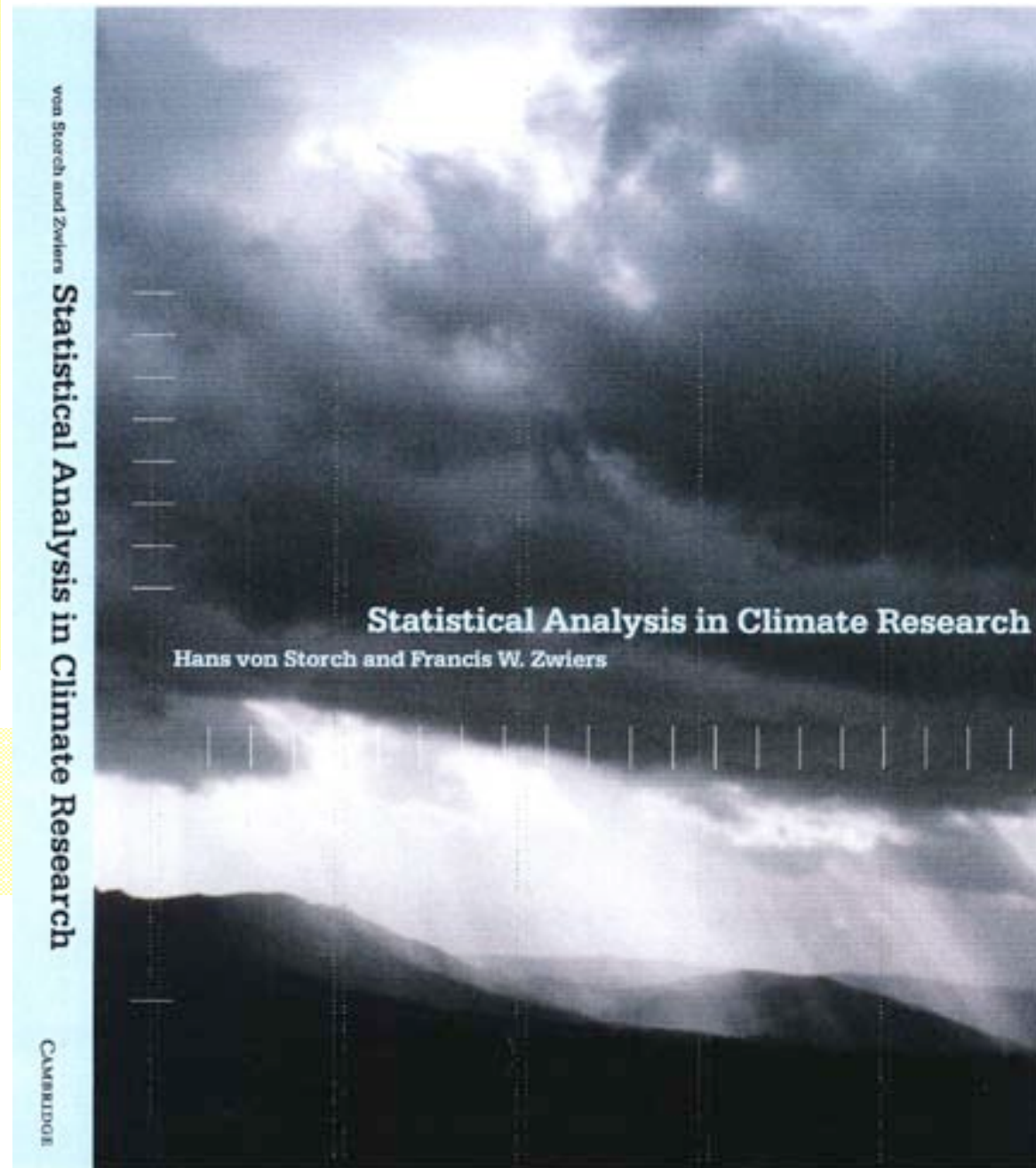


Reconstructing past climate from noisy data (Implications for climate change detection)

Hans von Storch
& Eduardo Zorita

Institute for Coastal Research
GKSS, Geesthacht



Abrupt Climate Change: Mechanisms, Early Warning Signs, Impacts, and Economic
Analyses
9-15 July 2005, Aspen (CO)

