Role of solar forcing in hemispheric and European temperatures of the past millennium

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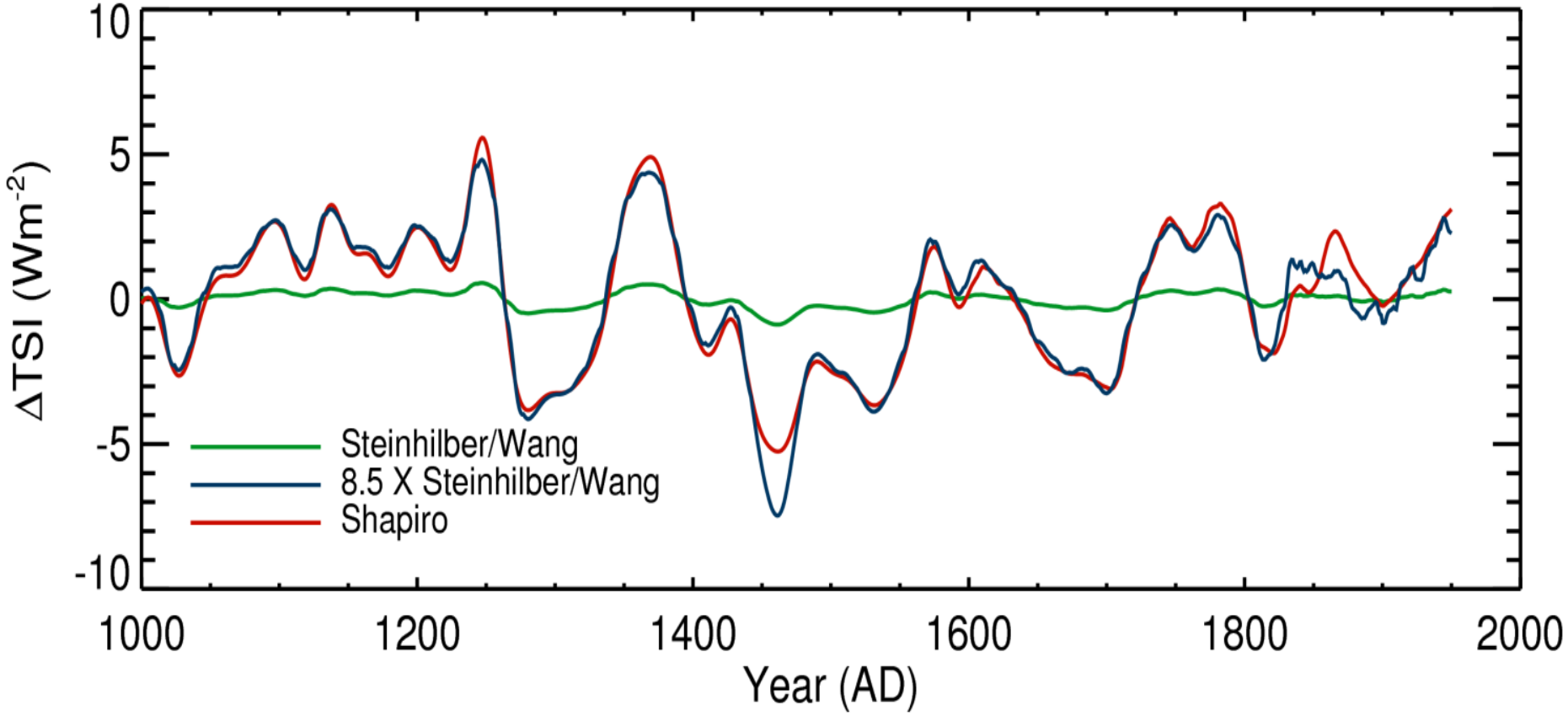
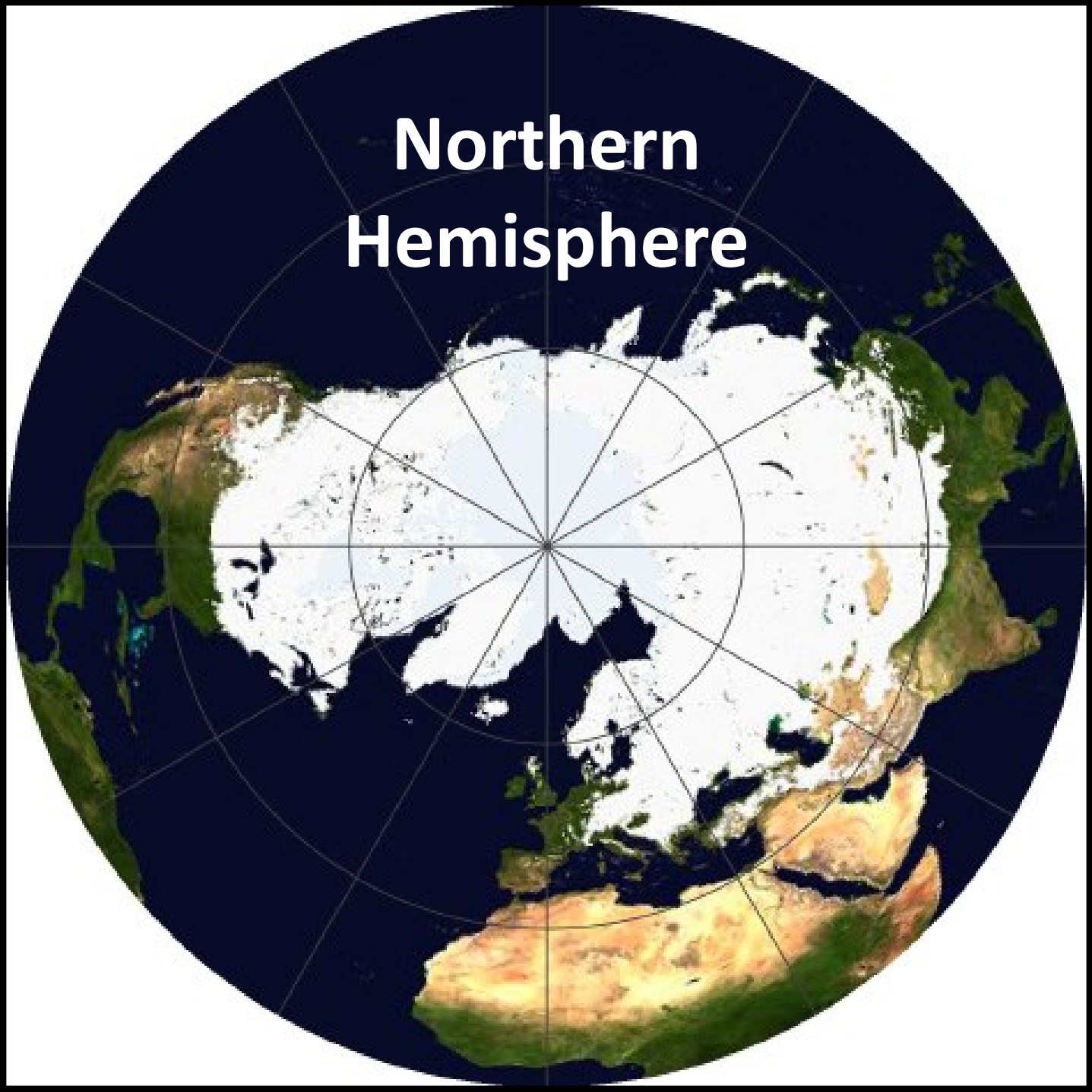
Transition Into The Anthropocene

