Millennial Temperature Reconstruction Evaluation and Intercomparison (MITRIE)

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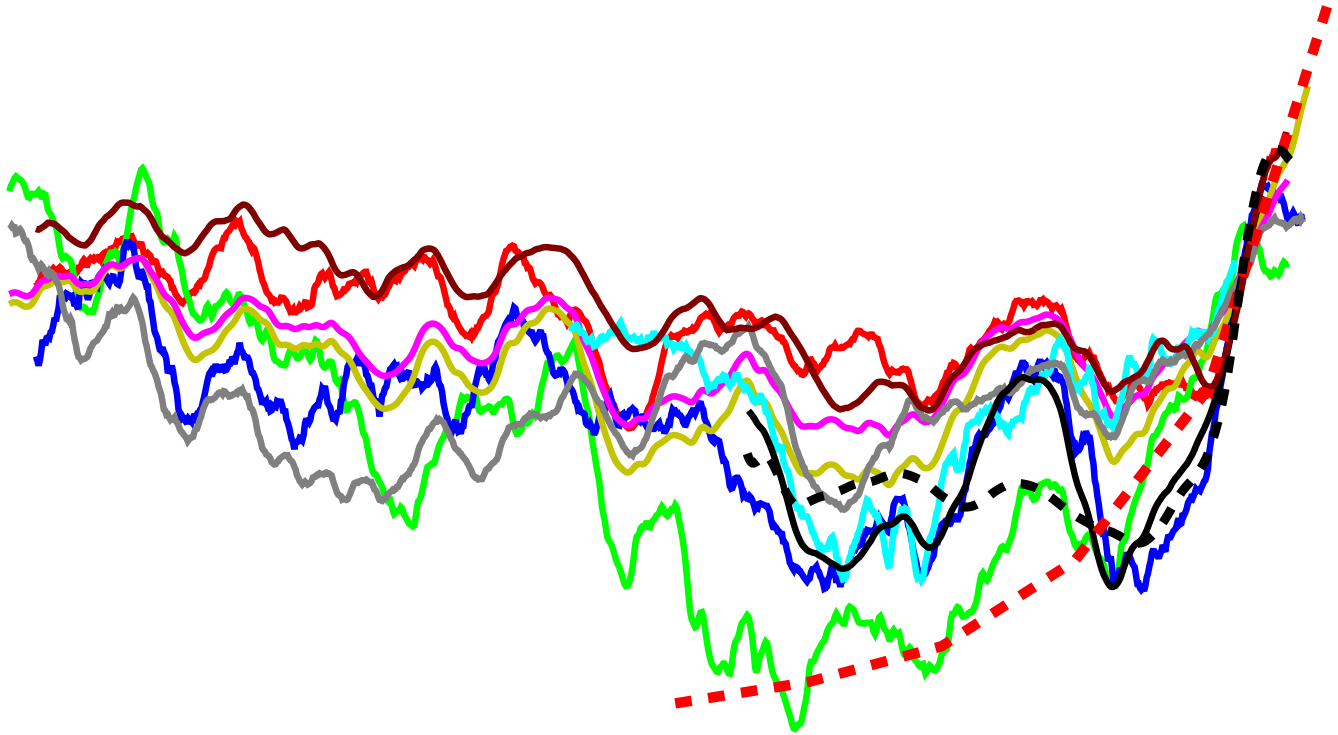


NERC Centres for Atmospheric Science

CCLRC

Millennial Temperature Reconstruction Intercomparison and Evaluation

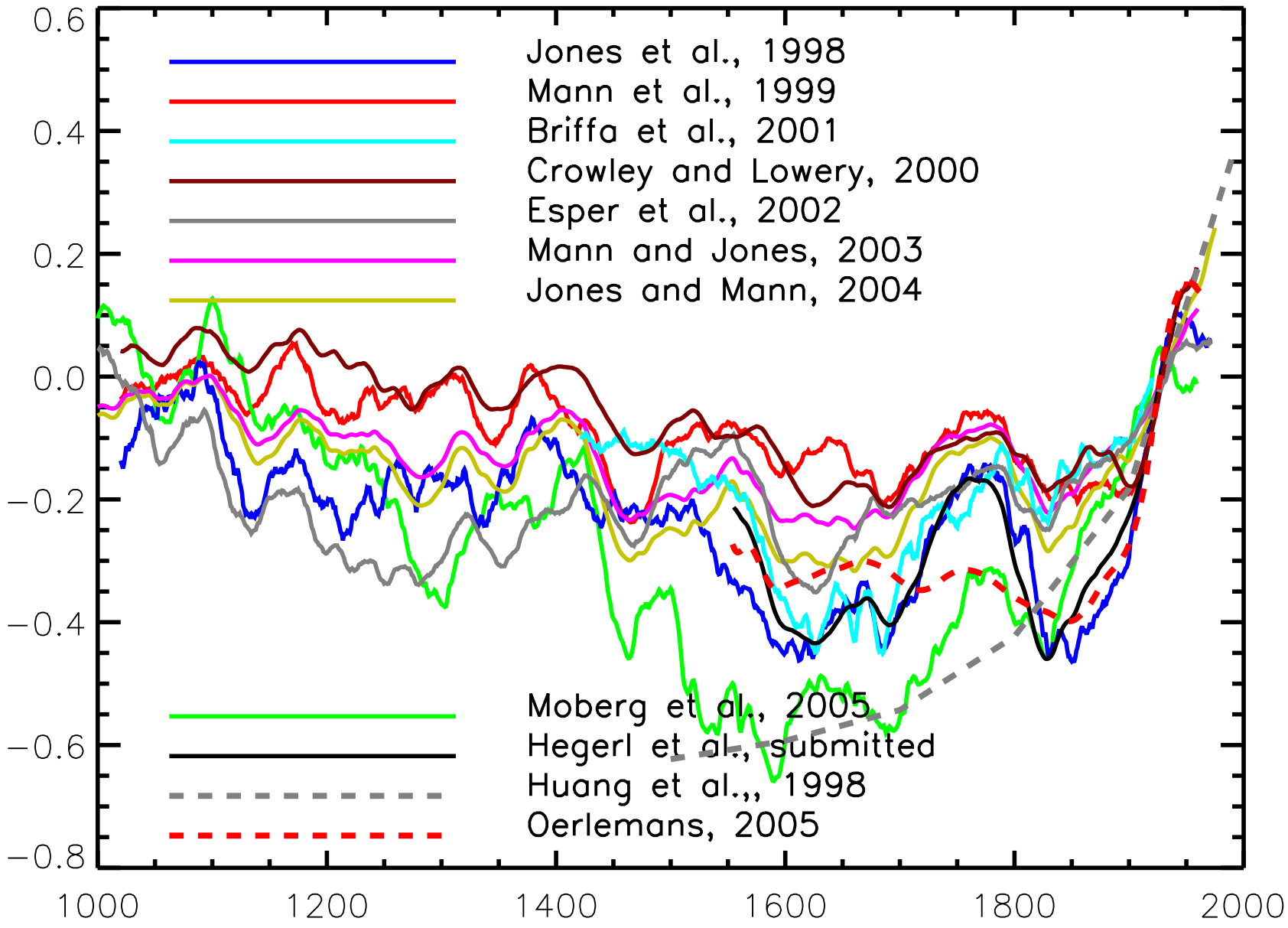
The project is funded by the Netherlands *Scientific Assessment and Policy Analysis* Programme.