Abstract

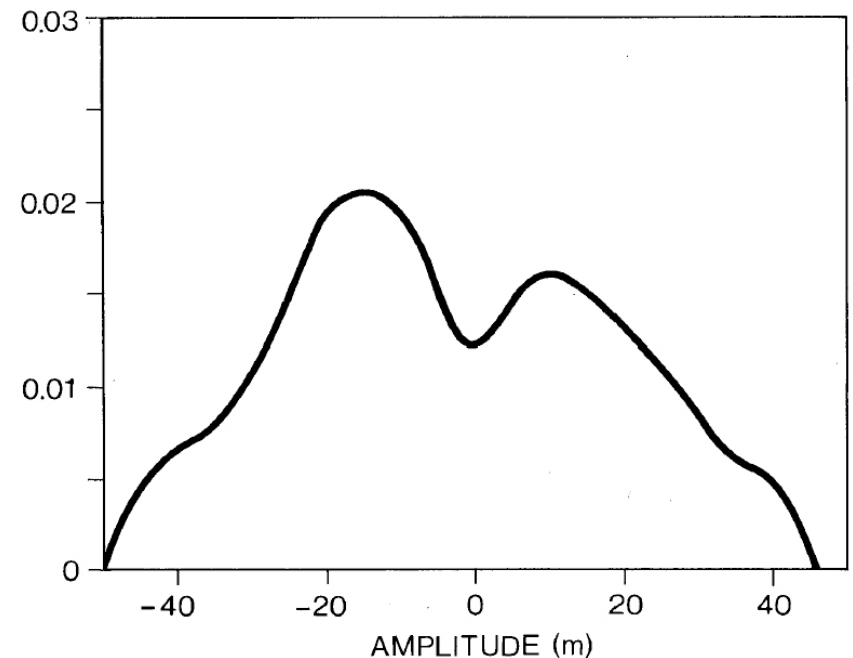
A series of multicentury simulations with the global climate model ECHO-G have been performed to generate a realistic mix of natural and externally (greenhouse gases, solar output, volcanic load) forced climate variations. Among others, these simulations are used to examine the performance of empirically based methods to reconstruct historical climate. This is done by deriving from the model output “pseudo proxies”, which provide incomplete and spatially limited evidence about the global distribution of a variable. These pseudo proxies serve as input in reconstruction methods – the result of which can then be compared with the true state simulated by the model.

The questions we have dealt with are:

- a) Is the MBH method (commonly known as hockeystick method) reliable in reconstructing low-frequency variability?
- b) Is the phenomenon, that an EOF analysis of a field of spatially incoherent, time wise red noise variables sometimes returns artificial hockey sticks when the time centering is done for a sub-period, relevant when applied to historical situations?
- c) Is the skill of the reconstruction on multi-decadal and centennial time scales significantly increased if the spatial density of proxy data is increased?
- d) Can a reconstruction be improved when longer time series are available?

Motivation: the failed quest for low-dimensional nonlinearity in 1986

- In the 1970s and 80s, scientists were eager to identify multi-modality of atmospheric dynamics – as a proof that low-dimensional system's theory is applicable to atmospheric dynamics.
- Hansen, A.R. and A. Sutera, 1986: *On the probability density function of planetary scale atmospheric wave amplitude*. J. Atmos. Sci. 43 – made widely accepted claims for having detected bimodality in data representative for planetary scale dynamics.
- J.M. Wallace initiated a careful review – and found the claim exaggerated because of methodical insufficiencies: Nitsche, G., J.M. Wallace and C. Kooperberg, 1994, J. Atmos. Sci. 51.



Alleged proof for bi-modality of extratropical atmospheric dynamics

Motivation: the failed quest for low-dimensional nonlinearity in 1986

- From the case of 1986 the scientific community has learned that it is wise to be reluctant before accepting wide-reaching claims which are based on purportedly advanced and complex statistical methods.
- Statistical analysis does not provide magic bullets. After a real pattern has been detected with an allegedly advanced method, it must be identifiable also with simpler methods.