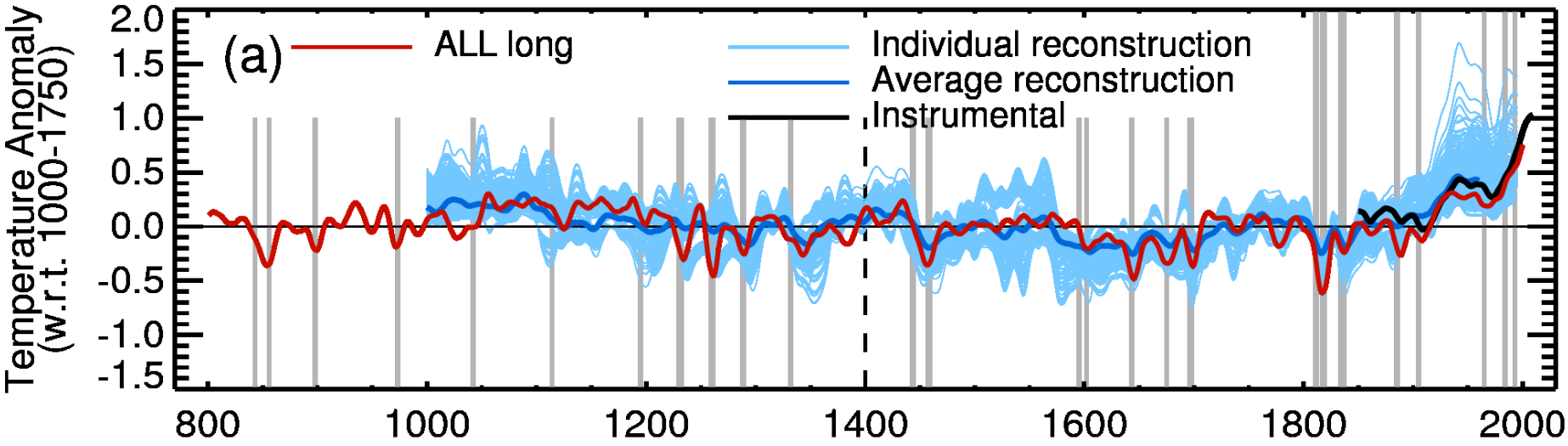
Motivation - How large is the Solar Forcing?

- Does solar forcing have a big or small role over the last millennium?
- Reconstructions of solar forcing differ by up to an order of magnitude..




Northern
Hemisphere

HadCM3 simulation results



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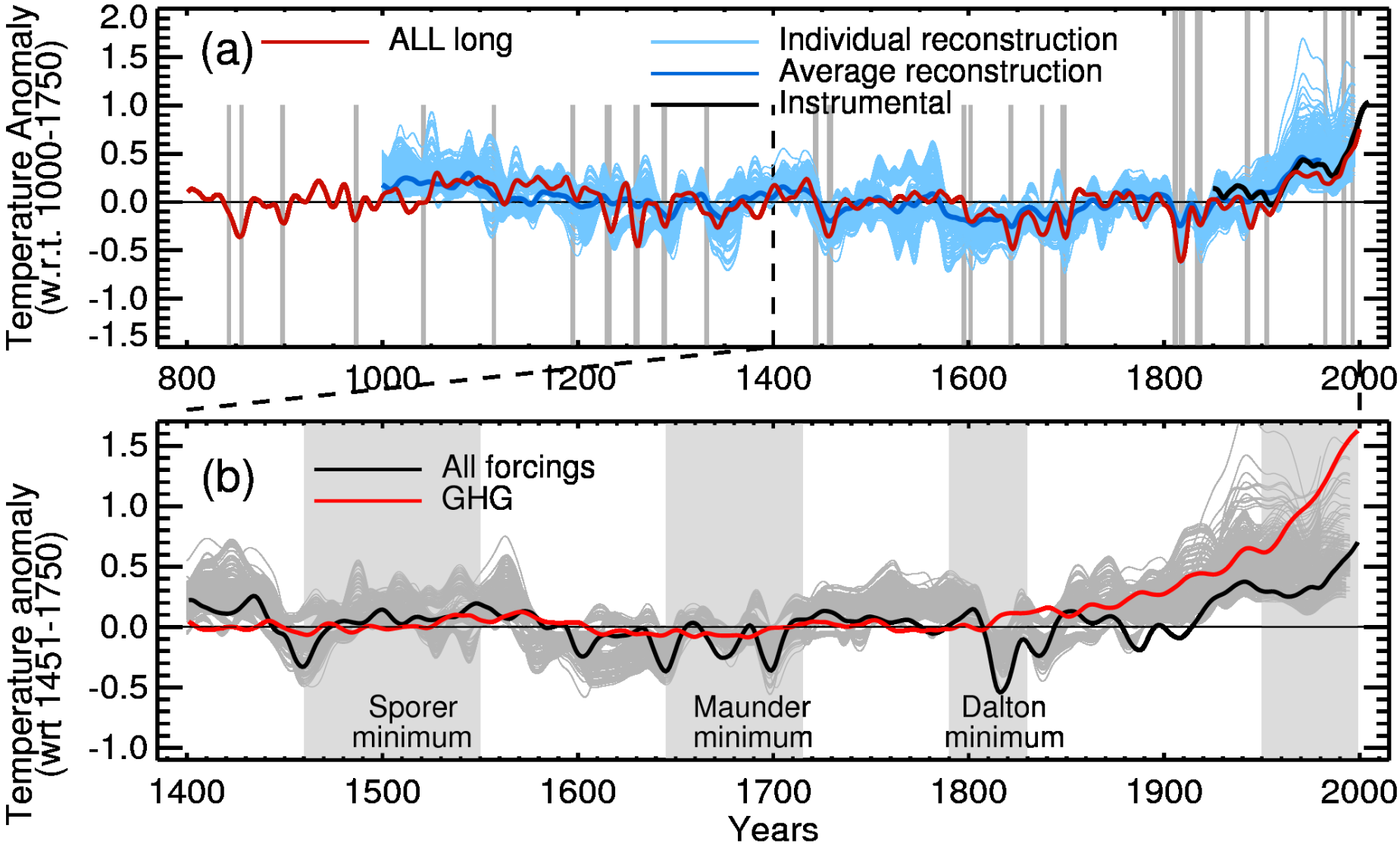

