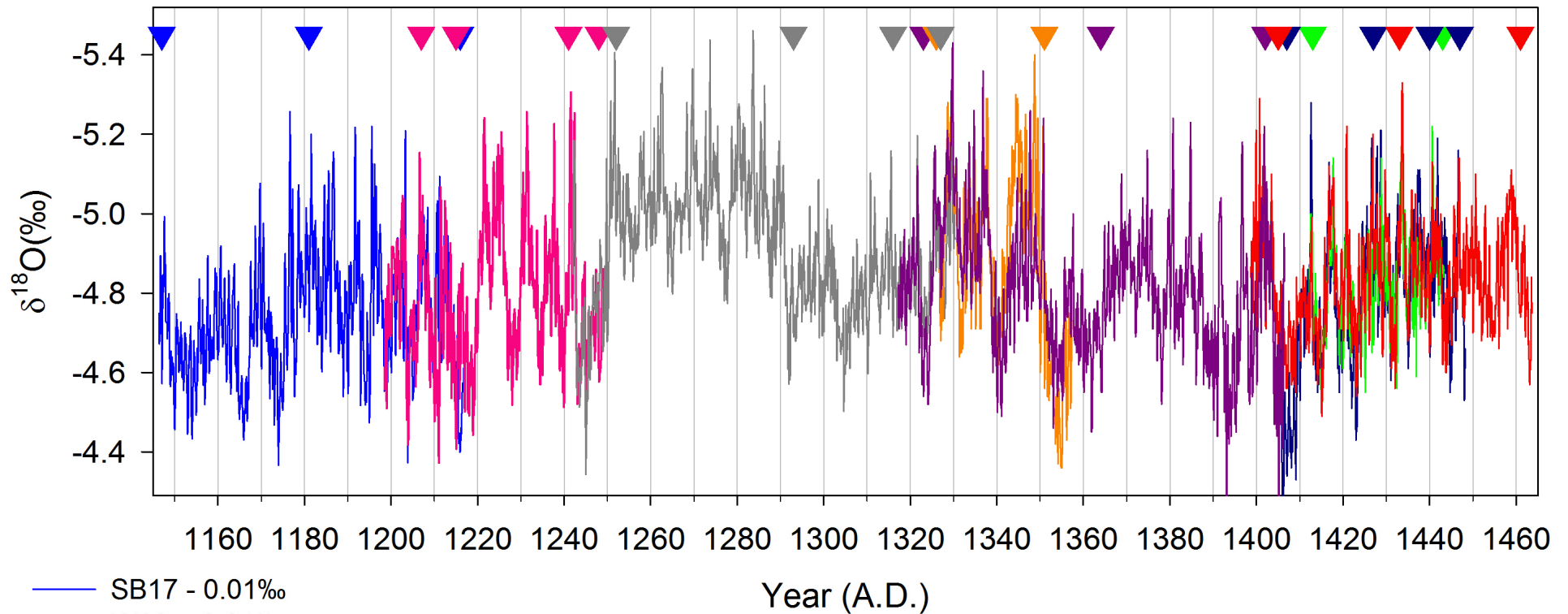
- correct for slight offset in mean coral  $\delta^{18}\text{O}$
- $R=0.72$  in interval of overlap