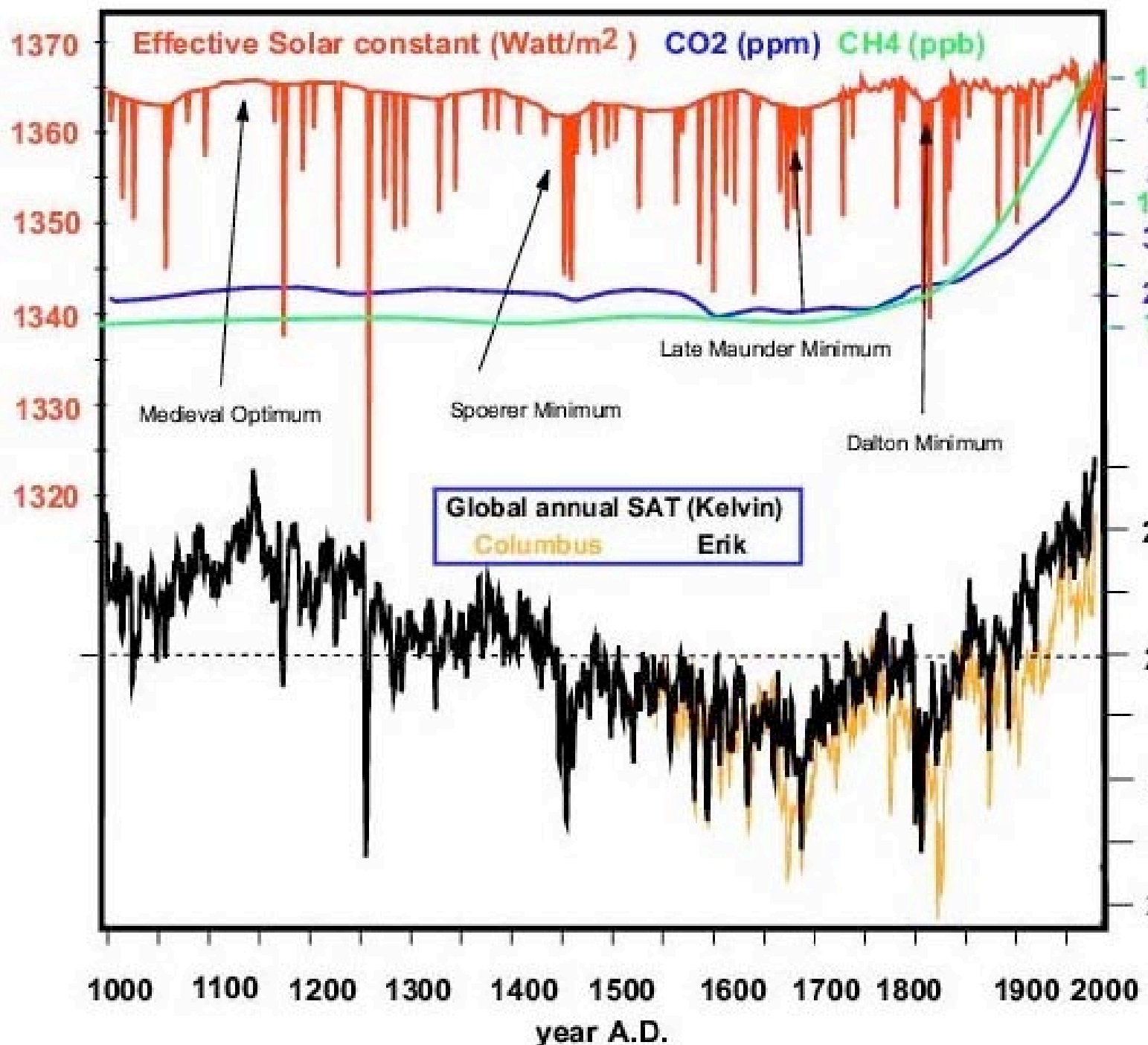
We have used a millennial simulation to examine the questions ...

- Is the hockey stick method reliable in reconstructing low-frequency variability?
- Is the phenomenon that an EOF analysis of a field of spatially incoherent, time wise red noise variables sometimes returns artificial hockey sticks when the time centering is done for a sub-period, relevant when applied to historical situations?