It aims to summarise the state of knowledge of temperature reconstructions for the last thousand years, and their relevance to predictions of future climate change.

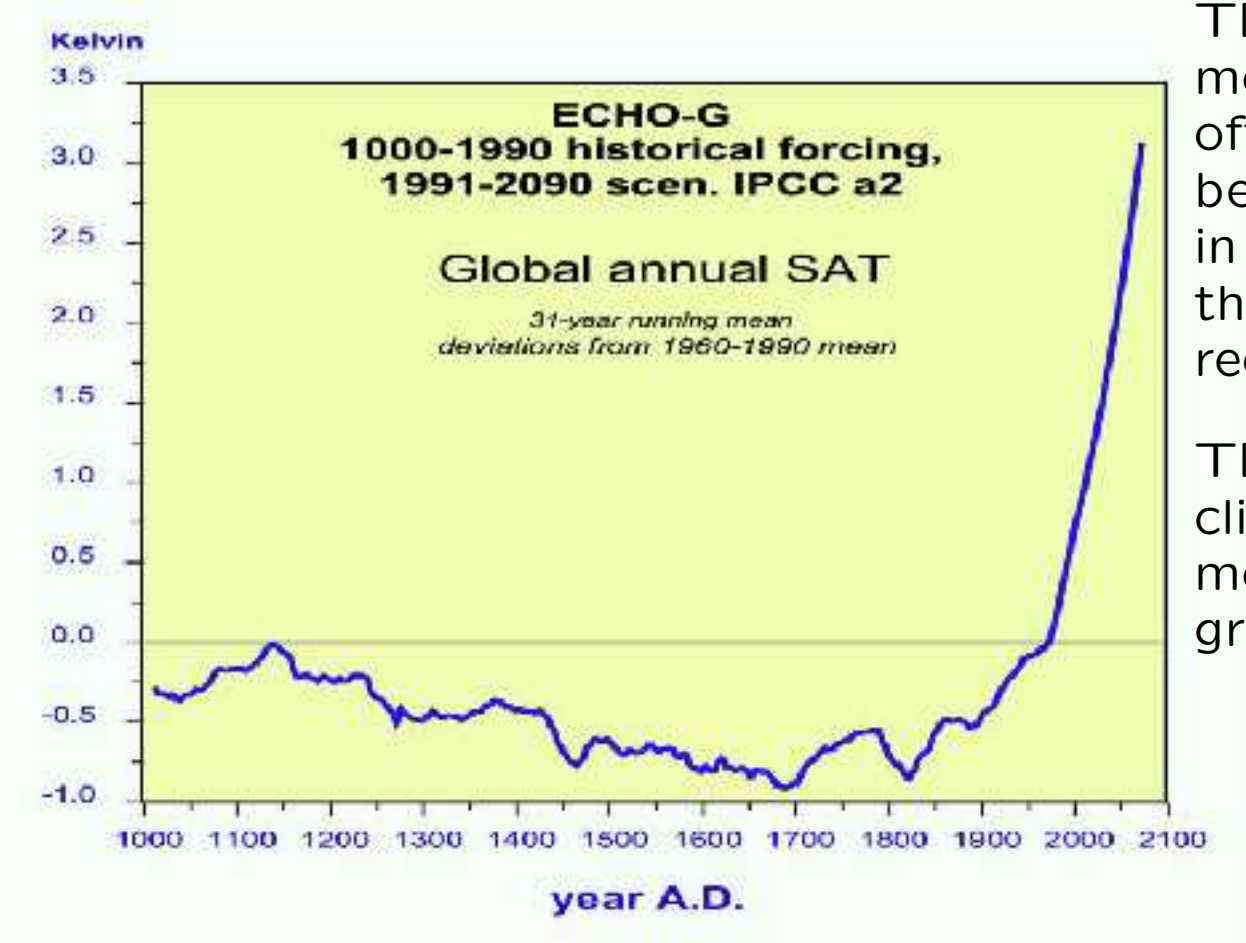
Public discussion is heavily influenced by papers by McIntyre and McKittrick, and Soon and Baliunas, which have little credibility in the scientific literature.

There are also many areas of ongoing scientific uncertainty.

Reconstructions, relative to 1900-1960 mean, 20 year mean.



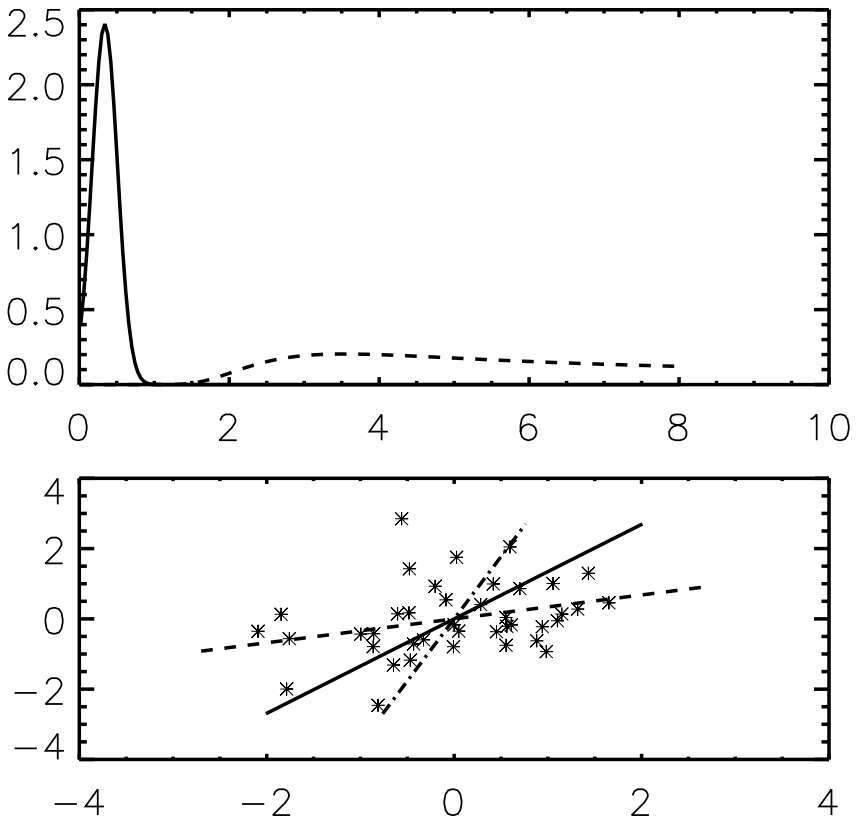
What the climate models say.



The results of the ECHO-G model (von Storch et al.) are often cited by climate sceptics because it shows more variability in the global mean temperature than the Mann et al. reconstruction.

This is because it has greater climate sensitivity than other models, and hence predicts greater warming in the future.

Various forms of regression



In the lower graph 3 lines are fitted to the data:
regressing y on x (dashed)
x on y (dot-dash)
Total Least Squares (solid)

All lines are fully consistent with the data. To determine which is right we need to have additional information.

