marum

Universität Bremen

Hydroclimate over the Common Era from Sr/Ca and $\delta^{18}O$ records of corals

Thomas Felis

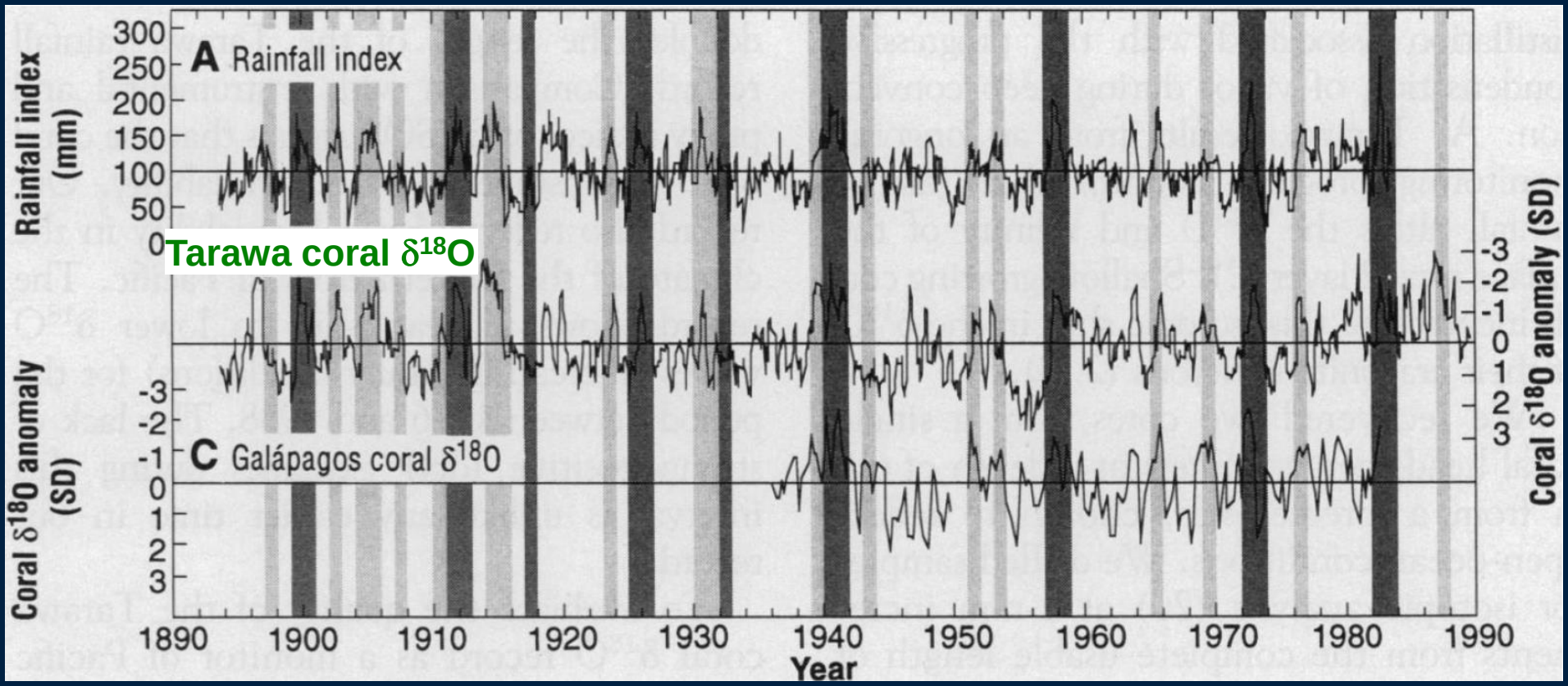
PAGES 2k – PMIP3 Workshop

Comparing data and model estimates of hydroclimate variability and change over the Common Era

June 1-3, 2016

Lamont-Doherty Earth Observatory

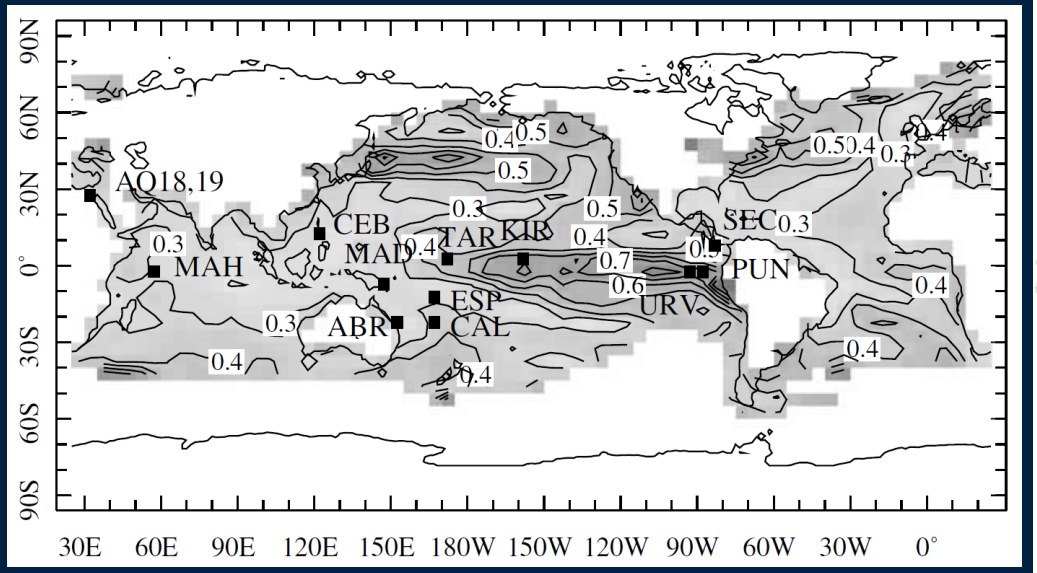
Tarawa coral $\delta^{18}O$ – ENSO rainfall proxy