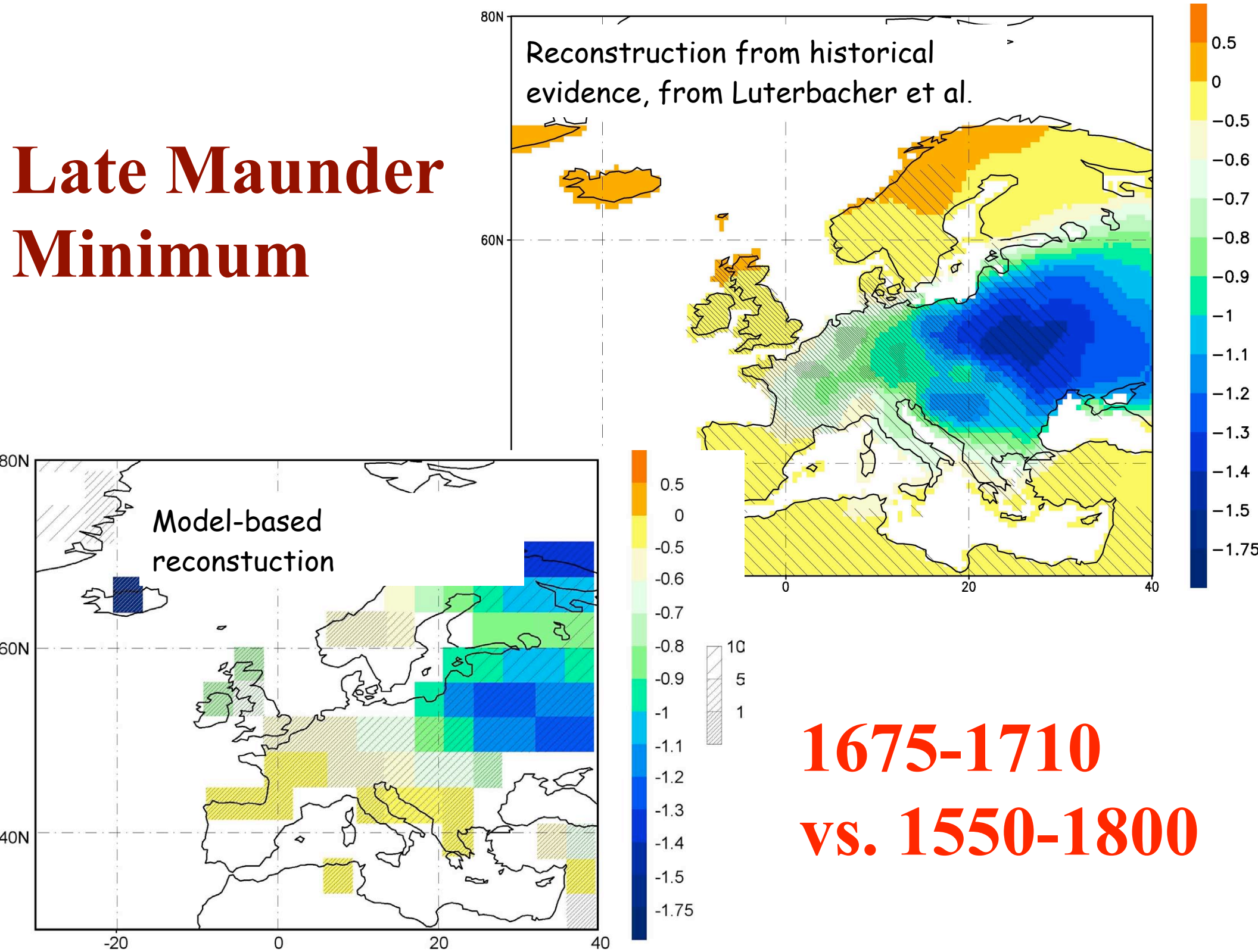


ECHO-G
simulations
„Erik den
Røde” (1000-
1990)
and
“Christoph
Columbus”
(1550-1990)
with
estimated
volcanic,
GHG and
solar forcing