## New 8-coral splice



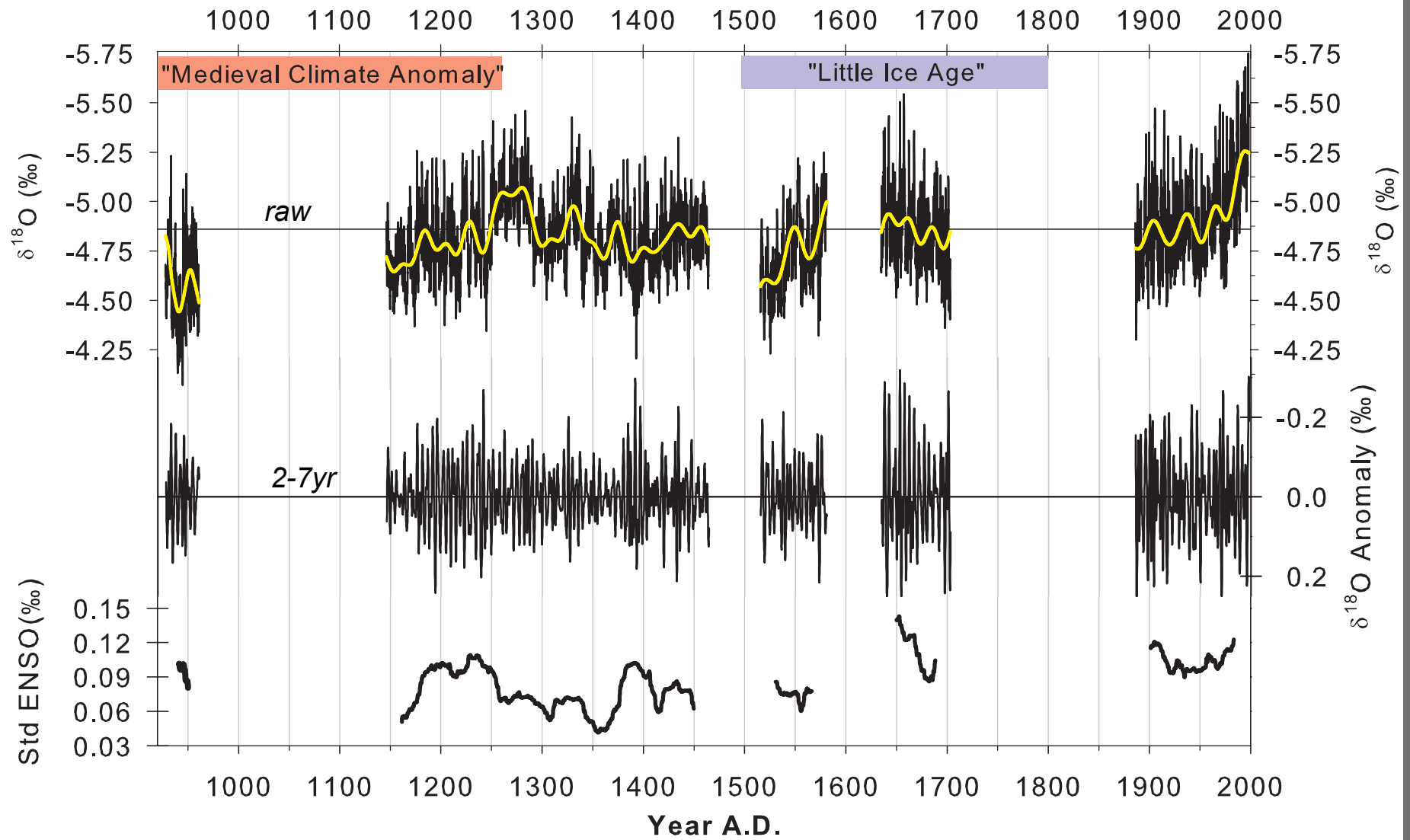
- very well-dated (>30 U/Th dates); near-absolute dating?
- large decadal-scale changes in coral  $\delta^{18}\text{O}$ ; significant ENSO activity

