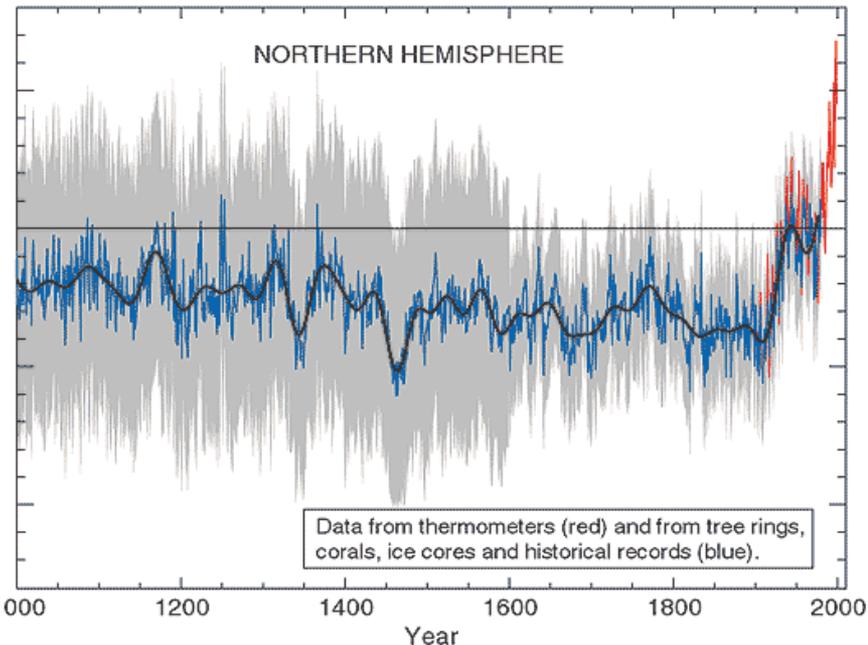
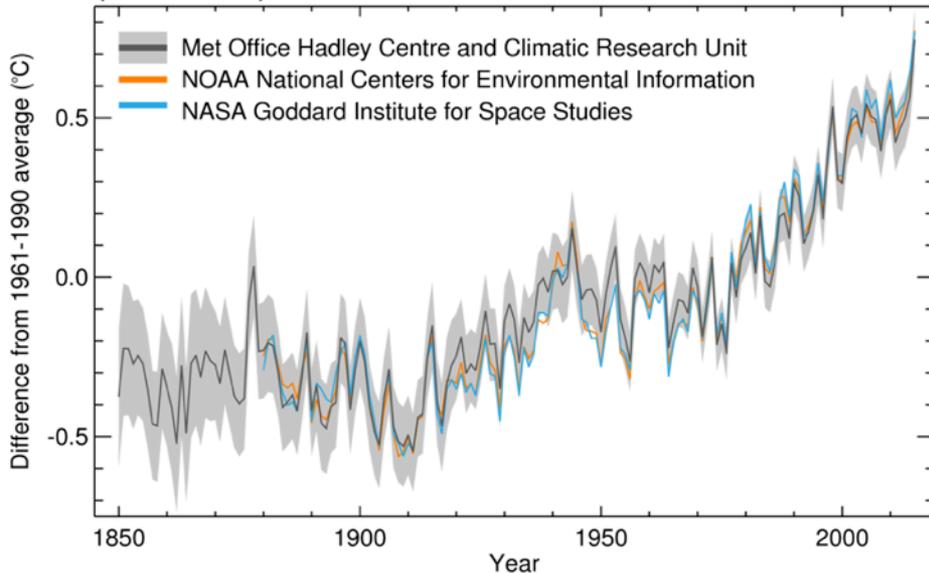


# An Australasian hockey stick and associated climate wars

Professor David Karoly

Oxford Martin School Visiting Fellow, Jan-July 2017  
School of Earth Sciences, University of Melbourne

Global average temperature anomaly (1850-2015)