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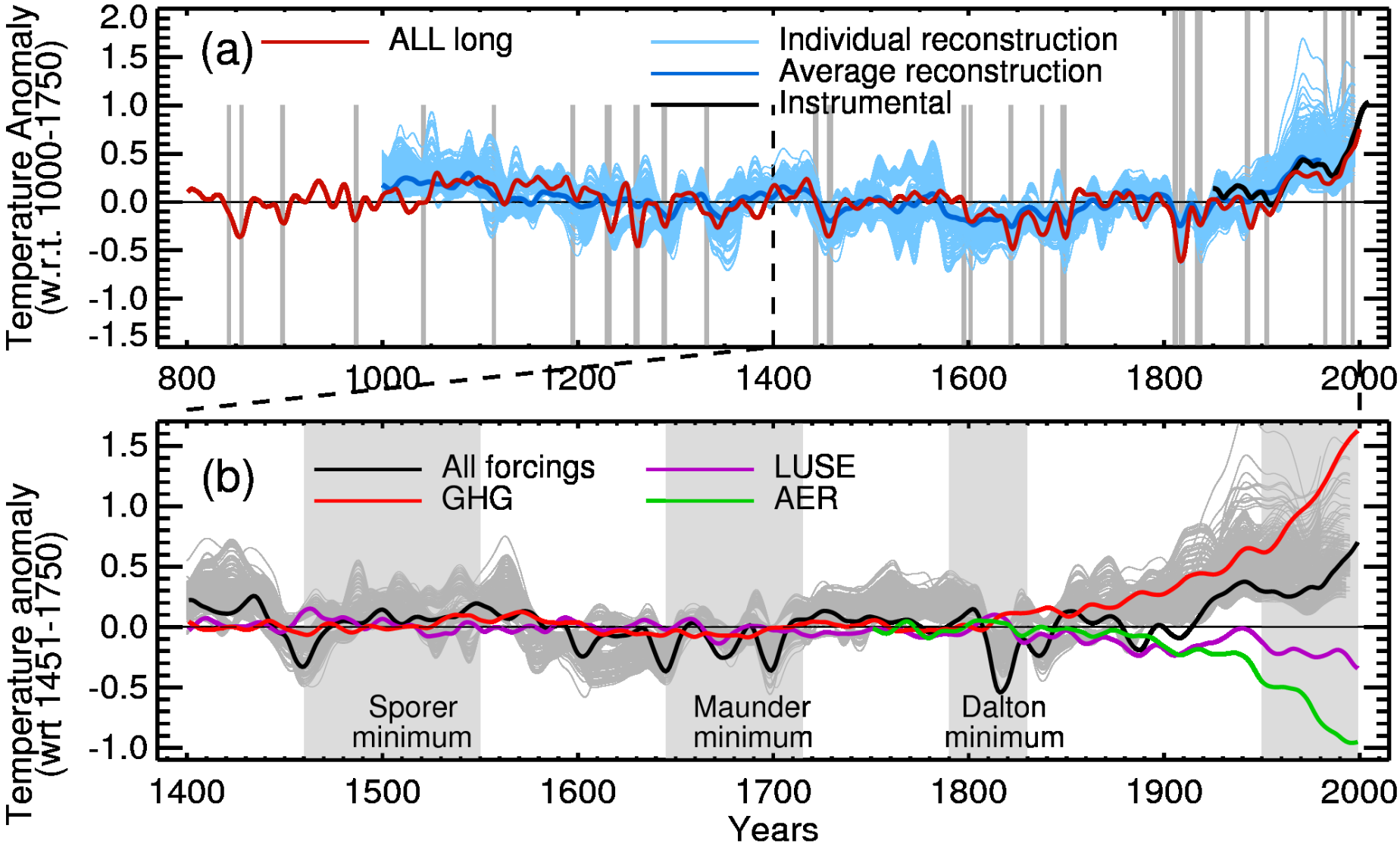

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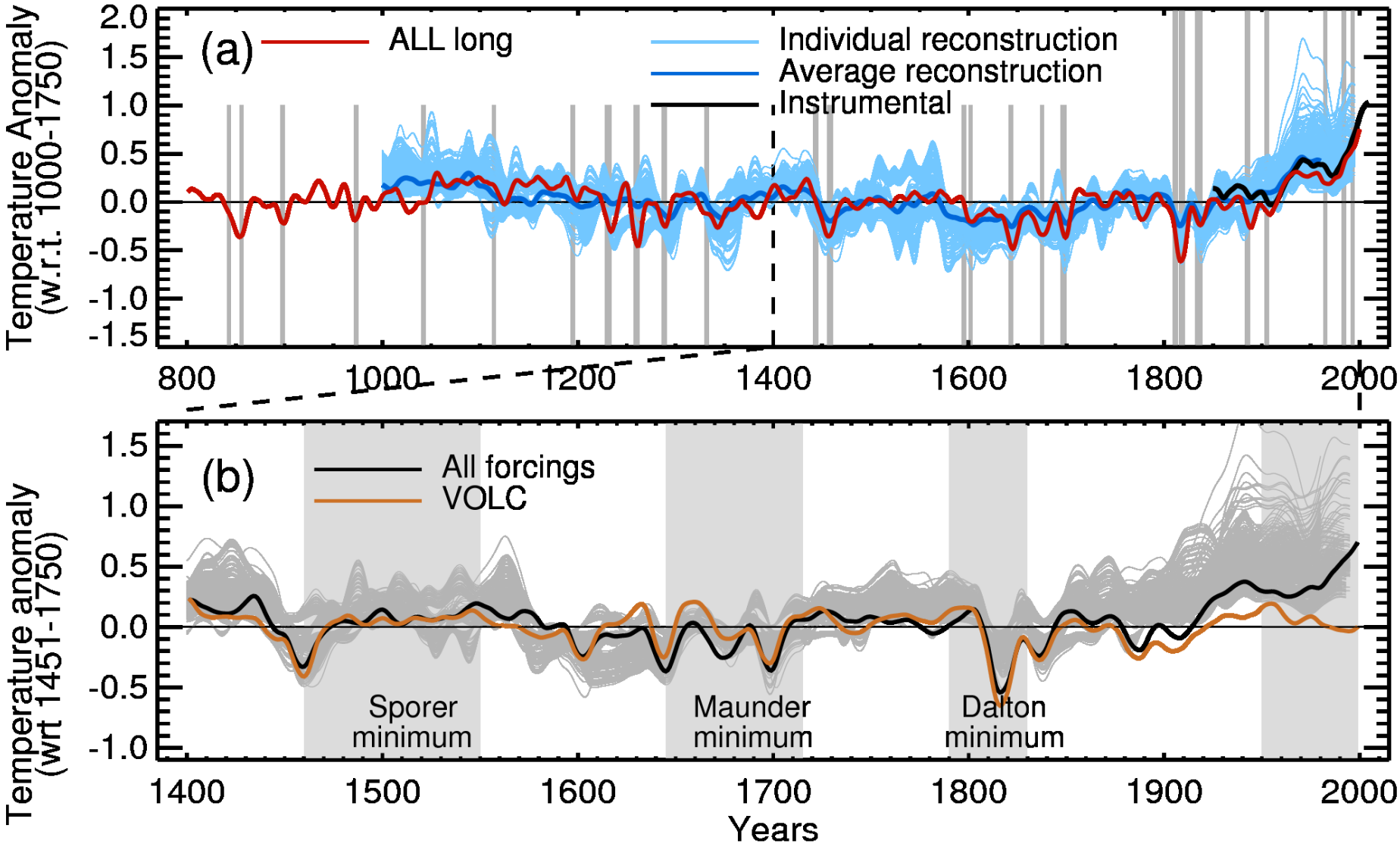

