

Asia 2k in a broader context: A comparison between regional and global surface temperature reconstructions

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Acknowledgements:

Julien Emile-Geay (USC)

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Dominique Guillot (Stanford)

Adam Vaccaro (USC)

Bala Rajaratnam (Stanford)

PAGES regional working groups



Asia 2k 4th workshop, Mar 19, 2015

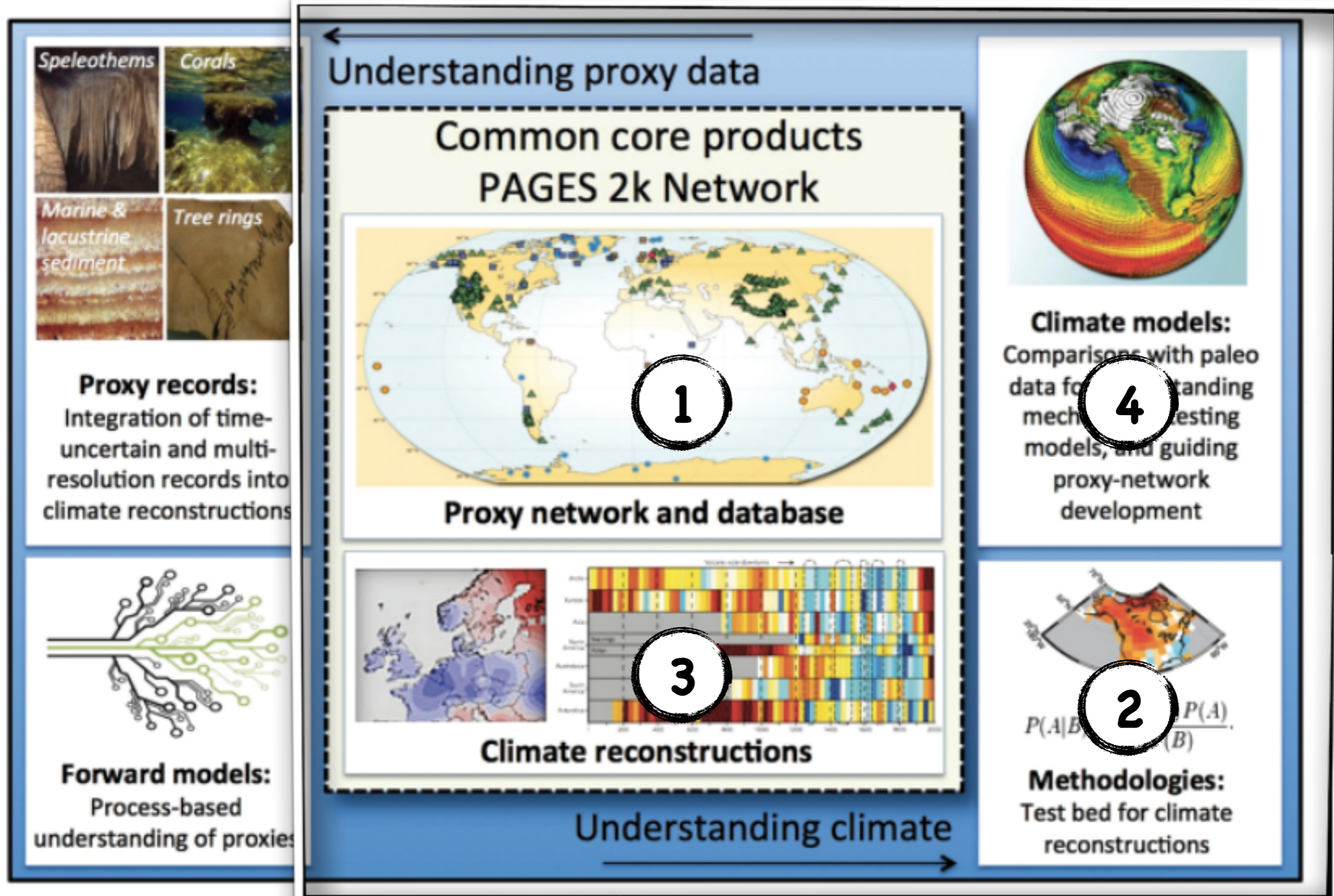


Fig. 1. The Past Global Changes (PAGES) 2k community has developed recommendations aimed at facilitating a global synthesis of proxy climate information. (middle) Near-term goals aim to generate a uniform suite of core products. In tandem, efforts are under way to improve understanding of (left) proxy records, including new process-based approaches, and understanding of (right) climate variability and change, including new climate reconstruction methods and comparisons with climate simulations.

OUTLINE

- ❖ **Global CFR w/ PAGES 2k phase 2:**

- ★ Is there a need for regional CFRs?

- ❖ **Asia 2k CFR**

- ★ How does it compare with regional features from the global CFR?

- ❖ **Data-model Comparison**

- ★ How does the reconstruction compare to GCM simulations?

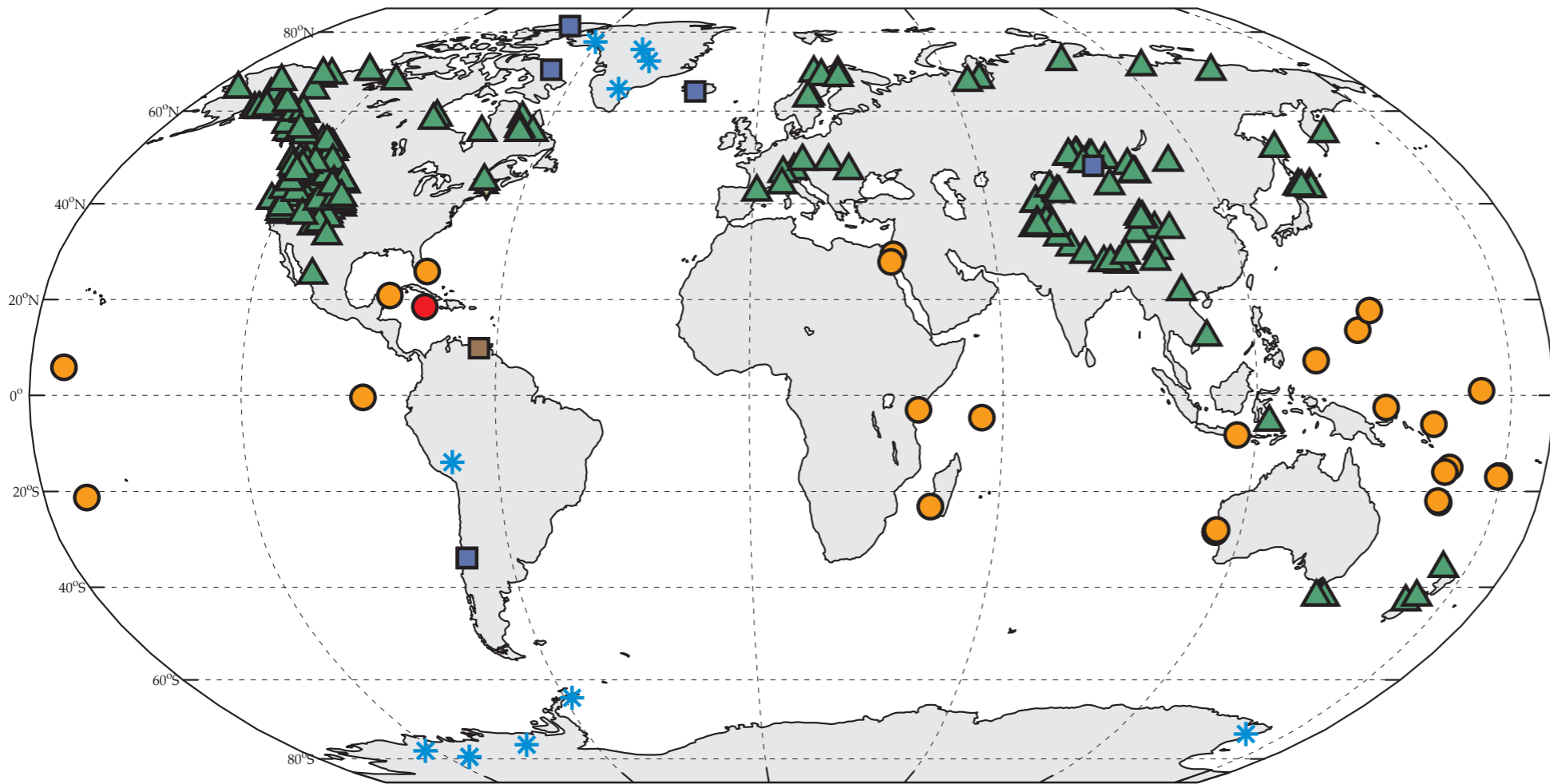
- ❖ **Discussion**

Part 1: PAGES 2k global CFR

DATA & METHOD

- ❖ **Target: HadCRUT4** (Morice et al., *JGR*, 2012) JJA
 - ★ With satellite temperature measurements
 - ★ > 30% available 1850 - now (1758/2592 grid cells)
- ❖ **Proxy: PAGES 2k synthesis** (PAGES 2k consortium, *Nature Geo.*, 2013; *Eos-transactions AGU*, 2014)
 - ★ Community-driven effort (9 regional working groups)
 - ★ Multi-resolution proxy records (925 as of Feb 10, 2015)
 - ★ Correlation-based screening: control for signal “color” (Ebisuzaki et al., *JClim.* 1997) and multiple hypothesis testing (Ventura, *JClim.* 2004)
 - ★ Only used high resolution proxies in this CFR

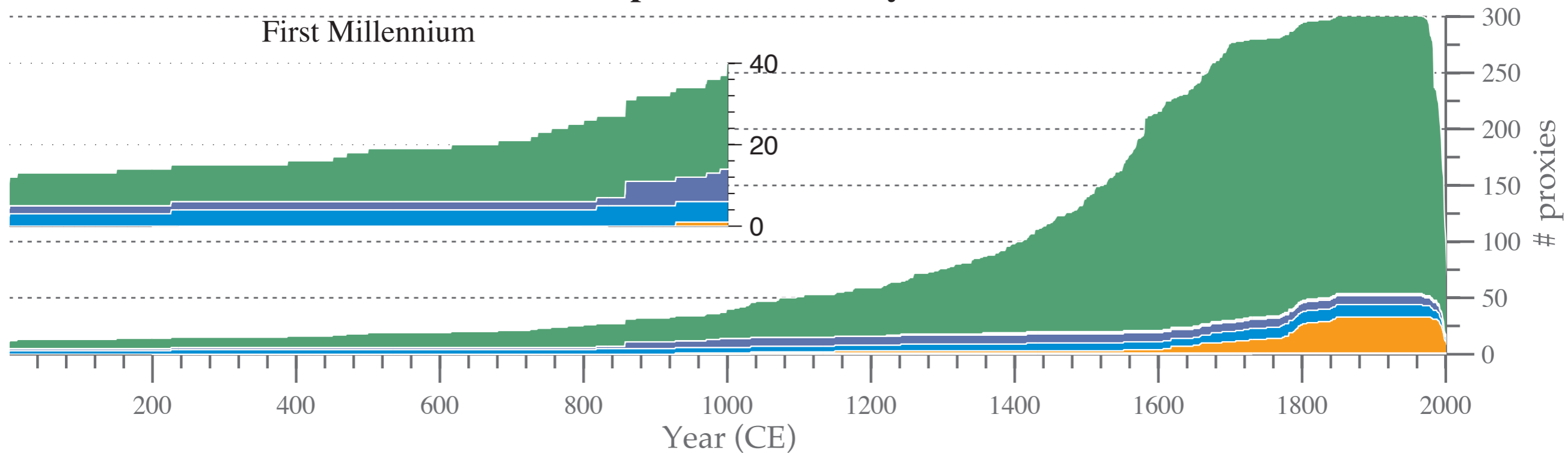
PAGES 2K network (Phase 2) as of 2015/02/10 (301 records from 301 sites)



- ☆ bivalve
- coral
- ★ ice core
- lake sediment
- marine sediment
- sclerosponge
- ▲ tree