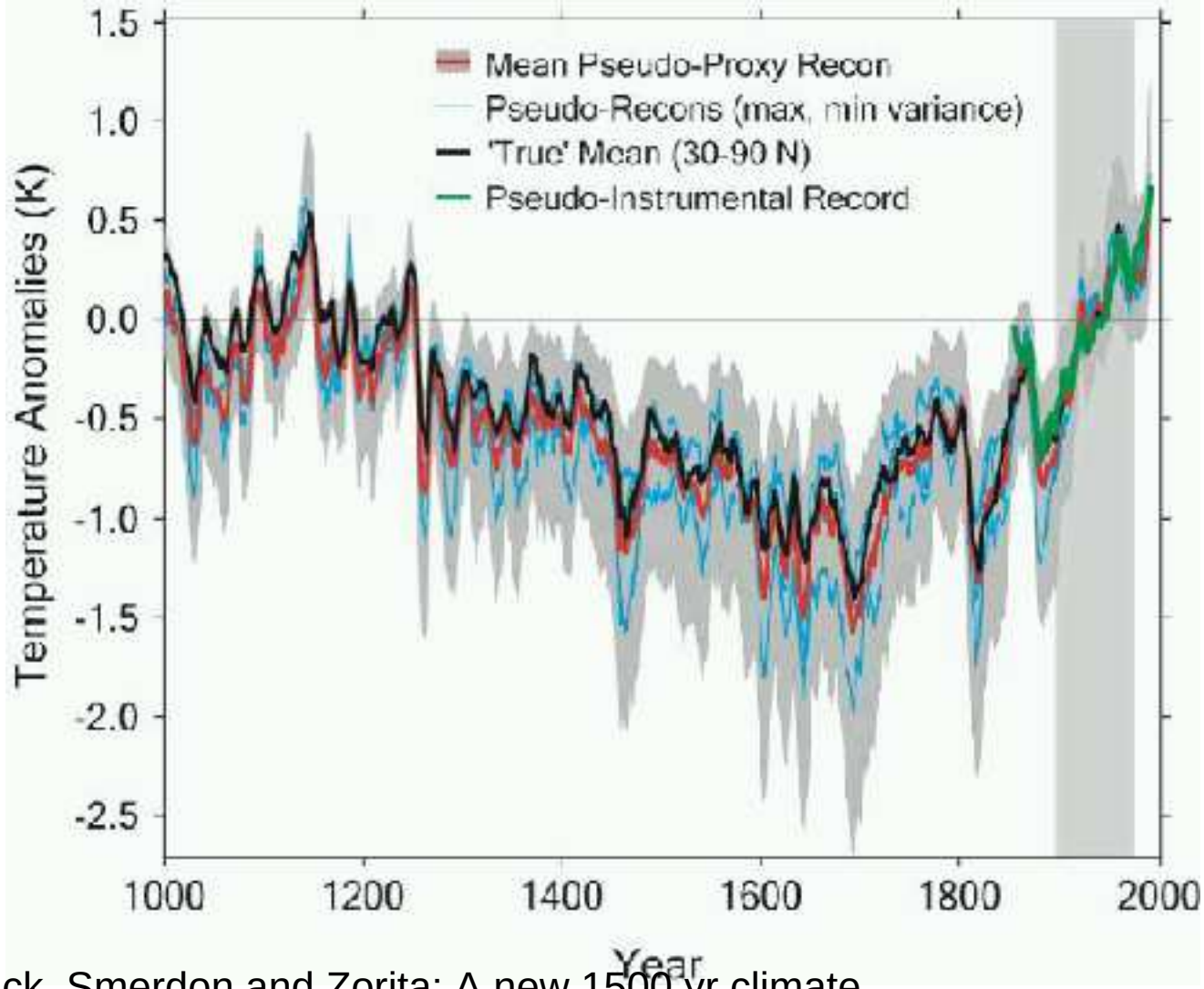
The upper graph shows Bayesian likelihood distribution functions for two of the models. The difference bewteen the two models is greater than the uncertainty estimated by either of them.

Testing with proxies from a climate simulation.

Assumptions:

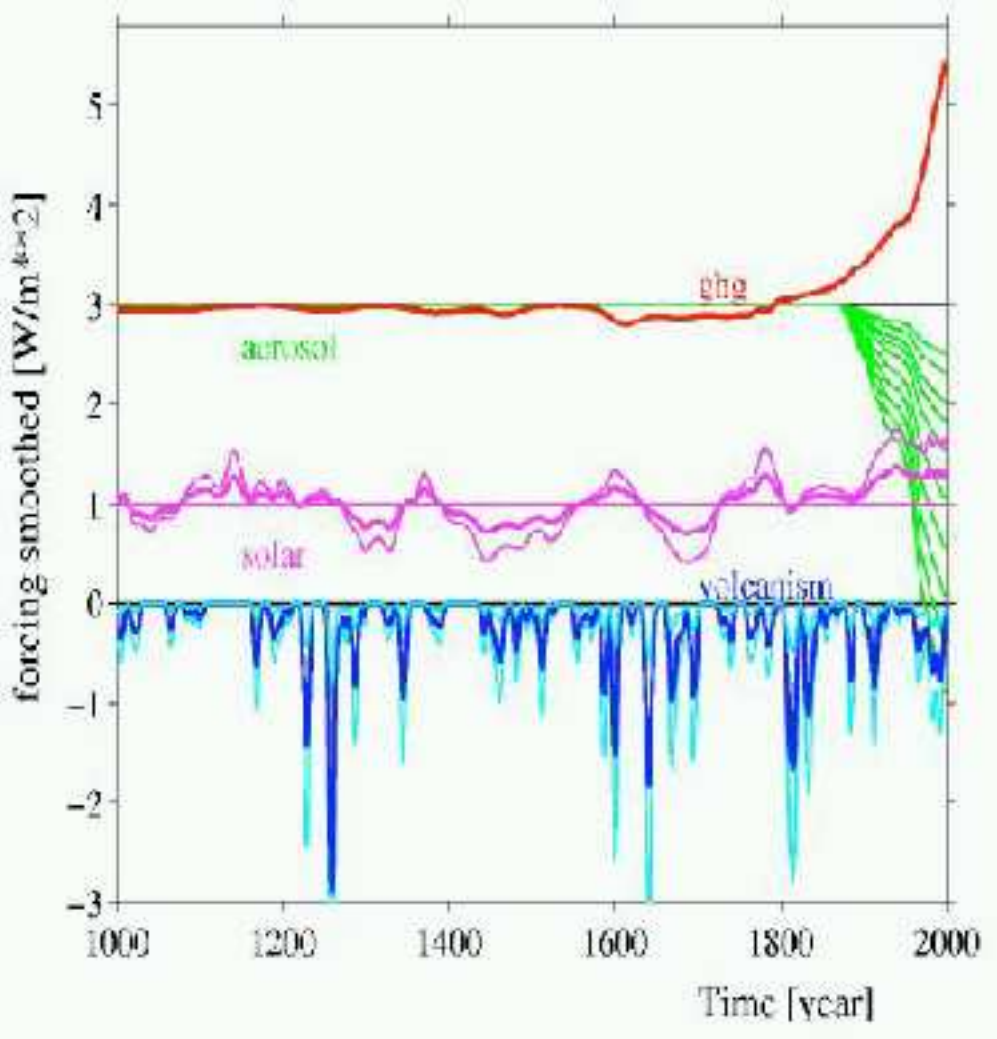
Noise on instrumental temperature is white with known variance.