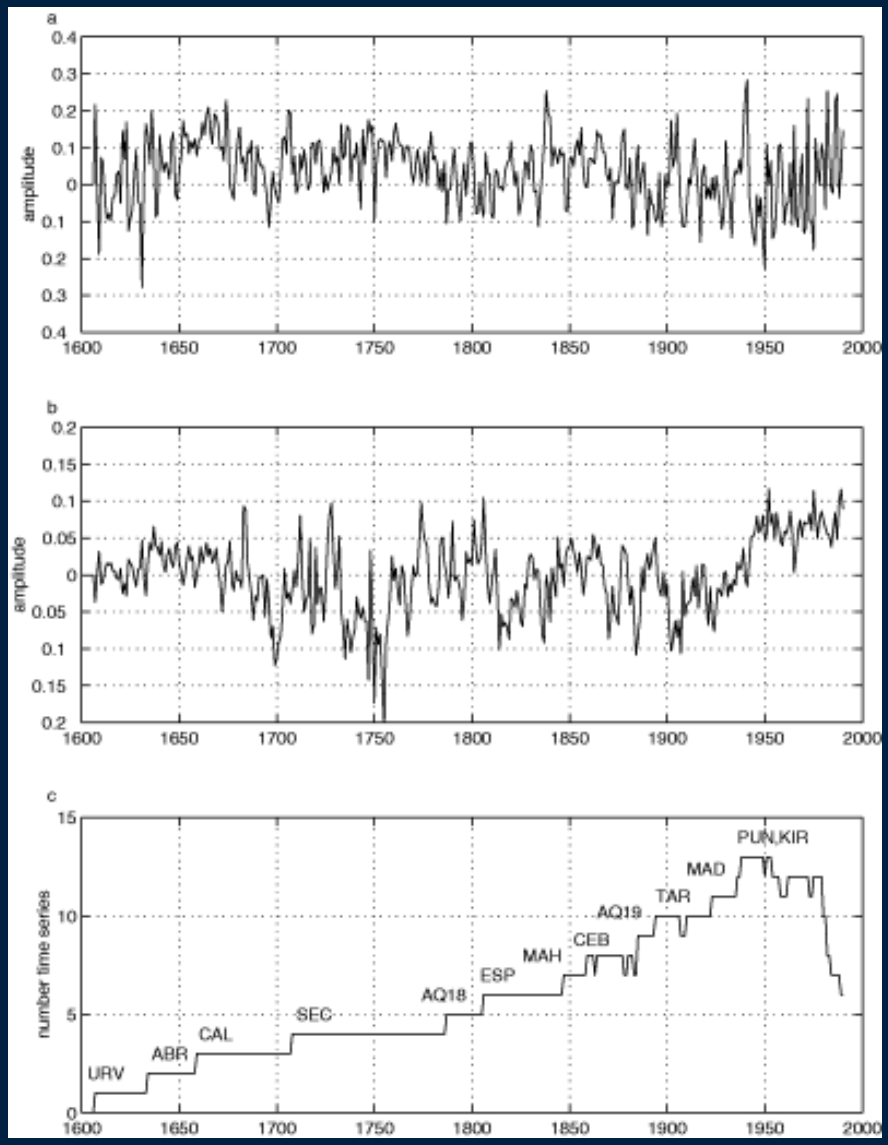
Cole et al., 1993, *Science*

SST field reconstruction from coral $\delta^{18}O$

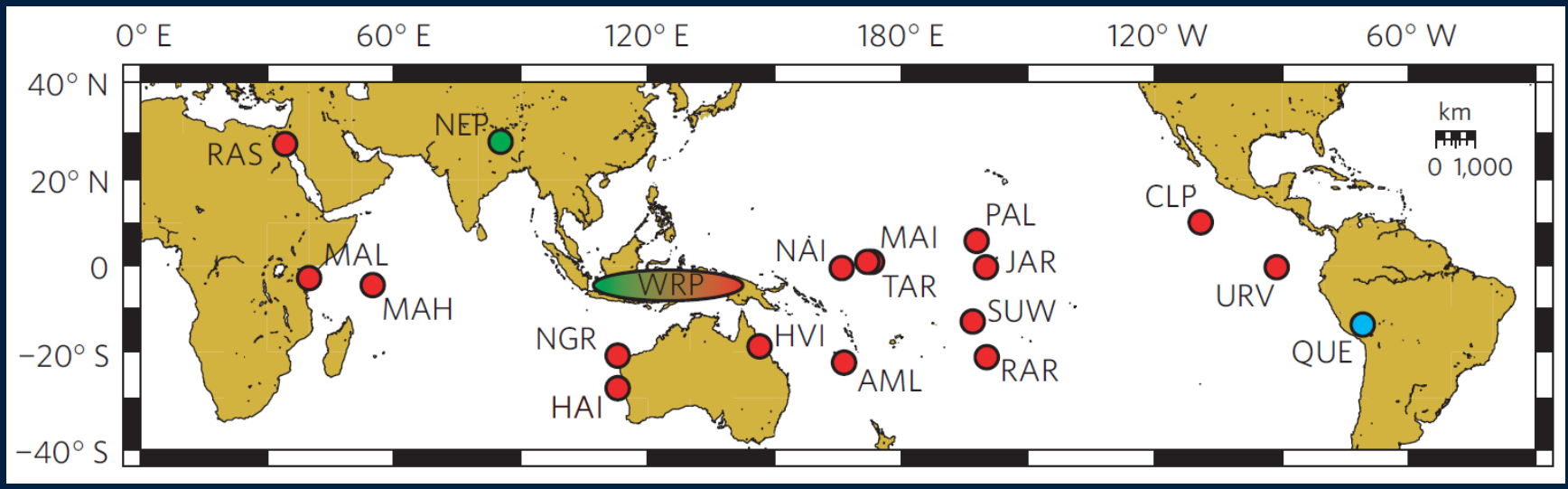
11 coral records

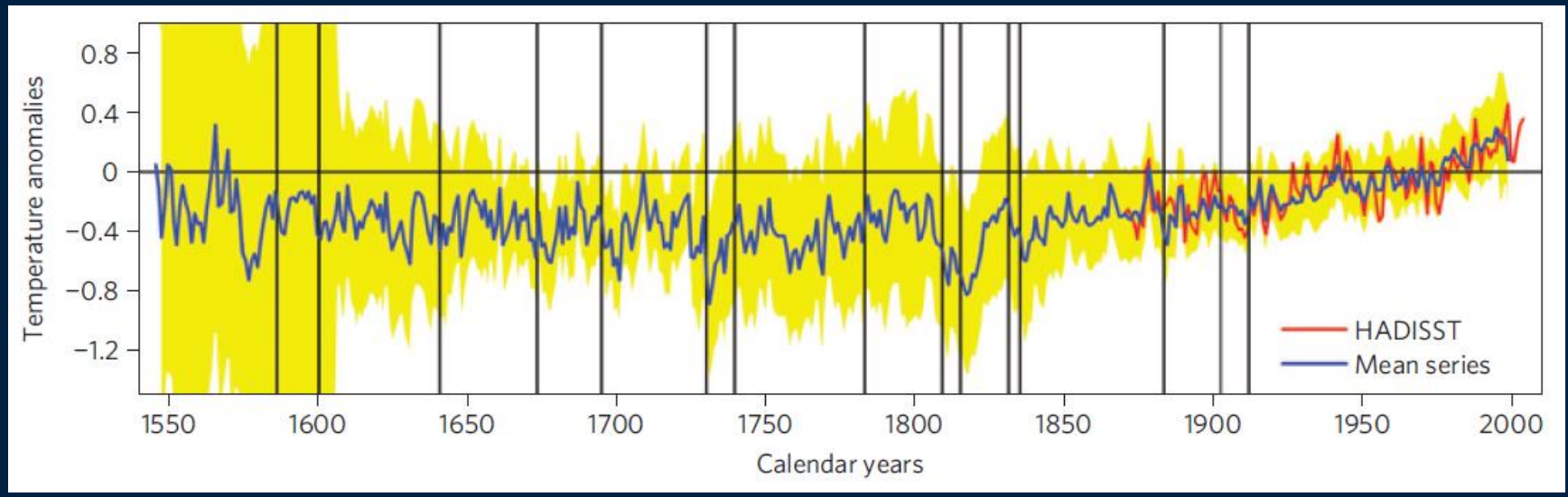


Evans et al., 2002, *Paleoceanography*



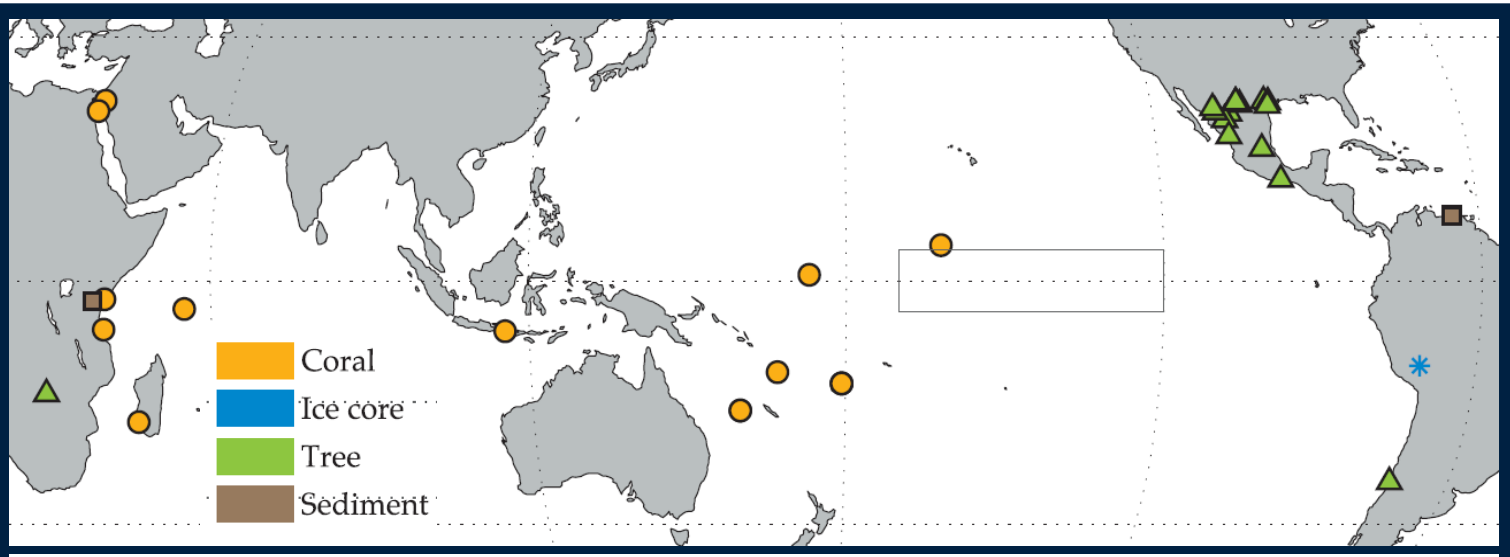
Volcanic forcing & tropical temperatures

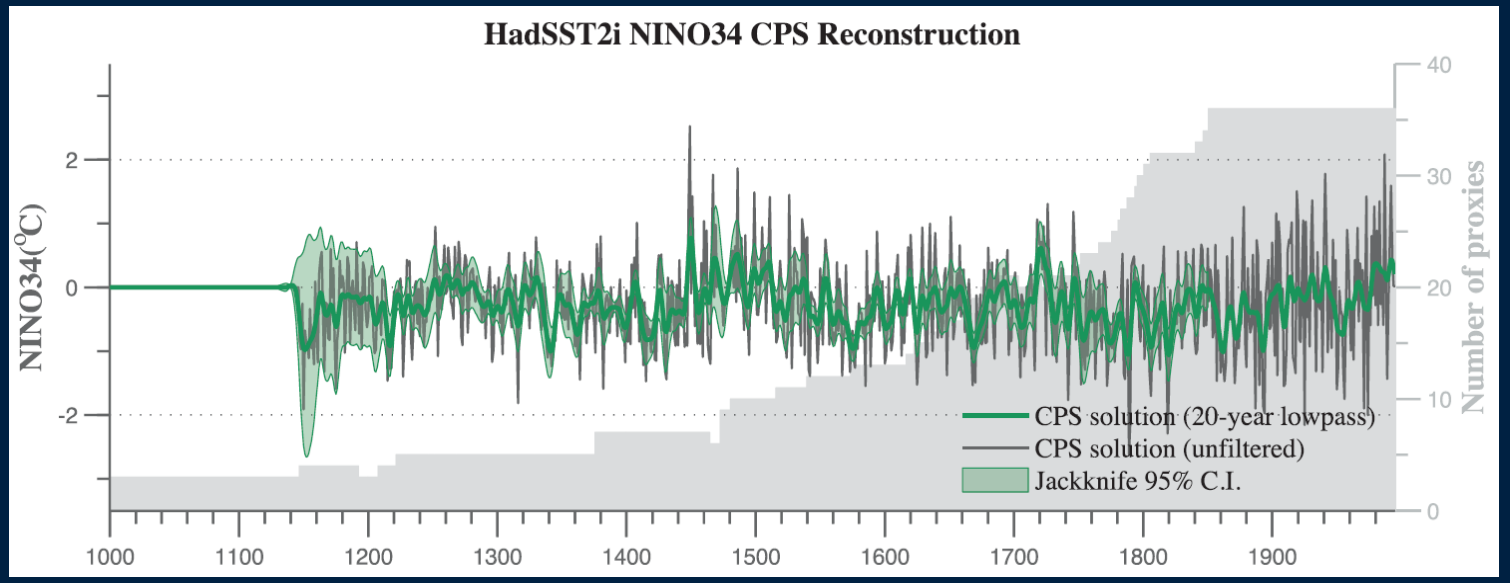




D'Arrigo et al., 2009, *Nature Geoscience*

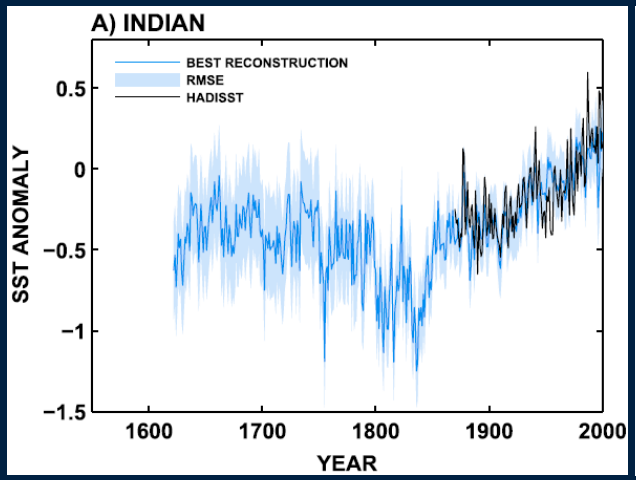
SST variability over past the millennium

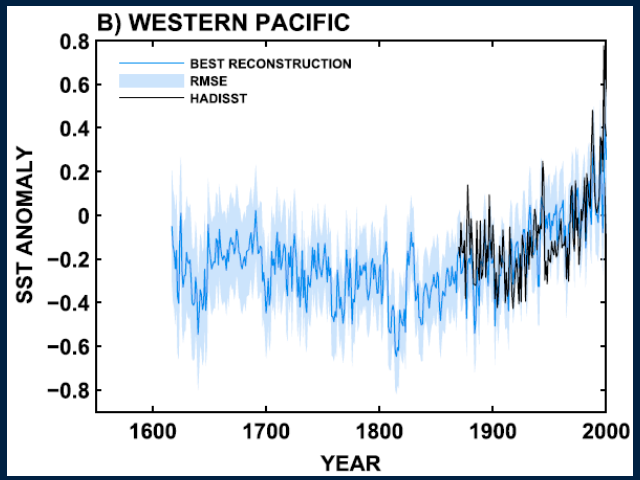


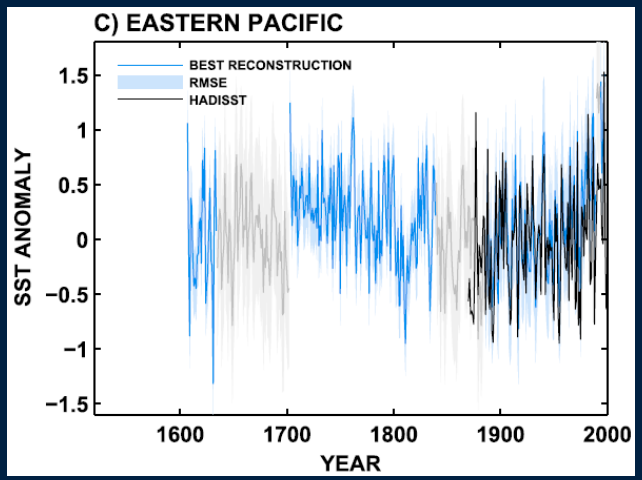


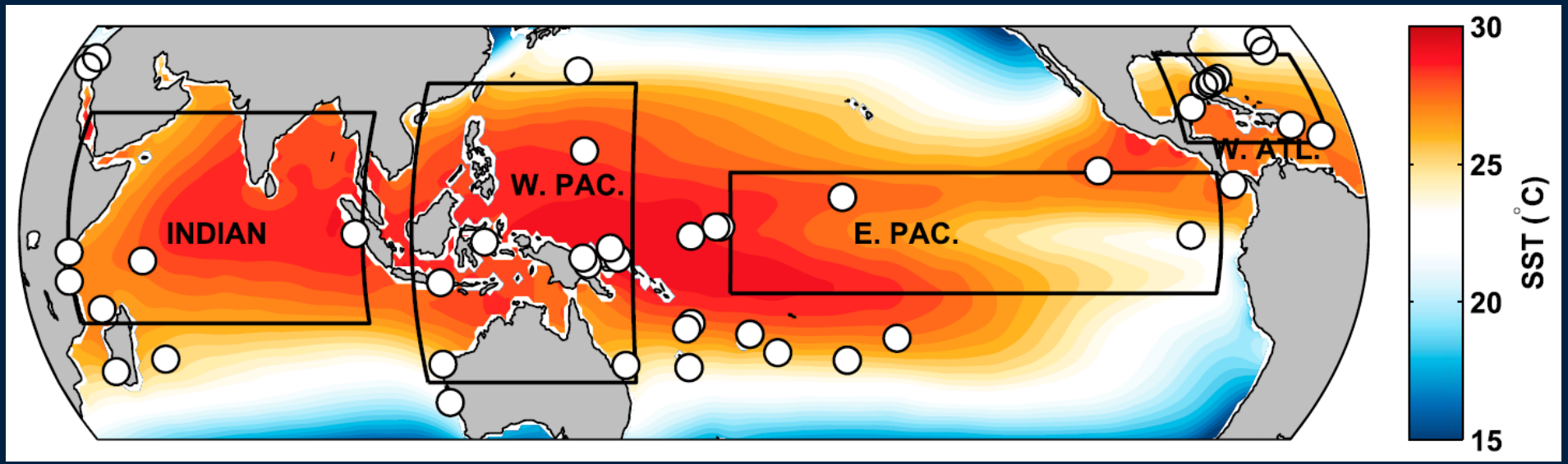
Emile-Geay et al., 2013, *Journal of Climate*