# Acknowledgements

Joelle Gergis, University of Melbourne

Raphi Neukom, Oeschger Centre, University of Bern

Ailie Gallant, Monash University

Funding from Aust Res Council and Dept Clim Change

## References

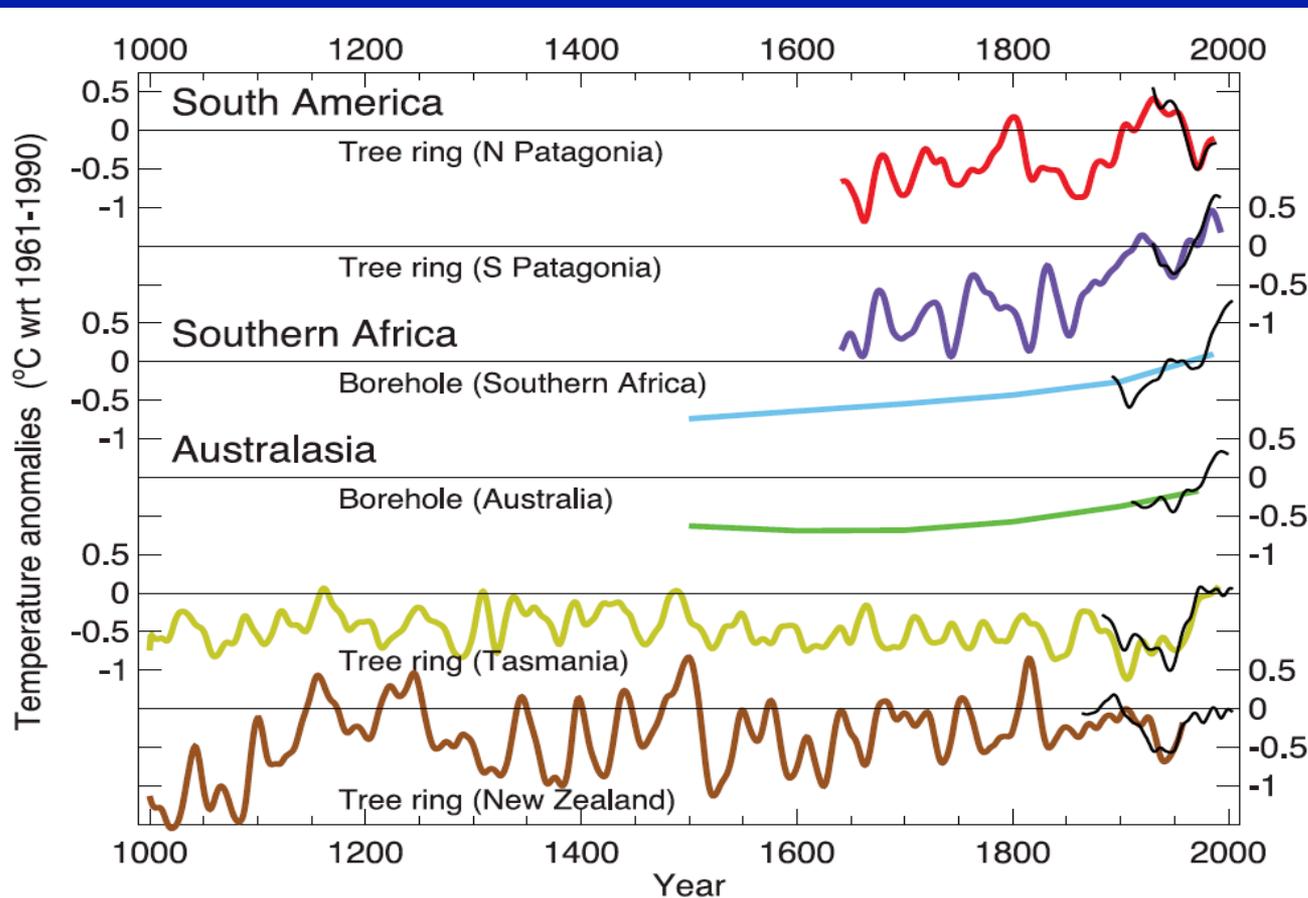
Gergis, J., R. Neukom, A. J. E. Gallant and D. J. Karoly (2016) Australasian temperature reconstructions spanning the last millennium. *J Clim.*, 29, 5365-5392.

Gergis, J., (2016) How a single word sparked a four year saga of climate fact checking and blog backlash. *The Conversation*, 11 July 2016.  
<https://theconversation.com/how-a-single-word-sparked-a-four-year-saga-of-climate-fact-checking-and-blog-backlash-62174>



# Southern Hemisphere temperature reconstructions

- IPCC AR4: 6 records used to reconstruct annual mean SH temperature variations over the past 1000 years
- Only 2 from Australia, a tree ring chronology and a borehole composite record, and 1 tree ring record from NZ



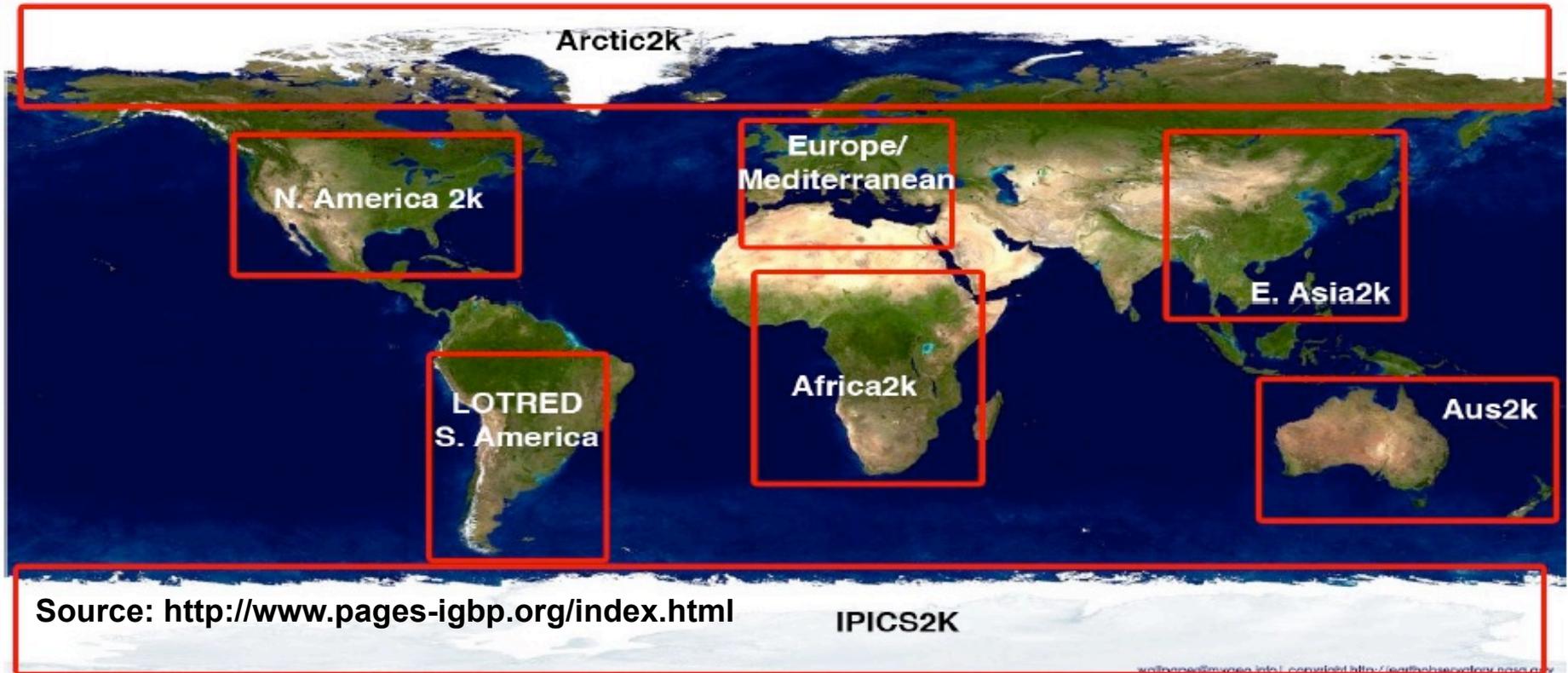
Jansen et al. (2007)

