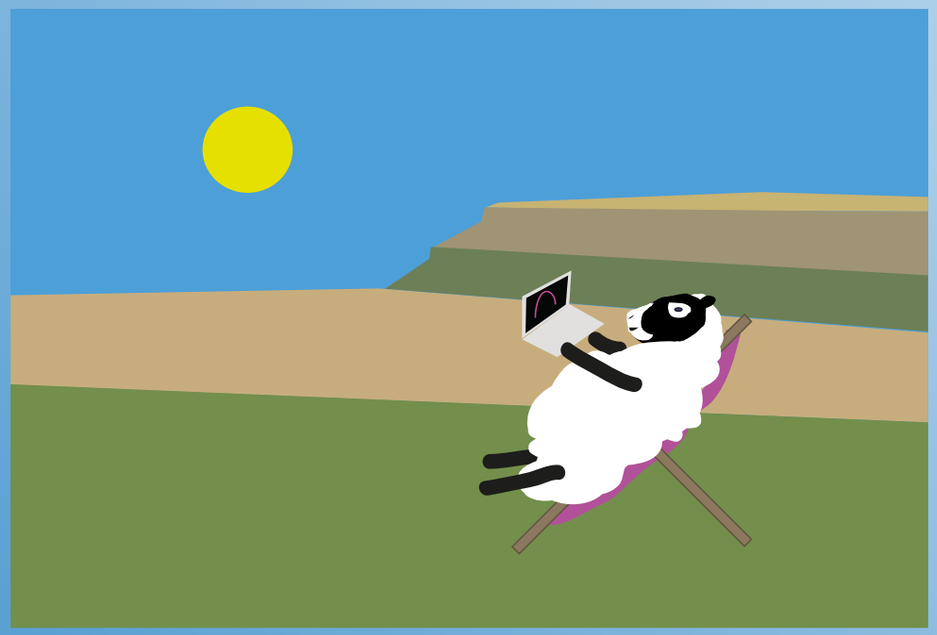
Reconstructing the surface temperature fields of the mid-Pliocene Warm Period using climate models and a variety of climate proxy data sets

JD Annan, JC Hargreaves, T Mauritsen and E McClymont

28 April 2023



BlueSkiesResearch.org.uk

Reconstructing the mid-Pliocene Warm Period (3.205 Ma BP)

- Ensemble of GCM simulations (PlioMIP1 and PlioMIP2) (smooth, global coverage, but possibly biased)
- Climate proxy estimates - several different data sets (local, sparse, limited coverage, also possibly biased)
- Combine, using data assimilation, into something better (not perfect!)

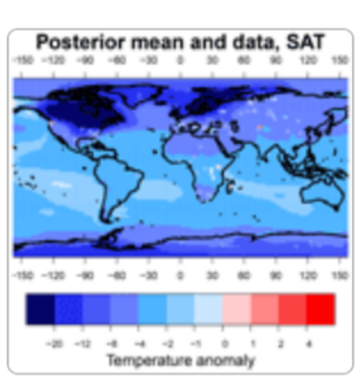
Method

- Method is same as: “A new global surface temperature reconstruction for the Last Glacial Maximum” recently out in Climate of the Past.

Research article

18 Aug 2022

A new global surface temperature reconstruction for the Last Glacial Maximum



James D. Annan[1], Julia C. Hargreaves[1], and Thorsten Mauritsen[2]

[1]Blue Skies Research Ltd, The Old Chapel, Albert Hill, Settle, BD24 9HE, UK

[2]Department of Meteorology, Stockholm University, Stockholm, Sweden

Correspondence: James D. Annan (jdannan@blueskiesresearch.org.uk)

Received: 03 Feb 2022 – Discussion started: 15 Feb 2022 – Revised: 14 Jul 2022 – Accepted: 26 Jul 2022 – Published: 18 Aug 2022