Tropical SST for the past four centuries









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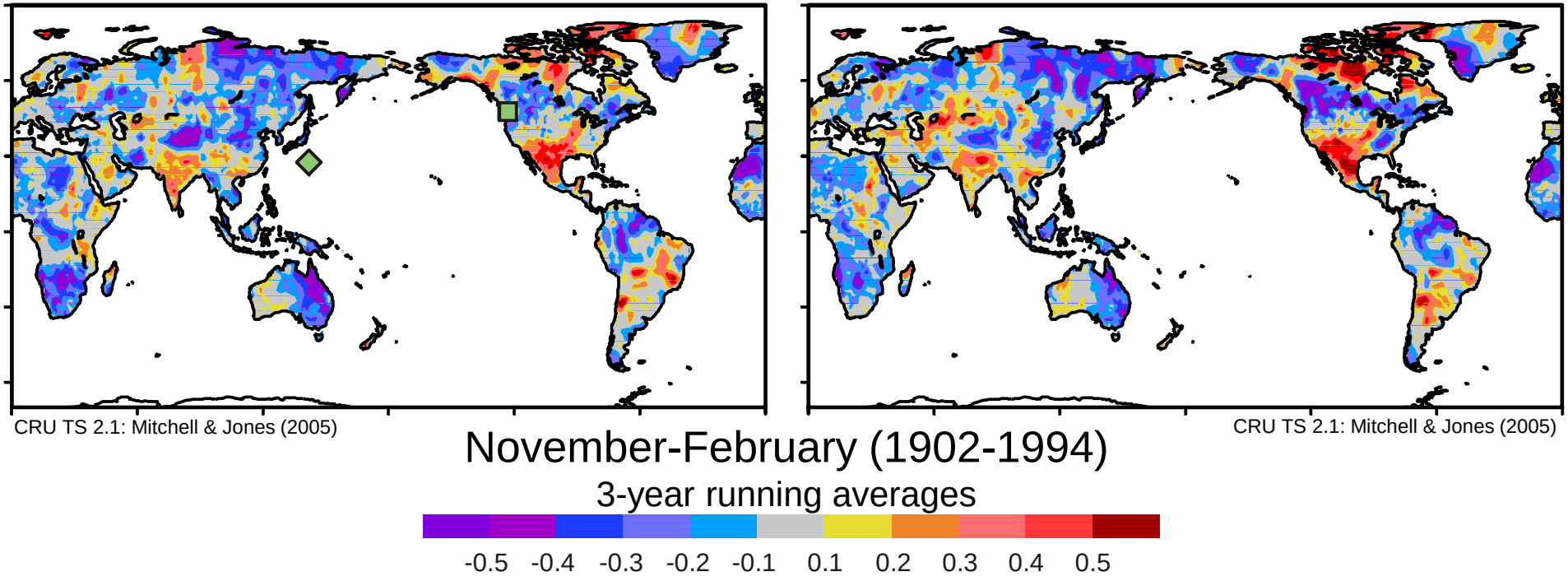
Tierney et al., 2015, *Paleoceanogr.*

Hydroclimate signals in coral records

Correlation with land precipitation

Coral-geoduck index

Winter PDO index



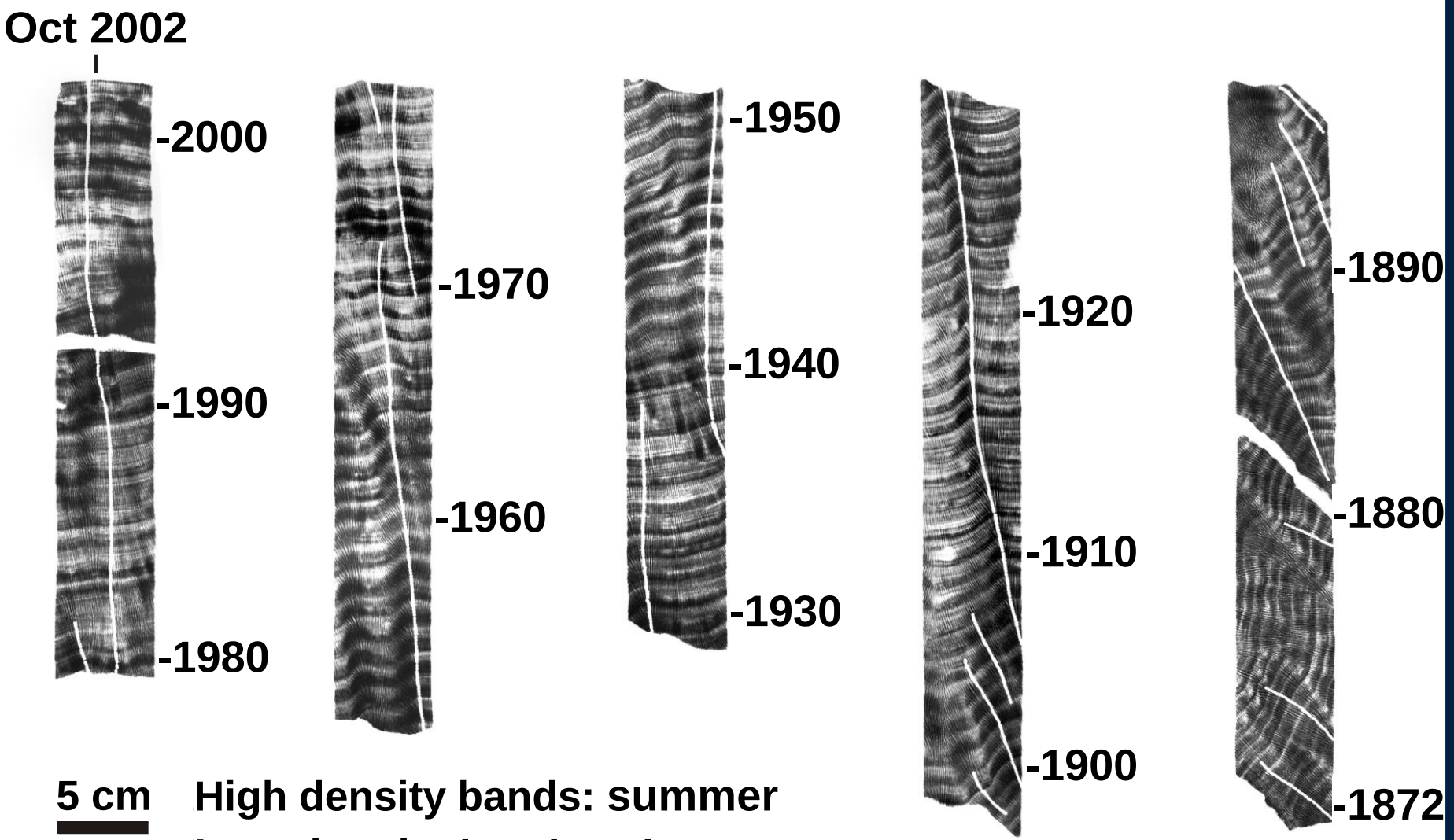
Felis et al., 2010, *Geophys. Res. Lett.*

Shallow-water coral archives

- skeleton of aragonite ($CaCO_3$)
- growth rate: ~1 cm/year
- annual density band pairs
- incorporate isotopic and elemental tracers
- live for several centuries

Figure credit: Thomas Felis, MARUM

Coral archives – Chronology



Felis et al., 2009, *Geology*

Coral archives – Chronology

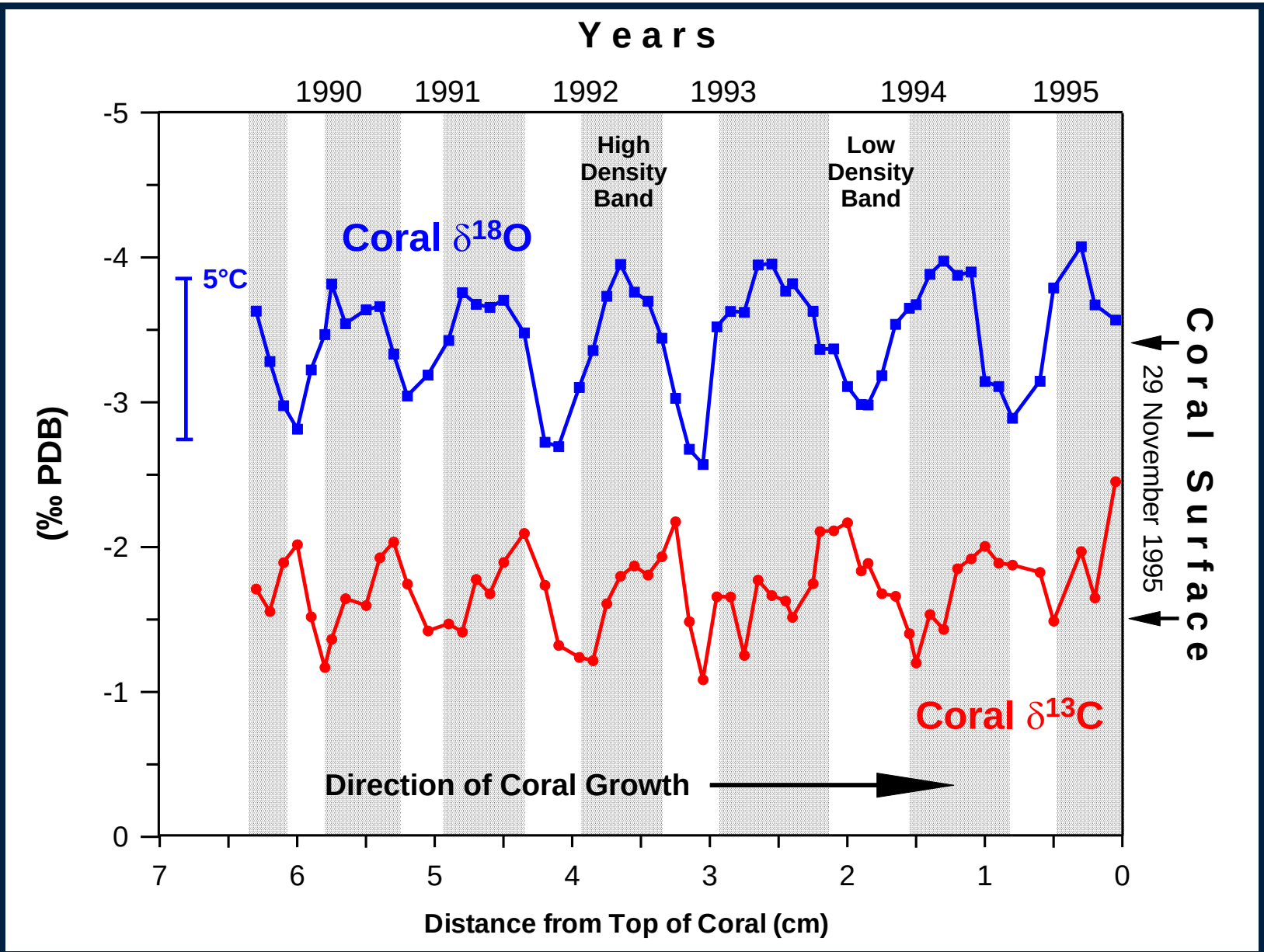


Figure credit: Thomas Felis, MARUM

Coral archives – Proxies

Coral growth rate

- Temperature
- Nutrients
- Food
- Light
- …

Coral $\delta^{18}O$

- Temperature
- Seawater $\delta^{18}O$ (related to salinity)