## What about mean coral $\delta^{18}\text{O}$ ?



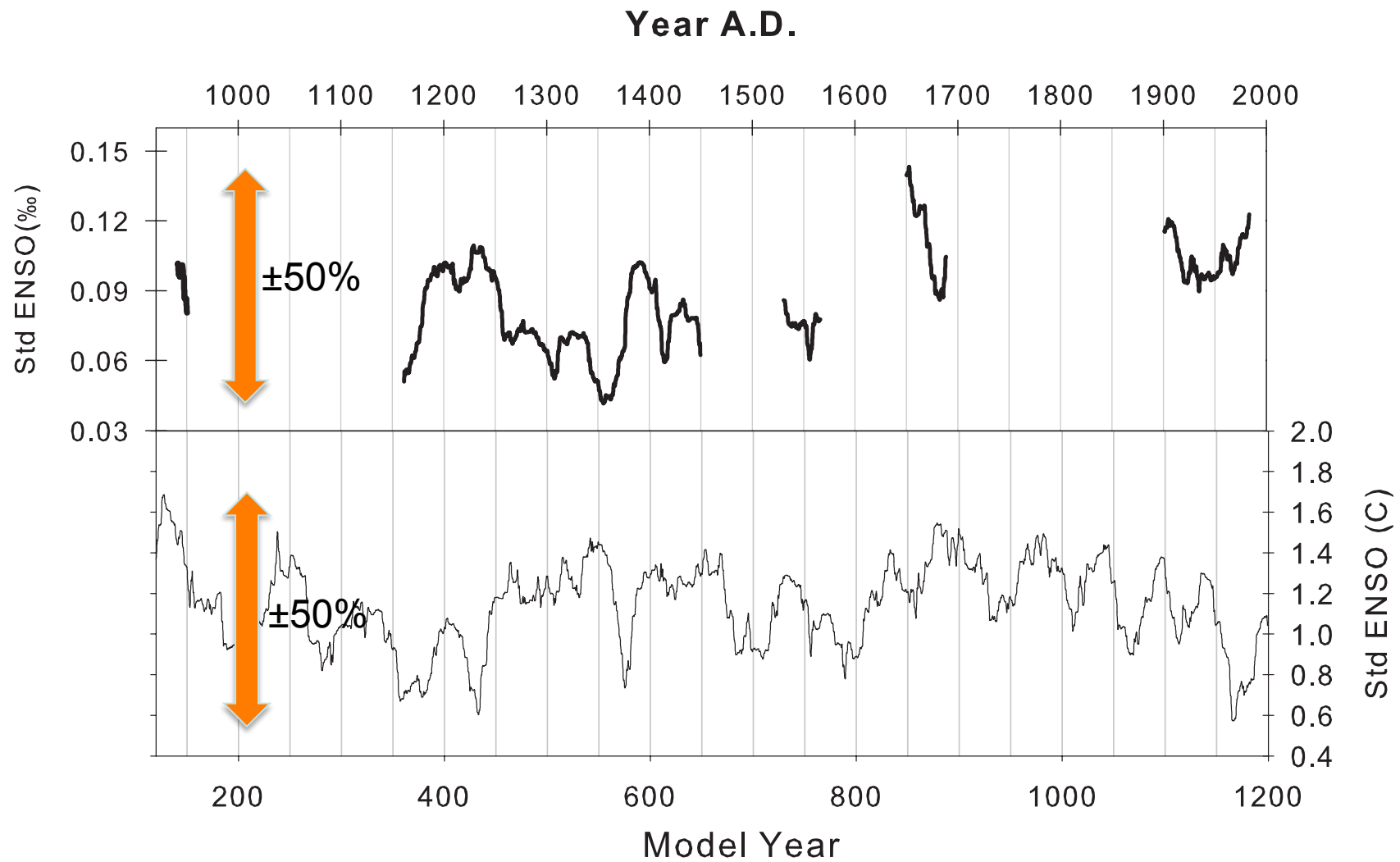
- SB17 - 0.01‰
- W23 + 0.01‰
- CH27 - 0.06‰
- SB7 - 0.05‰
- SB5 + 0.20‰
- SB6 - 0.10‰
- CH5 + 0.05‰
- CH9 - 0.05‰

←  $\pm 0.09\text{‰}$  ( $1\sigma$ ) offsets in mean coral  $\delta^{18}\text{O}$ ;  
but 6 out of 8 corals agree to within analytical error ( $\pm 0.06\text{‰}$ ,  $1\sigma$ )