Temporal Availability

First Millennium

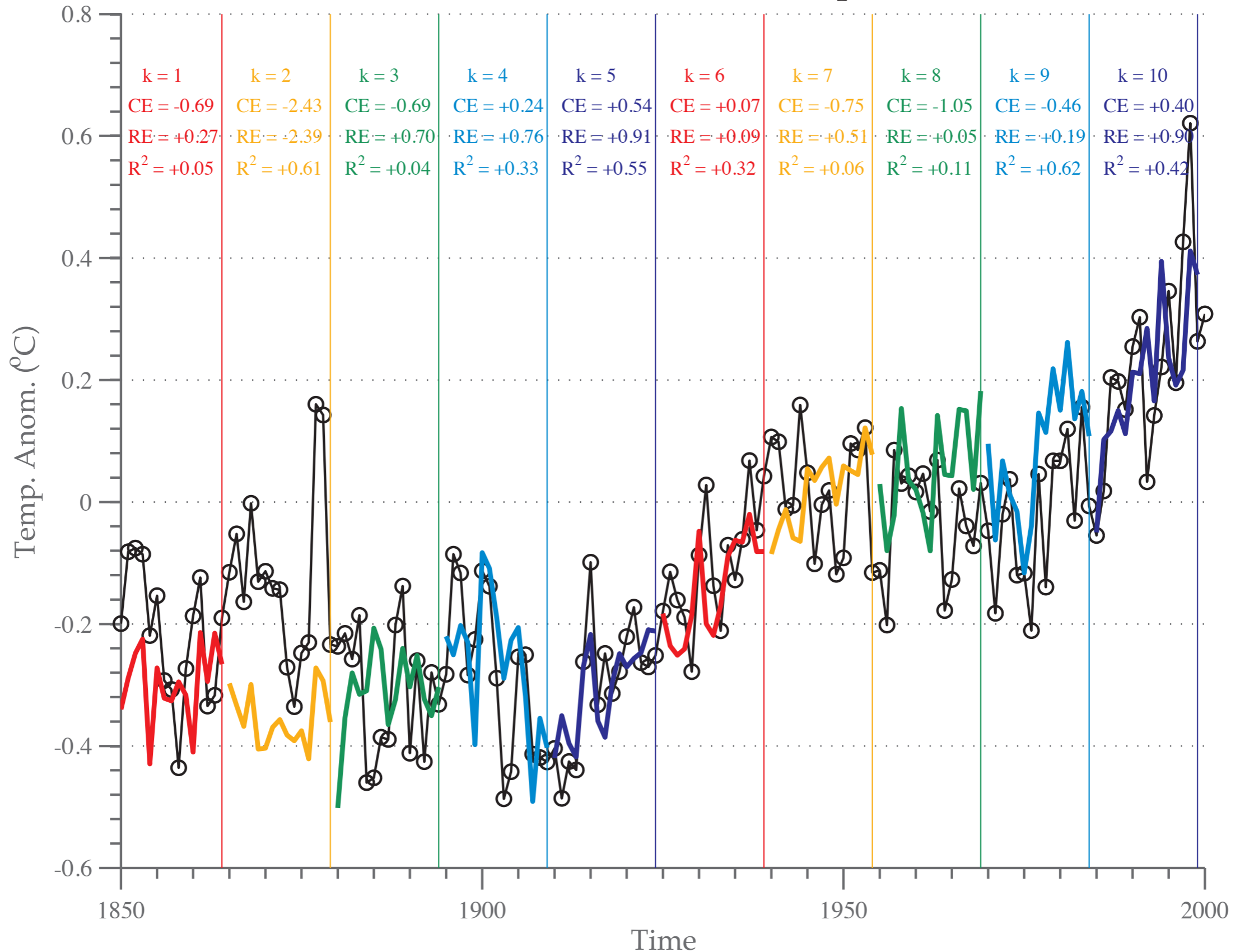


DATA & METHOD

- ❖ **Target:** HadCRUT4 (Morice et al., *JGR*, 2012) JJA
 - ★ With satellite temperature measurements
 - ★ > 30% available 1850 - now (1758/2592 grid cells)
- ❖ **Proxy:** PAGES 2k synthesis (PAGES 2k consortium, *Nature Geo.*, 2013; *Eos-transactions AGU*, 2014)
 - ★ Community-driven effort (9 regional working groups)
 - ★ Multi-resolution proxy records (888 as of Dec 11, 2014)
 - ★ Correlation-based screening: account for signal “color” (Ebisuzaki et al., *JClim.* 1997) and multiple hypothesis tests (Ventura, *JClim.* 2004)
- ❖ **Method:** GraphEM (Guillot et al., *AoAS*, in press)
 - ★ exploits conditional independence structure in field/proxies

HOW SKILLFUL IS THE CFR?

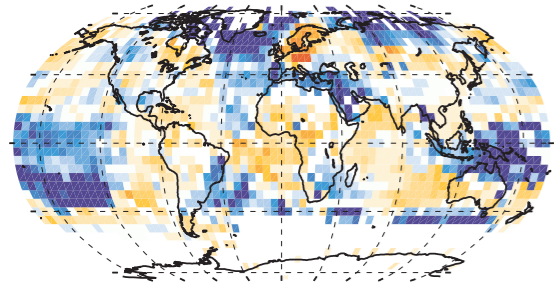
Global mean validation, GraphEM



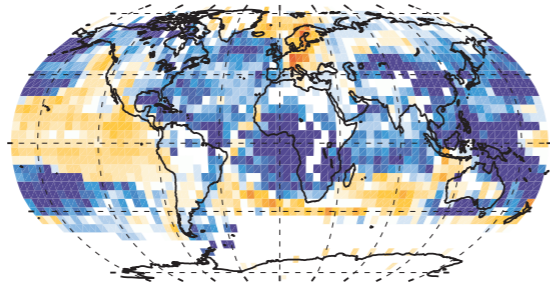
HOW SKILLFUL IS THE CFR?

10-fold Cross-validation RE scores

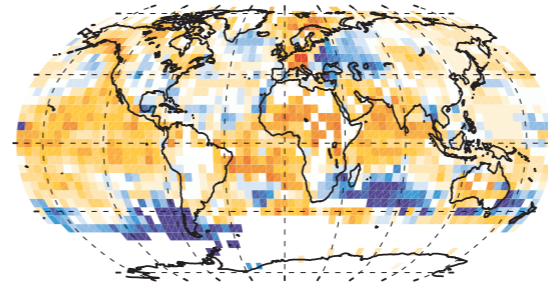
1850-1864 validation



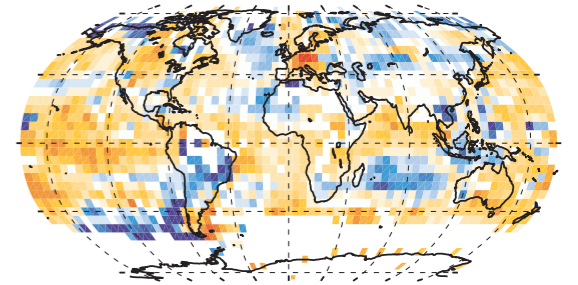
1865-1879 validation



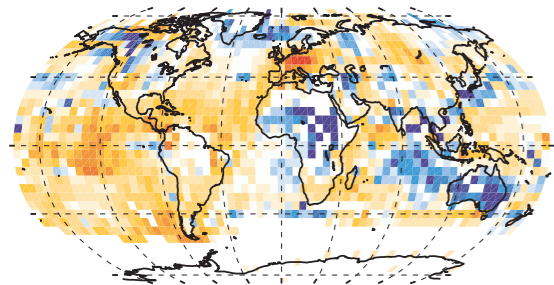
1880-1894 validation



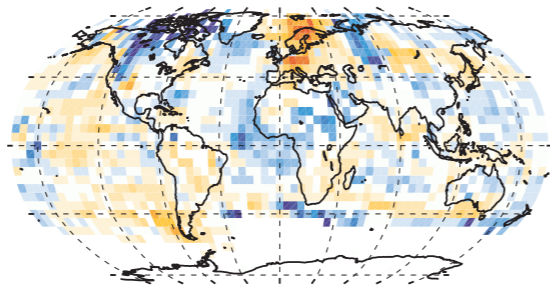
1895-1909 validation



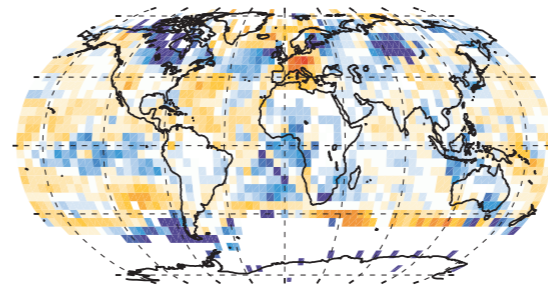
1910-1924 validation



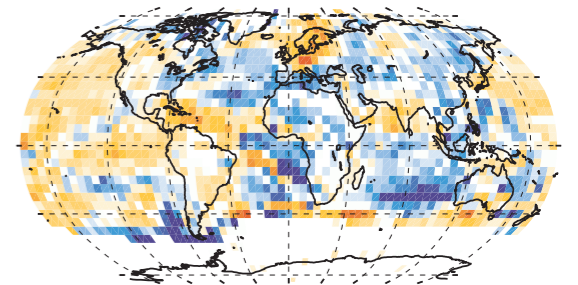
1925-1939 validation



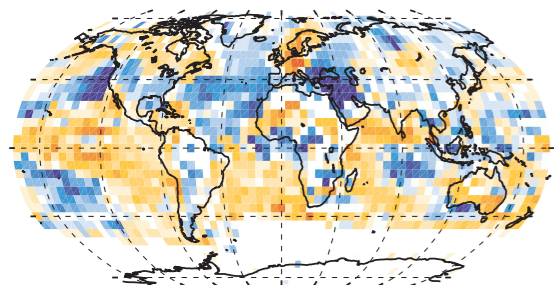
1940-1954 validation



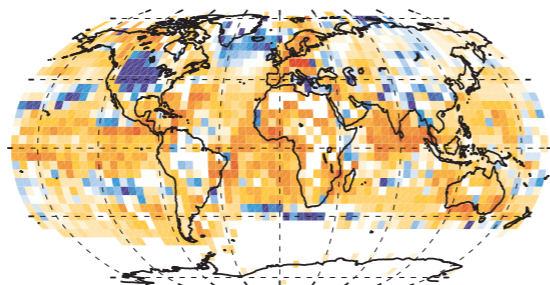
1955-1969 validation



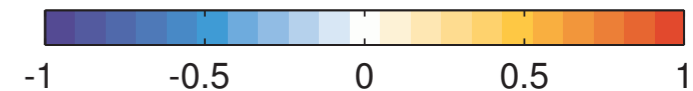
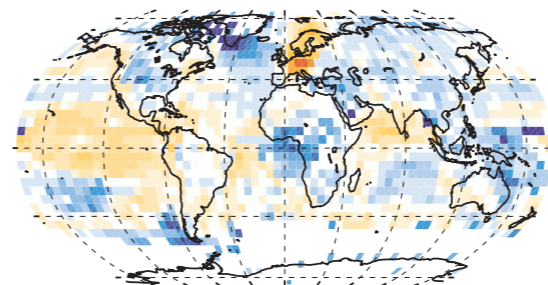
1970-1984 validation