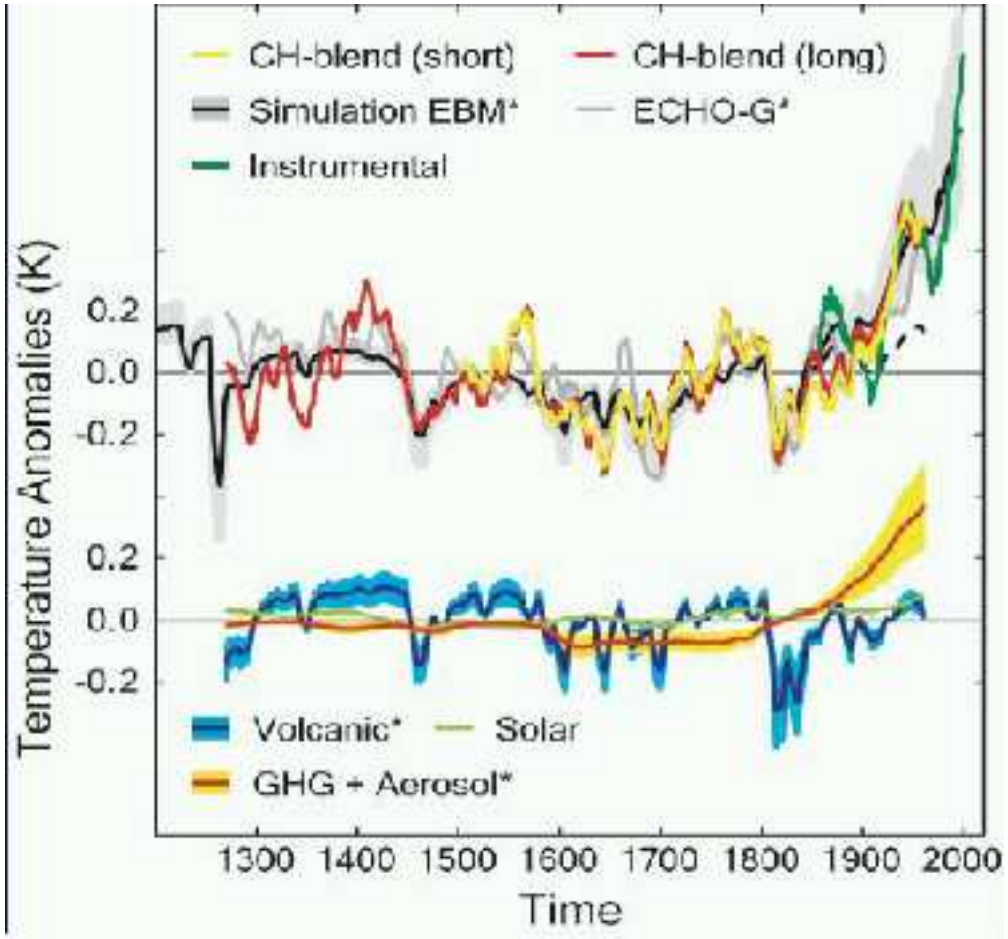
Noise on proxies is white.



Hegerl, Crowley, Allen, Hyde, Pollack, Smerdon and Zorita: A new 1500 yr climate reconstruction: enhanced low frequency variability and the fingerprint of anthropogenic warming.

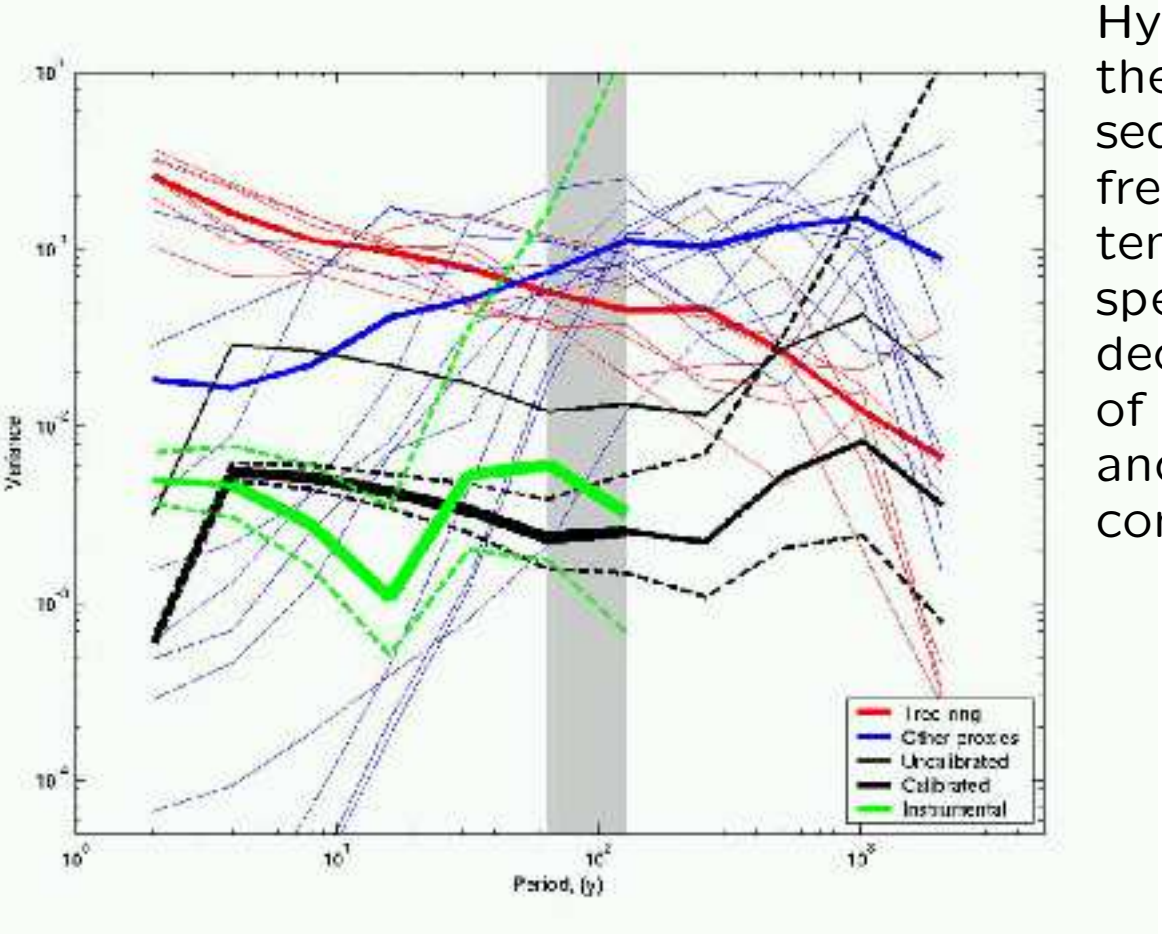
Exploiting the past to predict the future: Hegerl et al.