Coral Sr/Ca

- Temperature

Figure credit: Thomas Felis, MARUM

Coral archives – Proxies

Coral $\delta^{18}O$

- **Temperature**
- **Seawater $\delta^{18}O$** (related to salinity)

Coral Sr/Ca

- **Temperature**

Figure credit: Thomas Felis, MARUM

Coral archives – Proxies

Coral $\delta^{18}O$

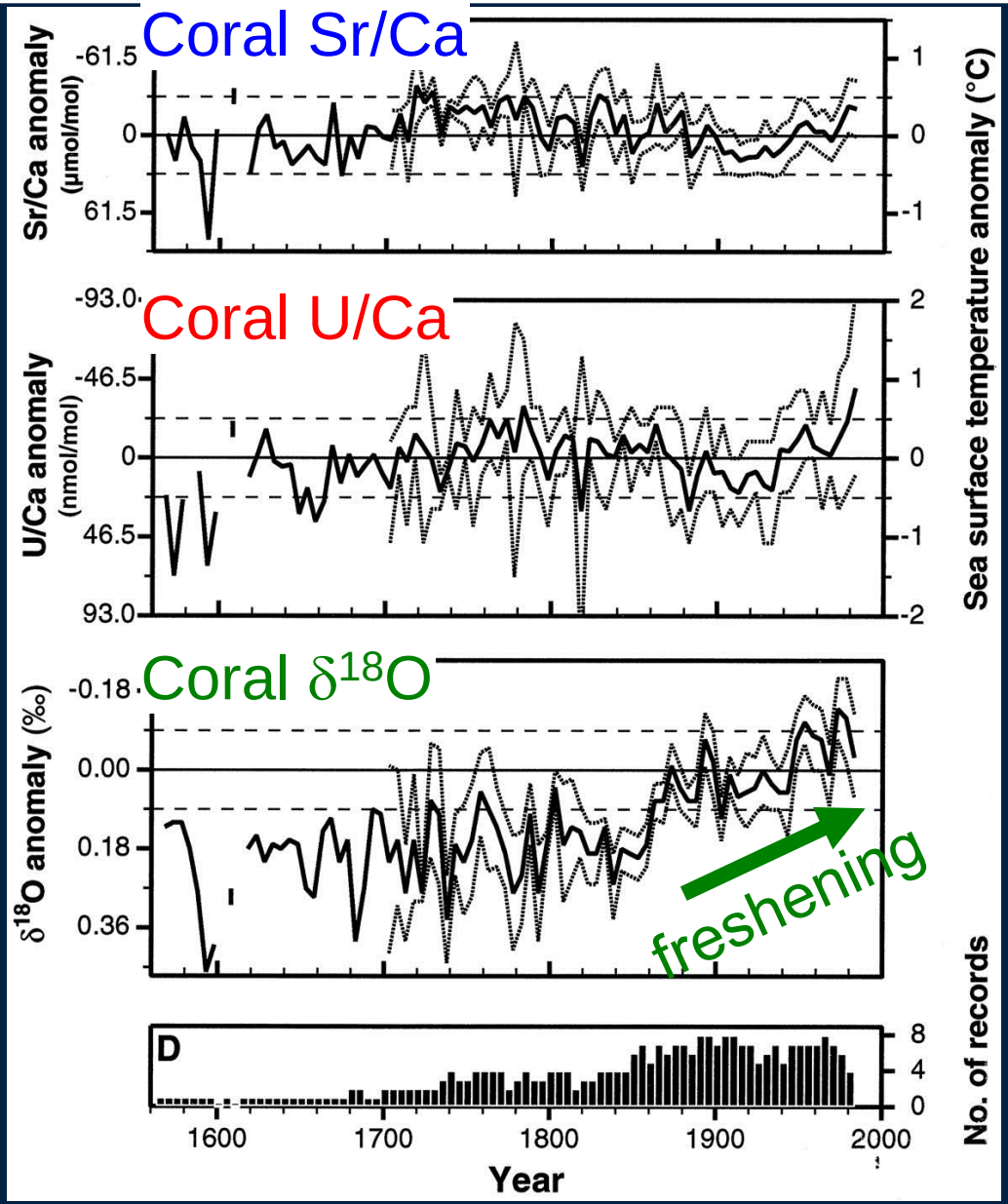
- Temperature
- **Seawater $\delta^{18}O$ > Hydrologic balance**
  > Oceanic processes