1985-1999 validation

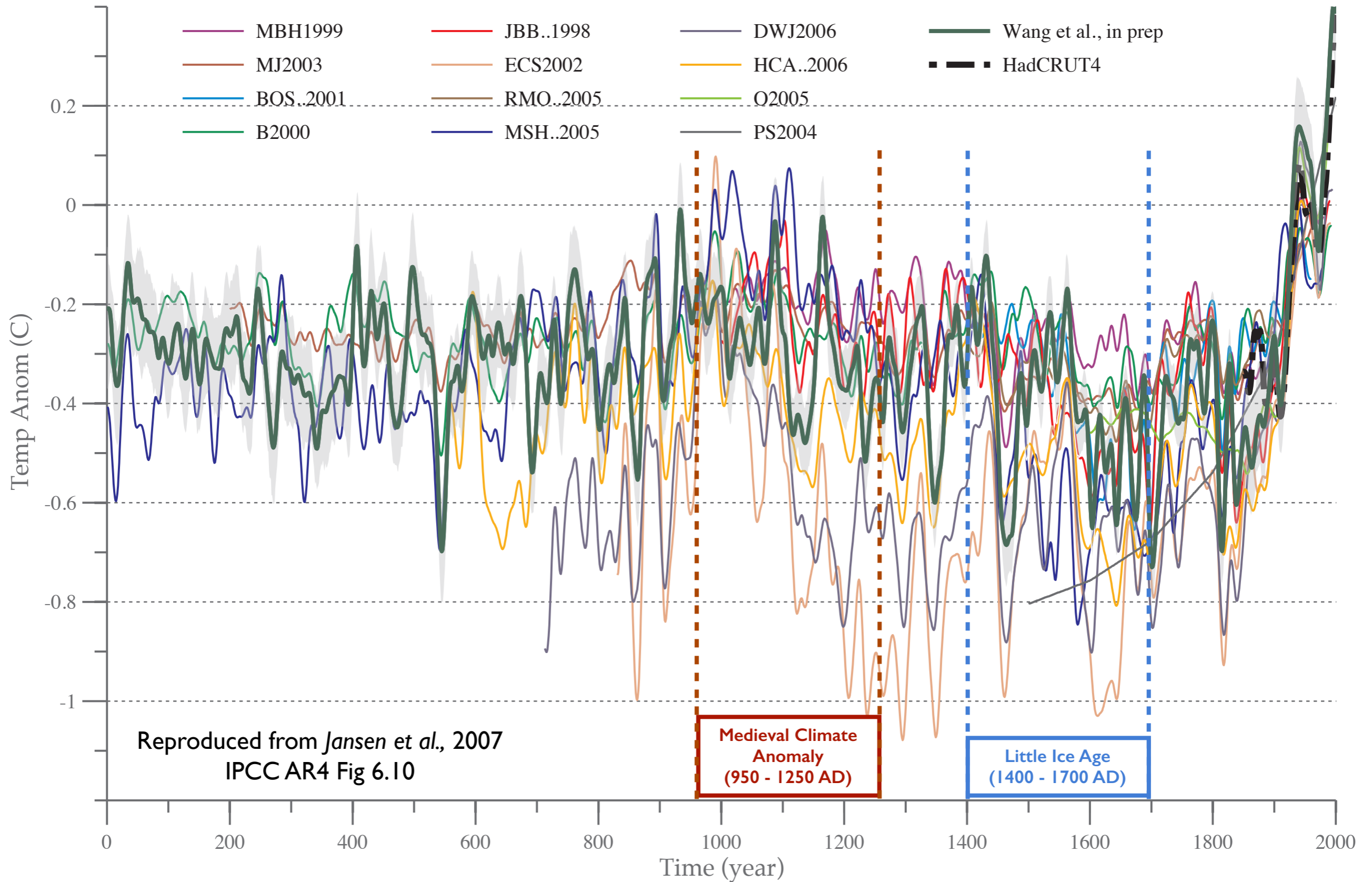


Average

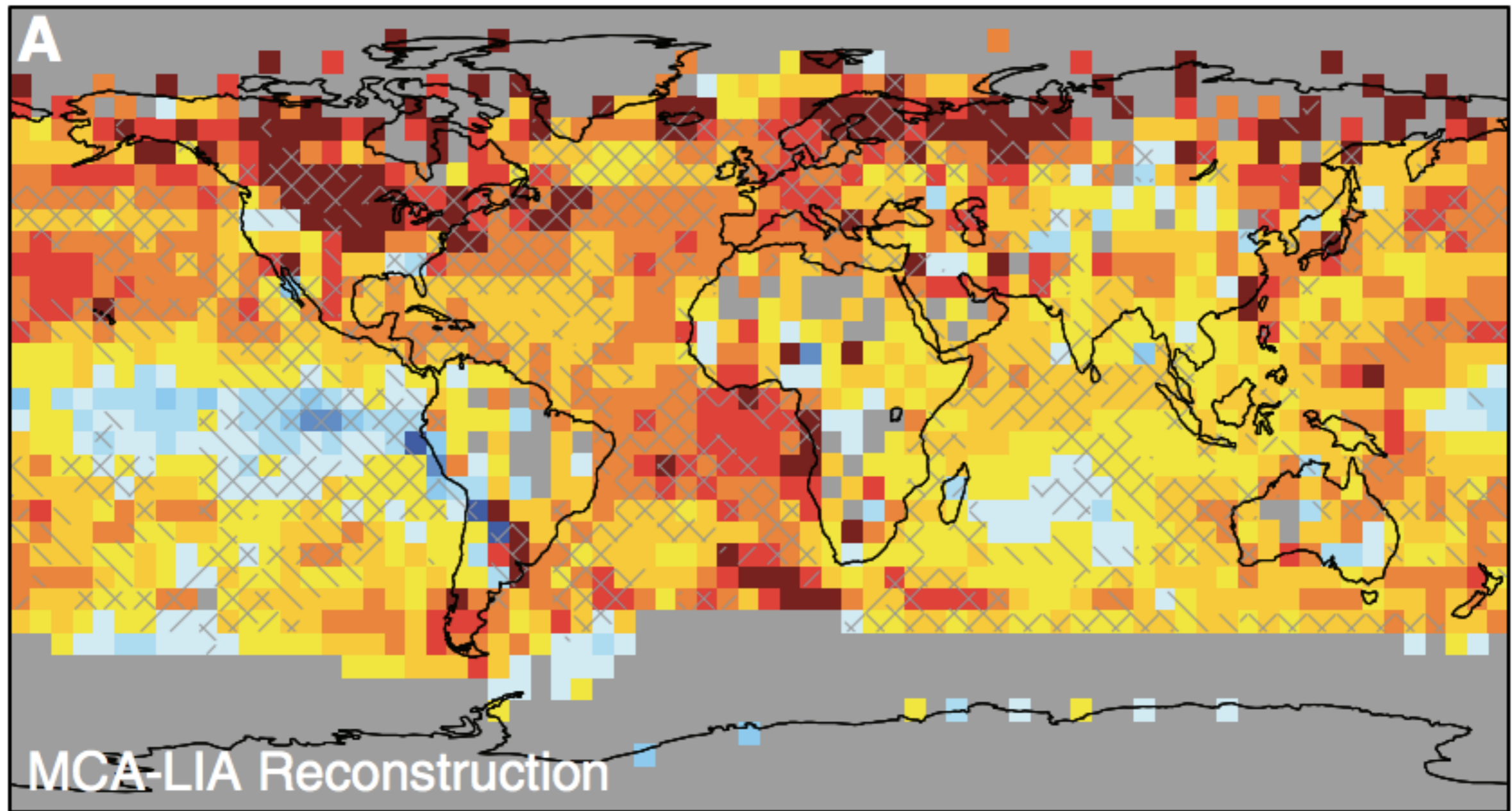


NH MEAN

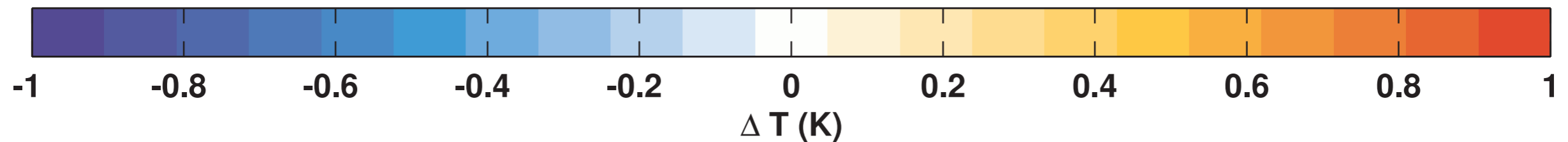
Reconstructed NH temperature (20-year lowpass)



SPATIAL FEATURES

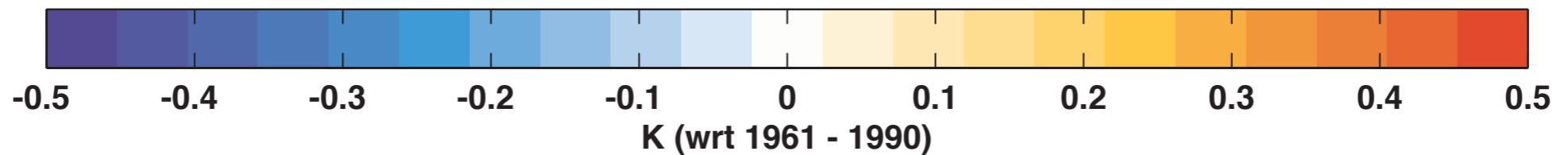
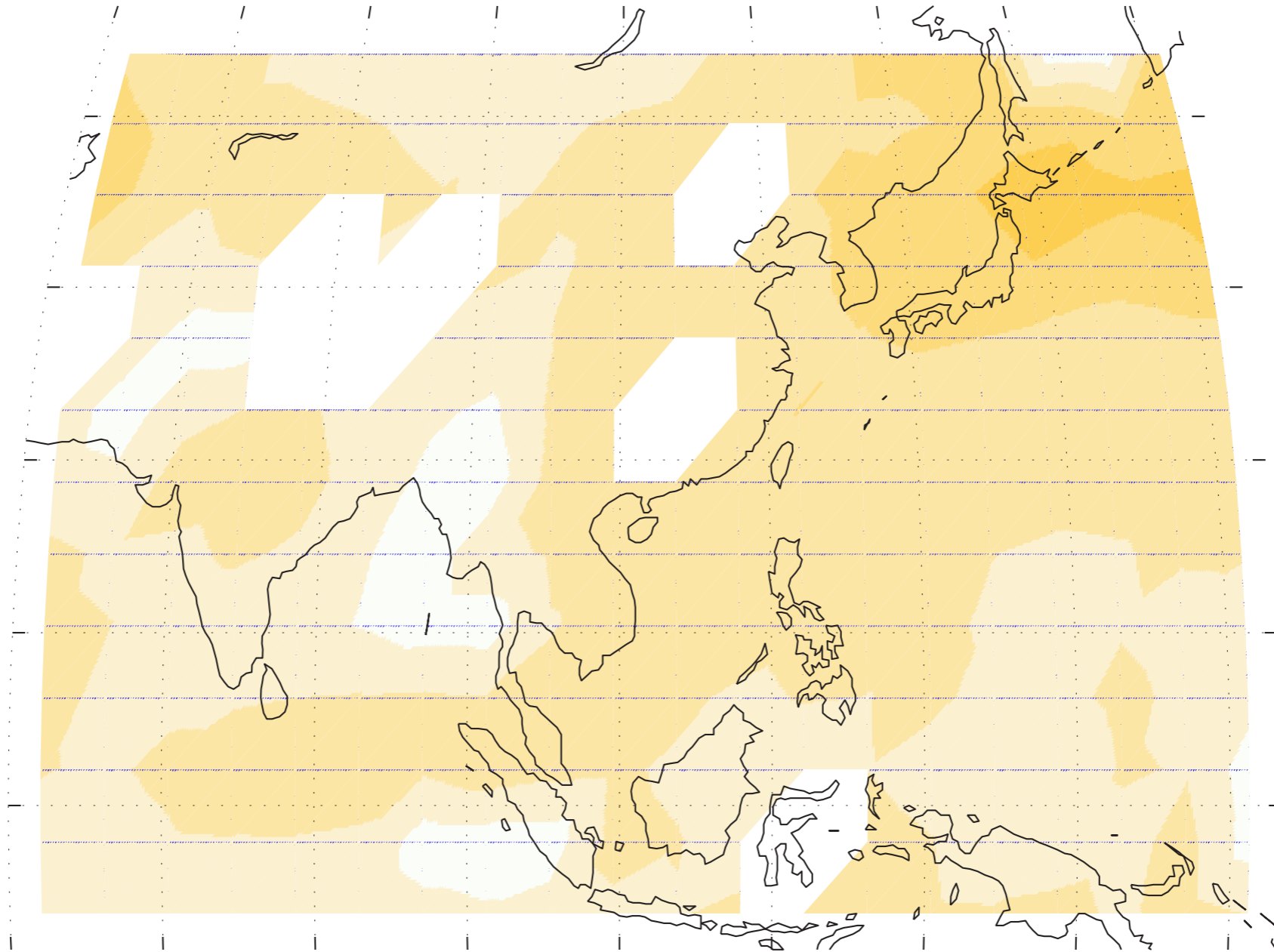


Mann et al., *Science* 2009, Fig. 3



RESTRICT TO ASIA

MCA - LIA



Note: colorbar scale is different from previous slide, color interpolated to easily identify spatial features

REGIONAL INDICES

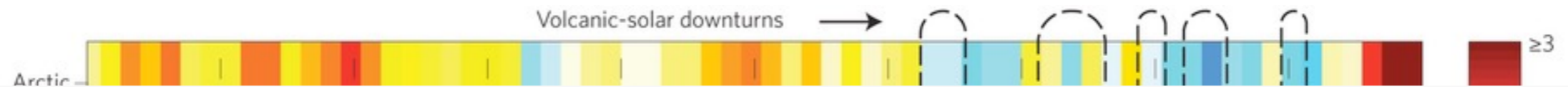
nature
geoscience

PROGRESS ARTICLE

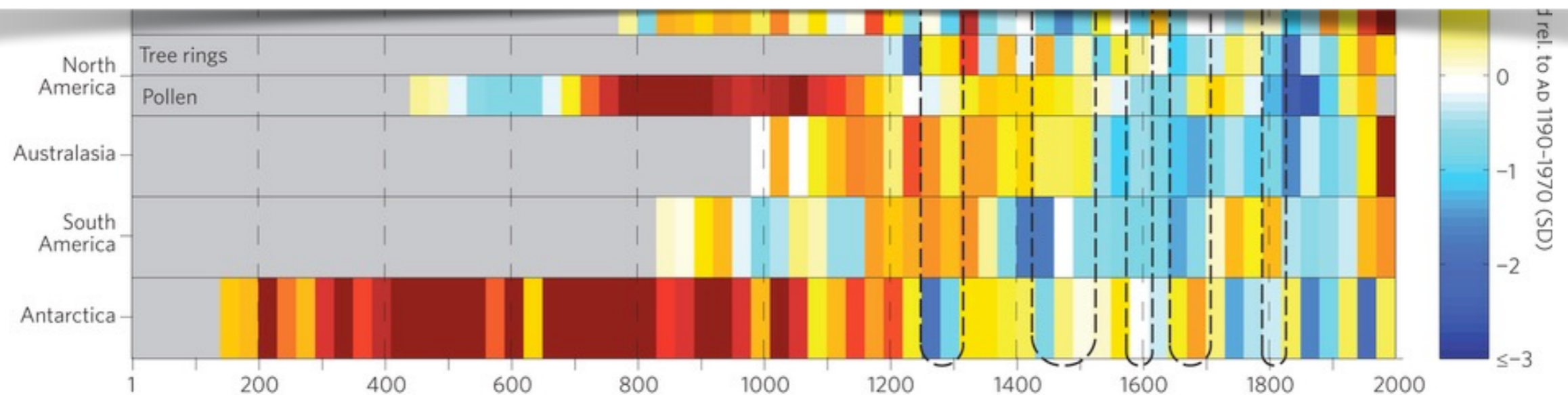
PUBLISHED ONLINE: 21 APRIL 2013 | DOI: 10.1038/NCEO1797

Continental-scale temperature variability during the past two millennia

PAGES 2k Consortium*



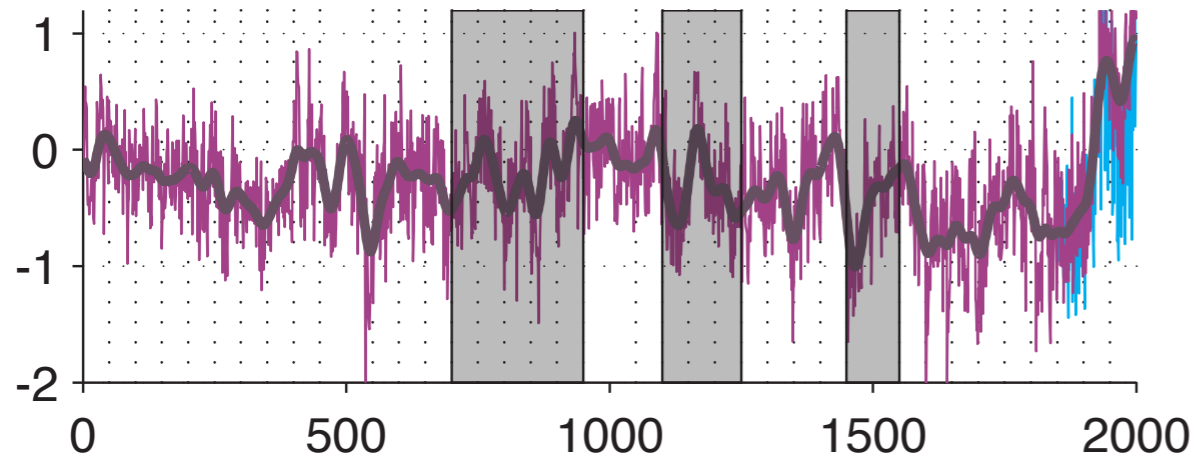
What if we derive them from a global CFR?