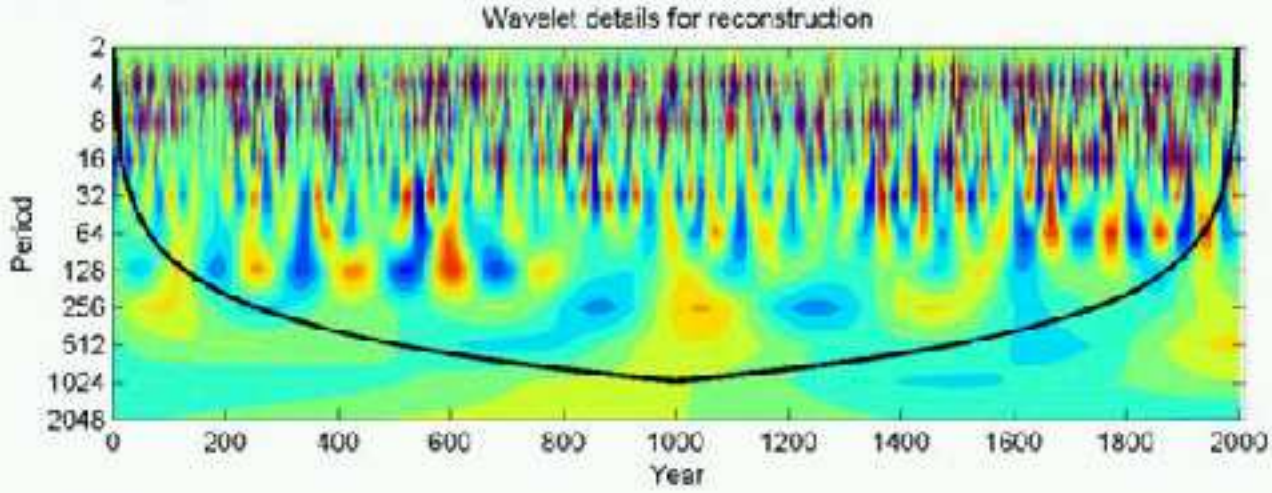
Using an energy balance model, the reconstructed temperature anomalies are partitioned between different forcing processes.

Moberg et al., 2005: time spectra of different proxies

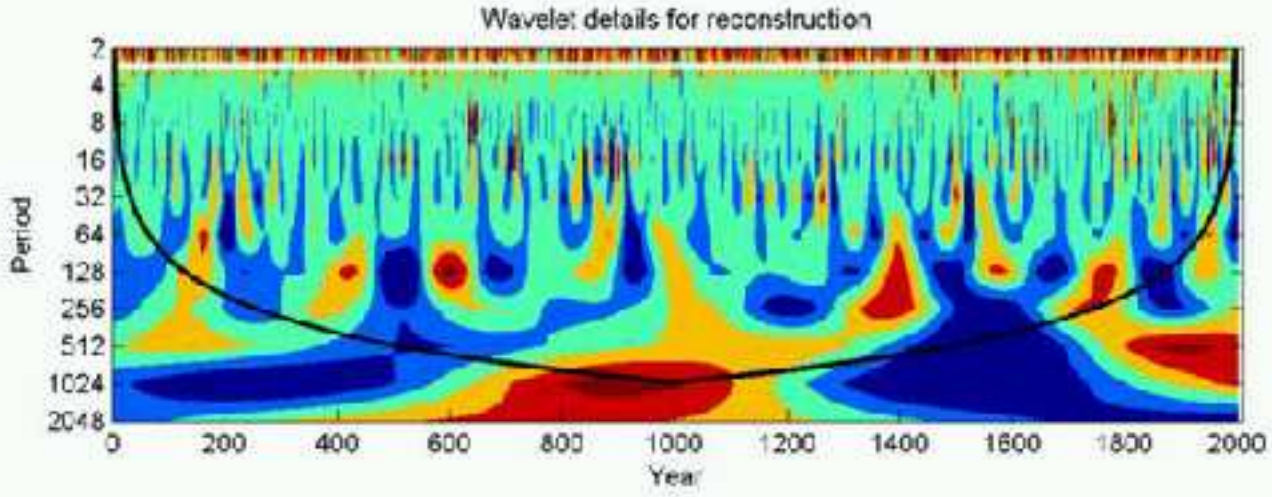


Hypothesis: the power spectra of the ice core, speleothem and sediment data decay at high frequencies because of lack of temporal resolution. The power spectra of the tree-ring data decay at low frequency because of the "segment length curse" and trees adapting to changing conditions.

Trees only (no <4yr)