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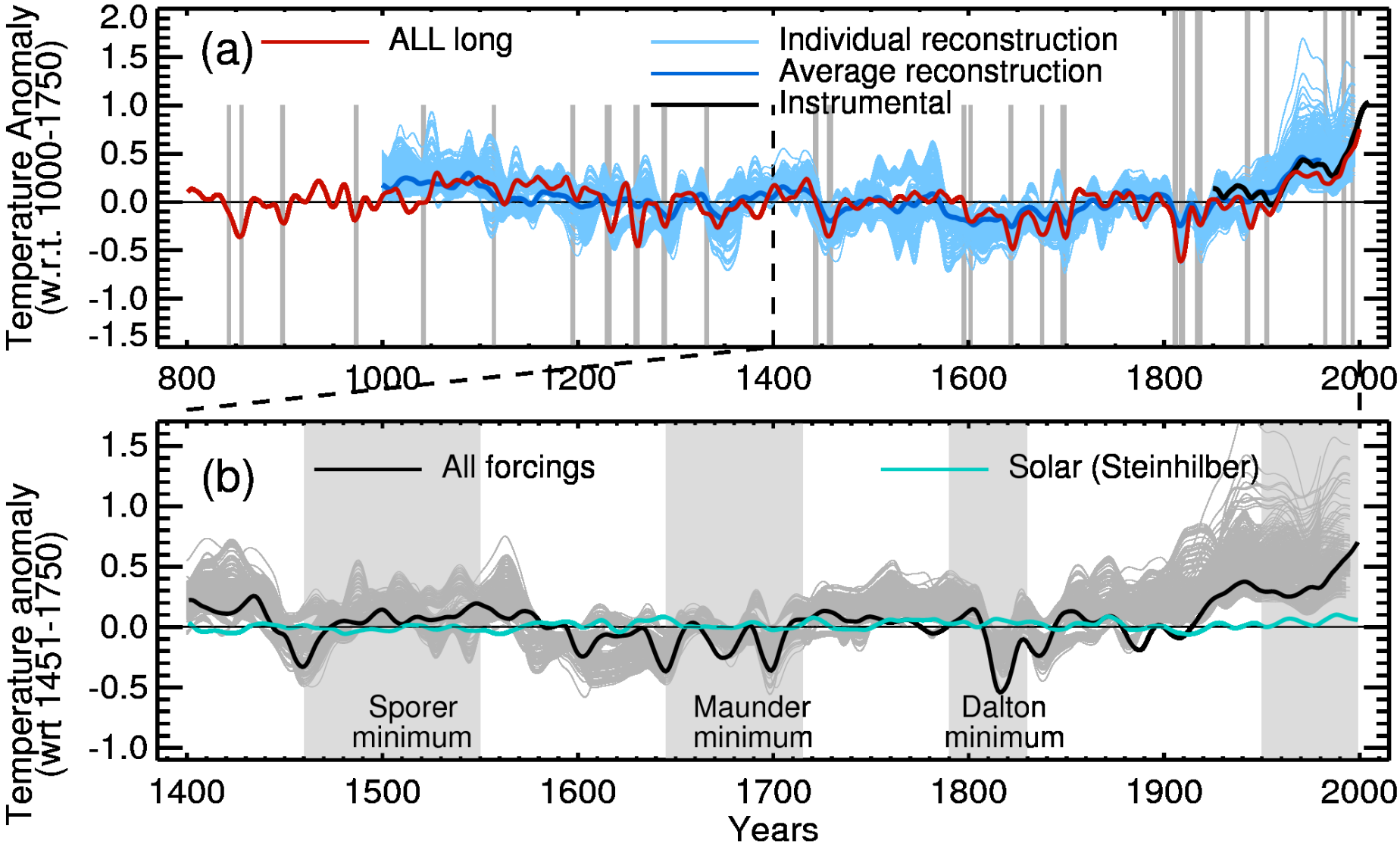

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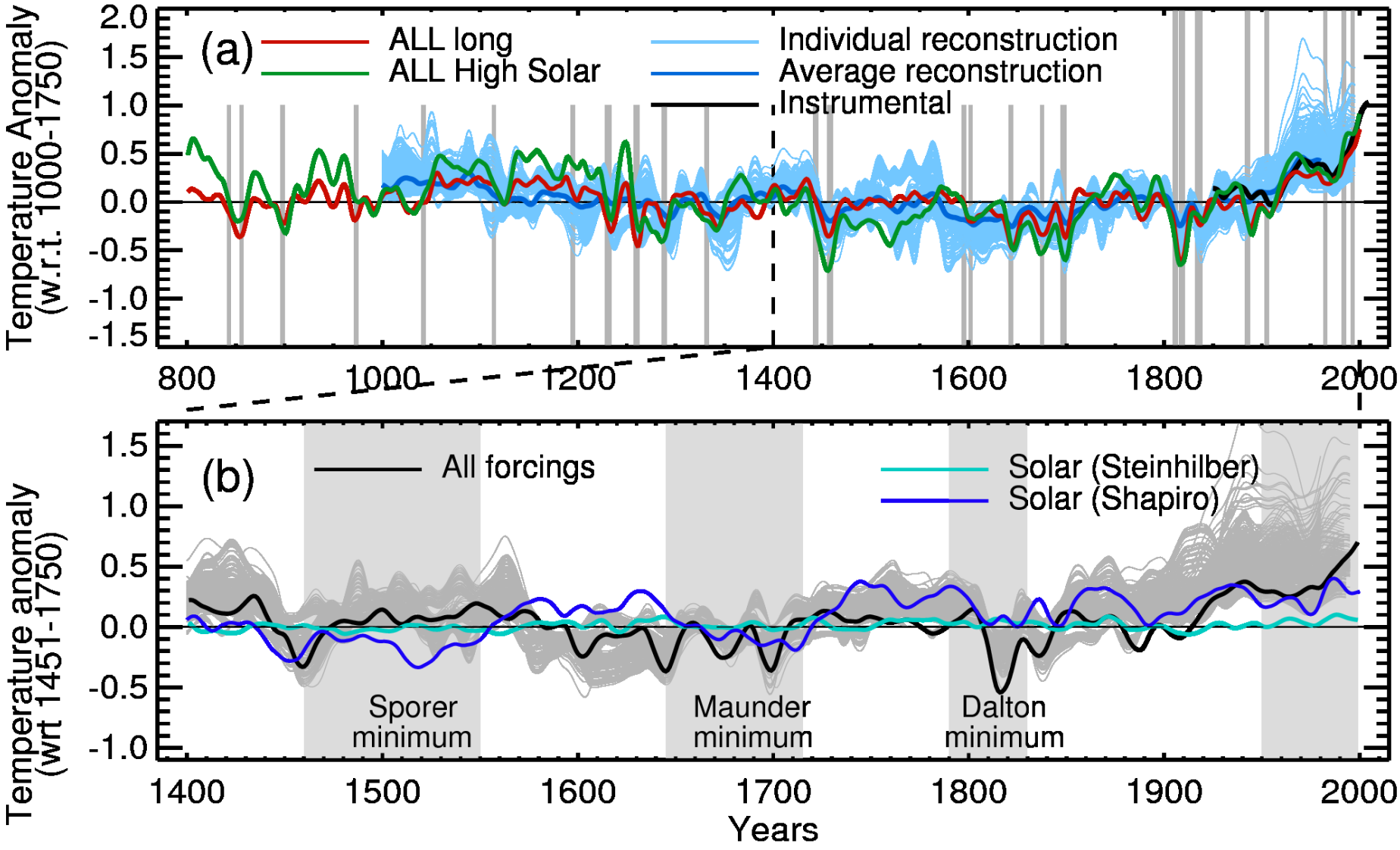