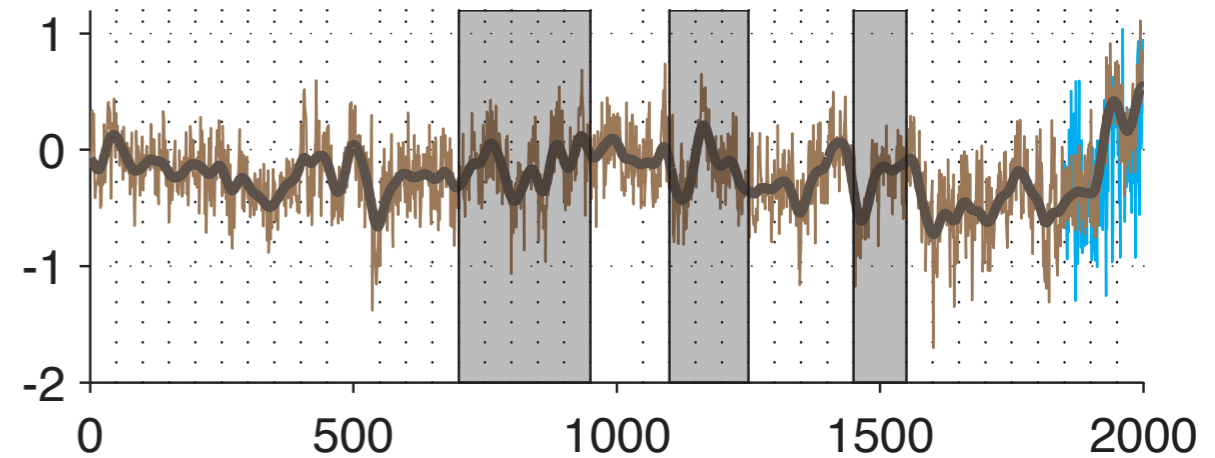
REGIONAL INDICES

GraphEM-based CFR

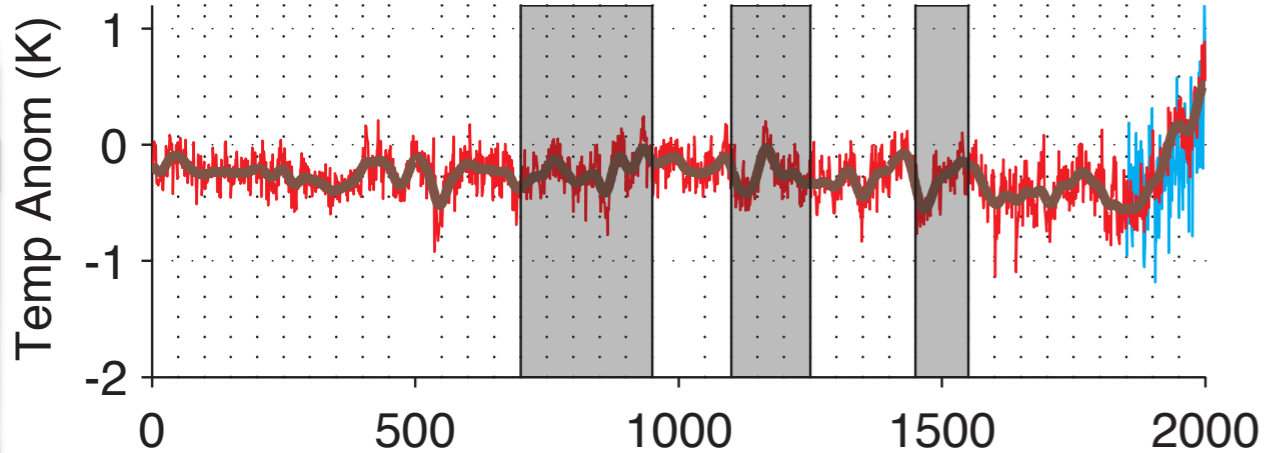
Arctic - multiproxy



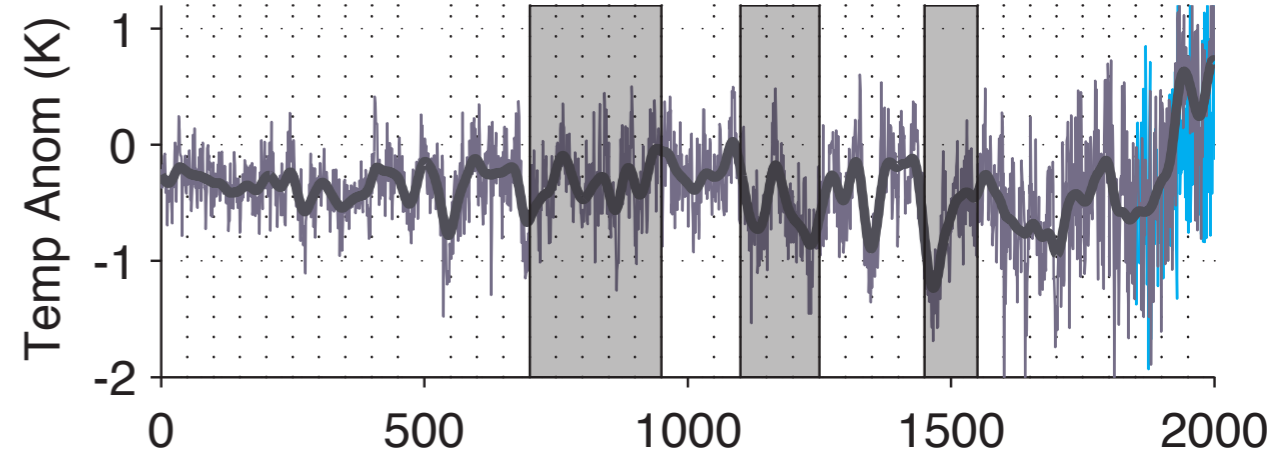
Europe - multiproxy



Asia - trees



North America - trees



Compared with PAGES 2k Consortium, *Nature Geo.*, 2013, Asia shows:

- ❖ Similar types + Smaller amplitudes of variation
- ❖ Spatial coherence with other regions during several periods

Part 2: Asia 2k CFR

DATA & METHOD

❖ **Target: CRU TS 3.22** (Harris et al., *Int. J. Climatol*, 2013)

★ $0.5^\circ \times 0.5^\circ$ regrided to $2^\circ \times 2^\circ$

★ 1901 - 2009 (769 grid cells)

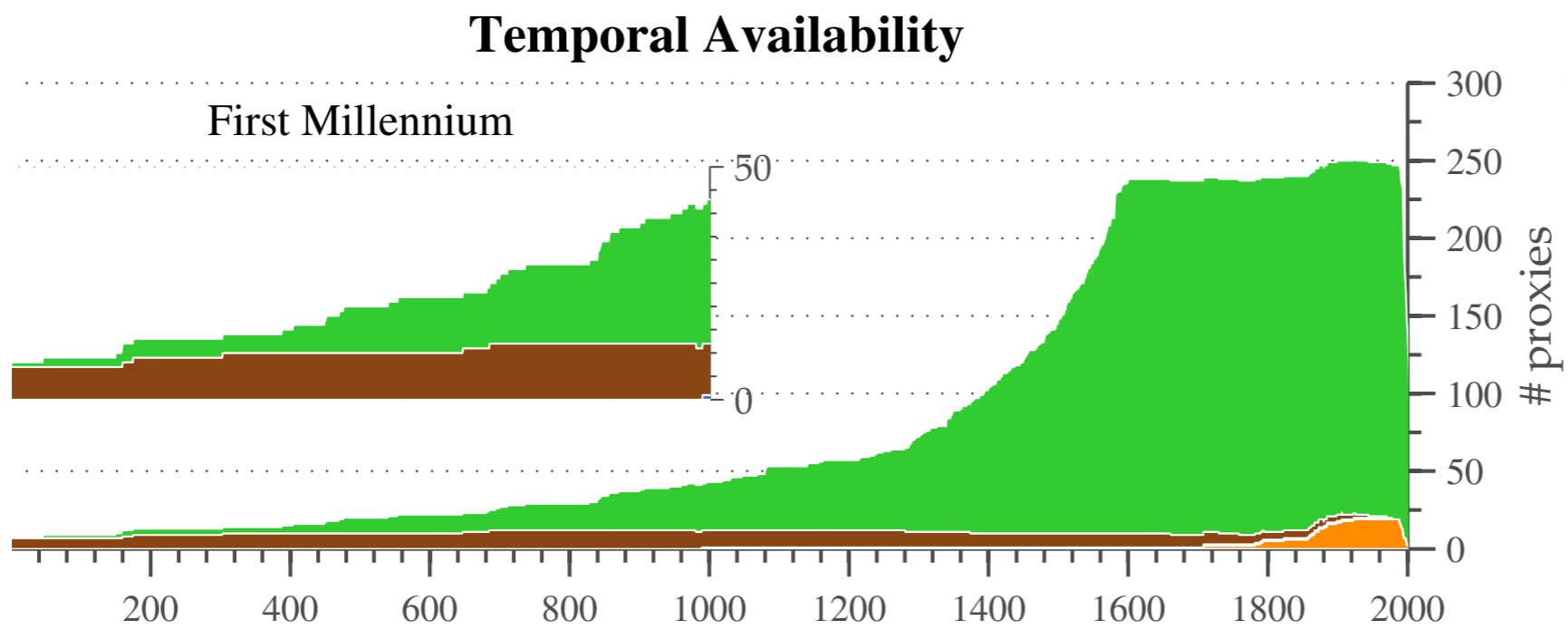
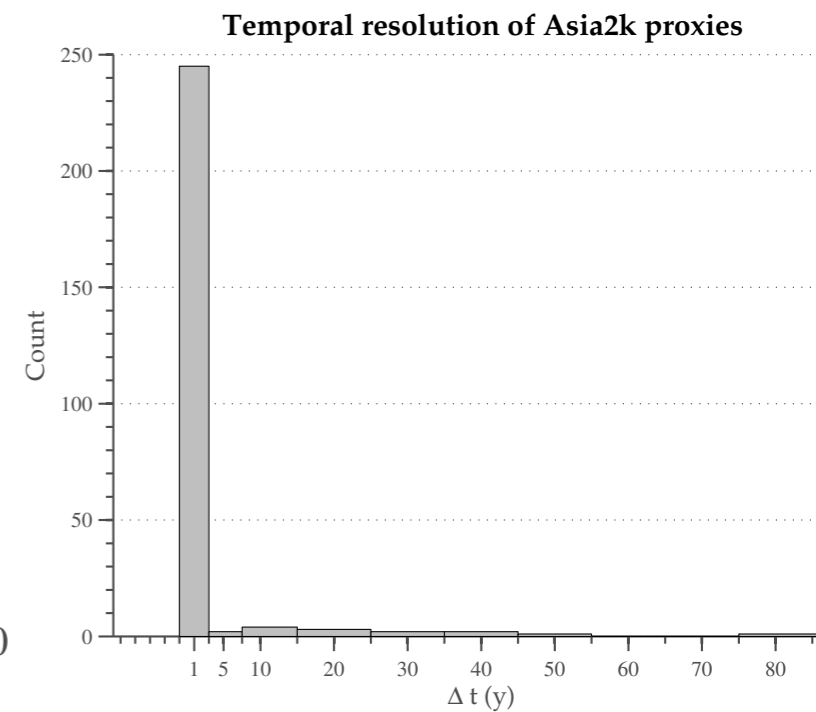
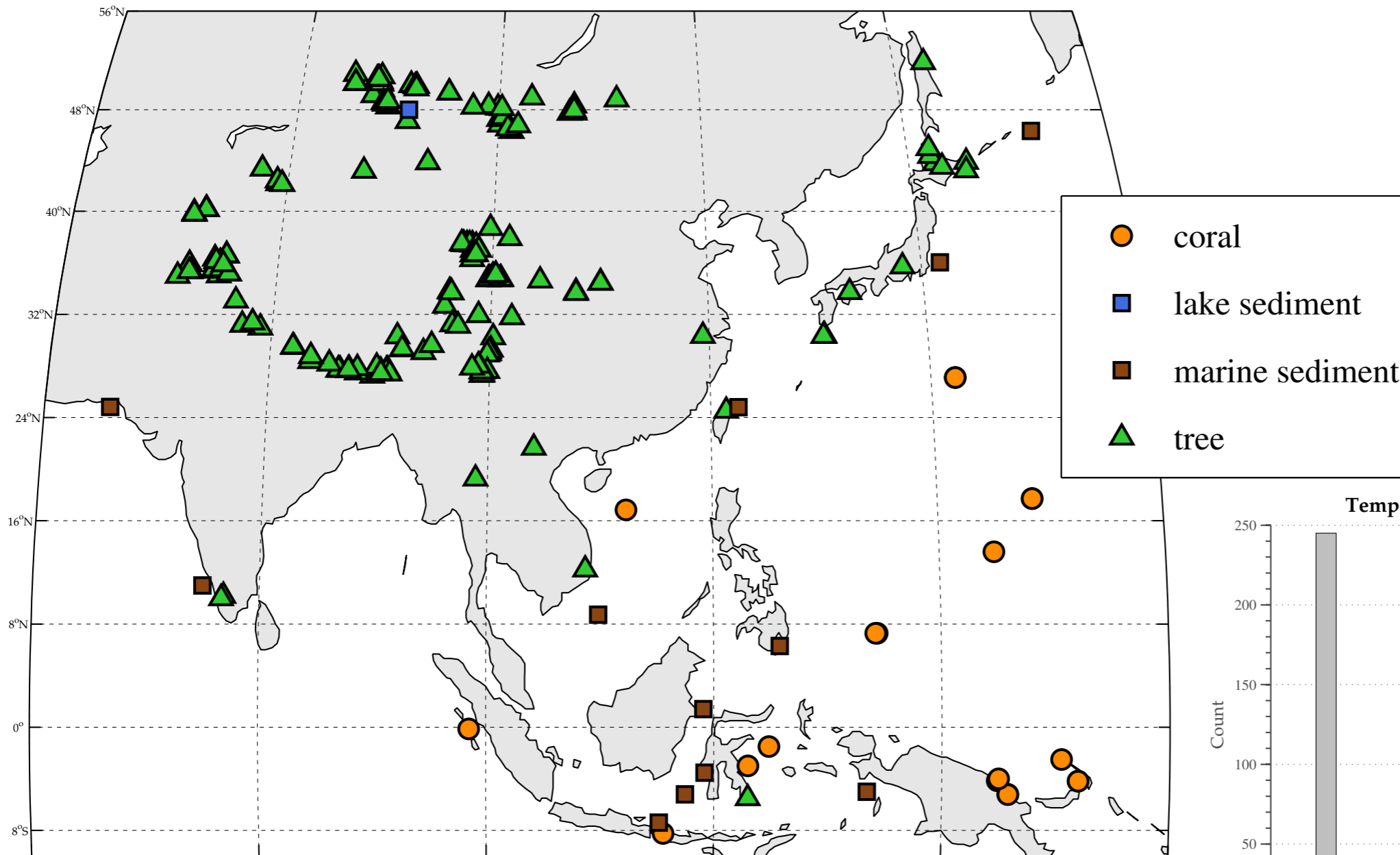
★ caveat: land only