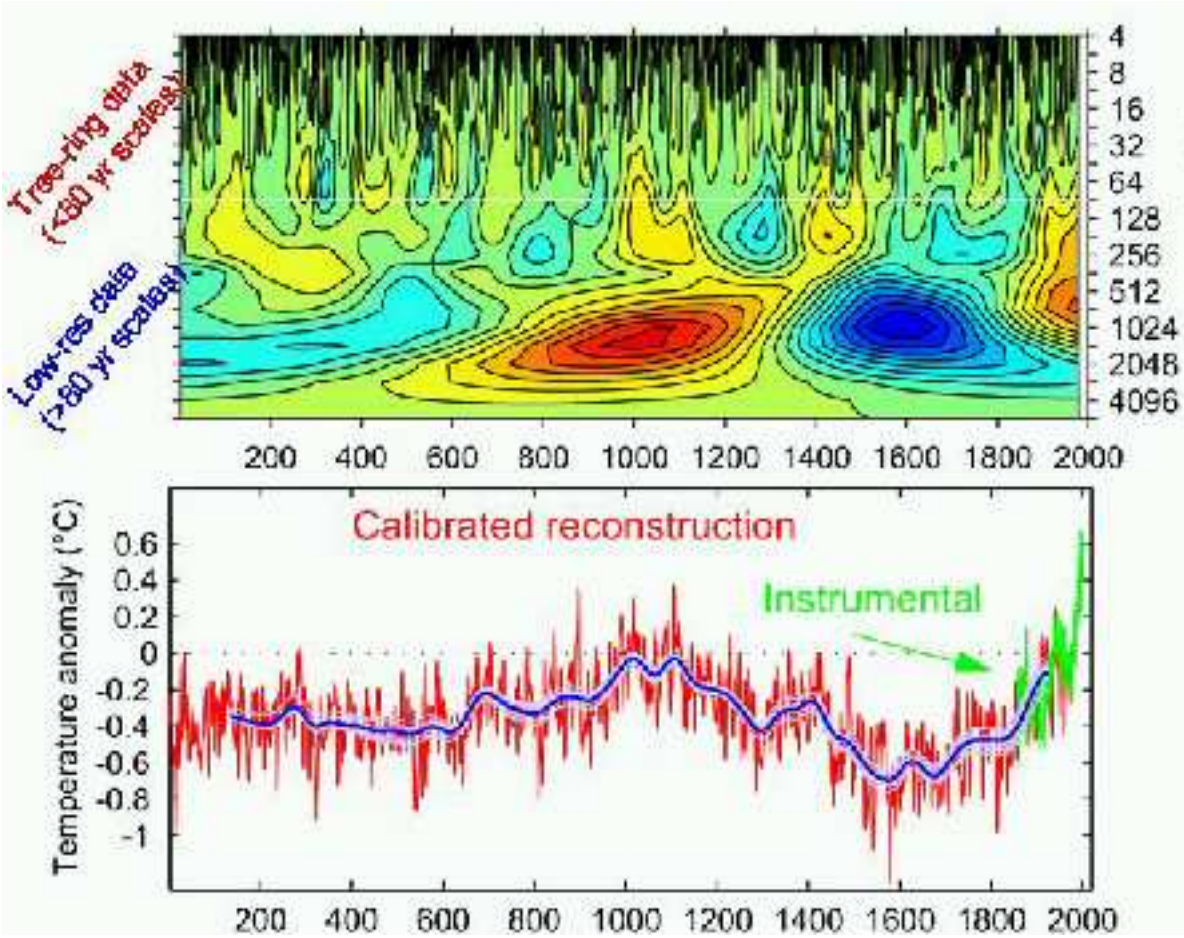


Separation 2/4yrs



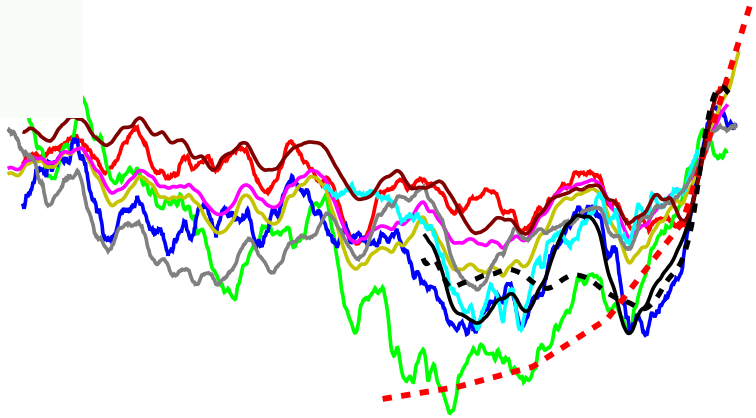
The wavelet transform shows that the low frequency and high frequency proxies have some coherent structure at periods of around the 64 to 128 years.

Looking at different time scales: Moberg et al., 2005



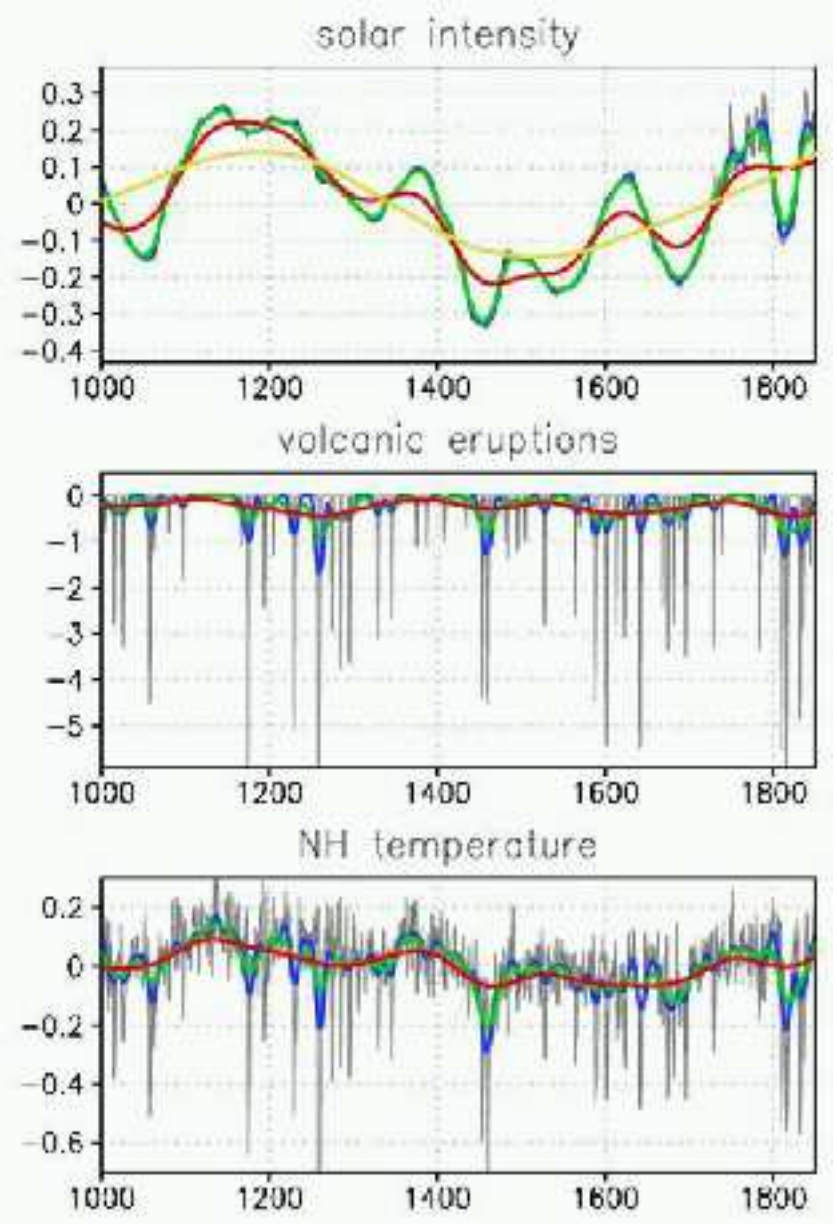
Using tree rings for timescales less than 80 years, and a combination of ice core, speleothem, bore hole, coral, shell composition and sediment data for longer time-scales, Moberg et al. seek to avoid the problems which may compromise tree ring calibrations on longer timescales.

They also use a variance matching calibration, which gives greater amplitude than an optimal least squares regression.