Coral Sr/Ca

- **Temperature**

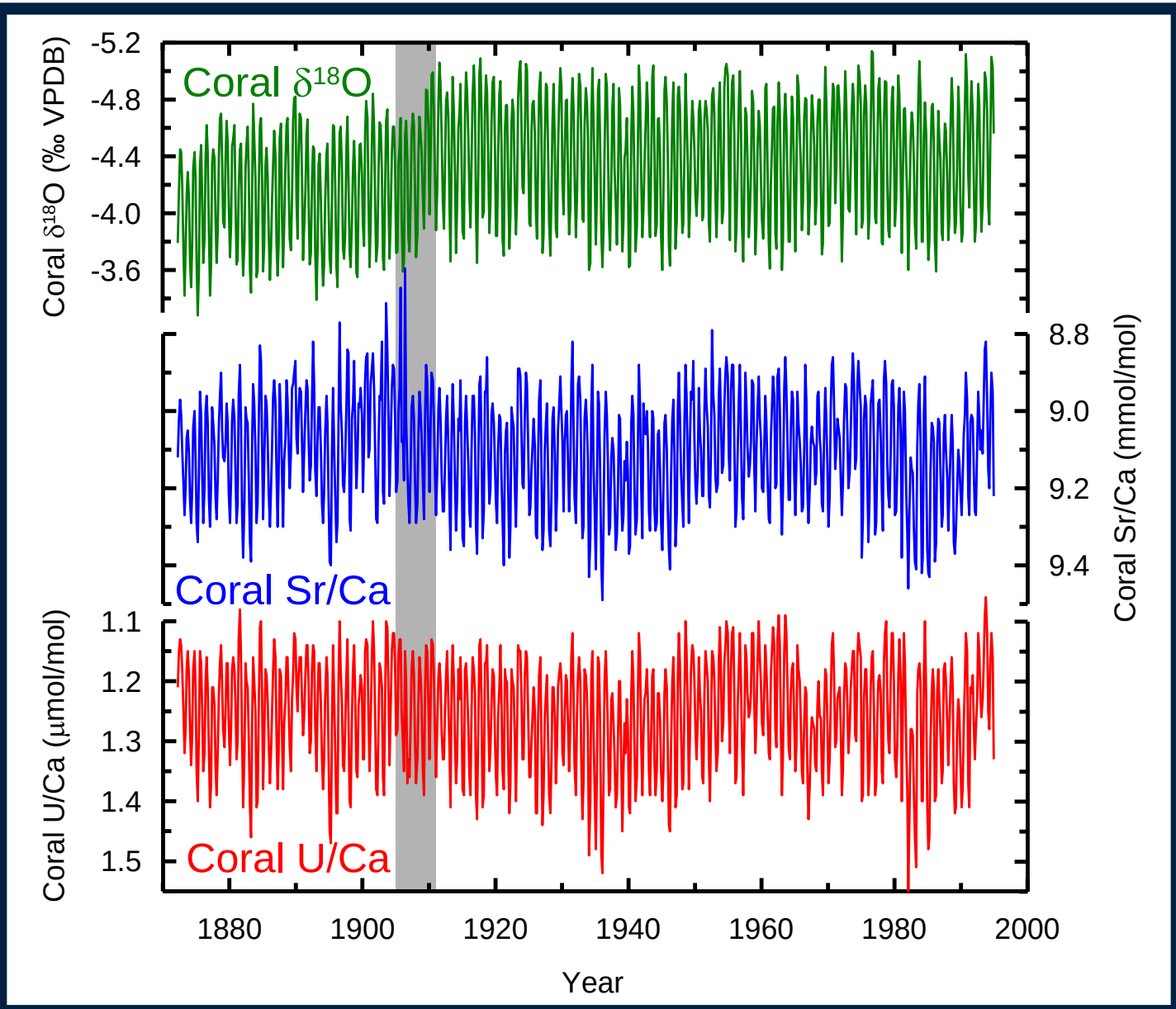
Figure credit: Thomas Felis, MARUM

Great Barrier Reef coral Sr/Ca, U/Ca, $\delta^{18}O$



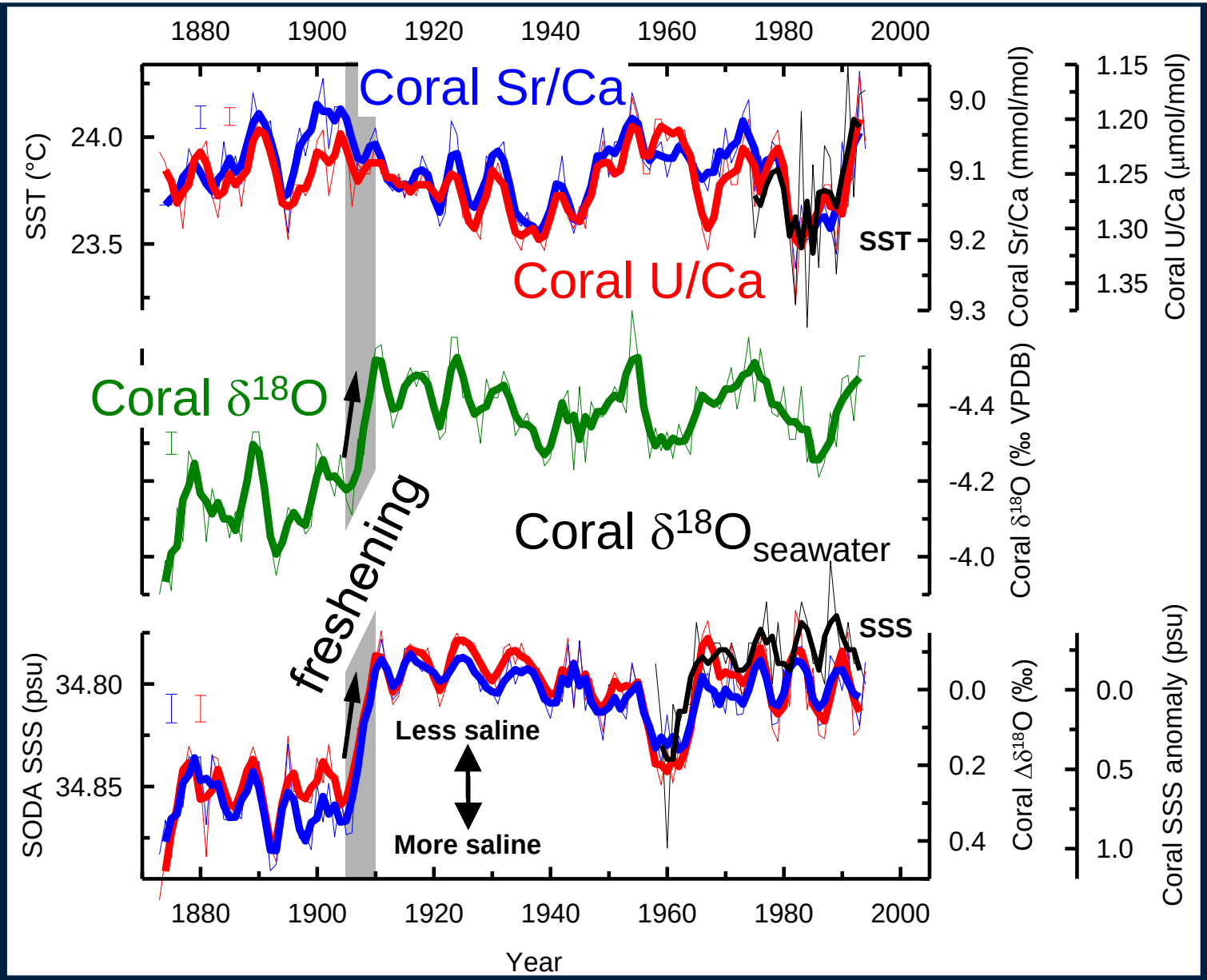
Hendy et al., 2002, *Science*

North Pacific coral Sr/Ca, U/Ca, $\delta^{18}O$



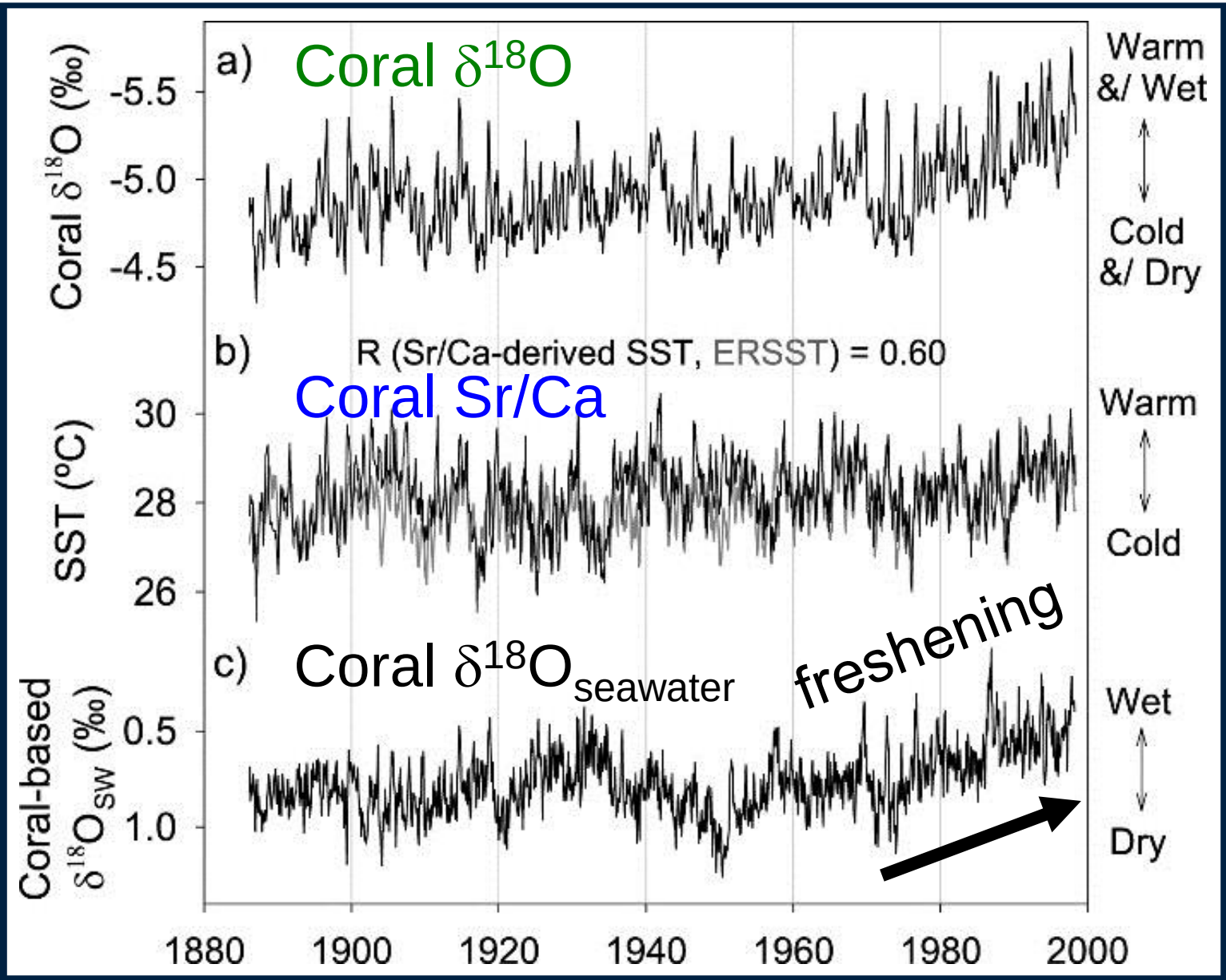
Felis et al., 2009, *Geology*

N. Pacific coral Sr/Ca, $\delta^{18}O$, $\delta^{18}O_{seawater}$



Felis et al., 2009, *Geology*

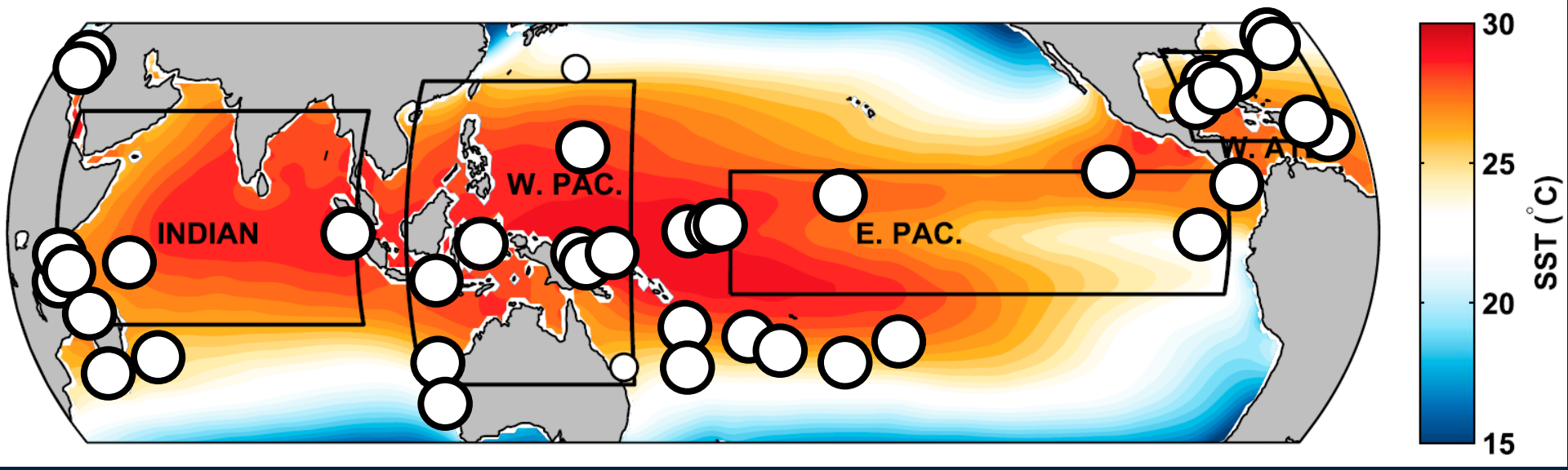
Cent. Pacific coral Sr/Ca, $\delta^{18}O$, $\delta^{18}O_{seawater}$



Cobb et al., 2001, *Geophys. Res. Lett.*
Nurhati et al., 2011, *J. Clim.*

Coral records (PAGES Ocean2k)

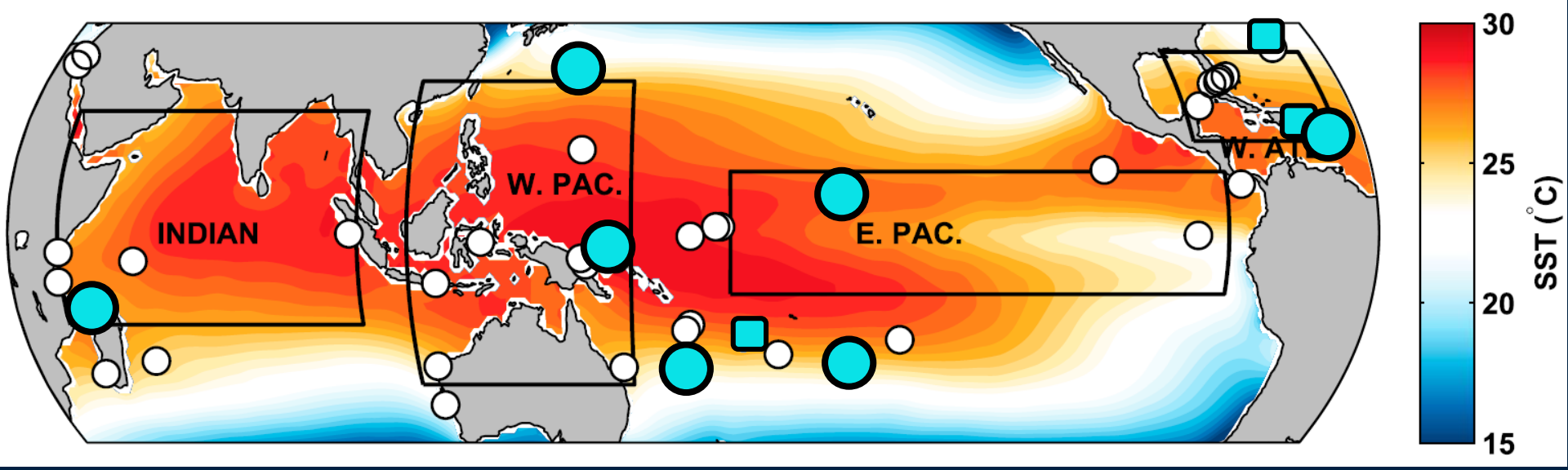
39 coral records



Tierney et al., 2015, *Paleoceanogr.*

Coral records (PAGES Ocean2k)

10 paired Sr/Ca and $\delta^{18}O$ records

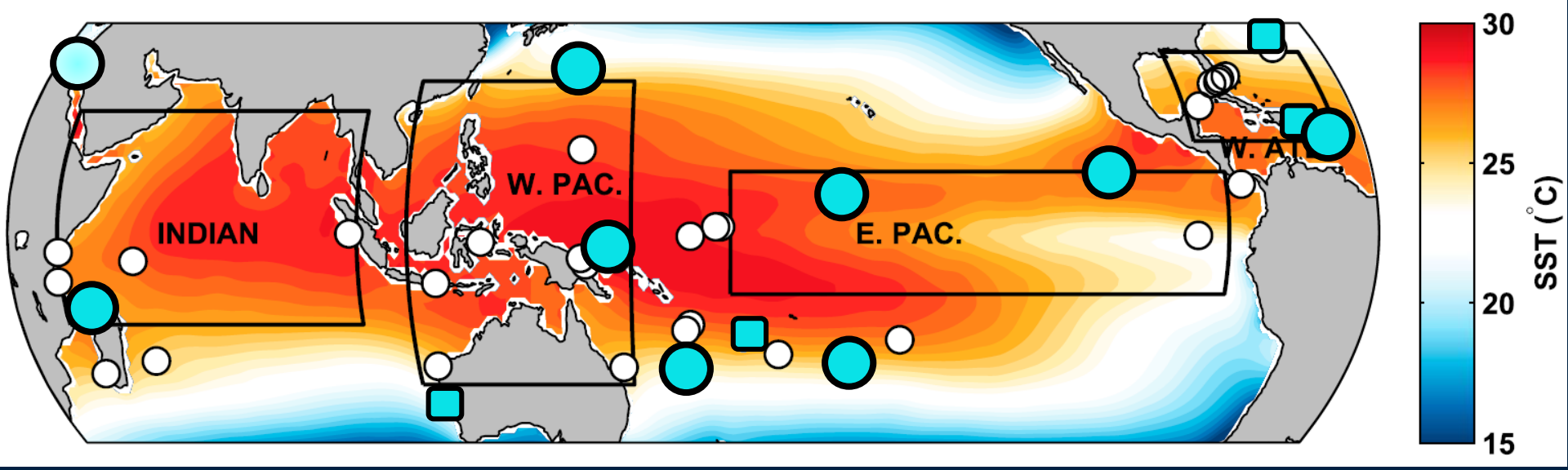


Tierney et al., 2015, *Paleoceanogr.*

- seasonal to monthly resolution
- annual resolution

Coral records

12 paired Sr/Ca and $\delta^{18}O$ records (+1 unpublished)