❖ **Proxy: PAGES 2k synthesis** (PAGES 2k consortium, *Nature Geo.*, 2013; *Eos-transactions AGU*, 2014)

★ Only records in Asia (260)

★ Mostly tree rings, some corals and sediment cores

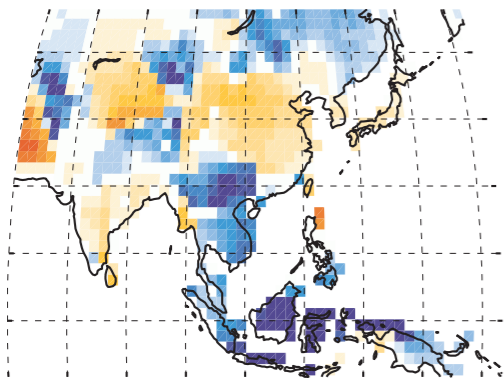
Asia 2k records as of 2015/02/10



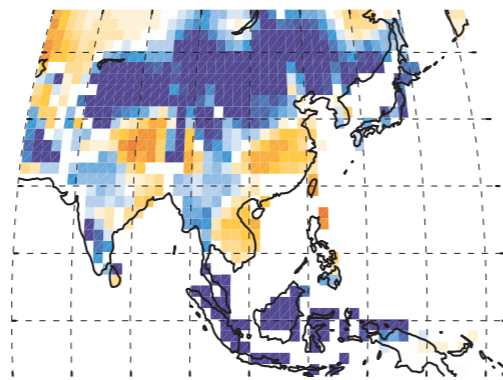
HOW SKILLFUL IS THE CFR?

10-fold Cross-validation RE scores

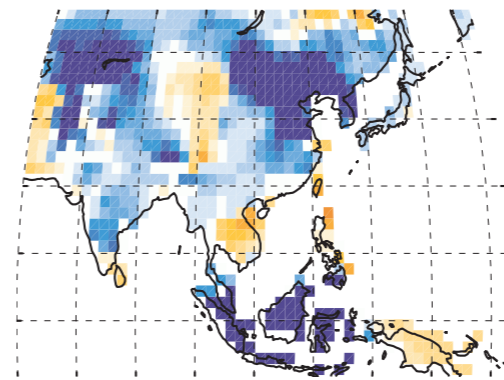
1901-1911 validation



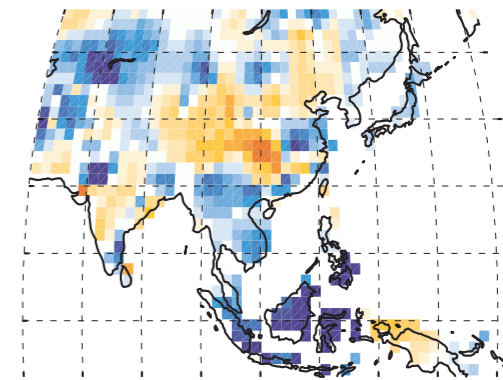
1912-1922 validation



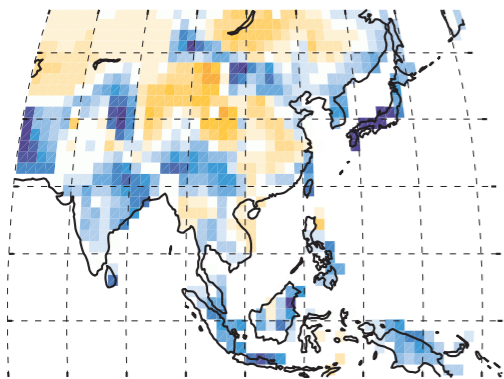
1923-1933 validation



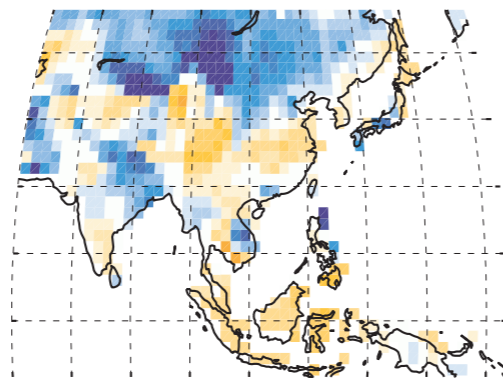
1934-1944 validation



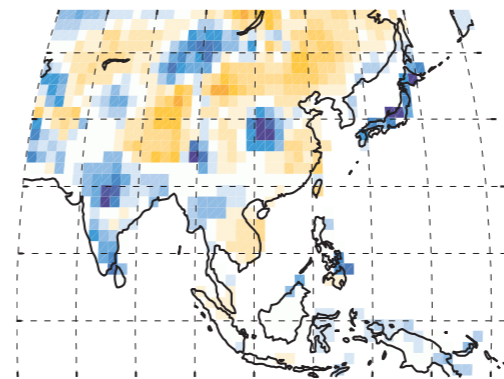
1945-1955 validation



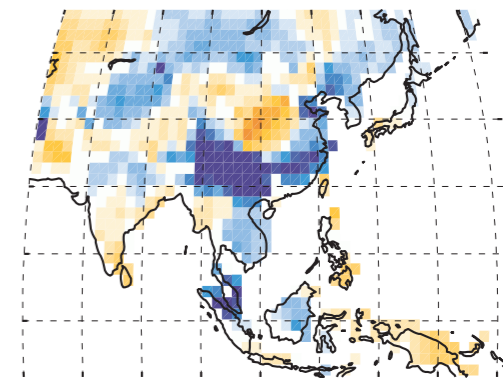
1956-1966 validation



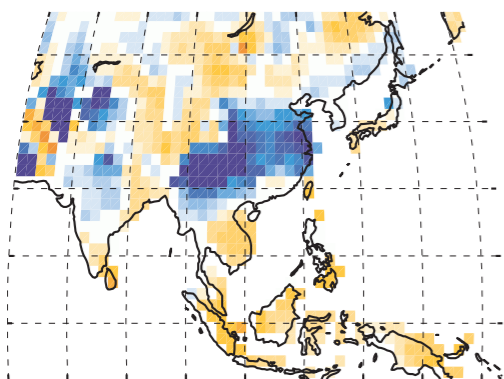
1967-1977 validation



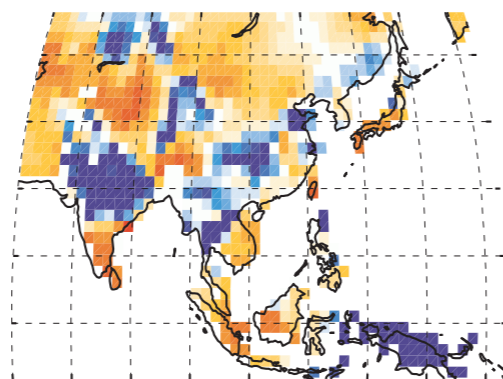
1978-1988 validation



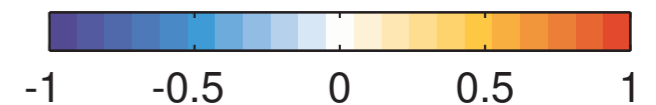
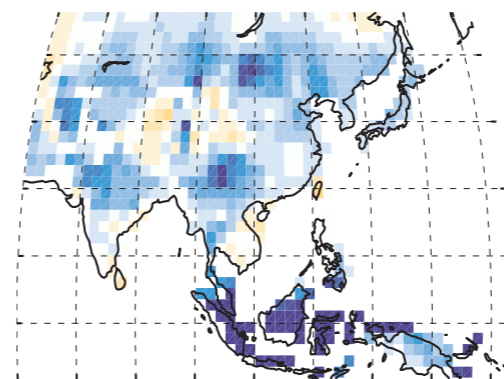
1989-1999 validation