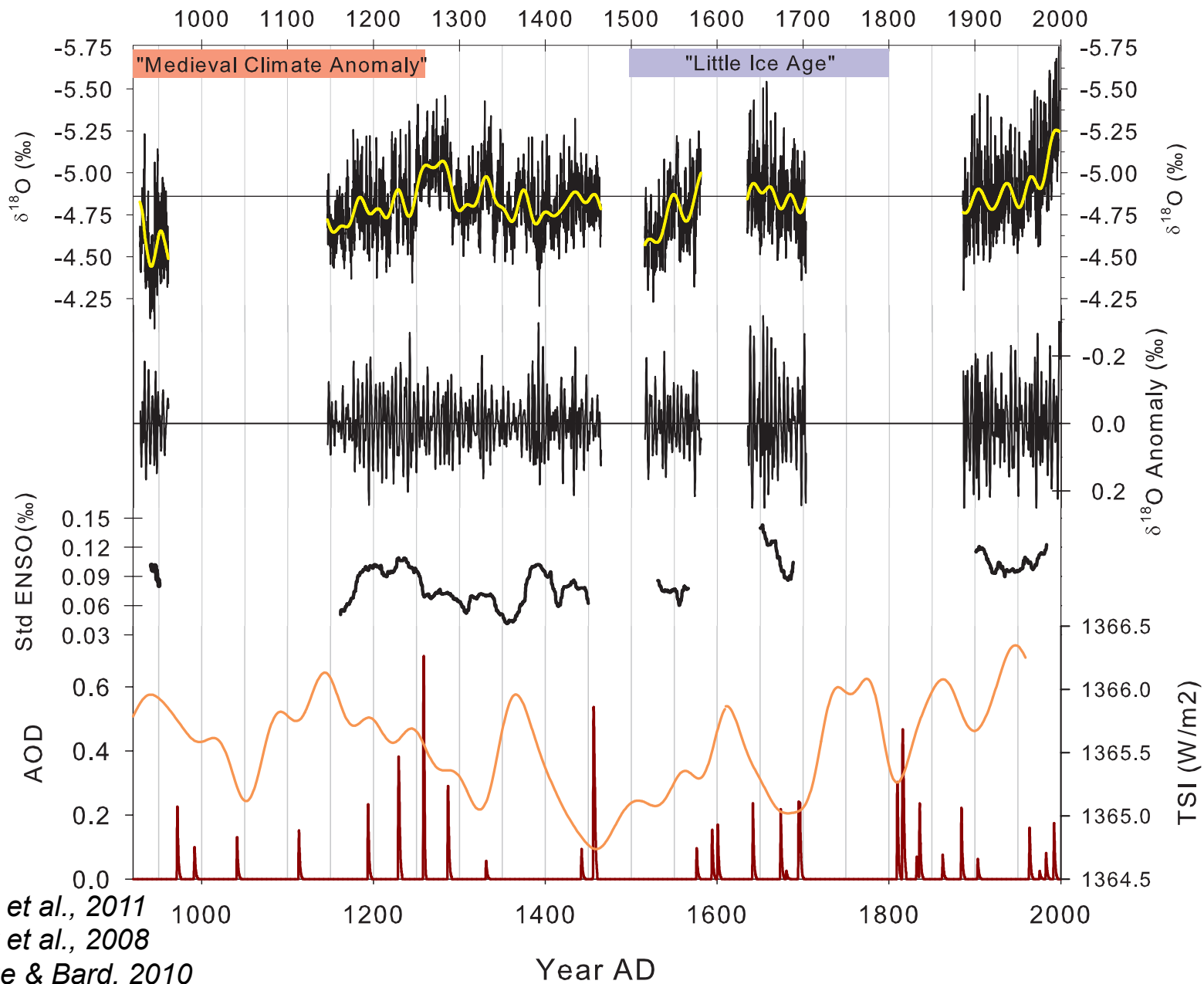
- no discernible MCA-LIA differences in mean or variance
- strong decadal-scale variability
- broad range of ENSO variances (>> 20<sup>th</sup> century)
- late 20<sup>th</sup> century trend unique