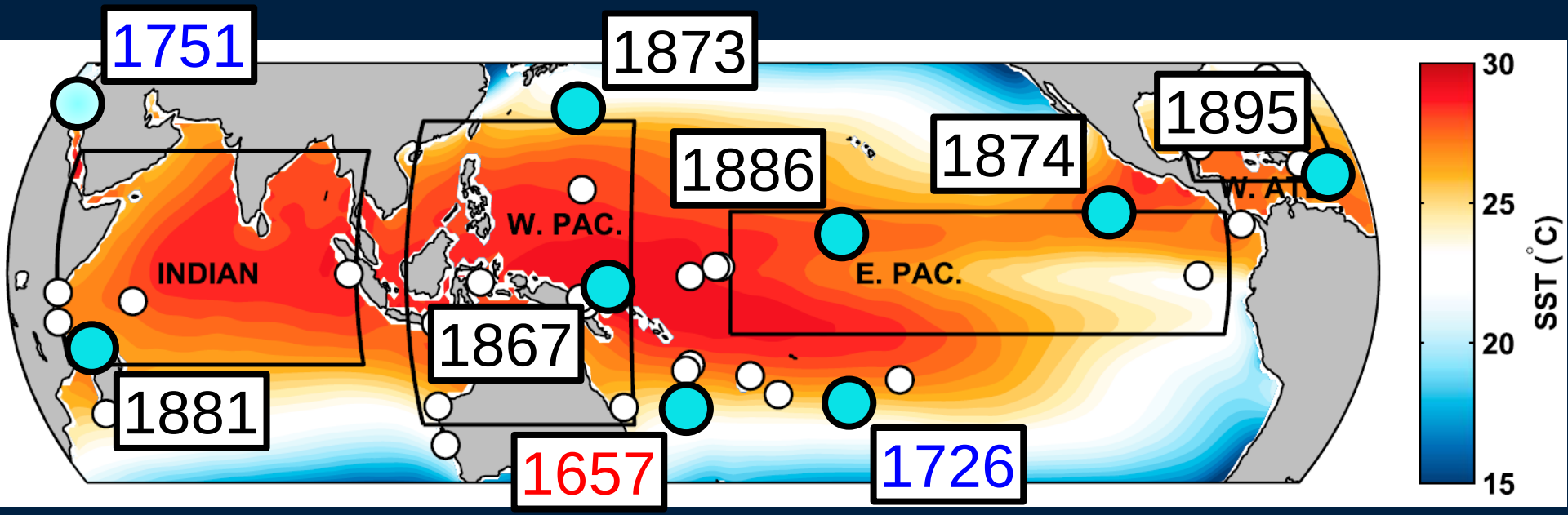


seasonal to monthly resolution (unpublished)

annual resolution

Coral records

9 paired Sr/Ca and $\delta^{18}O$ records (1 unpublished)

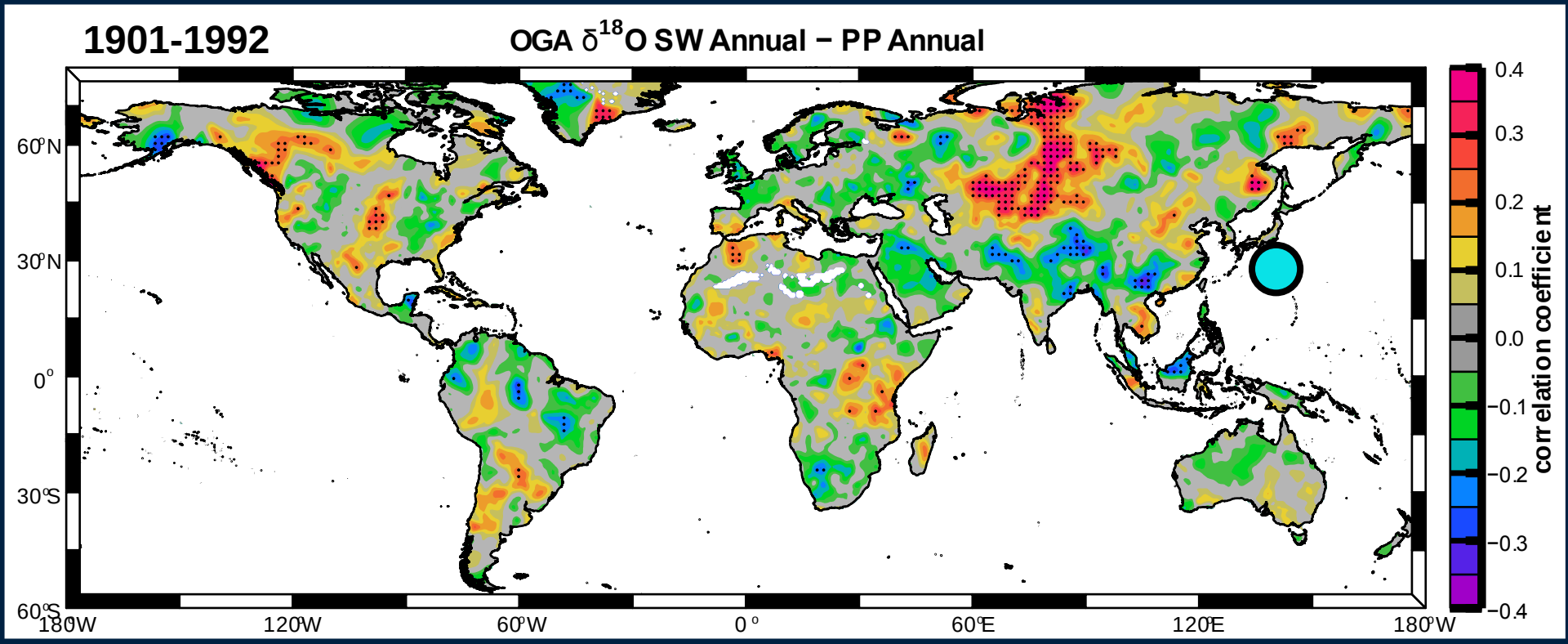


seasonal to monthly resolution (unpublished)

North Pacific coral seawater $\delta^{18}O$

correlation with precipitation (CRU TS3.22)

Harris et al., 2014, *Int. J. Climatol.*

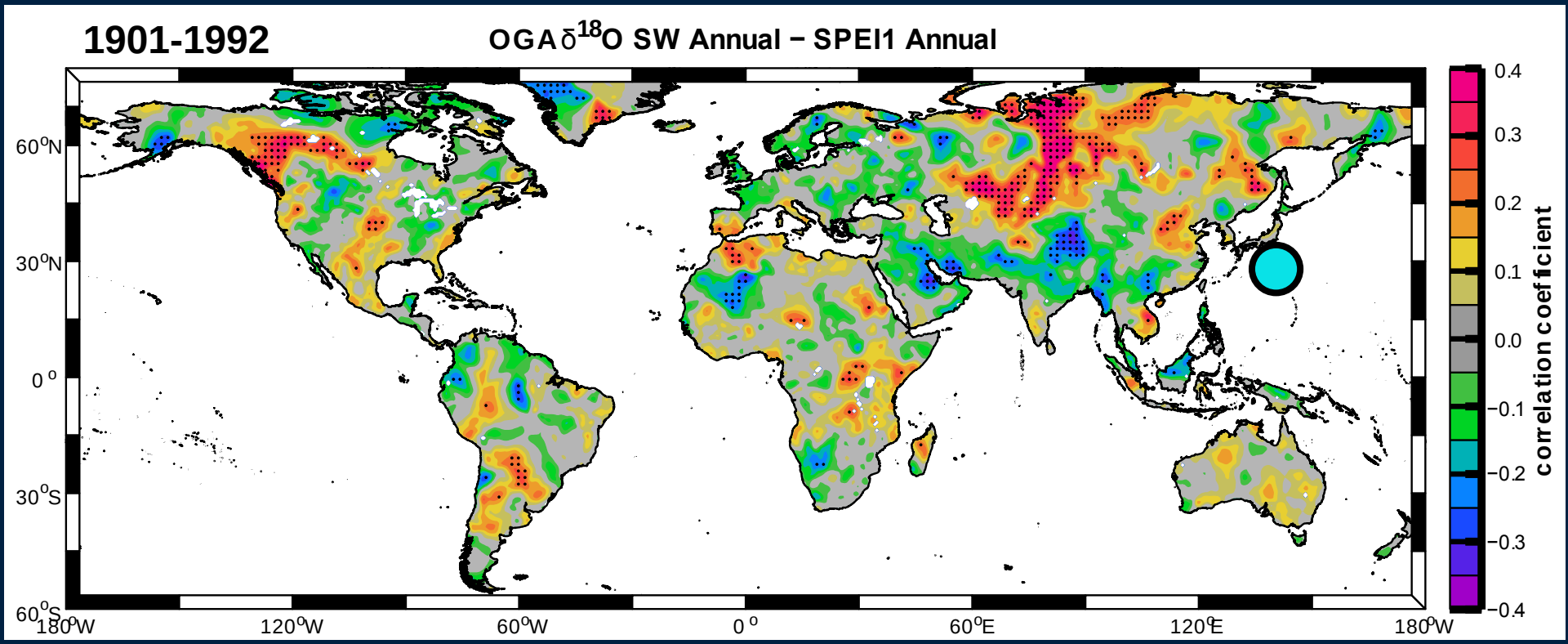


Ogasawara coral record - Felis et al., 2009, *Geology*

North Pacific coral seawater $\delta^{18}O$

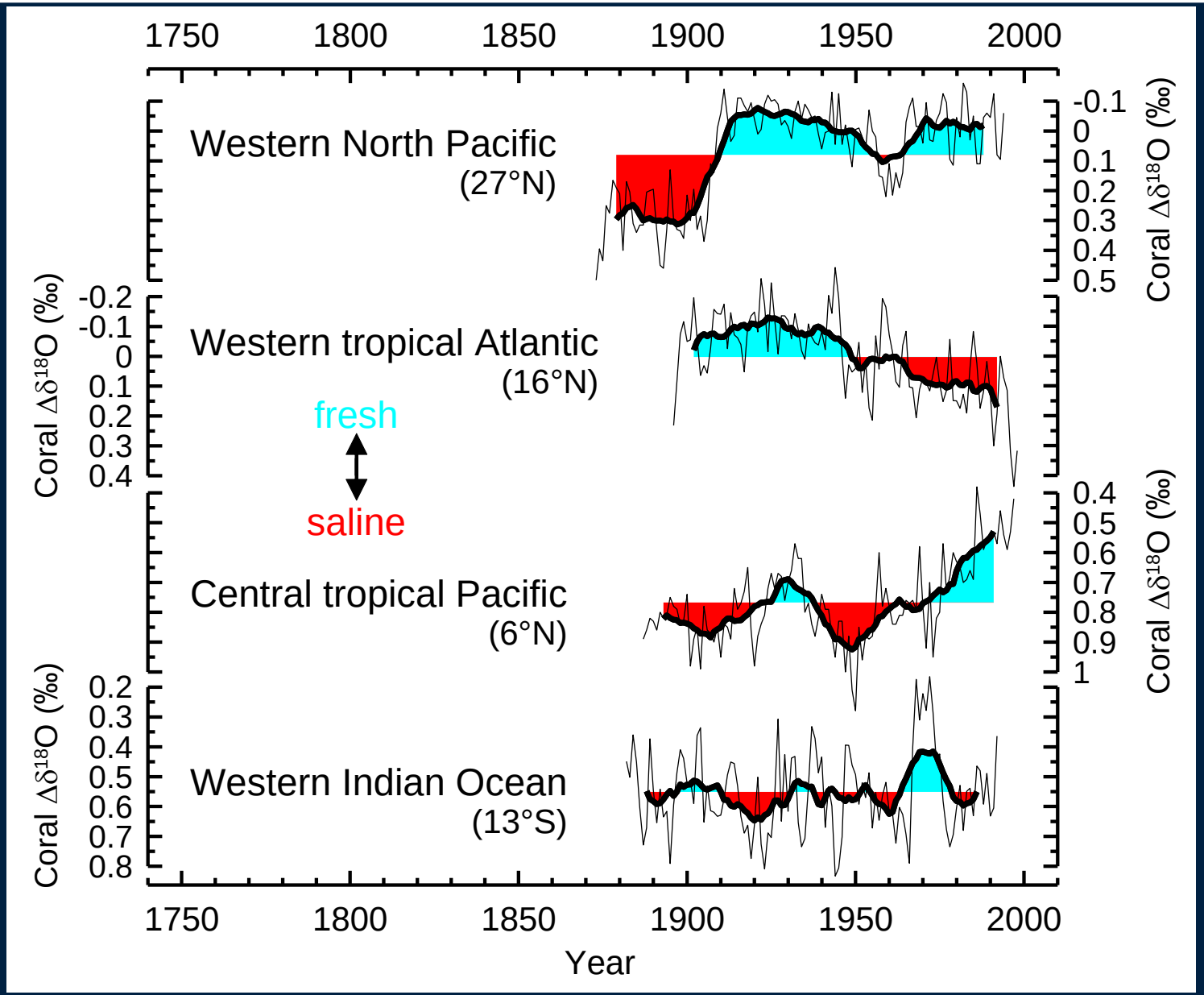
correlation with SPEI
(Standardized Precipitation Evapotranspiration Index)