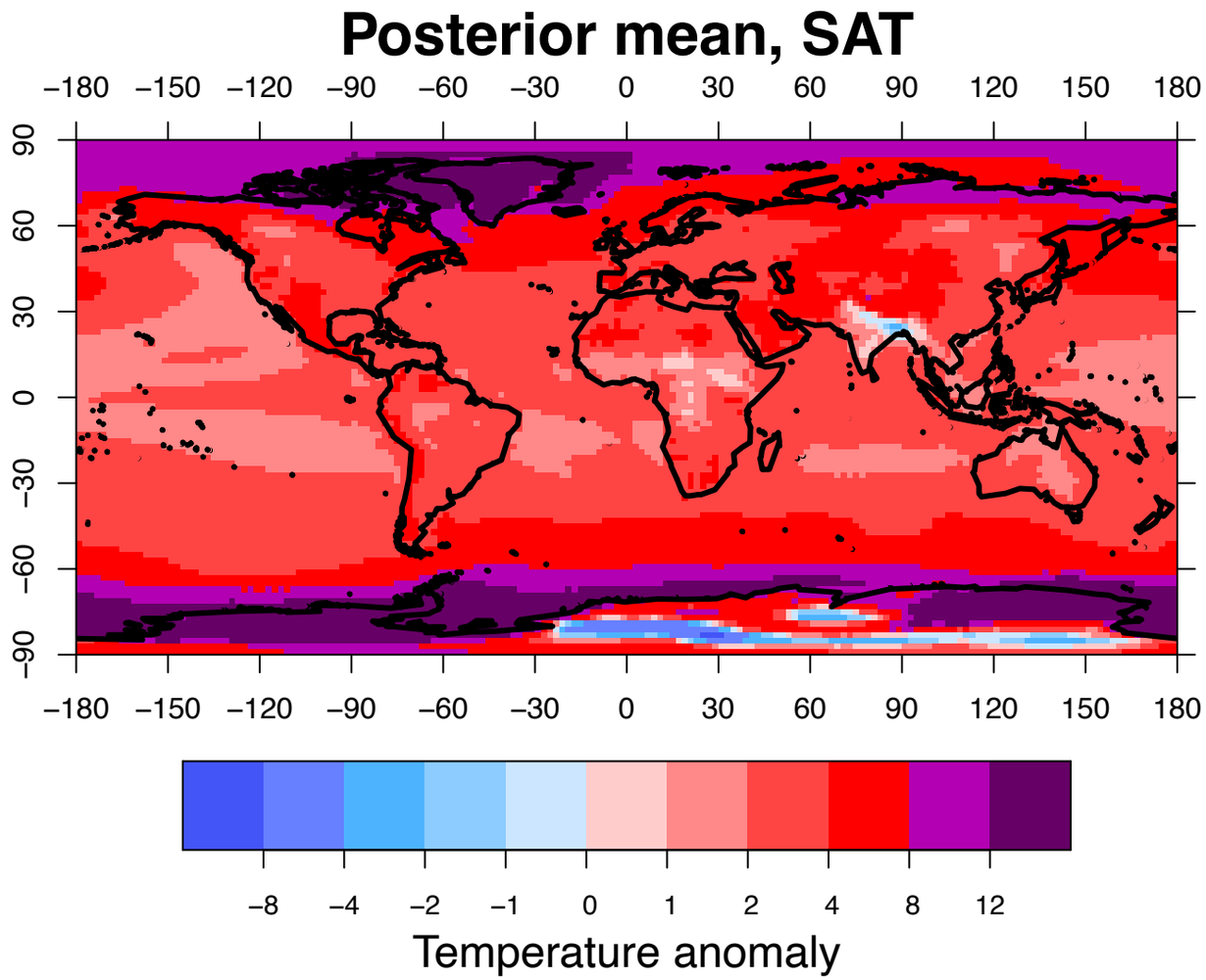
Data Assimilation

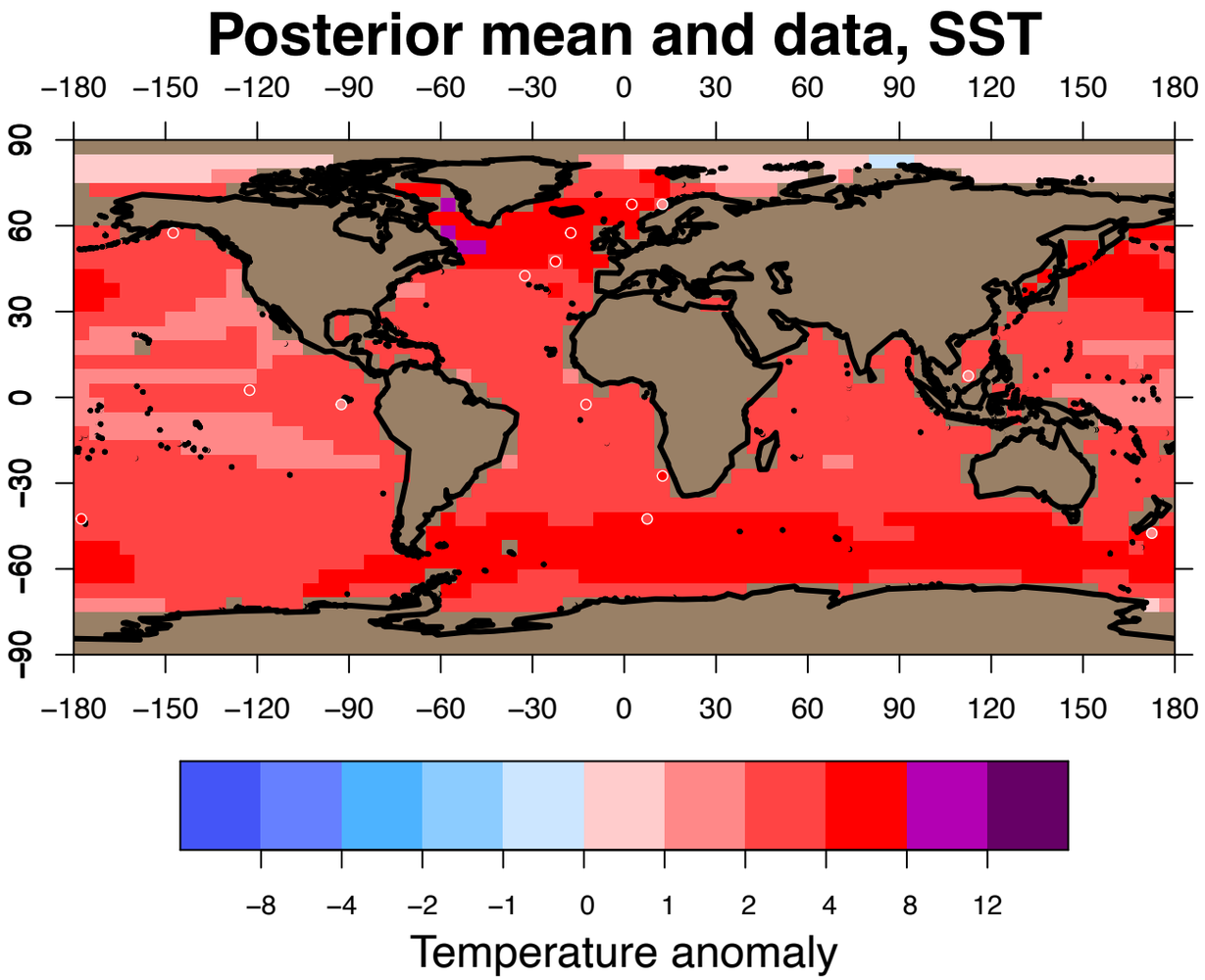
- ...is a field of general techniques used to update a model-based estimate ("Prior") with observational data.
- Bayes' Theorem applied to large data sets with spatial structure (gridded climate)
- Ensemble Kalman Filter is well established and widely used in geoscience (NWP)

Potential Problems

- Model ensemble (prior) may not be really trustworthy
- Data are very sparse, imprecise, also possibly with biases
- So we have to make judgements that have significant influence on results