Simulation with the model ECHO-G



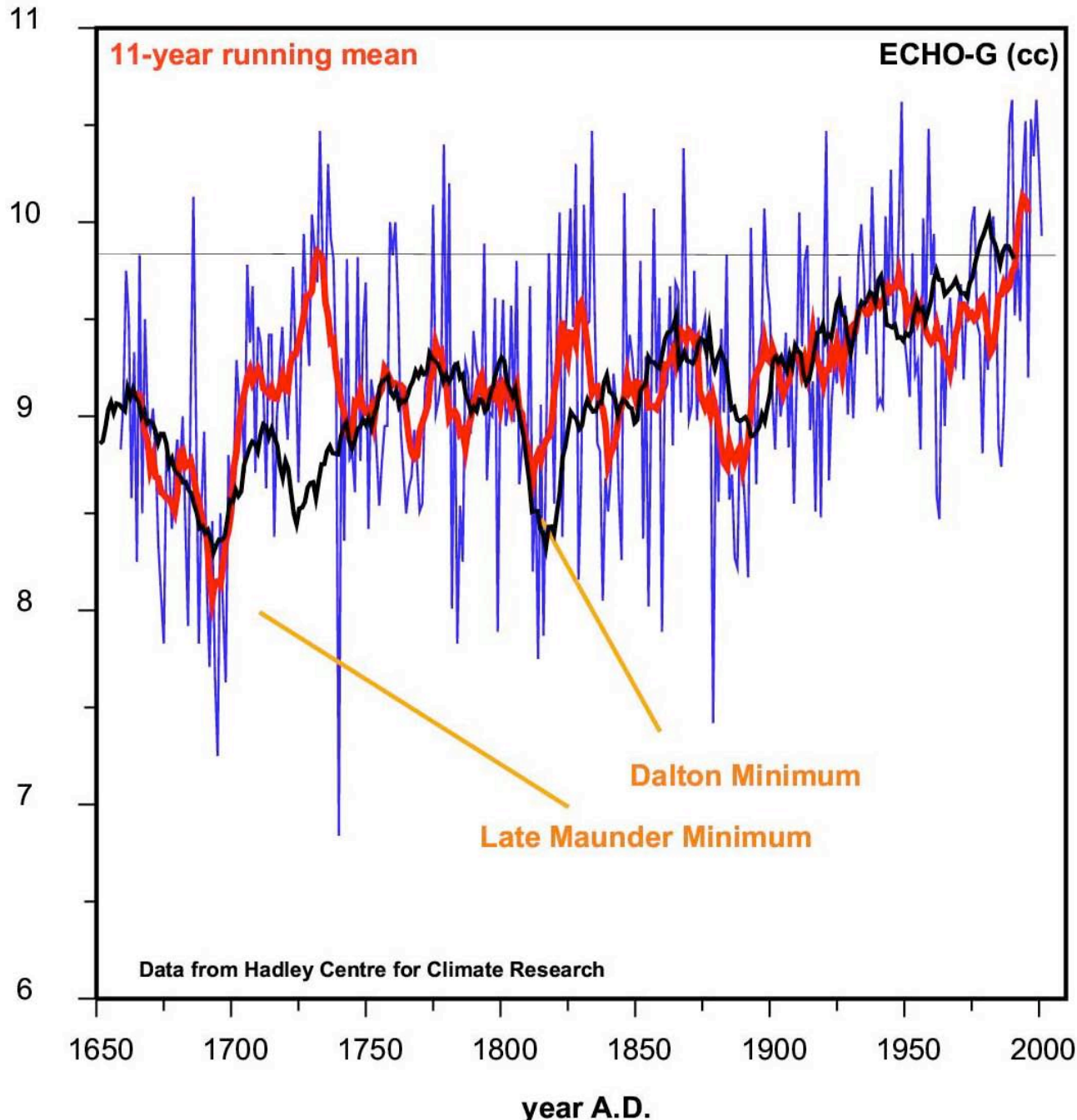
Late Maunder Minimum



Central England Temperature

centigrades

Annual means

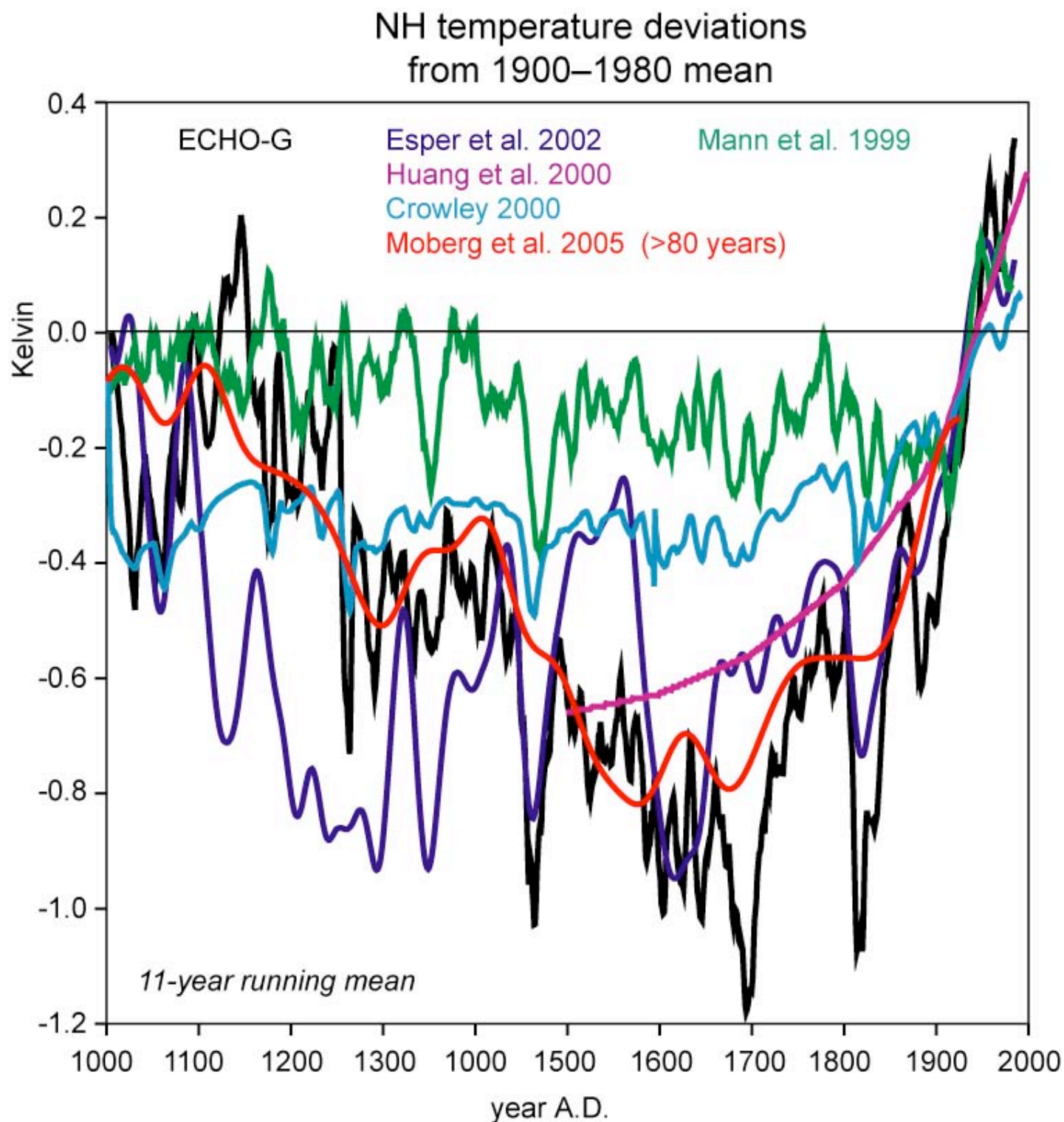


A more systematic comparison of the ECHO-G performance with various proxy data – during the Late Maunder Minimum episode (1675-1710):

KIHZ-Consortium: J. Zinke, et al., 2004: Evidence for the climate during the Late Maunder Minimum from proxy data available within KIHZ. In H. Fischer et al. (Eds.): *The Climate in Historical Times. Towards a synthesis of Holocene proxy data and climate models*, Springer Verlag

The millennial run generates temperature variations considerably larger than MBH-type reconstructions.

The simulated temperature variations are of a similar range as derived from NH summer dendro-data, from terrestrial boreholes and low-frequency proxy data.