Vicente-Serrano et al., 2010, *J. Clim.*



Ogasawara coral record - Felis et al., 2009, *Geology*

Coral seawater $\delta^{18}O$ reconstructions



Felis et al., 2009

Hetzinger et al., 2010

Cobb et al., 2001
Nurhati et al., 2011

Zinke et al., 2008

Central Pacific coral Sr/Ca, $\delta^{18}O$, SST

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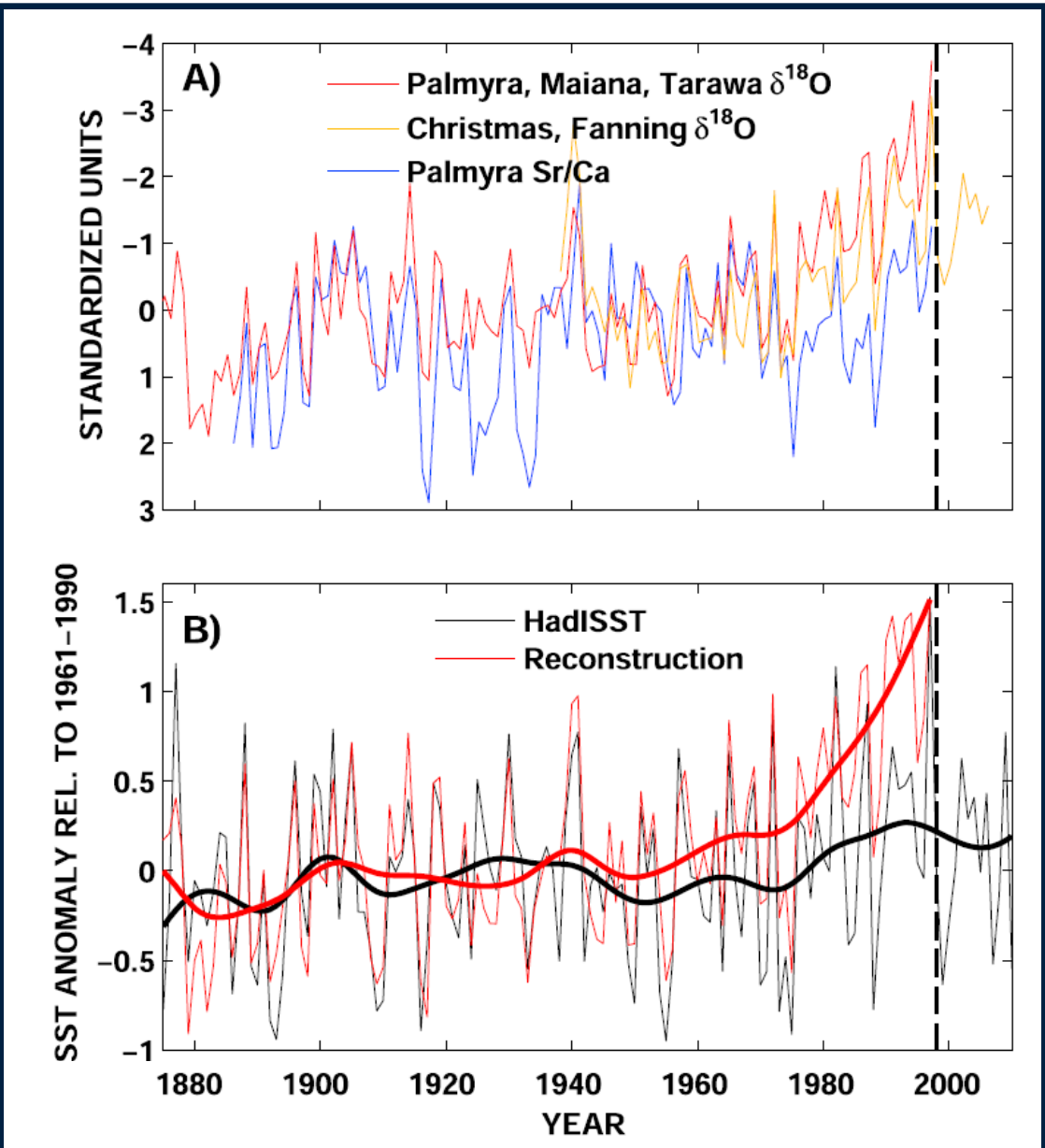
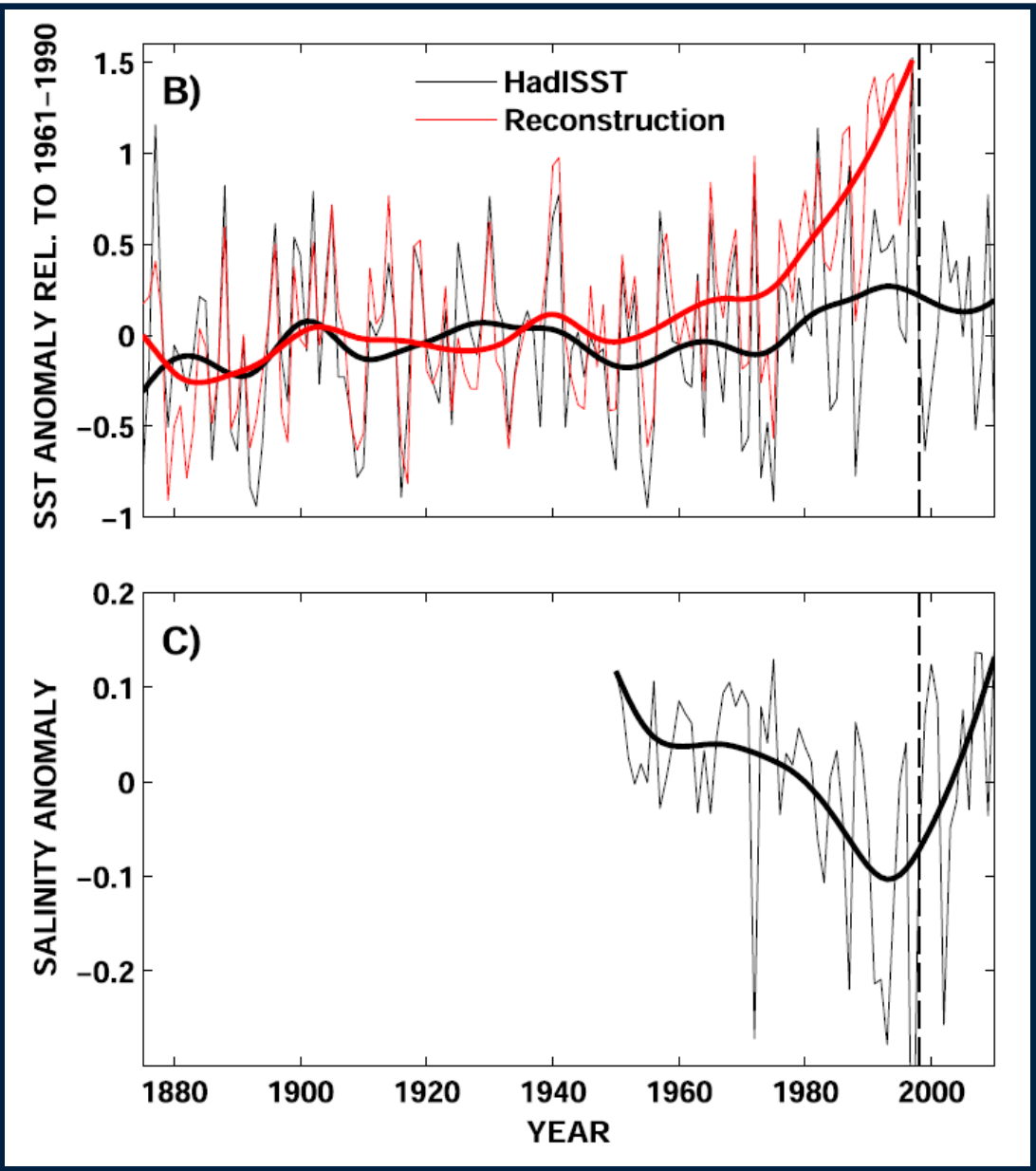
Tierney et al., 2015, *Paleoceanogr.*



Cobb et al., 2001, *Geophys. Res. Lett.*
Nurhati et al., 2011, *J. Clim.*

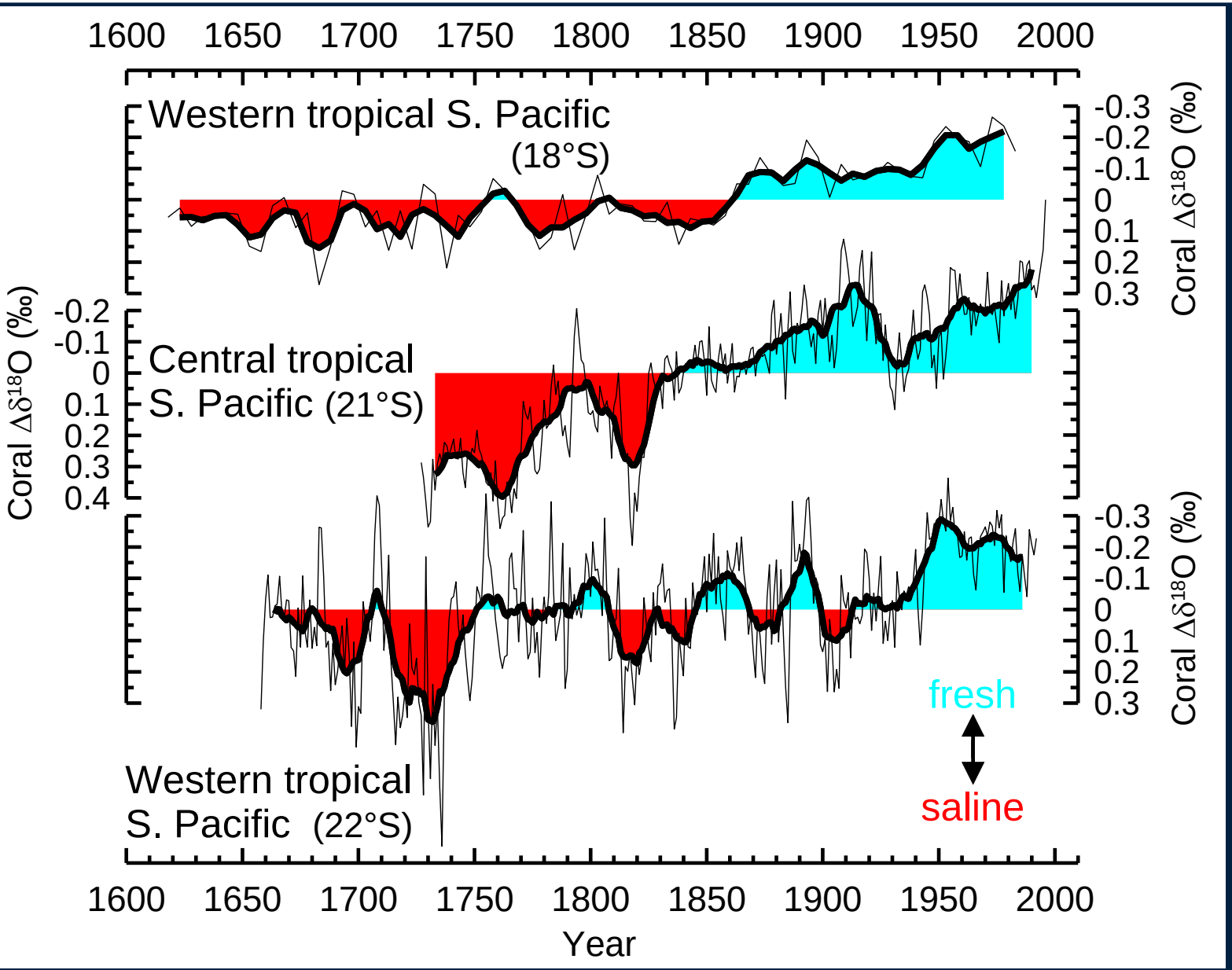
Central Pacific coral $\delta^{18}O$, SST, salinity