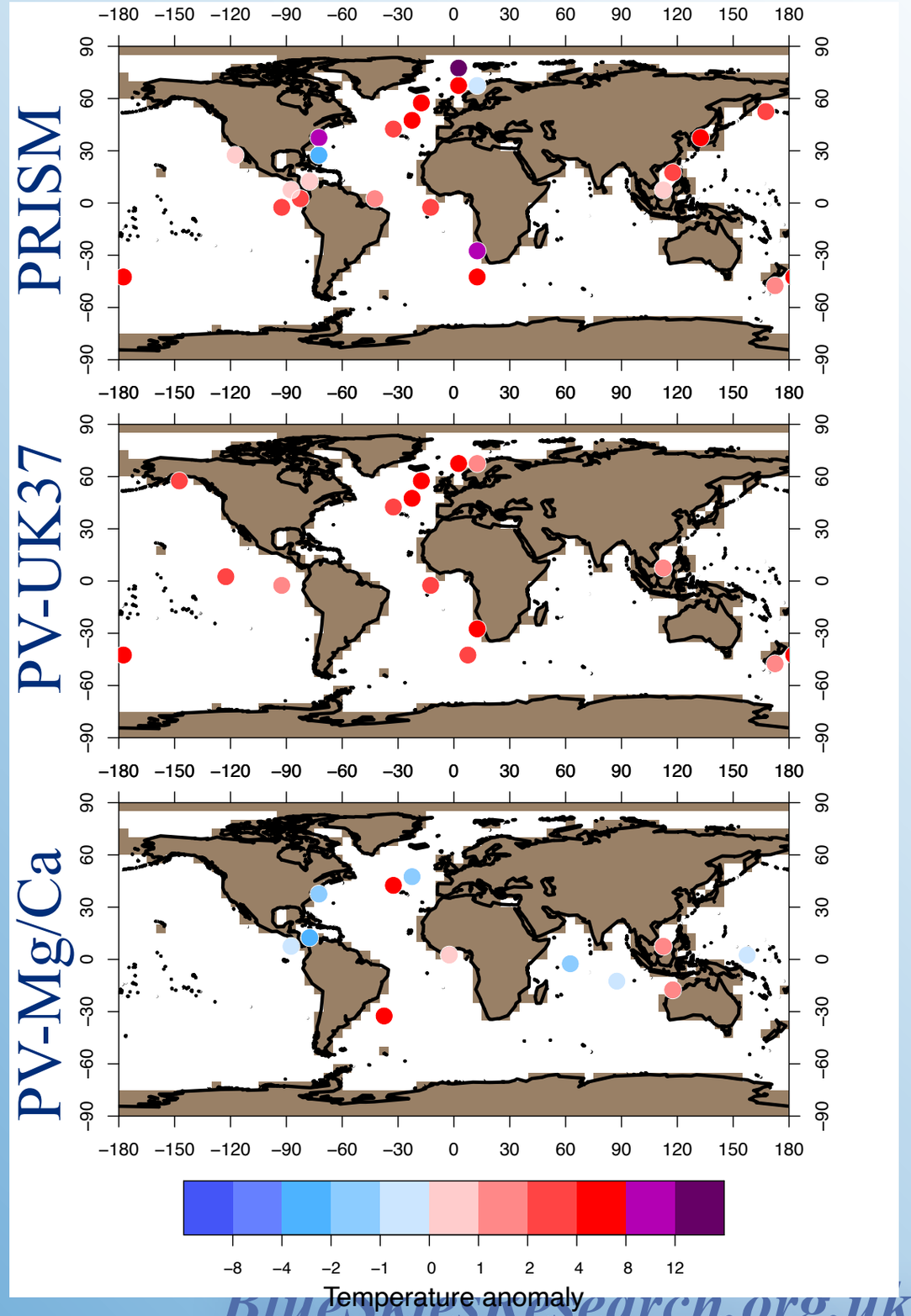
"Best" result using PlioVAR-UK37 data. 3.9 ± 1.0C warmer than Preindustrial