# A null hypothesis for ENSO variability



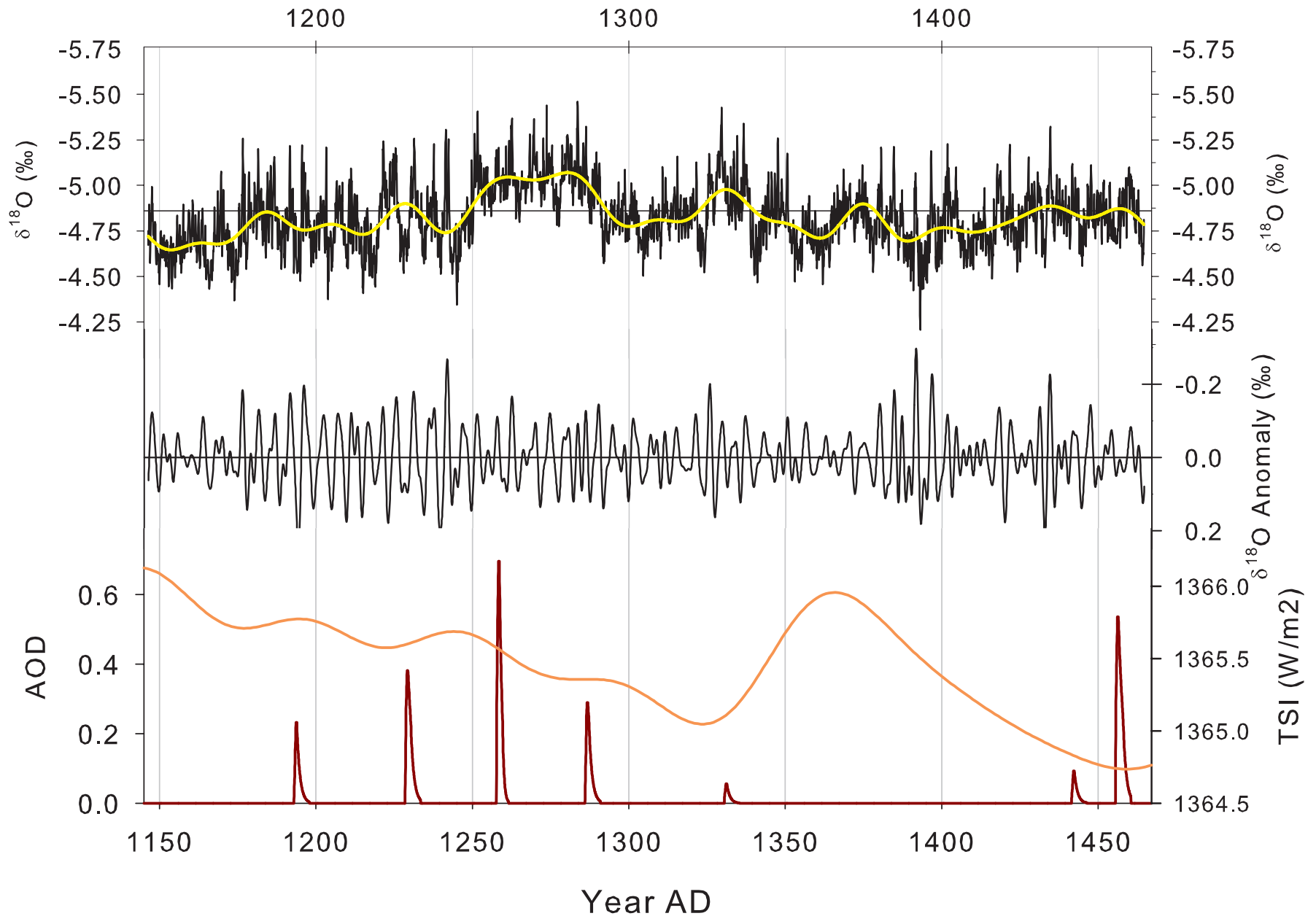
Model NINO3.4: Wittenberg, 2009

# Comparison with solar and volcanic forcing

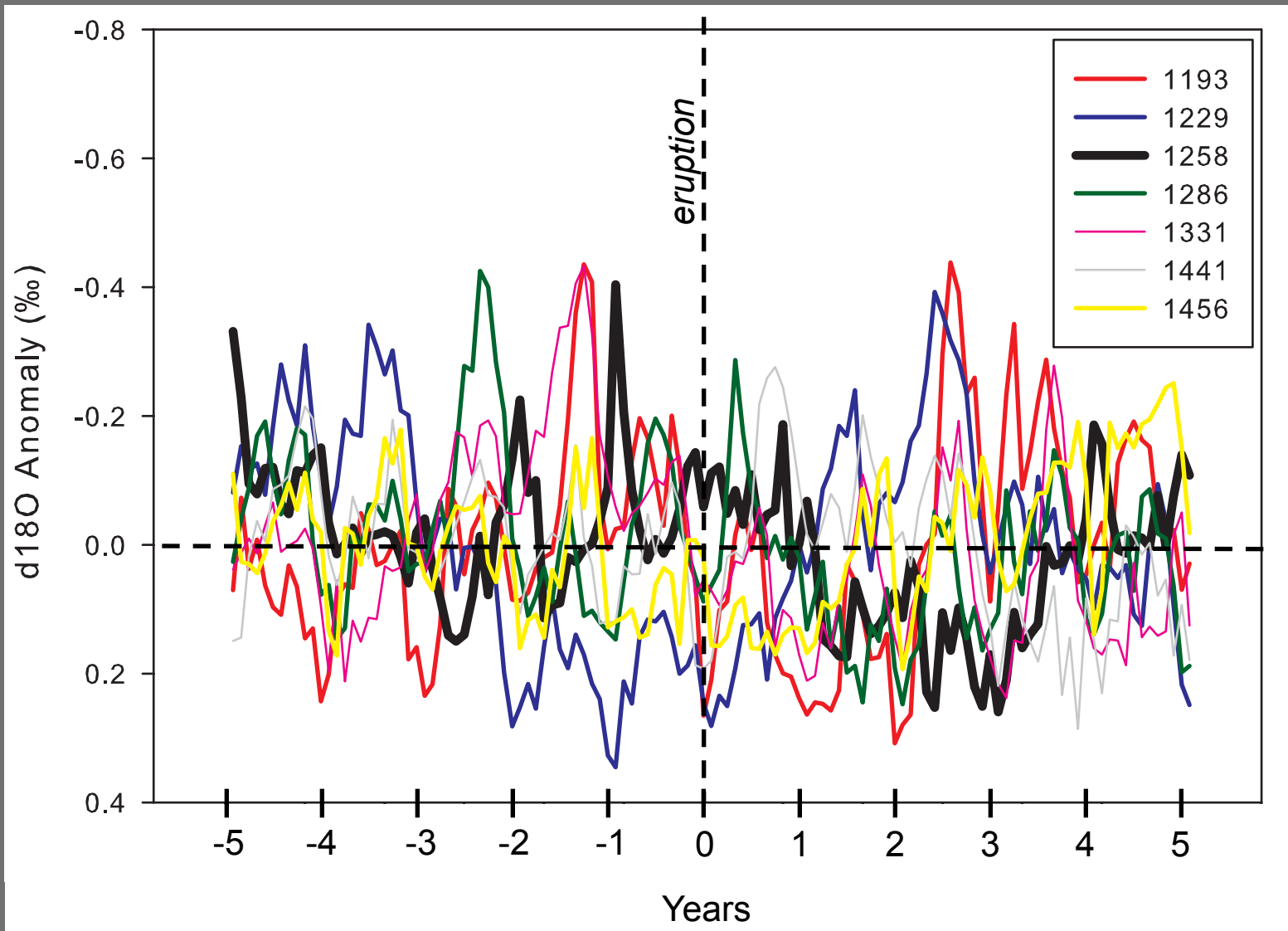