PAGES Ocean2k
Tierney et al., 2015, *Paleoceanogr.*



Cobb et al., 2001, *Geophys. Res. Lett.*
Nurhati et al., 2011, *J. Clim.*

Coral seawater $\delta^{18}O$ reconstructions



Hendy et al., 2002

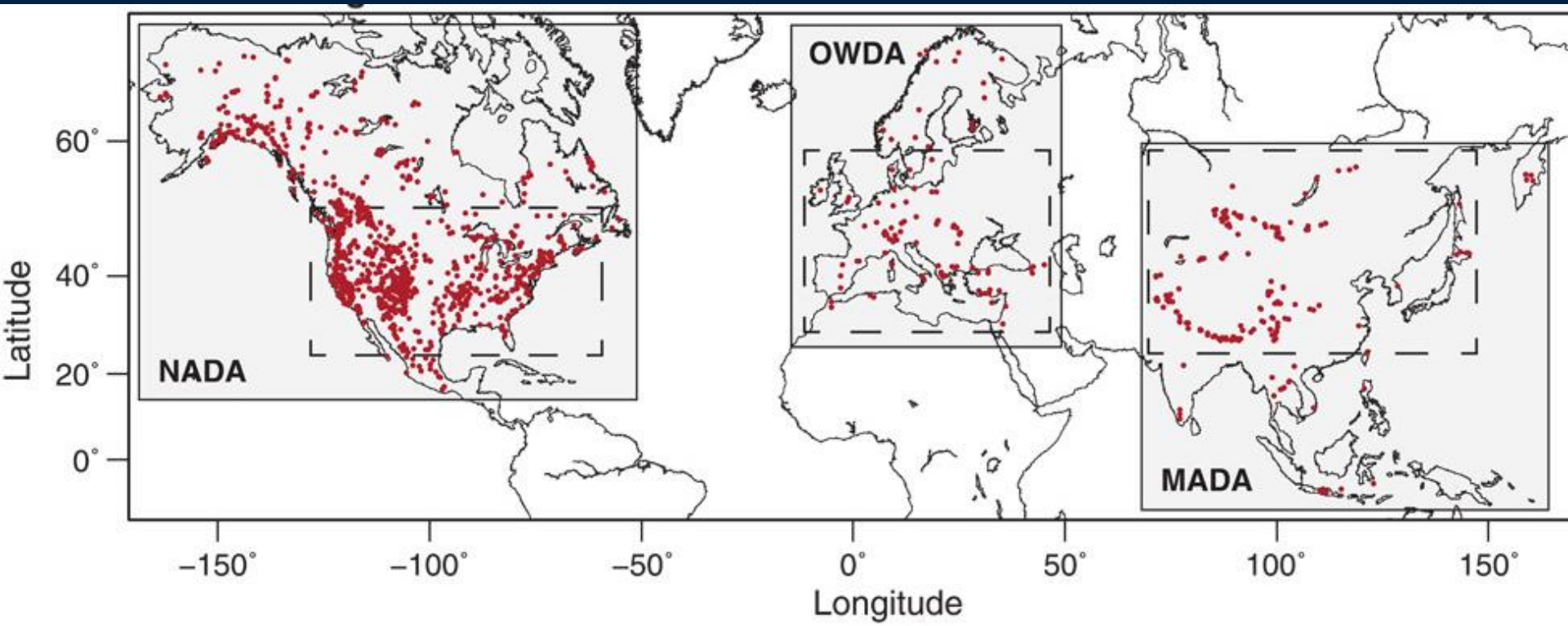
Linsley et al., 2000
Ren et al., 2002

Quinn et al., 1998
DeLong et al., 2012

Hydroclimate from coral Sr/Ca - $\delta^{18}O$

- Coral $\delta^{18}O$:
  - temperature AND seawater $\delta^{18}O$
- Coral Sr/Ca:
  - temperature
- Paired coral Sr/Ca and $\delta^{18}O$:
  - seawater $\delta^{18}O$ (calculated)
- Seasonally resolved records:
  - better chronology
- ~13 paired coral Sr/Ca and $\delta^{18}O$ records available
  - many back to the 1880s to 1870s
  - some back to the 18th and 17th century

Last millennium hydroclimate - tree rings



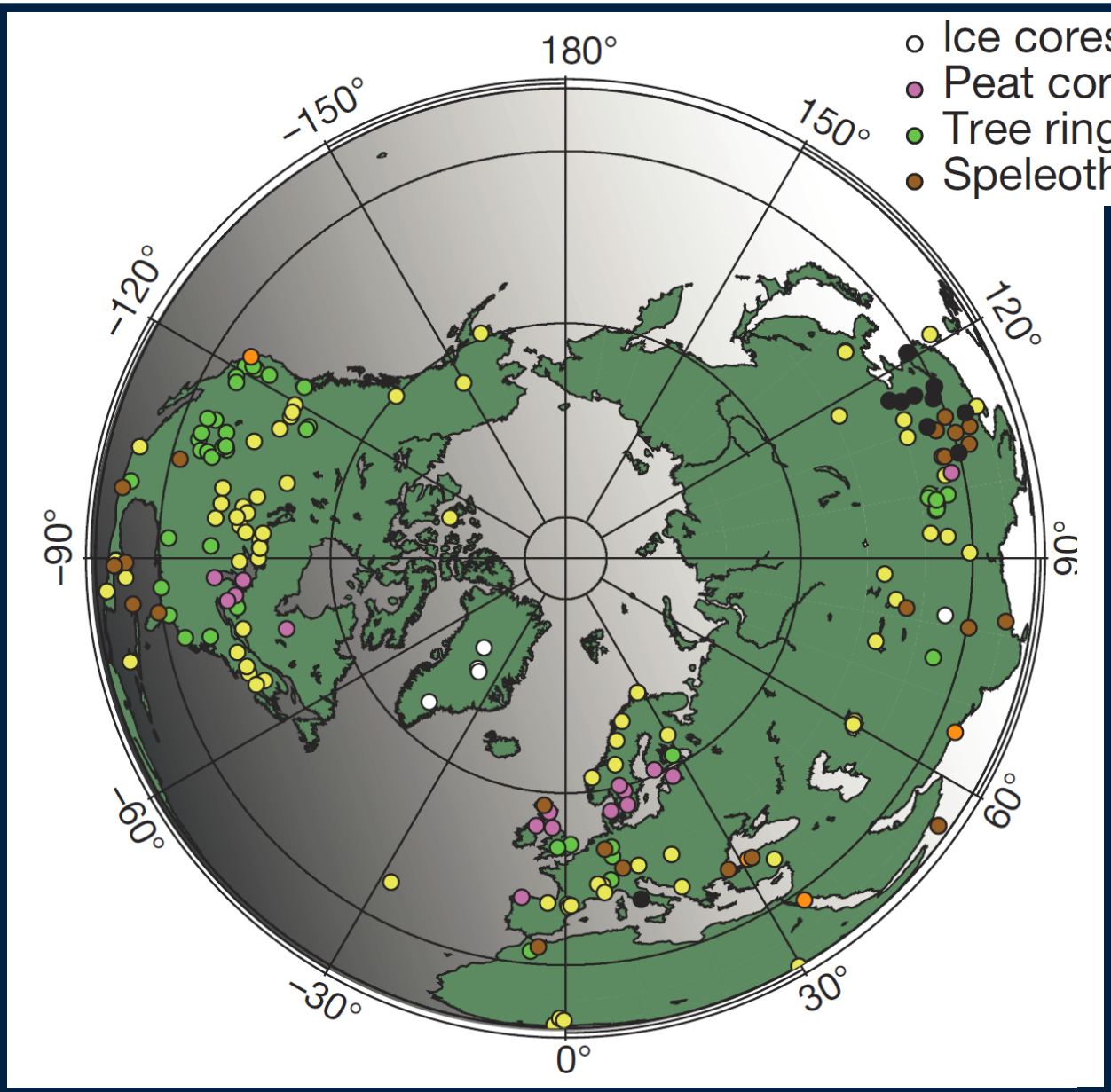
Cook et al., 2015, *Sci. Adv.*

NADA: North American Drought Atlas

OWDA: Old World Drought Atlas

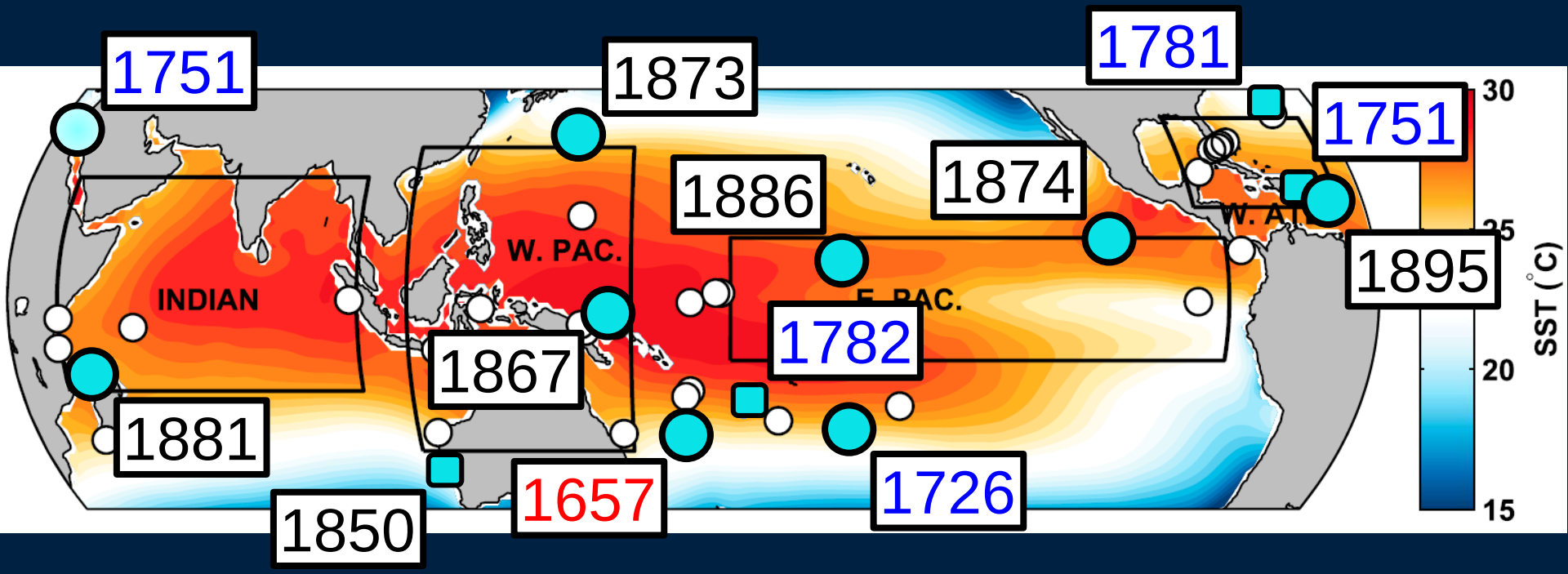
MADA: Monsoon Asia Drought Atlas

Last millennium hydroclimate - multiproxy



Ljungqvist et al., 2016, *Nature*

~13 coral seawater $\delta^{18}O$ reconstructions



- seasonal to monthly resolution (unpublished)
- annual resolution