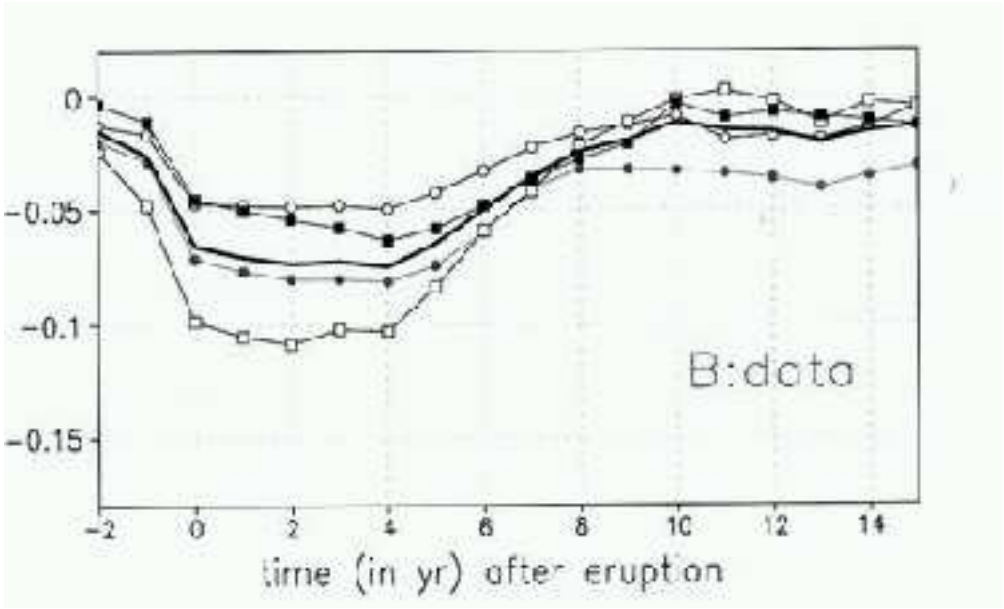


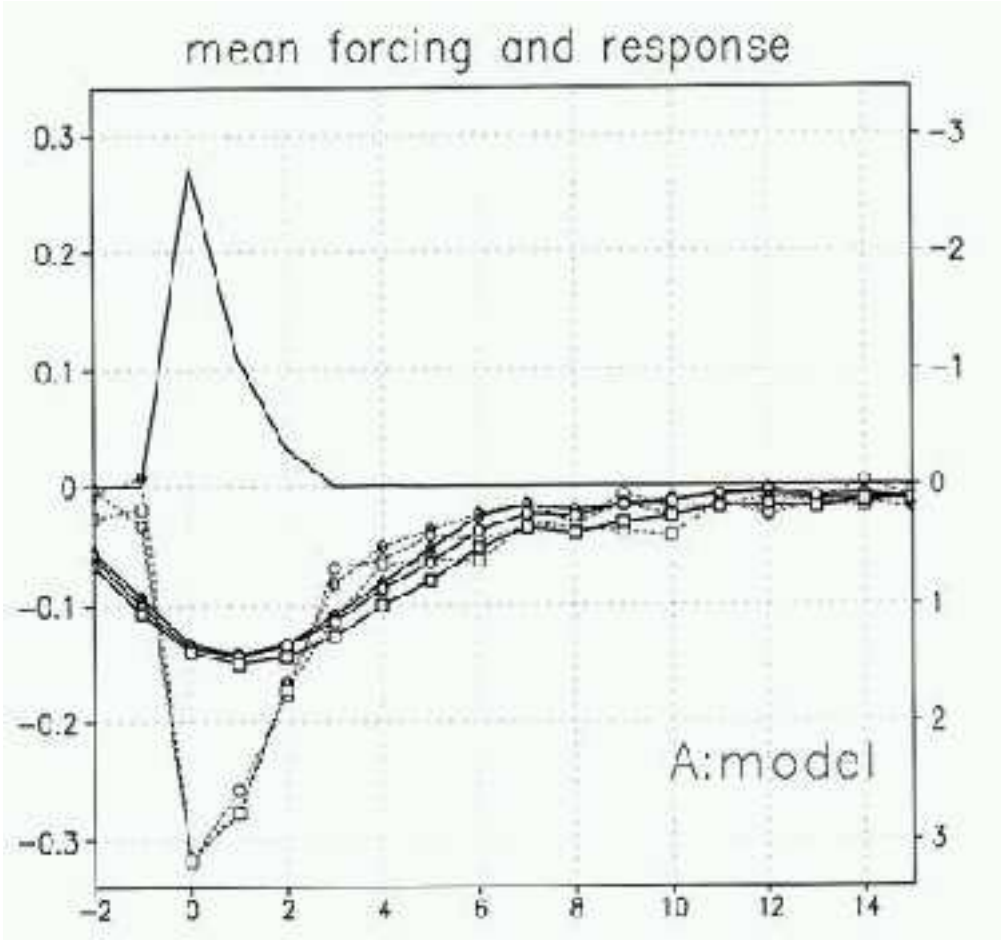
Correlations with estimated forcings. Nanne Weber, KNMI.

There are many uncertainties in estimates of the strength of past climate forcing, but they do provide an independent means of assessing the quality of temperature reconstructions.



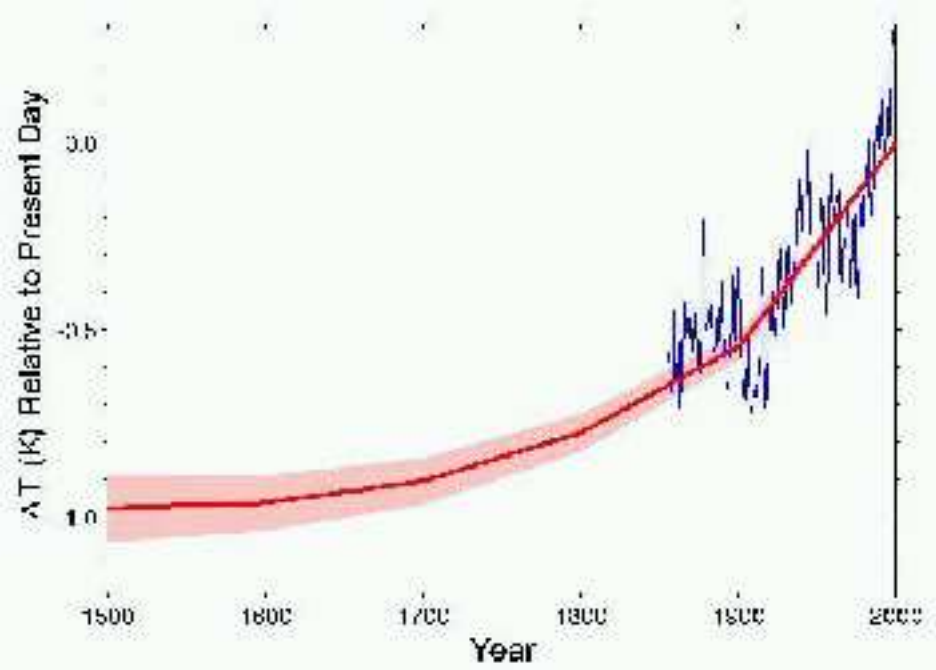
The lagged-correlations of temperature with estimated volcanic forcing show similar structure to the **low pass filtered** (10 year) model response, with a reduction in amplitude of about 40%.

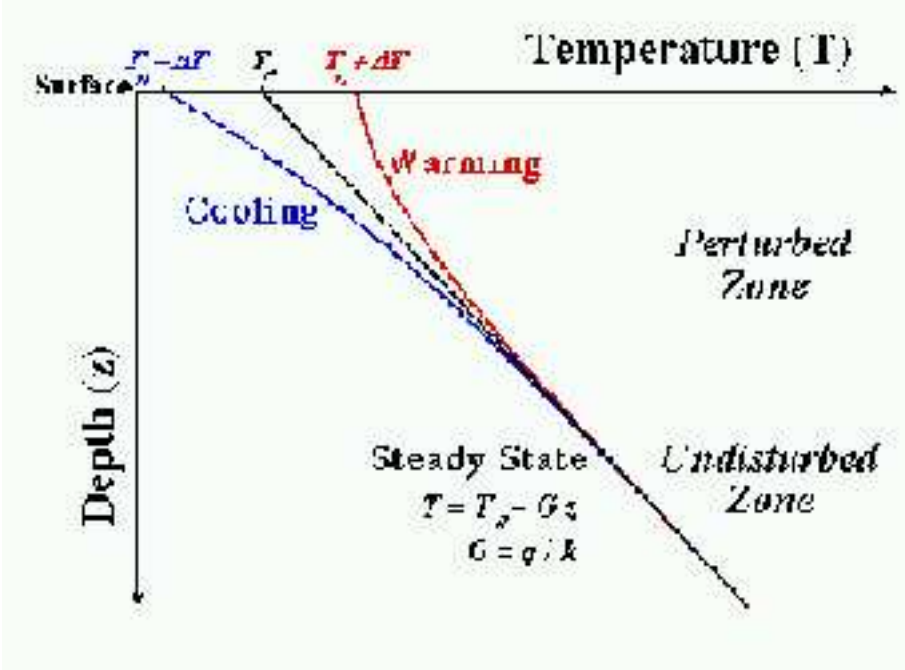




i.e. the reconstructions, model sensitivity, and forcing estimates would be consistent if scaled by A, B, and C respectively, where BC/A = 0.4