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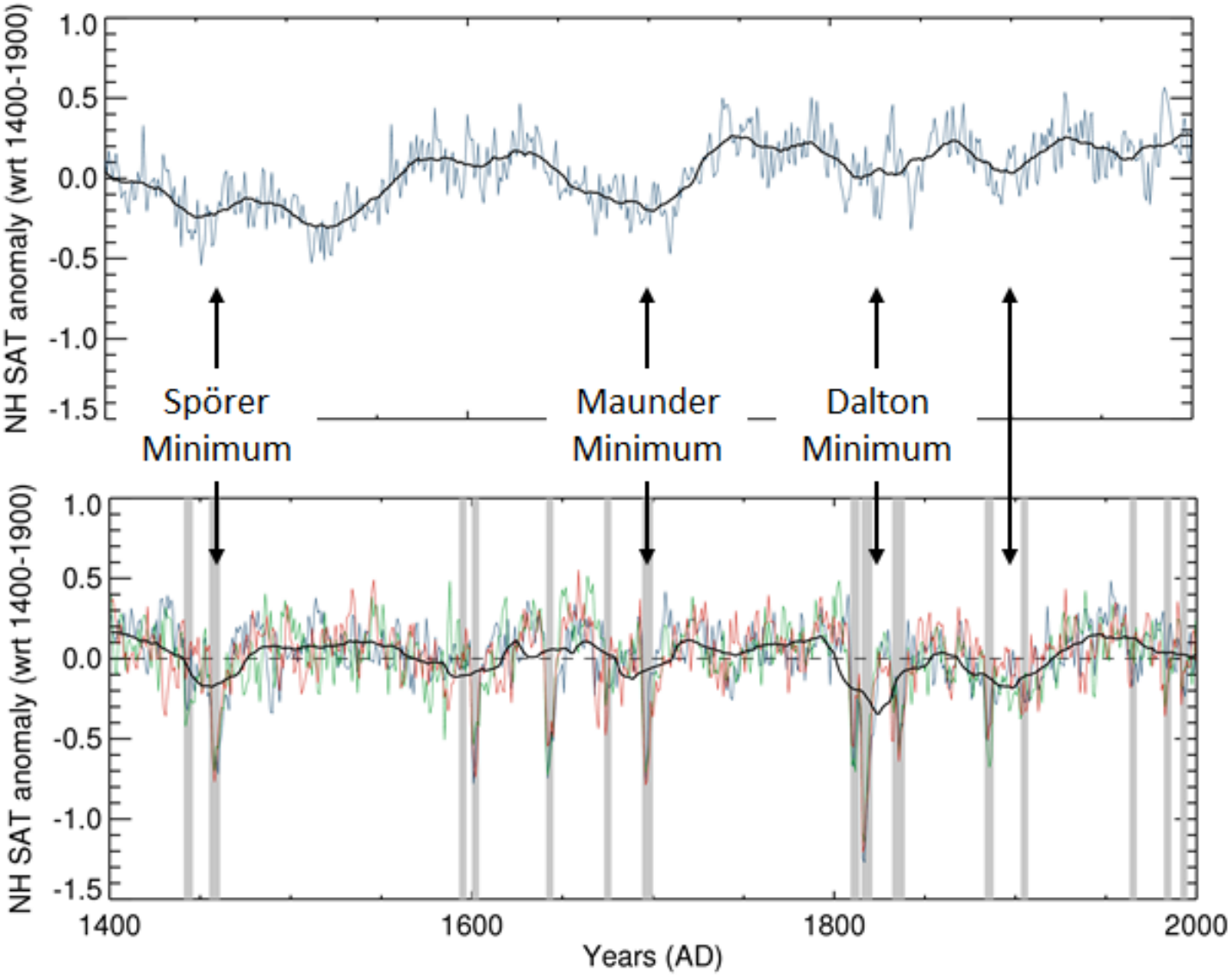


Strong SOLAR Simulation

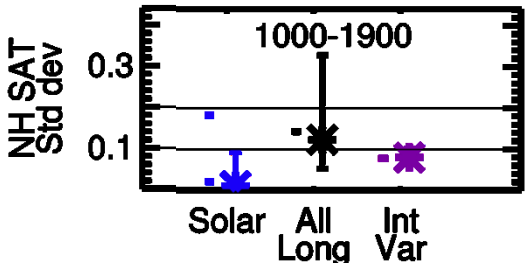
Volcanic Simulations
3 ensembles
red, green, blue

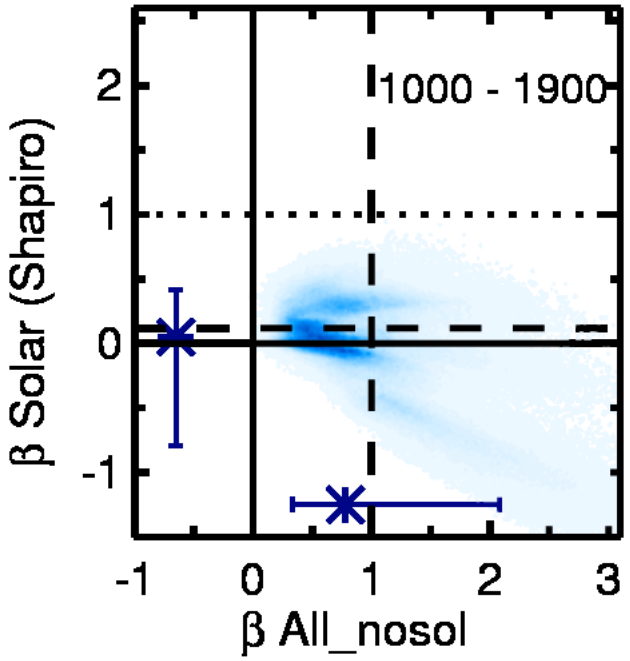
Use reconstructions to constrain role of forcings.