IPCC AR4 WG1 chapter 6



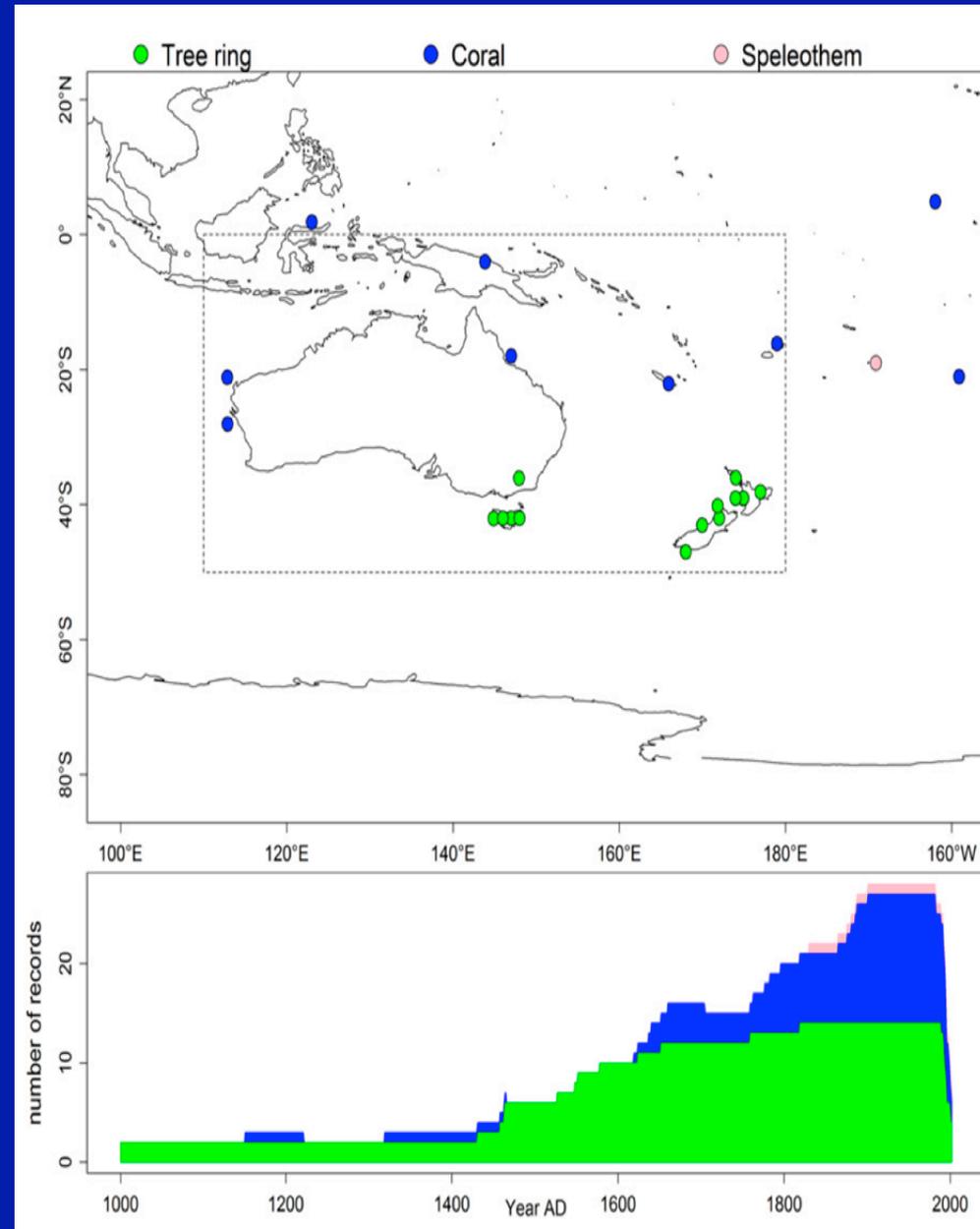
# PAGES regional 2K network

- Global effort from 2010 to consolidate regional palaeoclimate data
- Urgent need to develop 'best estimate' temperature reconstructions for the Australasian region