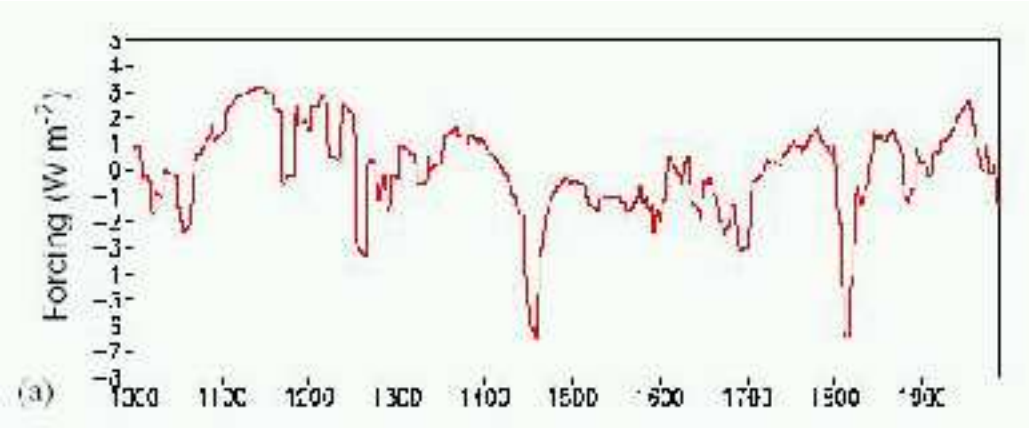
Bore hole temperatures





See also Mann, Rutherford, Bradley, Hughes and Keimig (2003, JGR) and Pollack and Smerdon (2004, JGR).

Natural variability



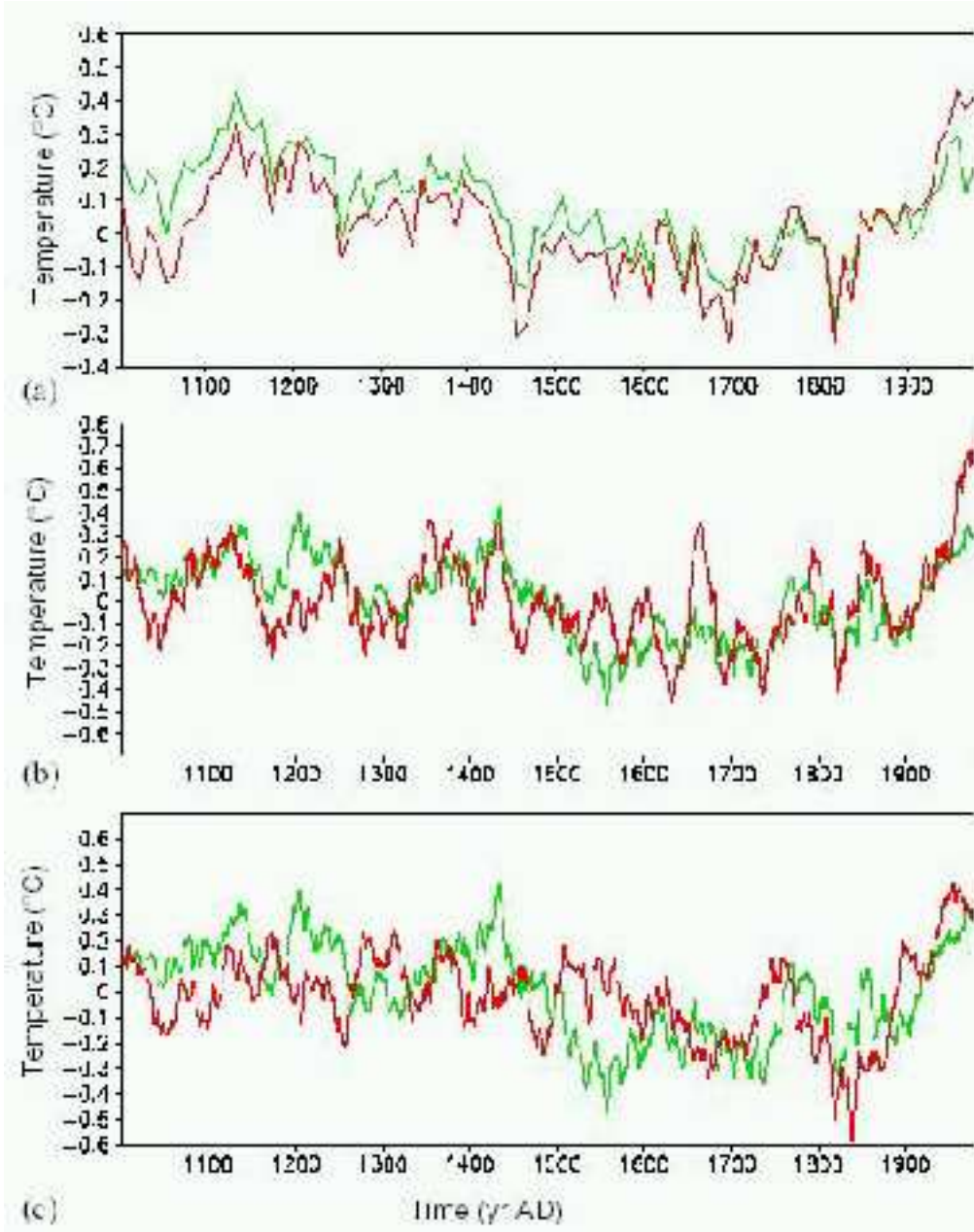
Goosse, Renssen, Timmermann and Bradley, (2005, Quart. Sci. Rev.), describe results from an ensemble of 25 model simulations of the last millennium, differing only in their initial conditions [3 level atmosphere, 20 level ocean: sensitivity is 1.8°C for doubled CO_2].

Forcing (above) includes: volcanic (Crowley, 2000); solar (Lean et al., 1995; Bard et al., 2000); sulphate aerosols (Charlson et al., 1991); greenhouse gasses (Fluecker, pers. comm.); and land use (Ramankutty and Foley, 1999).

The ensemble mean responses (top right) in Europe (green) and North America (red) are similar.

In any one ensemble member, however, there can be significant differences (centre right).

Similarly, the response in any one region can vary significantly between ensemble members – the bottom right figure shows the European temperature for two ensemble members.



Conclusions

- The Mann et al. conclusion that recent high global mean temperatures are exceptional has been verified by many studies.

- Reconstructions show a wide range of estimates for the strength of the negative temperature anomaly from 1700 to 1900 ("Little Ice Age").

- The statistical methods used have been verified by studies using pseudo-proxies from climate model simulations, but there are still gaps in our knowlegde about the appropriate noise structure (power spectra, coherence, correlation scales, etc.).

- Methods which explicitly account for properties of different proxies on different time scales may improve the skill of reconstructions.

- Different forms of regression can lead to significantly different results during the highly anomalous period 1700 to 1900, but have little impact on the period around 1000 (Song dynasties/"Medieval Warm Period").