ANALYSIS 1 *(1000 – 1900)*

$$\text{Recon.} = \beta_1(\text{ALL long} + \textit{model noise}) + \beta_2(\text{Solar Shapiro} + \textit{model nose}) + \text{noise}$$

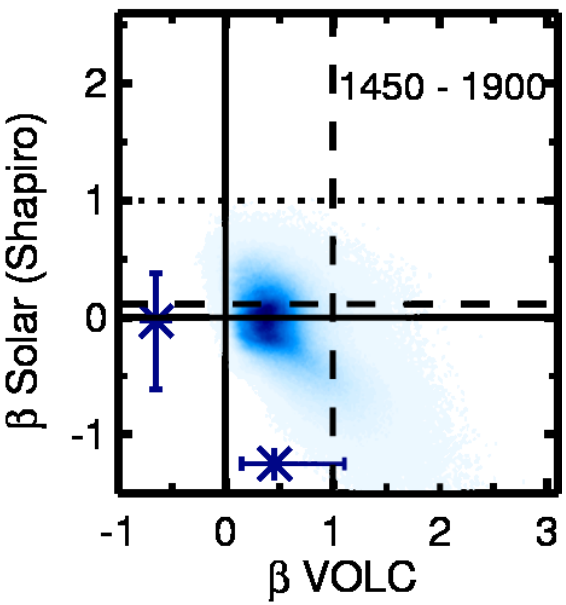
- For each of the 521 reconstruction **(*Frank et al 2010)*** use linear regression(***Total Least Squares***) to calculate scaling values, β.
- Superimpose samples of internal variability from control simulations to calculate a range of β values for each reconstruction.
- Combine all beta values into one distribution
- Blue "cloud" represents distribution of scaling valu
- Scale raw model fingerprints by βs to calculate importance of each forcing

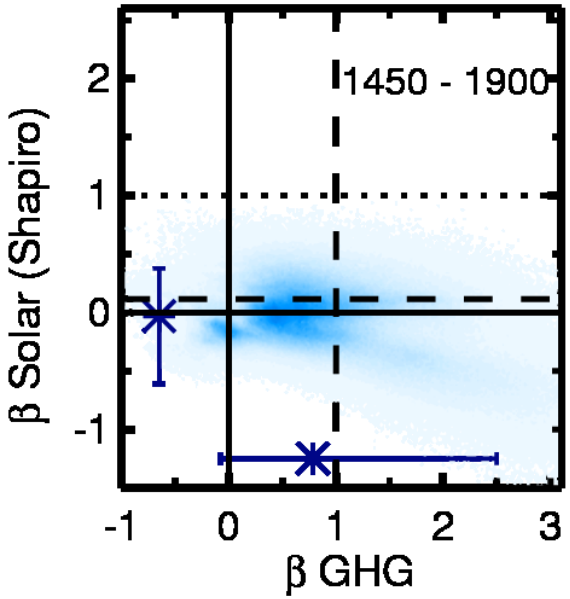


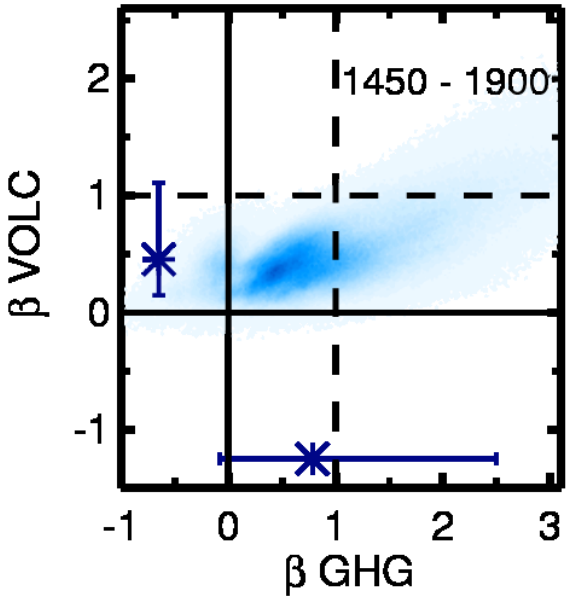


ANALYSIS 2 *(1450-1900)*

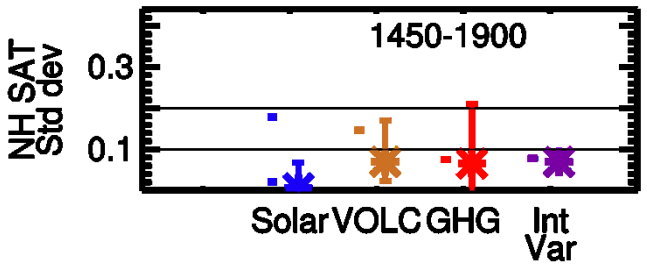
$$\text{Recons} = \beta_1(\text{VOLC} + \nu_1) + \beta_2(\text{GHG} + \nu_2) + \beta_3(\text{Solar Shapiro} + \nu_3)$$