# Australasian temperature reconstruction

- Multi-proxy warm season (Sept–Feb) temperature reconstruction
- Use annually resolved proxies
- Combined land–ocean region of Australasia ( $0^{\circ}$ – $50^{\circ}$ S,  $110^{\circ}$ E– $180^{\circ}$ ) over 1000–2001
- Between 2 (R2) and 28 (R28) records
- Gergis et al. (2016)
- Originally accepted in 2012



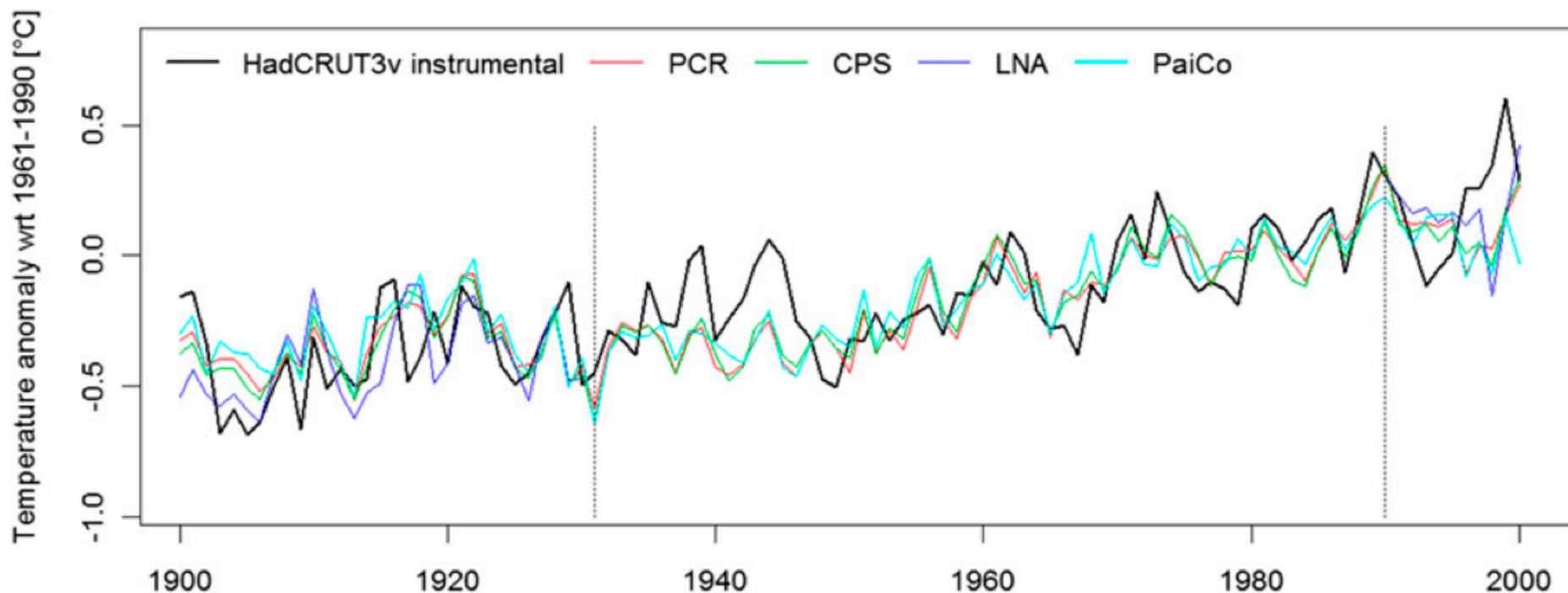


# Australasian temperature reconstruction

- Four 1000-member ensemble reconstructions developed using four statistical methods:
  - Principal component regression (PCR),
  - Composite plus scale (CPS),
  - Bayesian hierarchical models (LNA),
  - Pairwise comparison (PaiCo).
- Reconstructions compared with 3-member ensemble of GISS-E2-R climate model simulations