Schmidt et al., 2011  
Crowley et al., 2008  
Delaygue & Bard, 2010

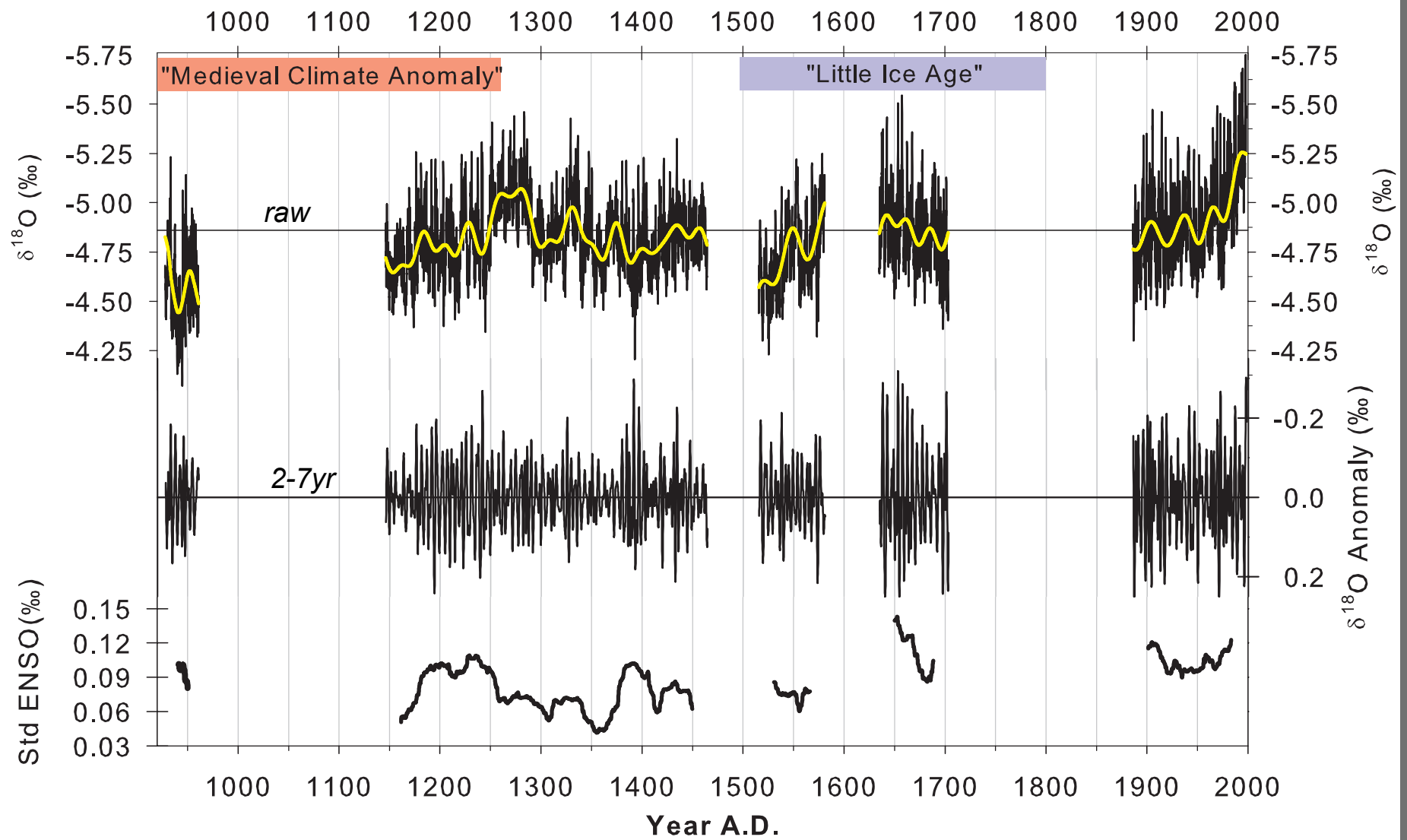
# Comparison with solar and volcanic forcing: a closer look