- Scale raw model fingerprints by βs to calculate importance of forcing

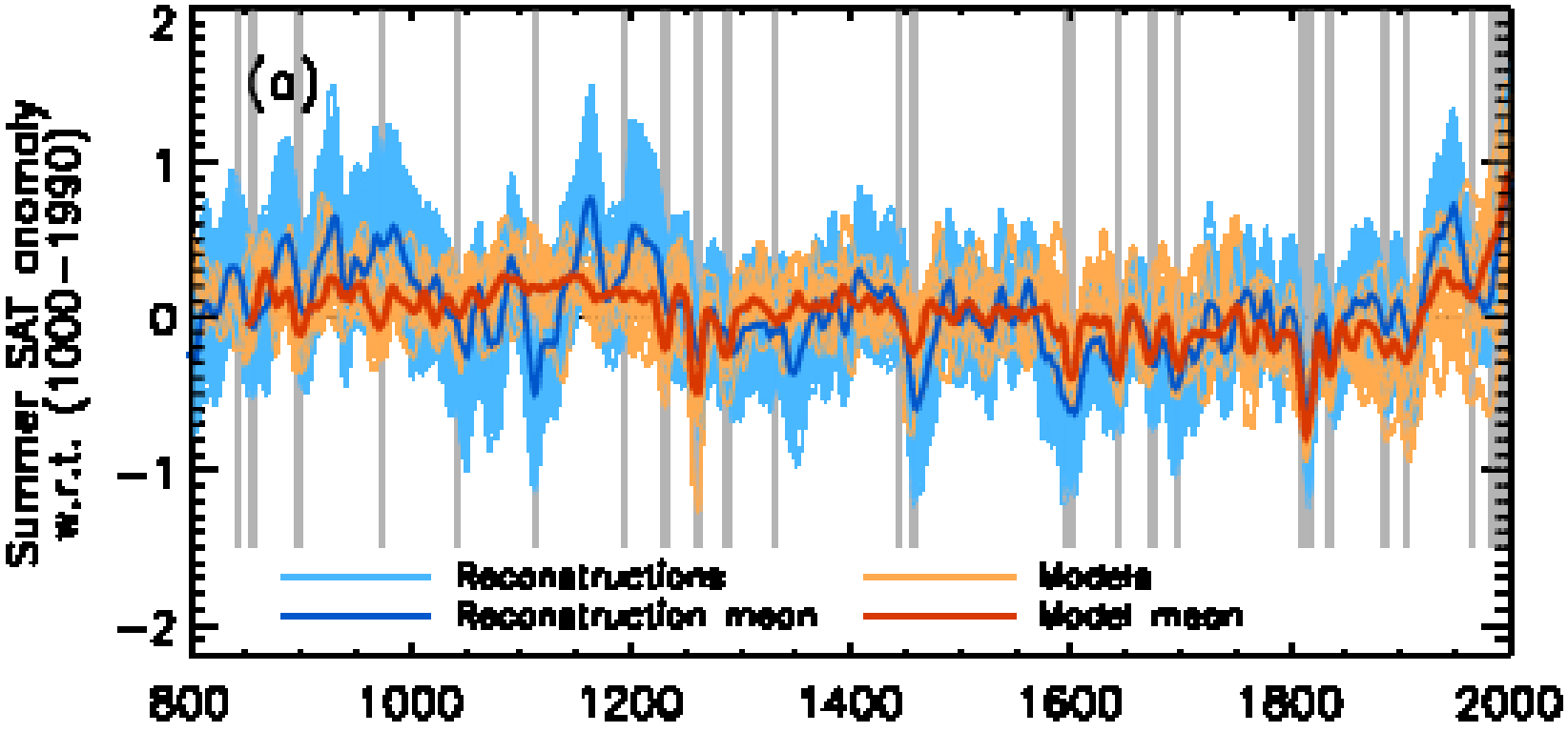



EUROPE

European summer temperatures

Compare:

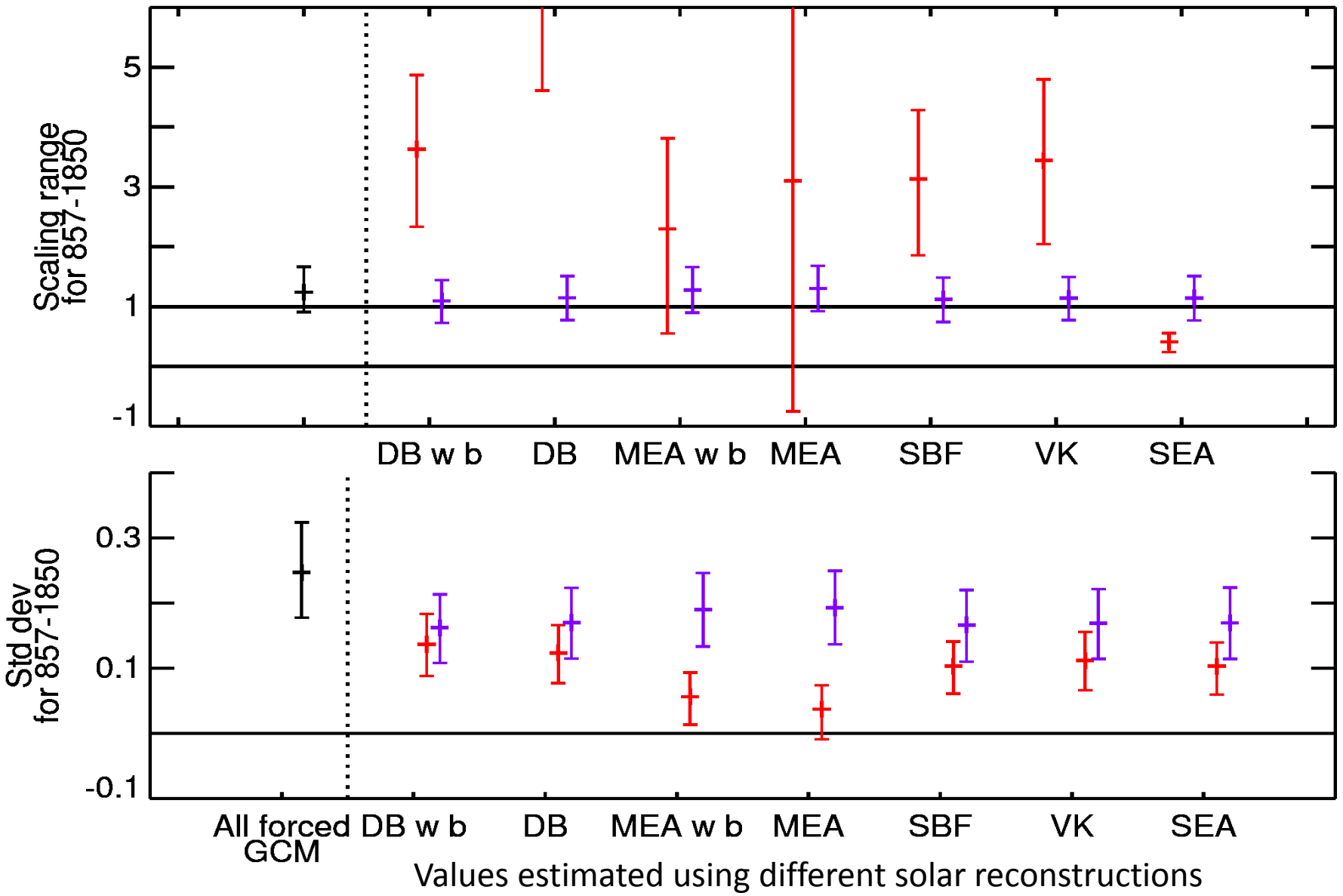
- Multi-model ensemble – predominately CMIP5/PMIP3
- New Bayesian hierarchical ensemble reconstructions – Luterbacher et al (in prep)



- **External forcing in European mean summer temperatures clearly detectable**
- Detectable small additional solar component present in the reconstructions that is not in the weak solar forced models.