# Australasian temperature reconstruction

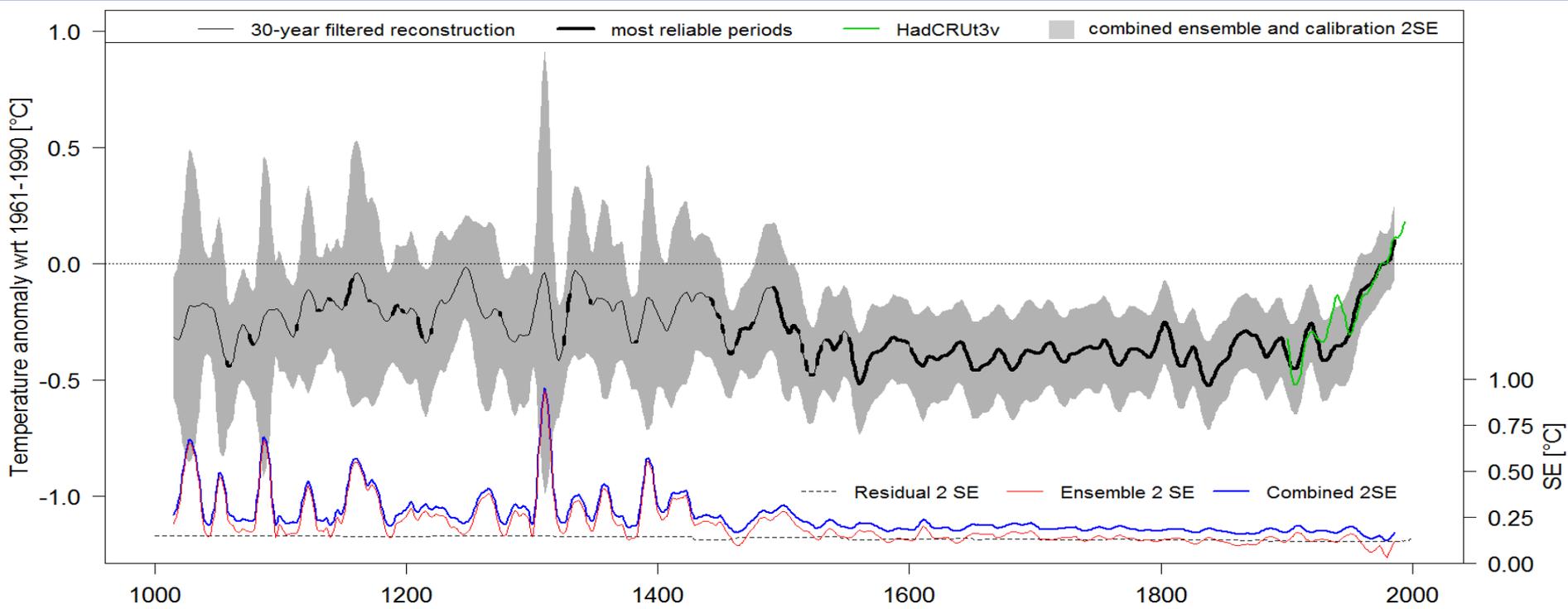


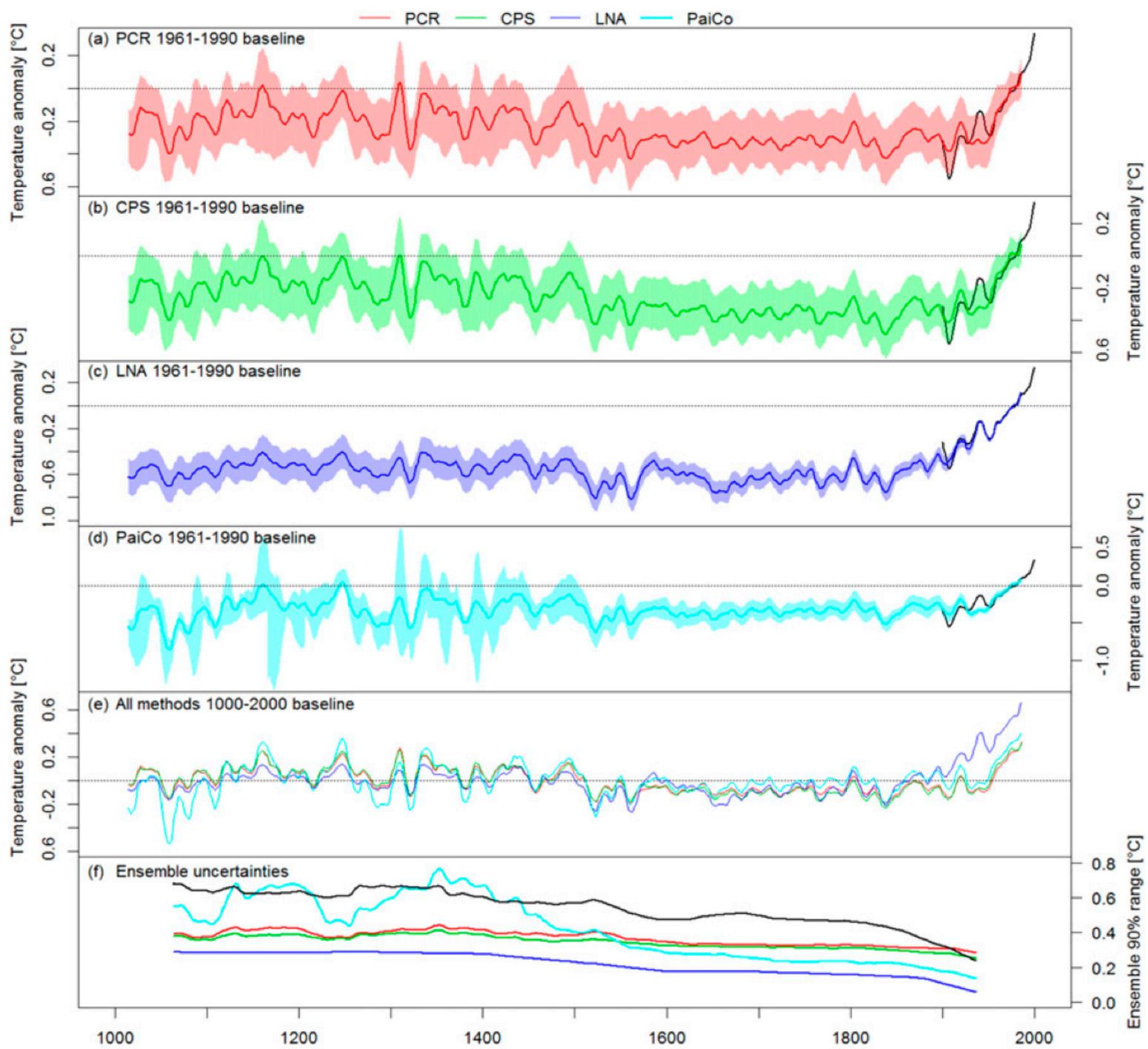
Calibration over 1930-1990, verification over 1900-1930:  
Calibration R28 all methods  $r > 0.7$  interannual  
Best verification R28 CPS and PCR,  $r = 0.55$  interannual  
Poorest R28 LNA  $r = 0.39$ , R3 PCR  $r = 0.17$