# “Stack” of volcanic eruption years across 8-coral splice

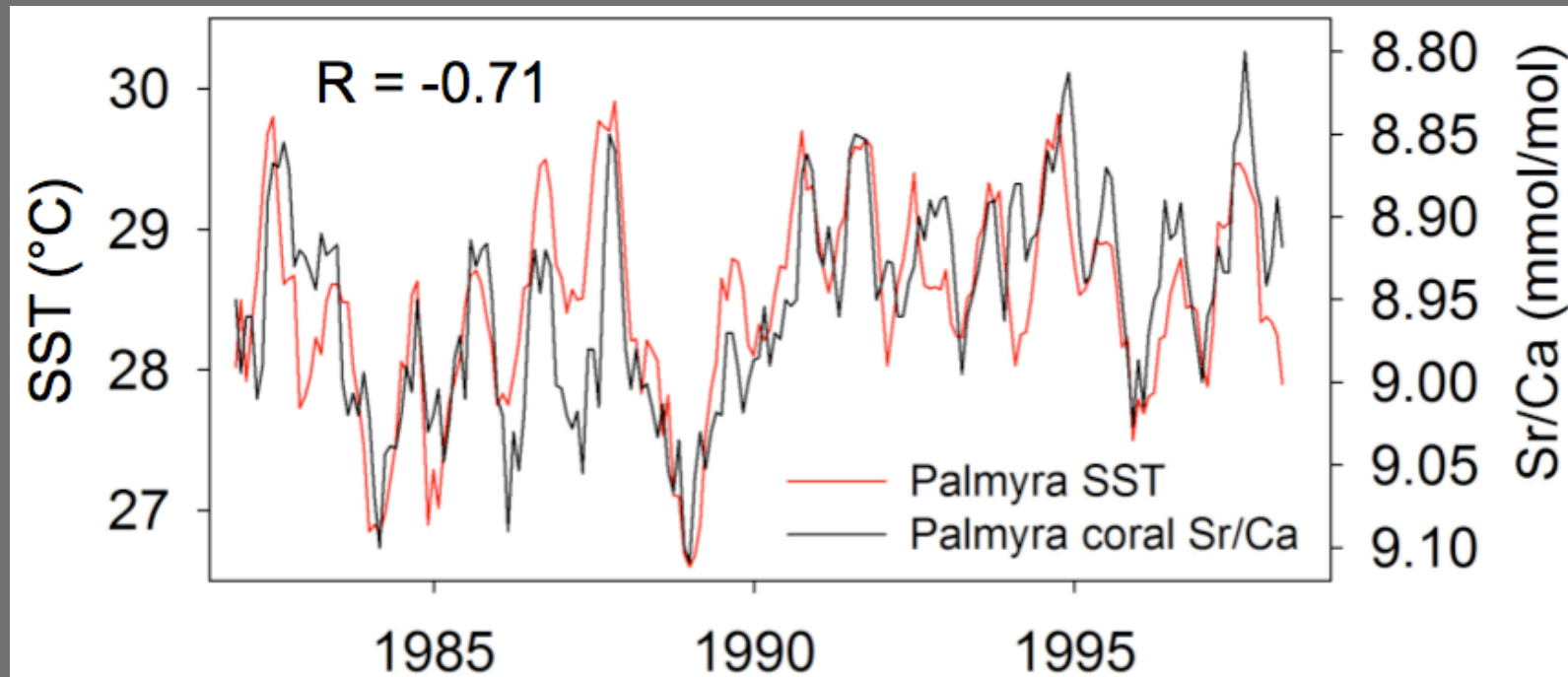




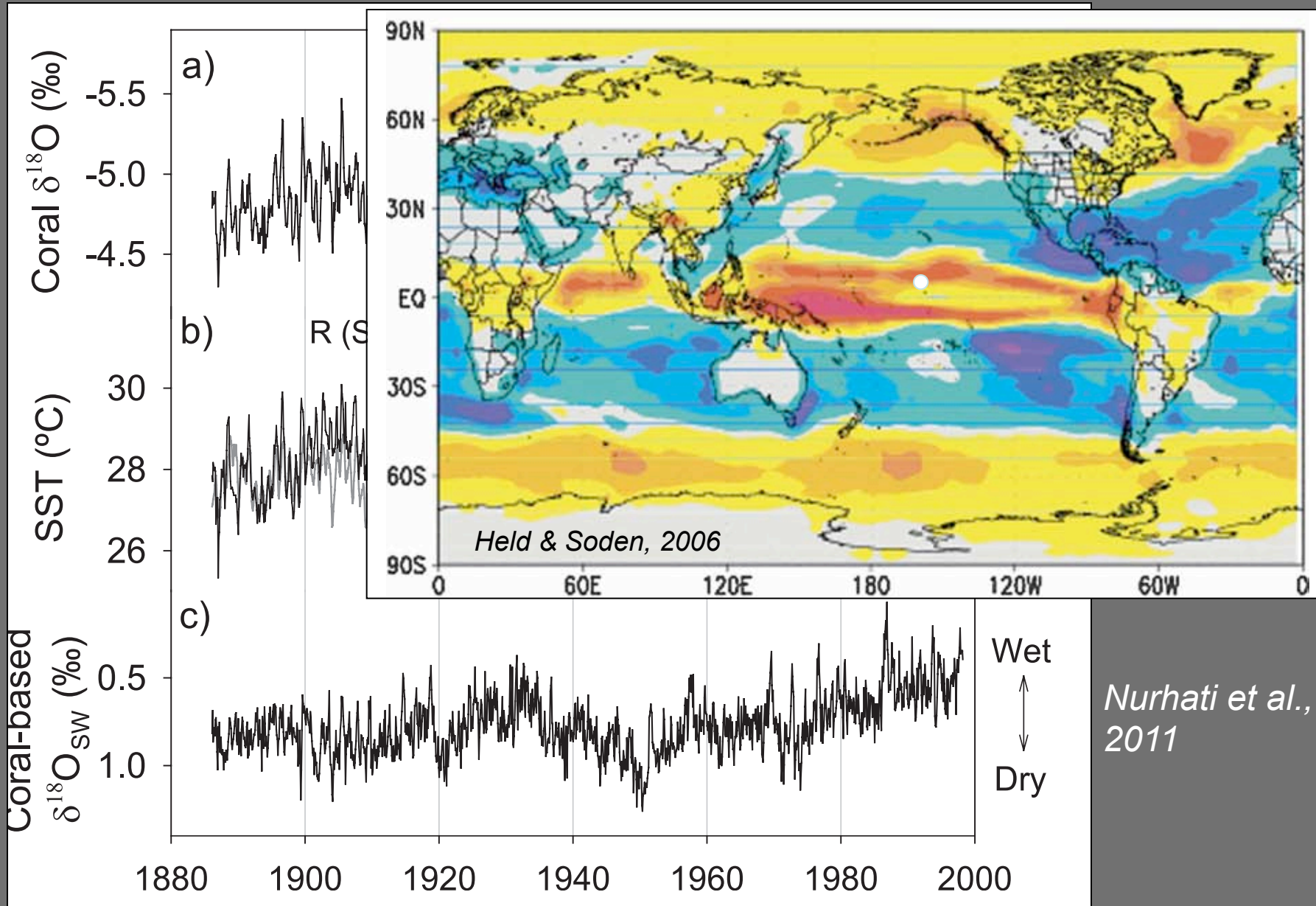


Late 20<sup>th</sup> century trend in coral  $\delta^{18}\text{O}$  may be response to anthropogenic forcing:  
 What's causing it?

# Use coral Sr/Ca to distinguish SST from $\delta^{18}\text{O}_{\text{sw}}$ changes over the last century



*Nurhati et al., 2009*



Modern coral contains SST trend similar to instrumental record;  
 reveals large negative  $\delta^{18}\text{O}_{\text{sw}}$  trend  $\rightarrow$  regional freshening consistent  
 with model hydrological responses to  $\text{CO}_2$  forcing

# Conclusions

- No evidence for significant differences in central tropical Pacific climate from MCA to LIA (although there are many alternate versions of reality)
- No evidence that central tropical Pacific climate/ENSO is sensitive to solar and volcanic forcing over the last millennium
- Clear evidence that central tropical Pacific climate is changing in response to GHG forcing → large freshening signal