2000-2009 validation

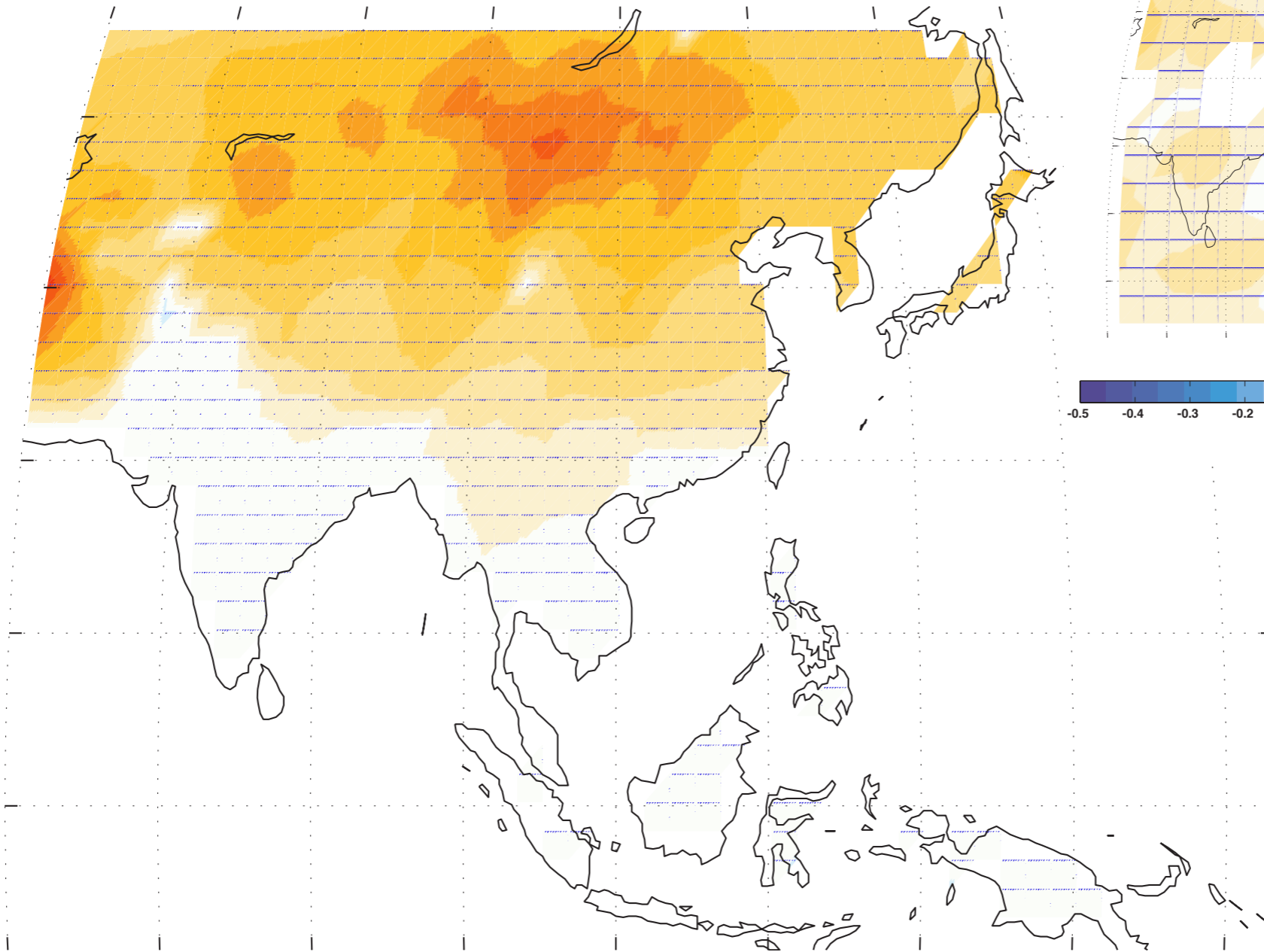


Average

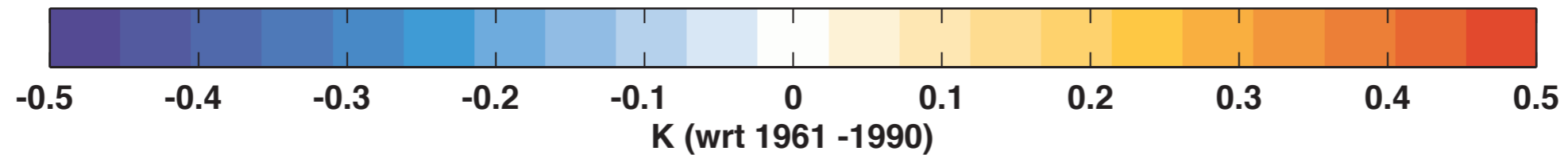
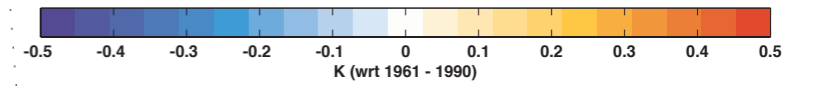
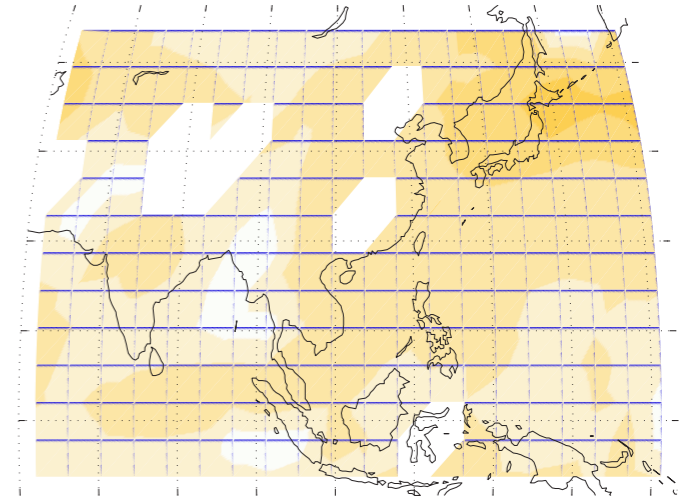


SPATIAL FEATURES

MCA - LIA



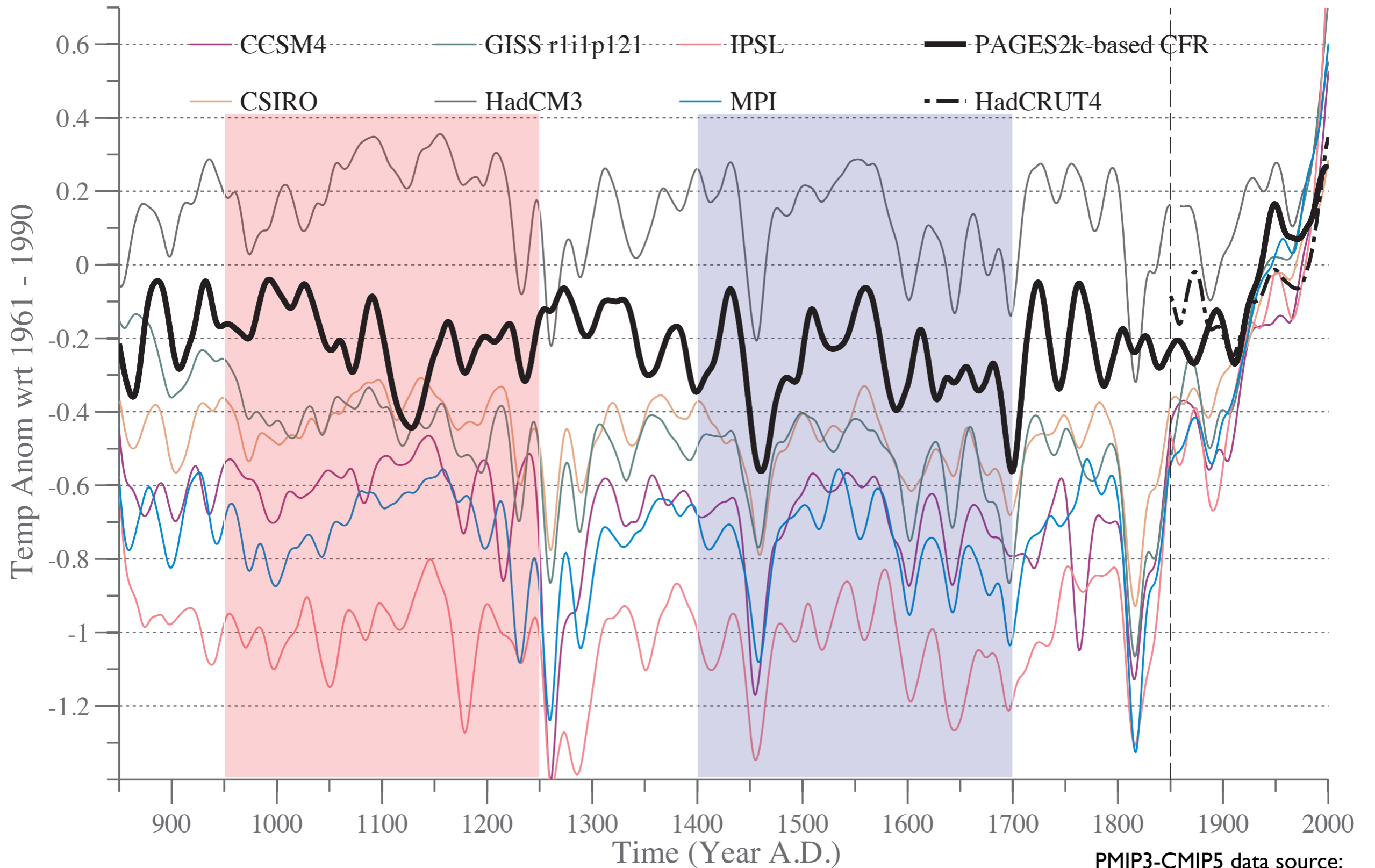
MCA - LIA



Part 3: Data-model comparison

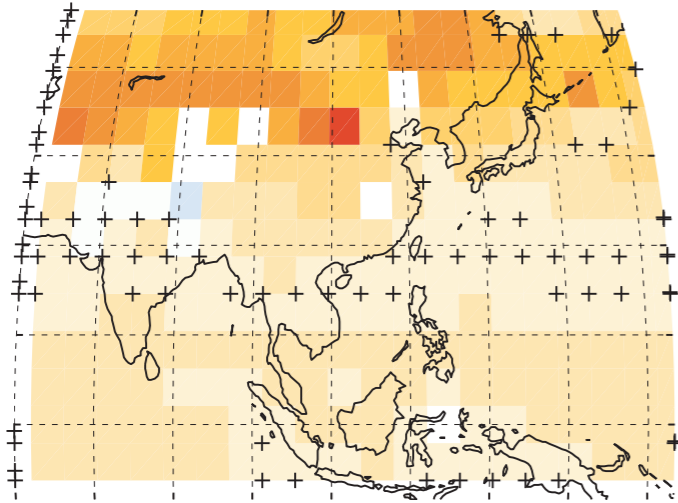
DATA-MODEL COMPARISON

Asia Summer temperature (30-year lowpass)

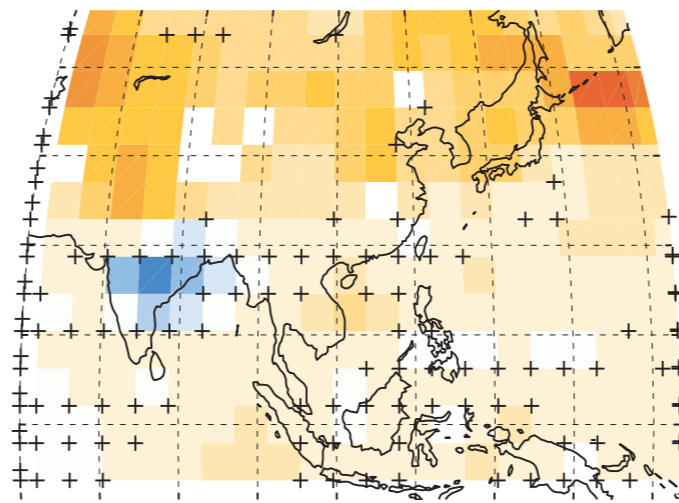


DATA-MODEL COMPARISON

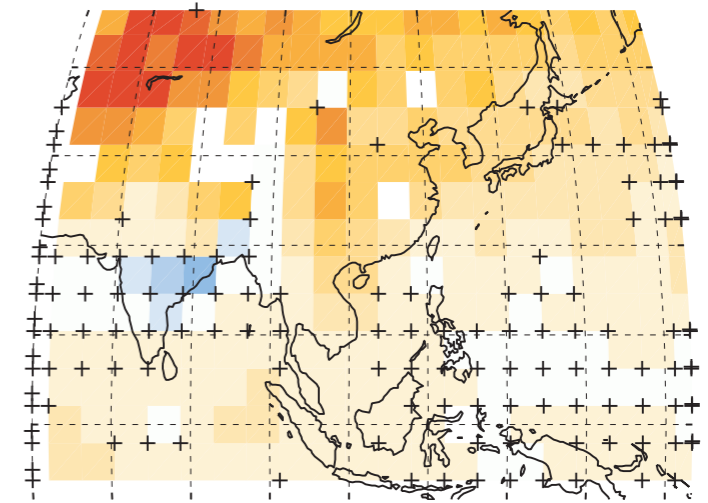
CCSM4 (global mean=0.19K)



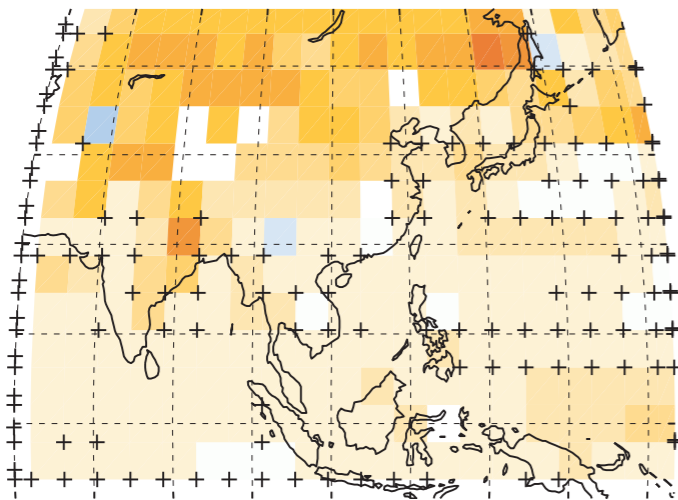
CSIRO (global mean=0.09K)



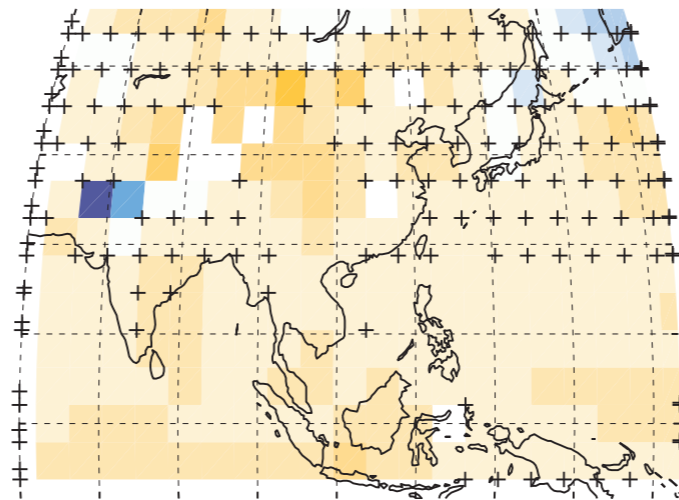
GISS r1i1p121 (global mean=0.12K)