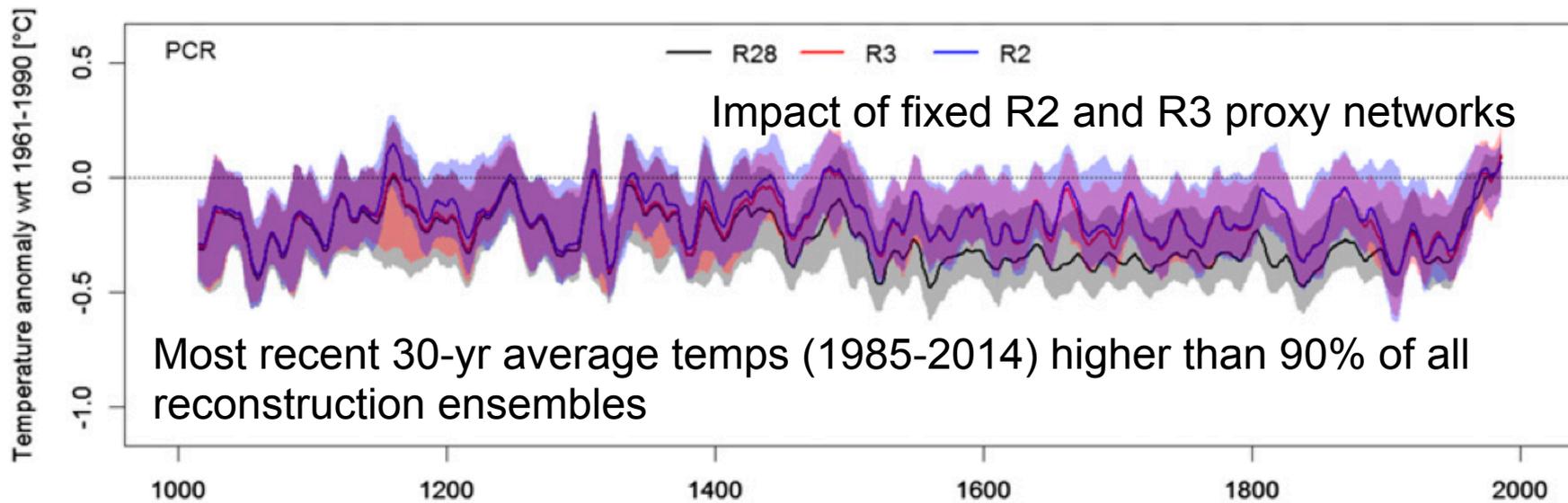
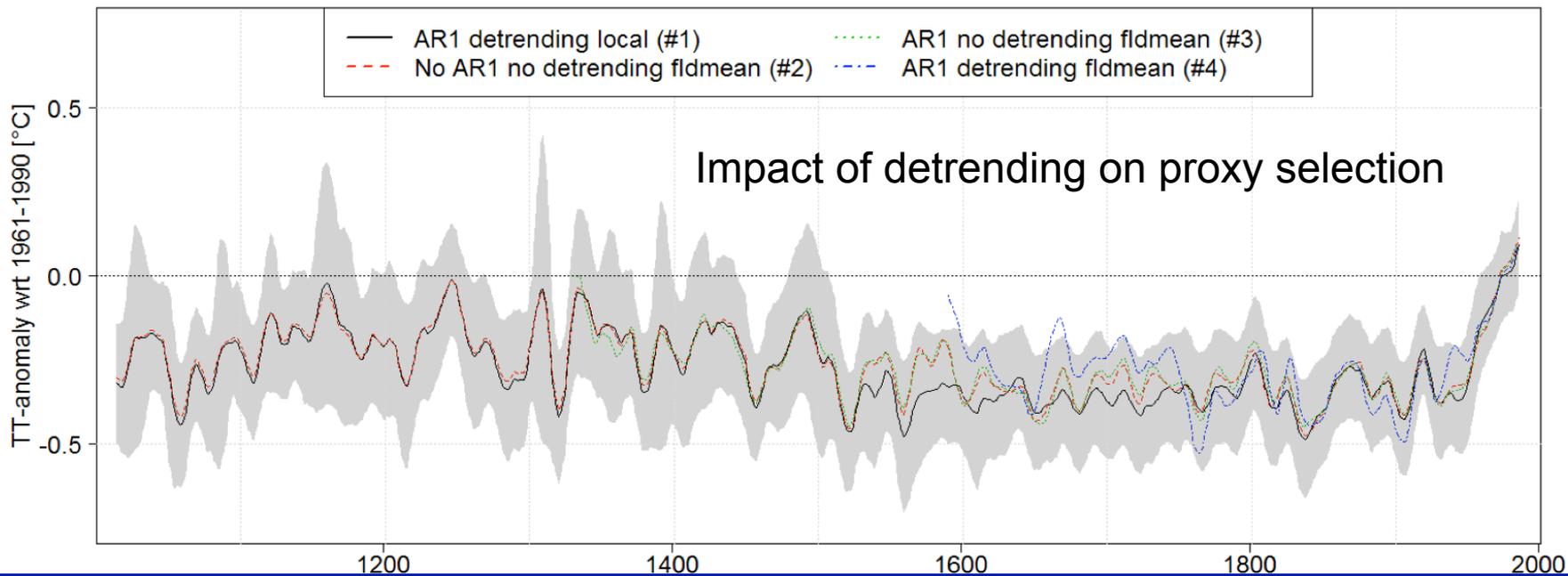