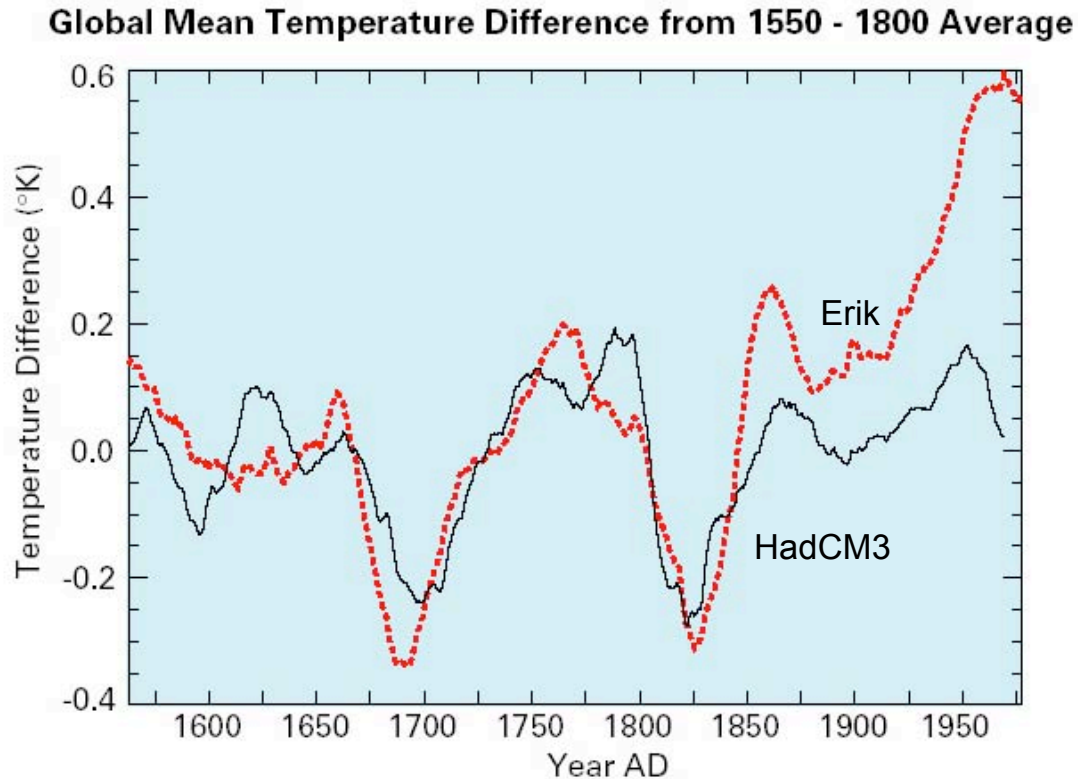


Conclusion

“Erik den Røde”, an effort to simulate the response to estimated volcanic, GHG and solar forcing, 1000-1990.

Low-frequency variability in Erik den Røde
> Mann, Jones, and others, but
~ Esper, boreholes, Moberg, (some)
instrumental data

Testing with HadCM3 simulation

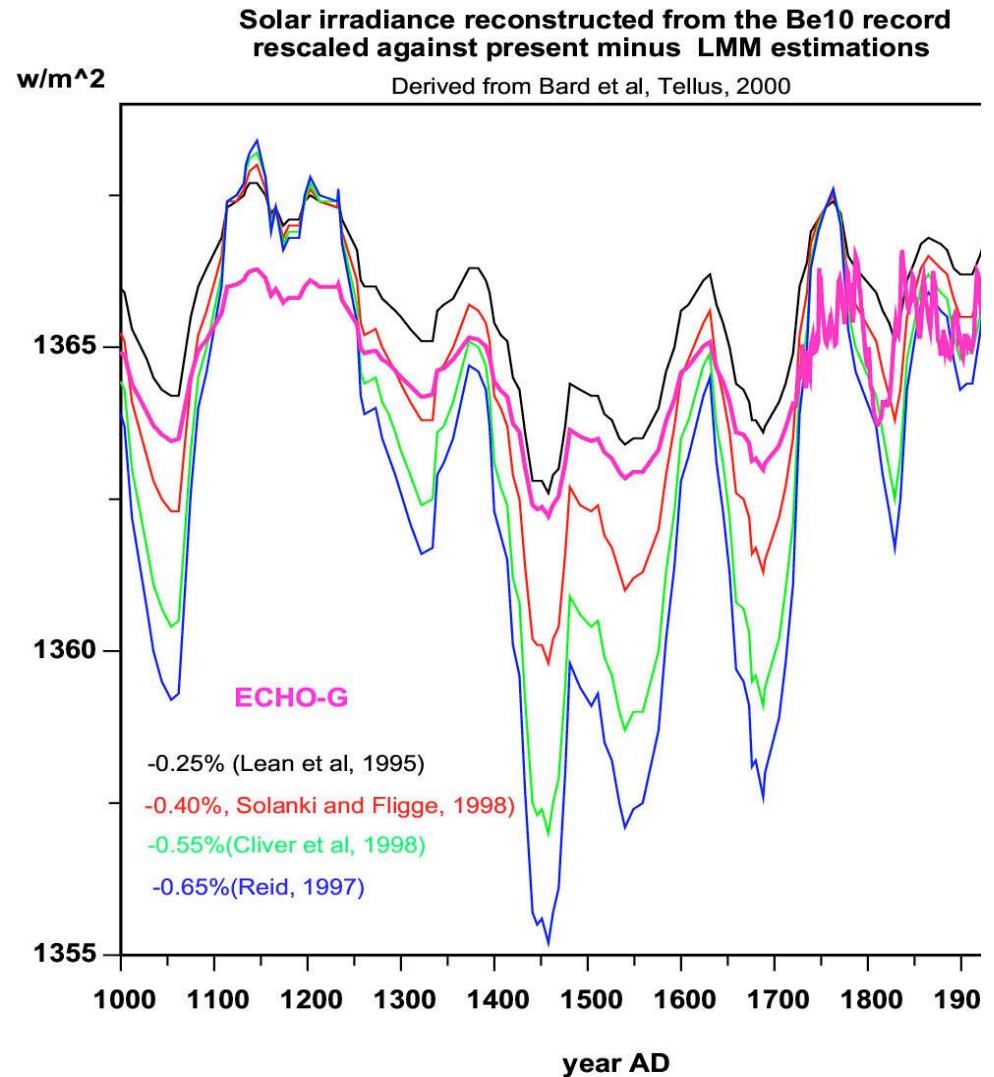


differences relative to the 1550-1800
average;
25-year running averages.