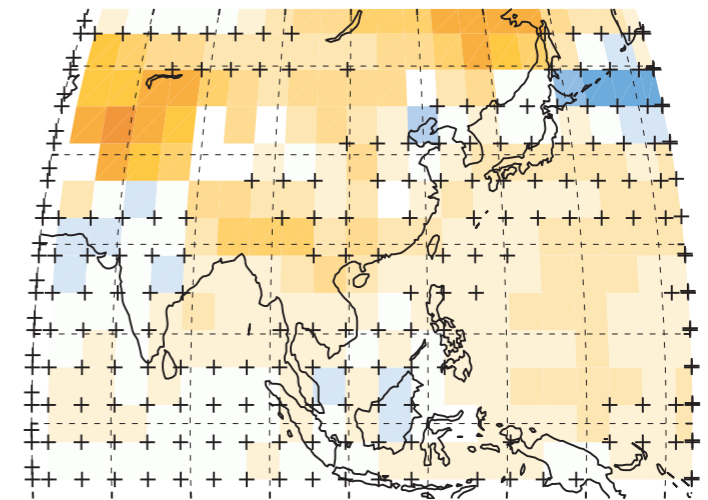
HadCM3 (global mean=0.10K)



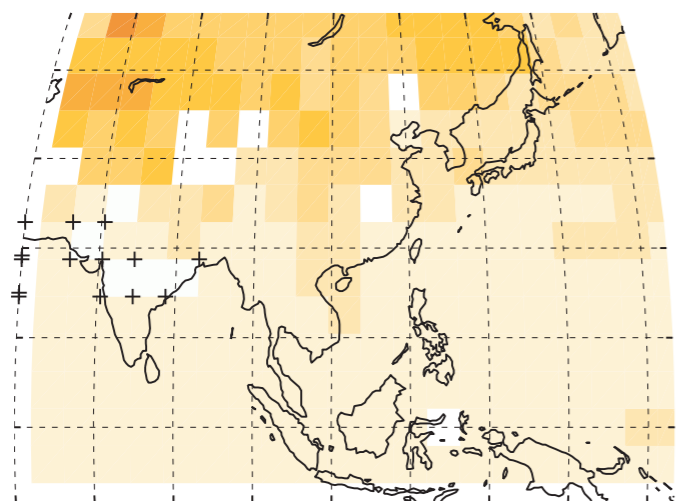
IPSL (global mean=0.09K)



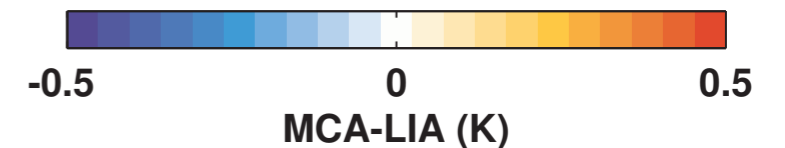
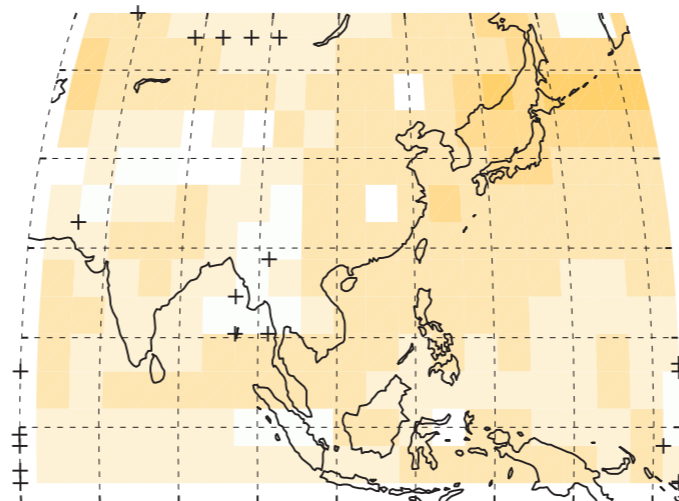
MPI (global mean=0.07K)



Model Mean (global mean=0.11K)



CFR (global mean:0.10K)



Wrapping up

CONCLUSIONS

❖ **Is there a need for regional CFRs**

★ Yes, but global CFRs allow for direct comparisons among regions

❖ **Asia 2k CFR**

★ Distinctly different LIA, less skillful than the global CFR

❖ **Data-model Comparison**

★ General agreement of spatial patterns

DISCUSSION

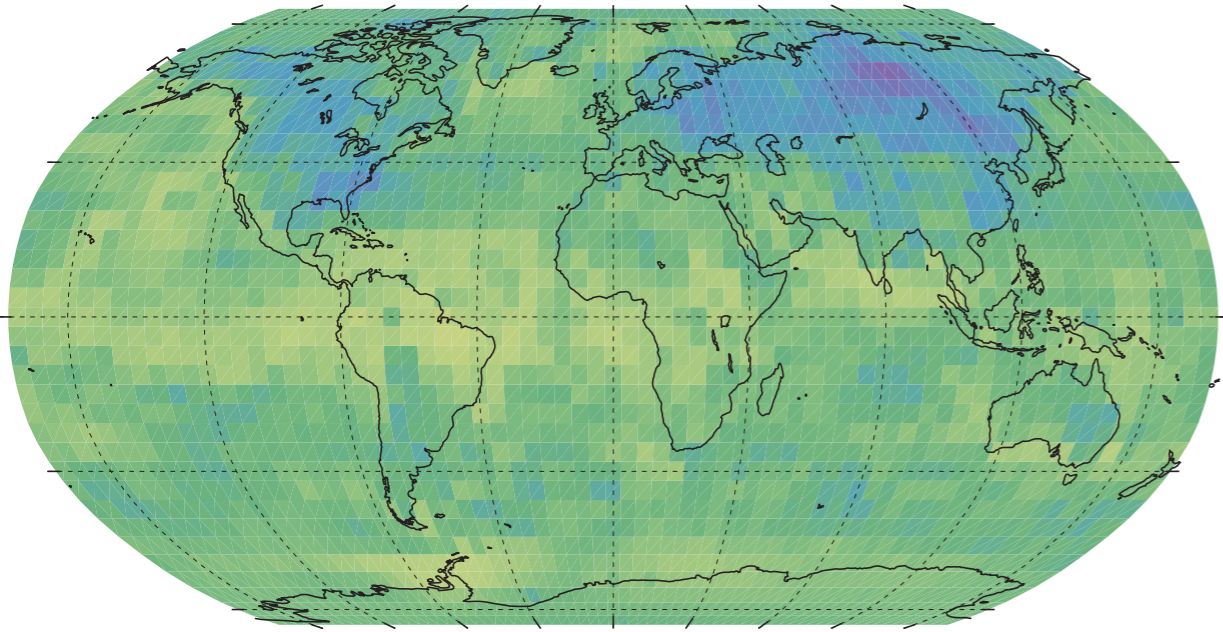
❖ Seasonality

- ★ Trees record growing season temperature
- ★ High-lat: T is limiting, so summer temp proxy: not suited for MAT or blending two hemispheres together (global CFR)

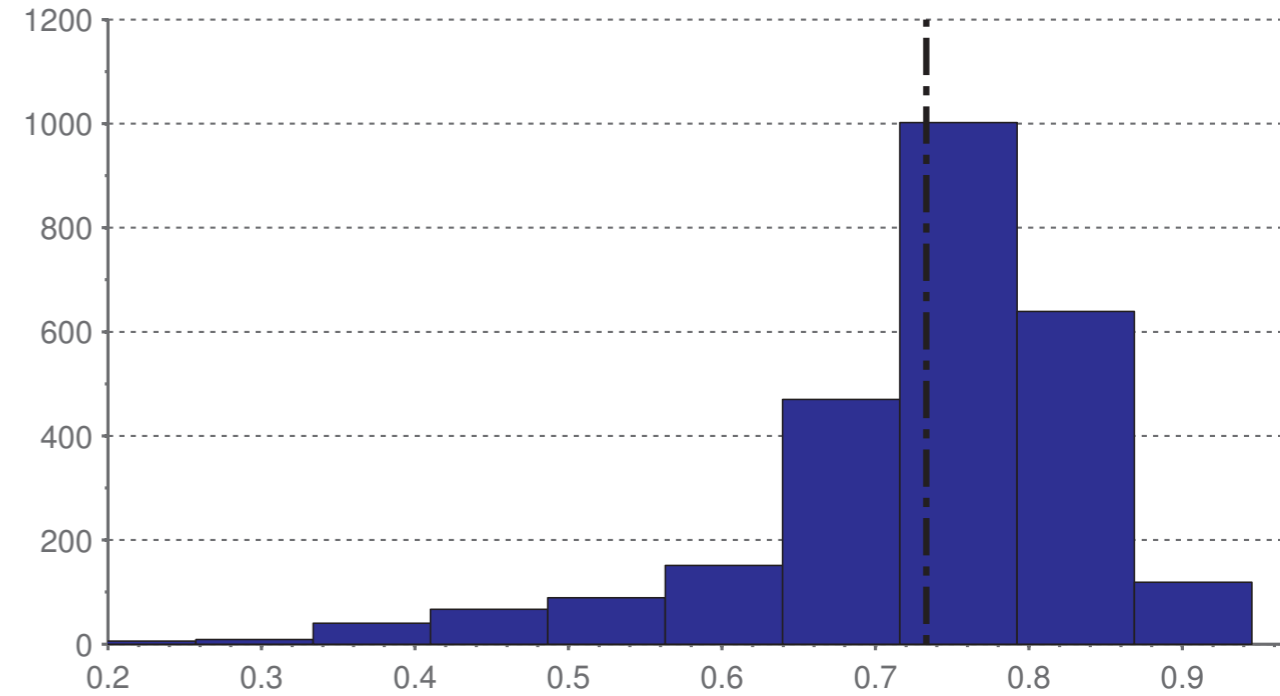
DISCUSSION

❖ Seasonality

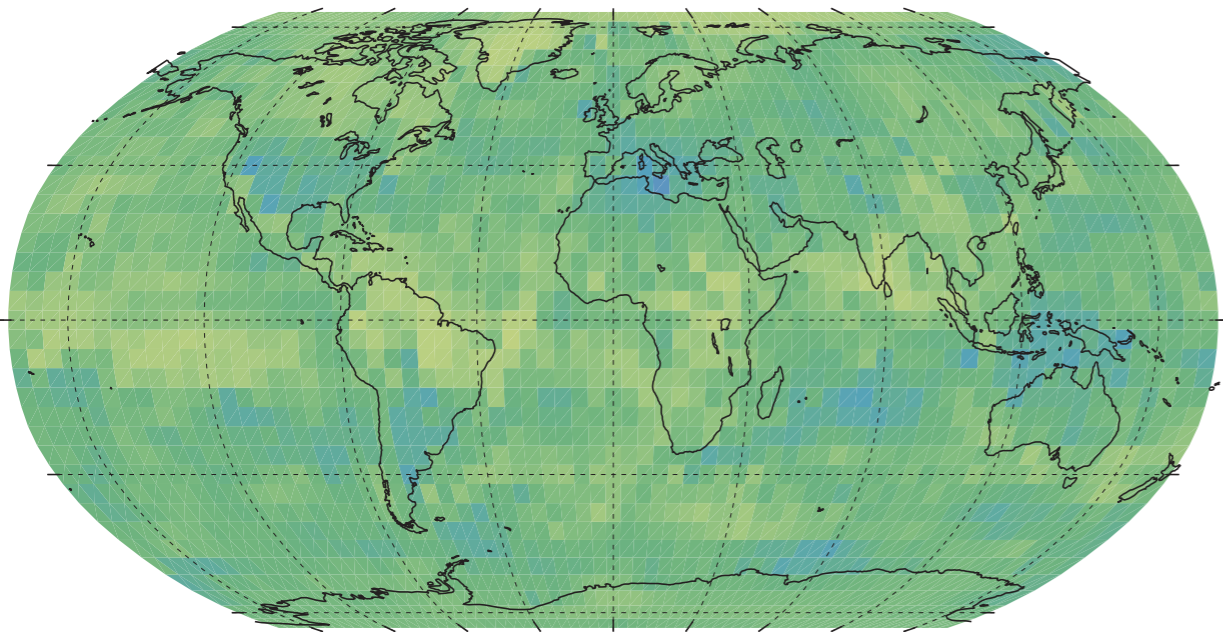
Annual vs. JJA



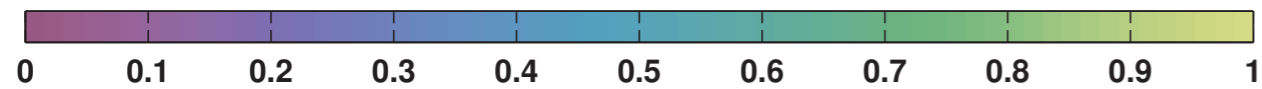
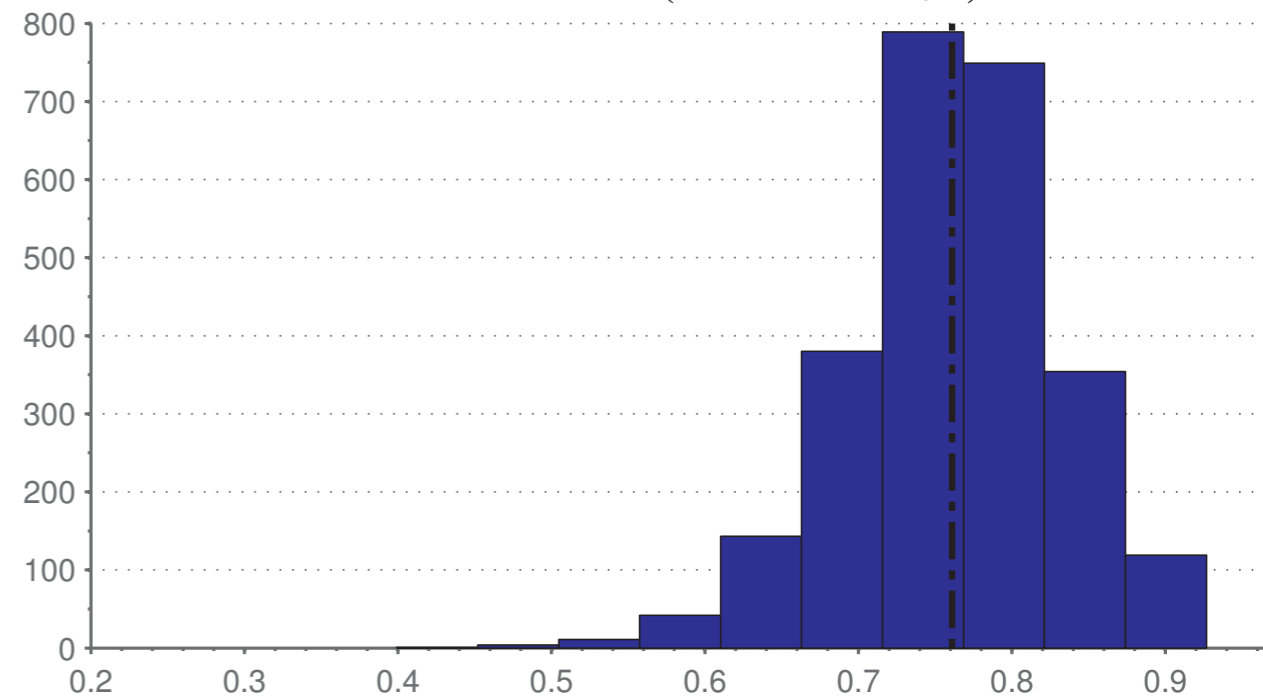
Correlation (Annual vs. JJA)