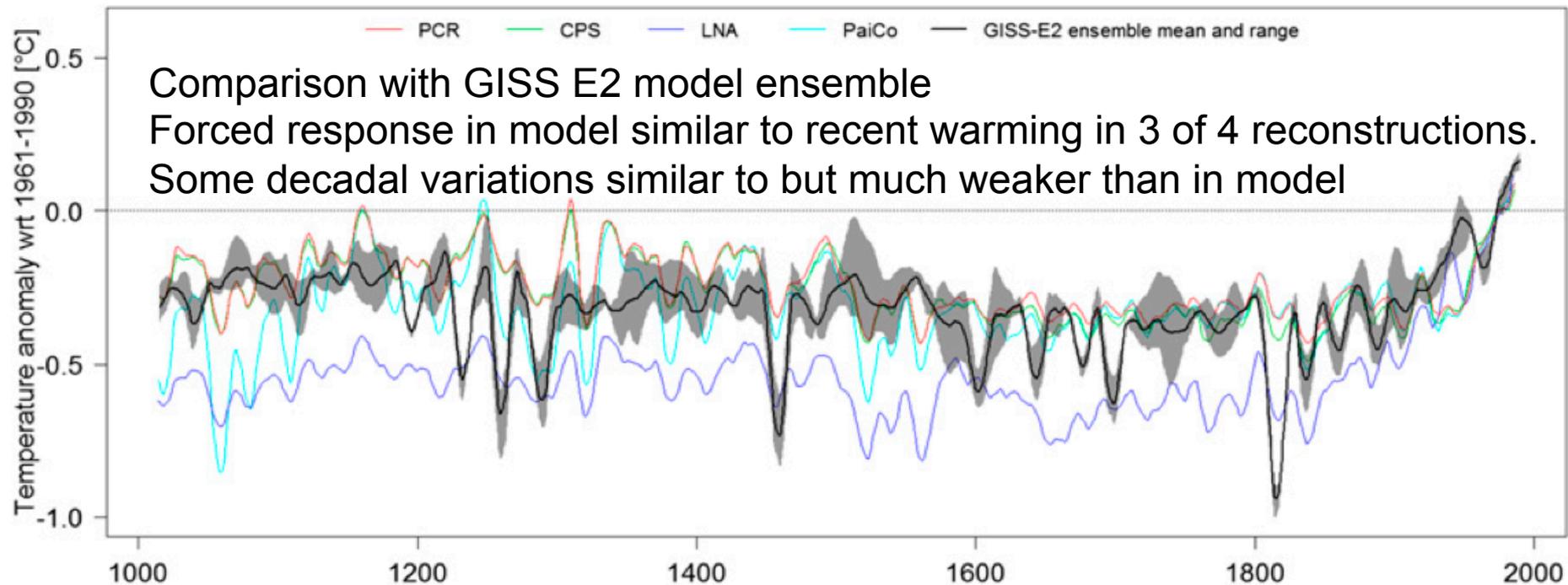
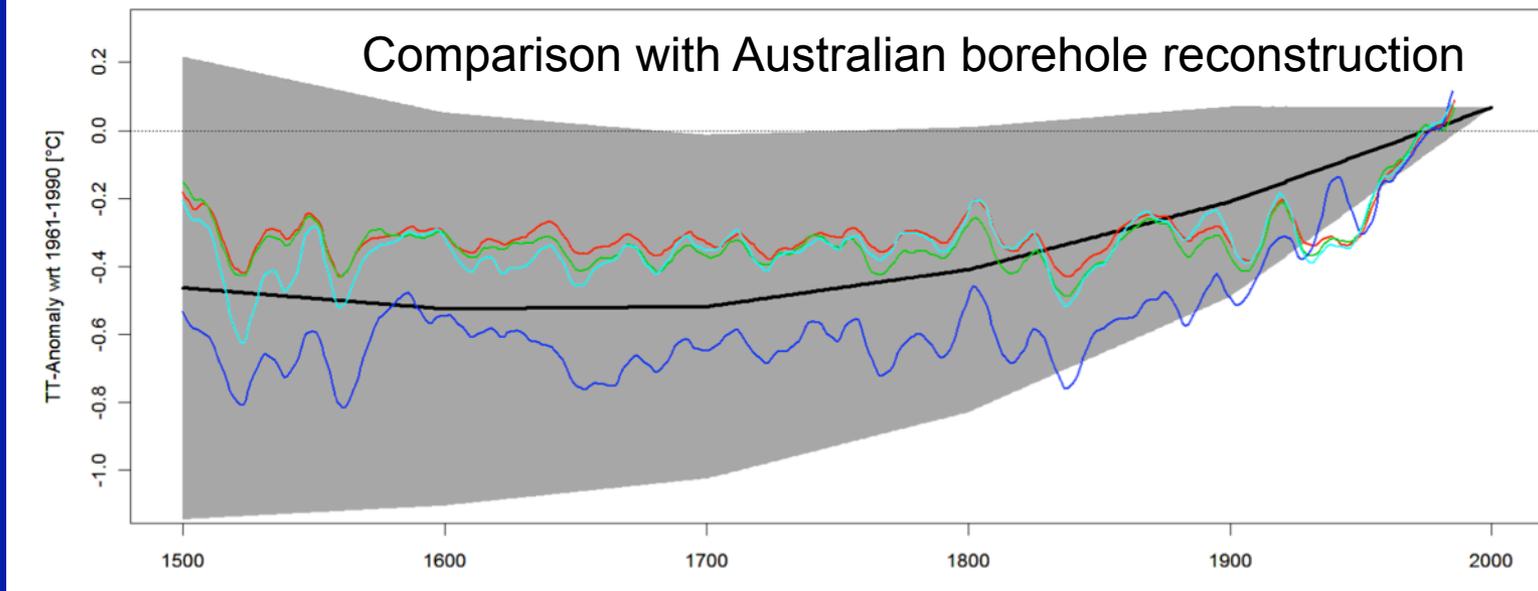
# Australasian temperature reconstruction