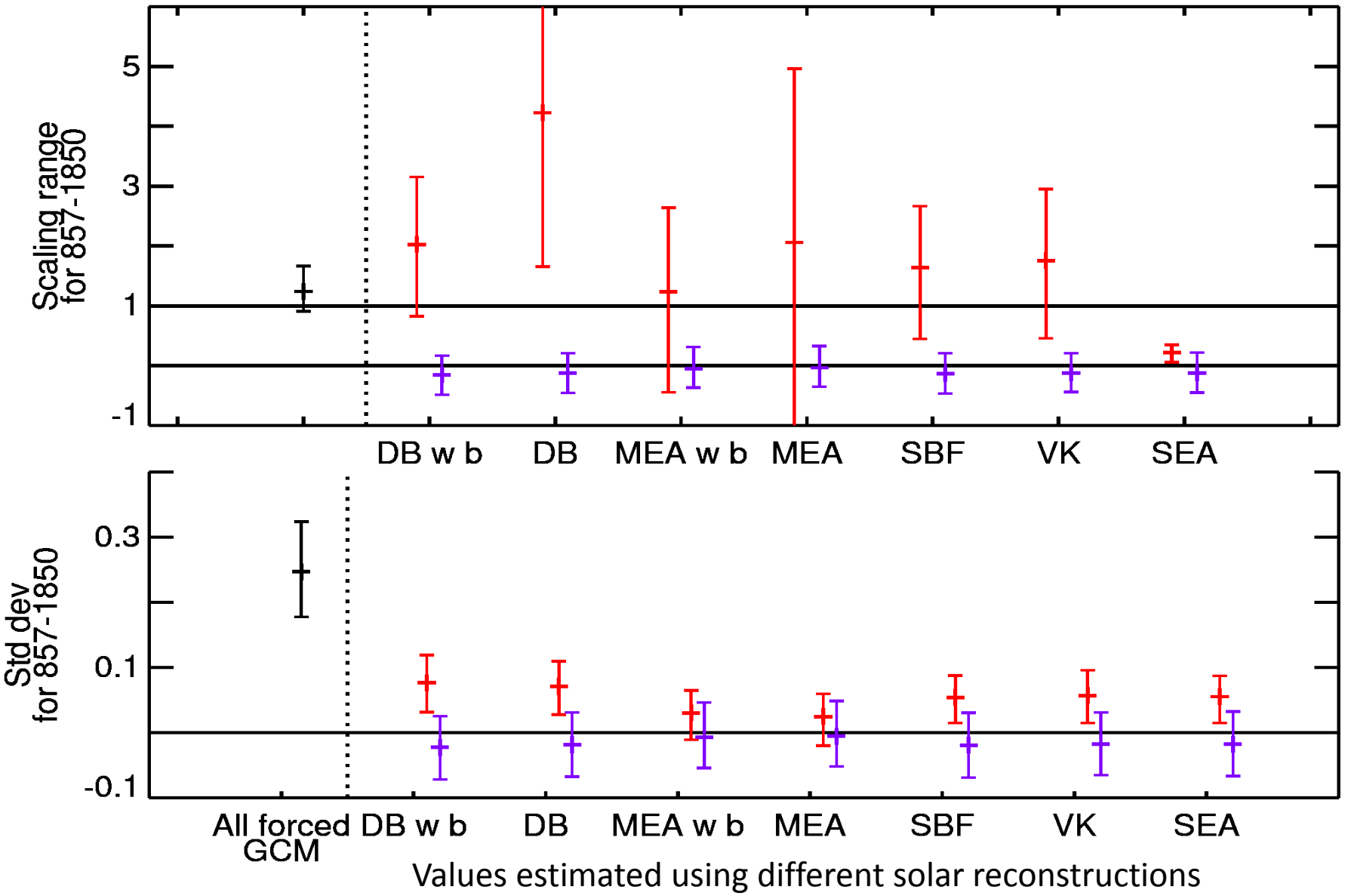
Detecting individual forcings in the European **reconstructions** – using **EBMS**

Solar forcing in red , Volcanic forcing in purple

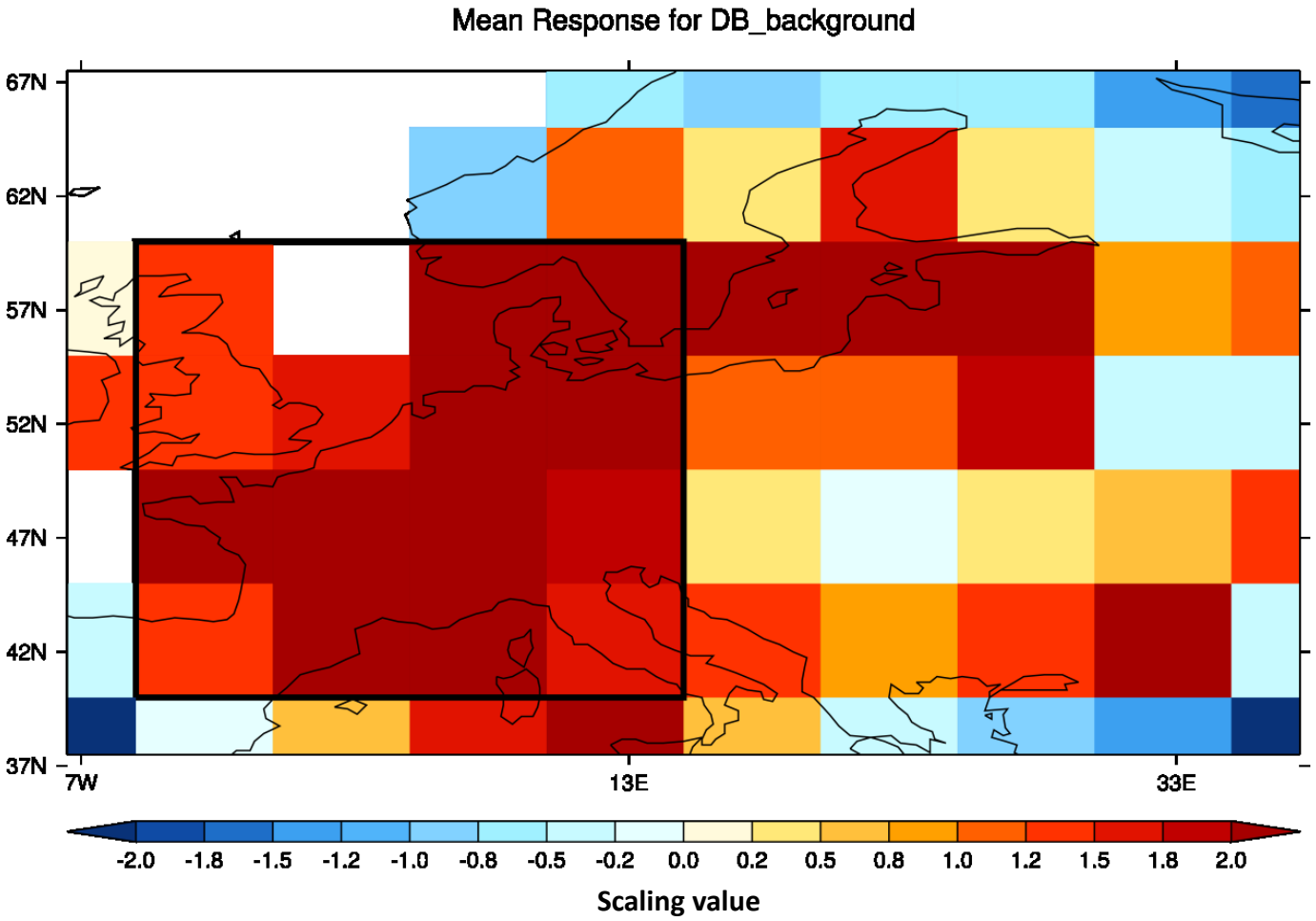


Detecting individual forcings in the **residuals** from the fit to the GCM simulations (using EBMs)

Solar forcing in red , Volcanic forcing in purple



Investigating whether there is any spatial pattern in the residual of the fit



Conclusions

Northern Hemisphere:

- Explosive volcanism the main driver of pre-industrial climate change,
- Additional detectable contribution from GHGs.
- No evidence for a strong solar effect,
    - especially not one as large as in Shapiro et al 2012

Europe

- External forcing in European mean summer temperatures clearly detectable
- Detectable small *additional* solar component
- Strongest signal in central Europe.
- But this result is not robust to different European reconstructions.