Comparing the different data sets

- All data on 5x5° grid, masked to ocean.
- PRISM
  Foley and Dowsett 2019, Haywood et al 2020
- Some PlioVAR outputs (McClymont et al 2020):
  - PlioVAR-UK37 agrees well with PRISM (17 points)
    cor(PRISM,PV-UK37) = 0.97
    difference = 0.0±0.7C
  - PlioVAR-Mg/Ca disagrees with PRISM (6 points)
    cor(PRISM,PV-Mg/Ca) = 0.1
    difference = 3.3±5.1C (Mg/Ca cooler)
  - Only 2 coincident points between PlioVAR-UK37 and PlioVAR-Mg/Ca, so was hard to compare in McClymont et al 2020.

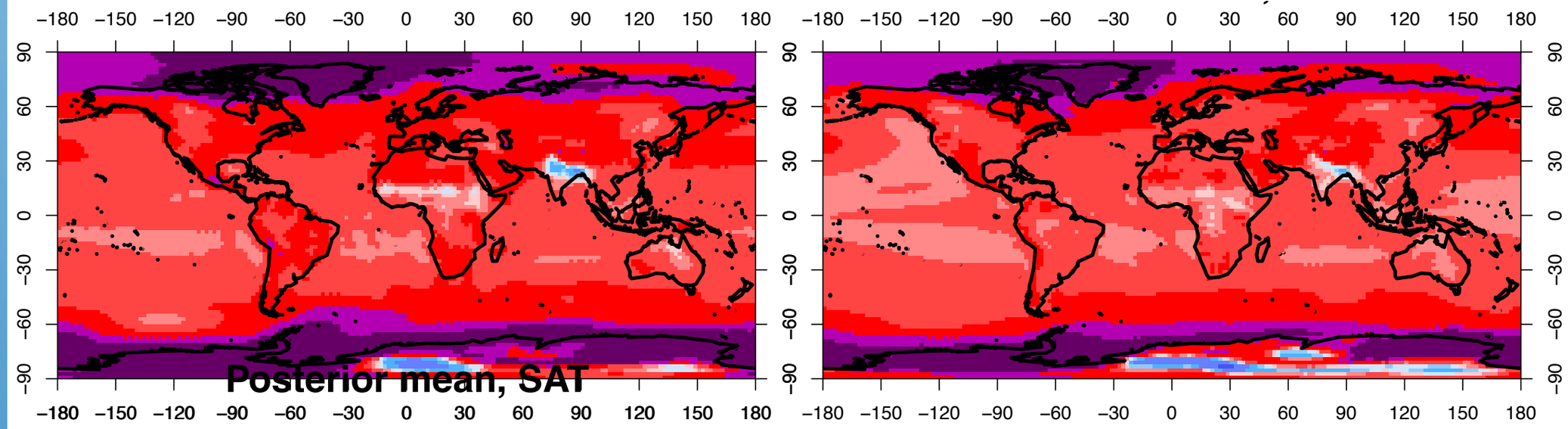


Summary of results using different data sets

Data set	# points	# gridded points	ΔT	usable points	ΔT	GSAT (GSST) K	Polar Amp.
PRISM	37	34	4.0	23	3.7	5.0 ± 1.0 (3.6 ± 0.9)	2.8
PlioVAR-UK37	23	22	4.1	14	3.6	3.9 ± 1.0 (3.0 ± 0.9)	2.6
PlioVAR-Mg/Ca	13	13	0.1	12	0.2	0.7 pm1.0 (0.7 ± 1.0)	3.1

PRISM

PV-UK37



PV-Mg/Ca

rg.uk

Conclusions

- We present a new result based on PlioVAR-UK37 data, with PlioMIP1 and PlioMIP2 models
- Global Mean SAT 3.9 ± 1.0C
- Many uncertainties - different data sets produce large differences
- It's the best we can do at present
- Reliable quantitative land data would be particularly helpful
- Reconciling Mg/Ca vs UK37 is important