- Australasian spring–summer temperature anomalies: mean of 1000-member Principal Component Regression (PCR) ensemble based on varying reconstruction parameters (using 28 records)
- Ensemble uncertainty estimates represented as the 90% confidence interval of combined ensemble & calibration error (grey shading)
- Evaluated the influence of loss of records back in time repeating the process with three proxy subsets (R28, R3, R2)









# Summary

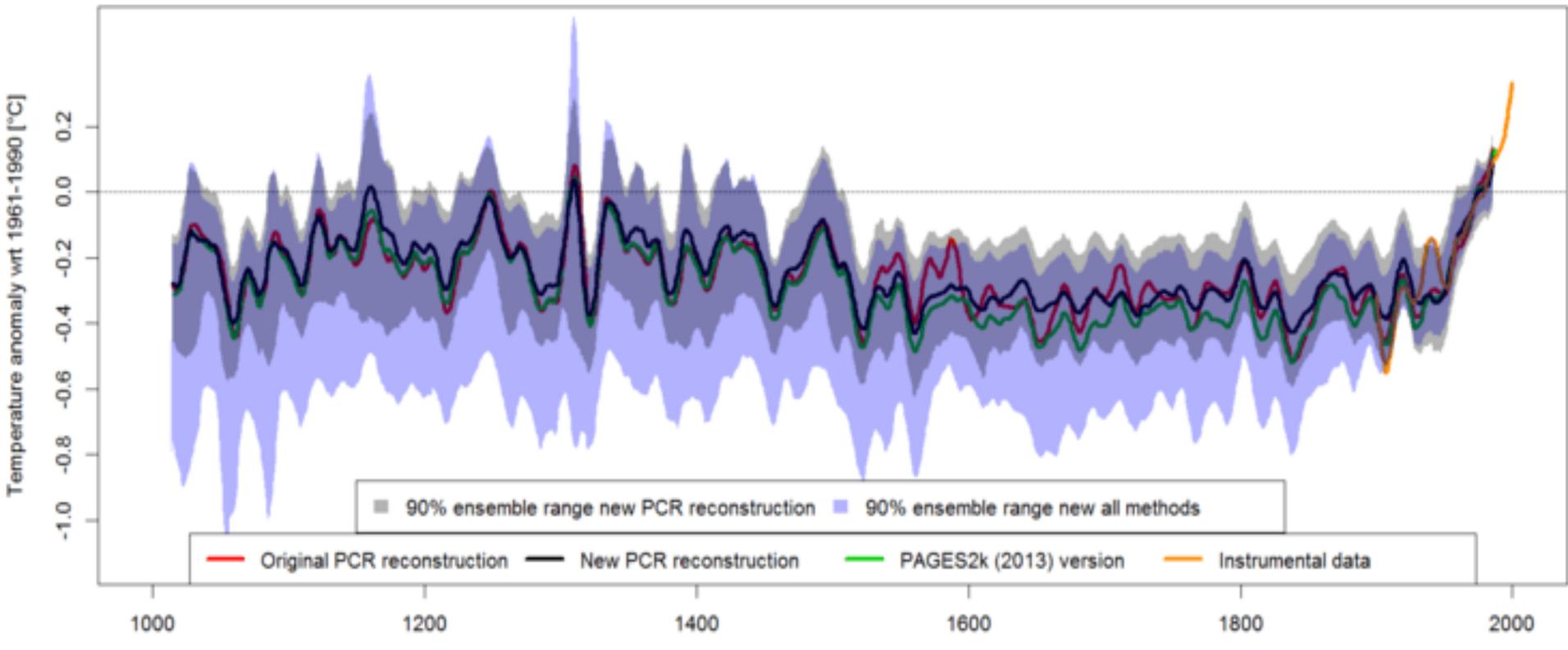
- High-resolution palaeoclimatology is our best way of assessing pre-industrial climate variability
- Developed first combined ocean and land temperature reconstruction for Australasia spanning the last 1000 years
- Ensemble approach provides rigorous uncertainty estimates (e.g. four different methods, three data subsets)
- 1985–2014 period was the warmest 30-year period in last 1000 years (90% confidence based on 12,000 reconstructions)
- Post 1950 warming cannot be explained by natural variability alone using GISS-E2-R model. Anthropogenic forcing is required to produce the rate and magnitude of recent warming observed and reconstructed in the Australasian region.
- Model response to volcanic forcing appears to be too large

# The back story

- Paper accepted for EOR in *J Climate* in 2012 after 6 reviews over 2 rounds, with media release
- A minor inconsistency identified between text and actual data processing, so paper was put on hold
- Enter the sceptics: hundreds of abusive emails and blog posts, and requests for data that was already available
- Journal decided to withdraw manuscript, required revise and resubmit, further three rounds of peer review and four new reviewers over next 4 years, including two additional analysis methods
- Freedom of information requests: three in 2012/13 and two in 2016



# Comparison of various iterations of the Australasian temperature reconstruction



Original (2012) results effectively the same as revised results but with expanded uncertainty estimates from using ensembles of four different methods (not all equal)