Annual vs. DJF



Correlation (Annual vs. DJF)



DISCUSSION

❖ **Seasonality**

- ★ Trees record growing season temperature
- ★ High-lat: T is limiting, so summer temp proxy: not suited for MAT or blending two hemispheres together (global CFR)

❖ **Proxy quality control/screening**

- ★ Base on statistics? physical knowledge?
- ★ How should we blend high-resolution, cross-dated records with low-resolution, time-uncertain records?

❖ **Period of interest to reconstruct**

❖ **The missing oceanic component**



Thank you!

**Comments & questions:
jianghaw@usc.edu**

SCREENING

❖ For each proxy

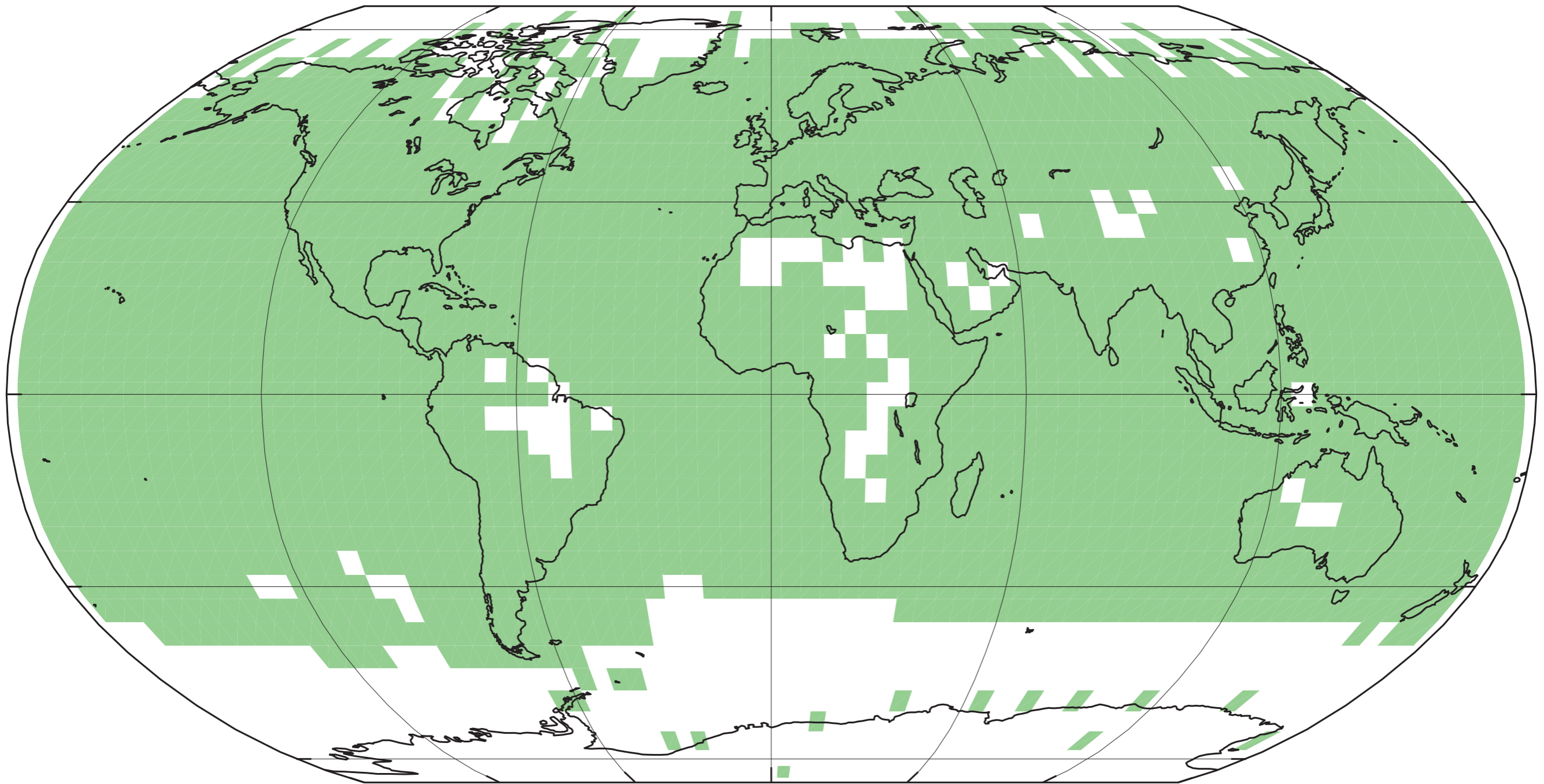
- ★ Calculate correlations w/ 10 closest HadCRUT4 temperature neighbors
- ★ Statistical significance established via:
 - ▶ A non-parametric significance test (Ebisuzaki, *JClim.*, 1997)
 - ▶ Considering the effect of multiple hypotheses tests (Ventura et al., *JClim.*, 2004)

❖ Caveats:

- ★ Proxies must have instrumental overlap w/ temperature
- ★ Purely statistical-based screening, no physical interpretation

HADCRUT4

HadCRUT4 (1758 grid cells)



CFR METHOD

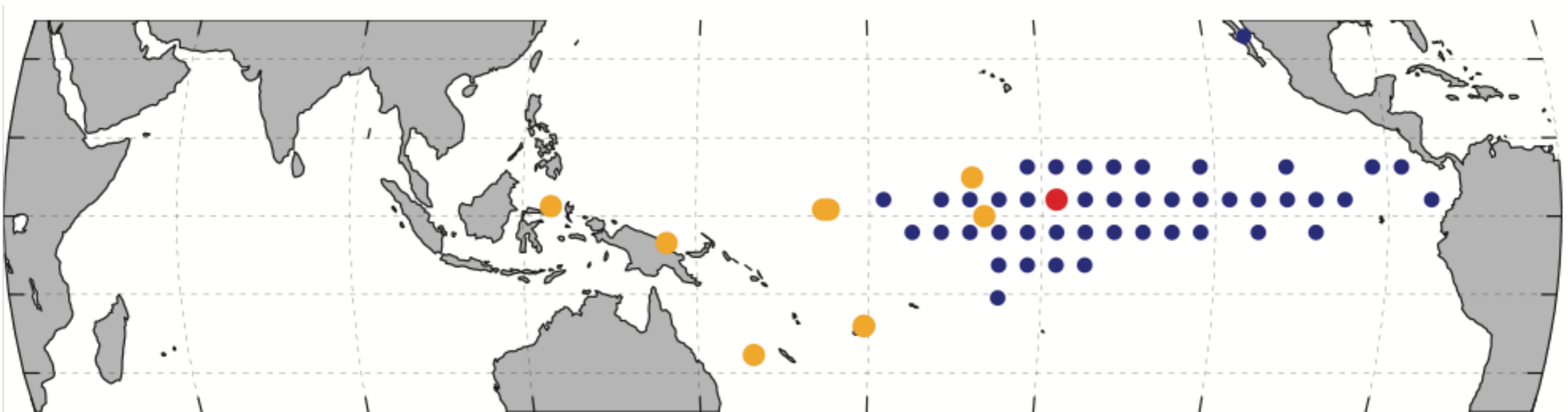
- ❖ **Fundamental challenge:**

- ★ $n \ll p$, ill-conditioned covariance matrix

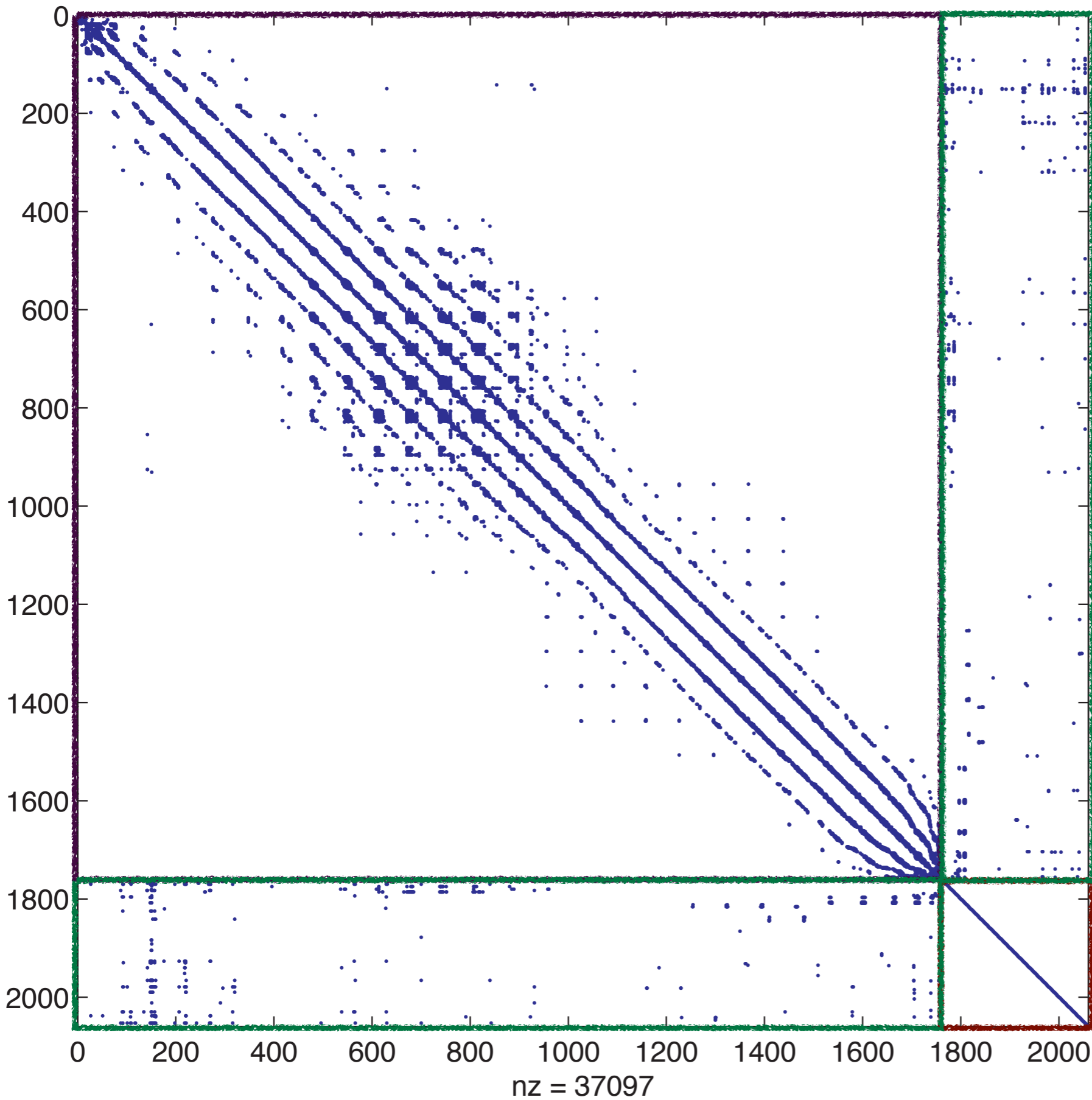
- ❖ **GraphEM** (Guillot et al., *AoAS*, in press)

- ★ Gaussian Graphical Models (GGMs)

- ★ Models conditional independence in the climate field



Graph choice



Temperature (T)
TT: correlation graph
with loose penalty
(long-range dependencies)

Temperature-Proxy (TP)
TP: correlation graph
with high penalty
(local correlation)

Proxy (P)
PP: diagonal
(conditional independence)