Data provided by Simon Tett.

Conclusion

- Not a specific result of ECHO-G
- Forcing is not particularly strong
- Sensitivity of ECHO-G about 2.5K



*Different reconstructions of
solar irradiance*

For the purpose of testing reconstruction methods, it does not really matter how „good“ the historical climate is reproduced by a millennial simulation.

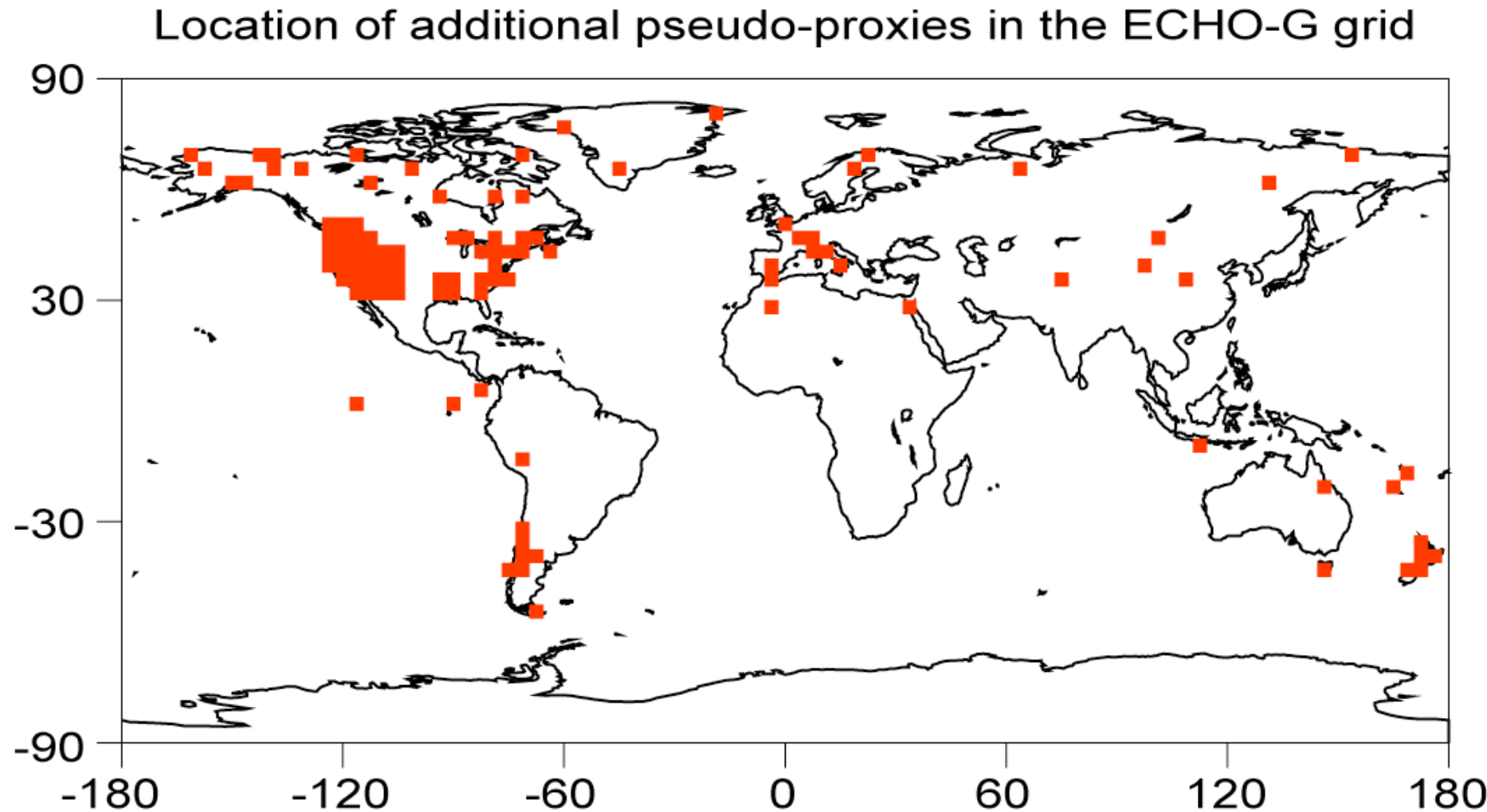
Such model data provide a laboratory to test MBH, McMc and other questions.

Testing Claims - #1



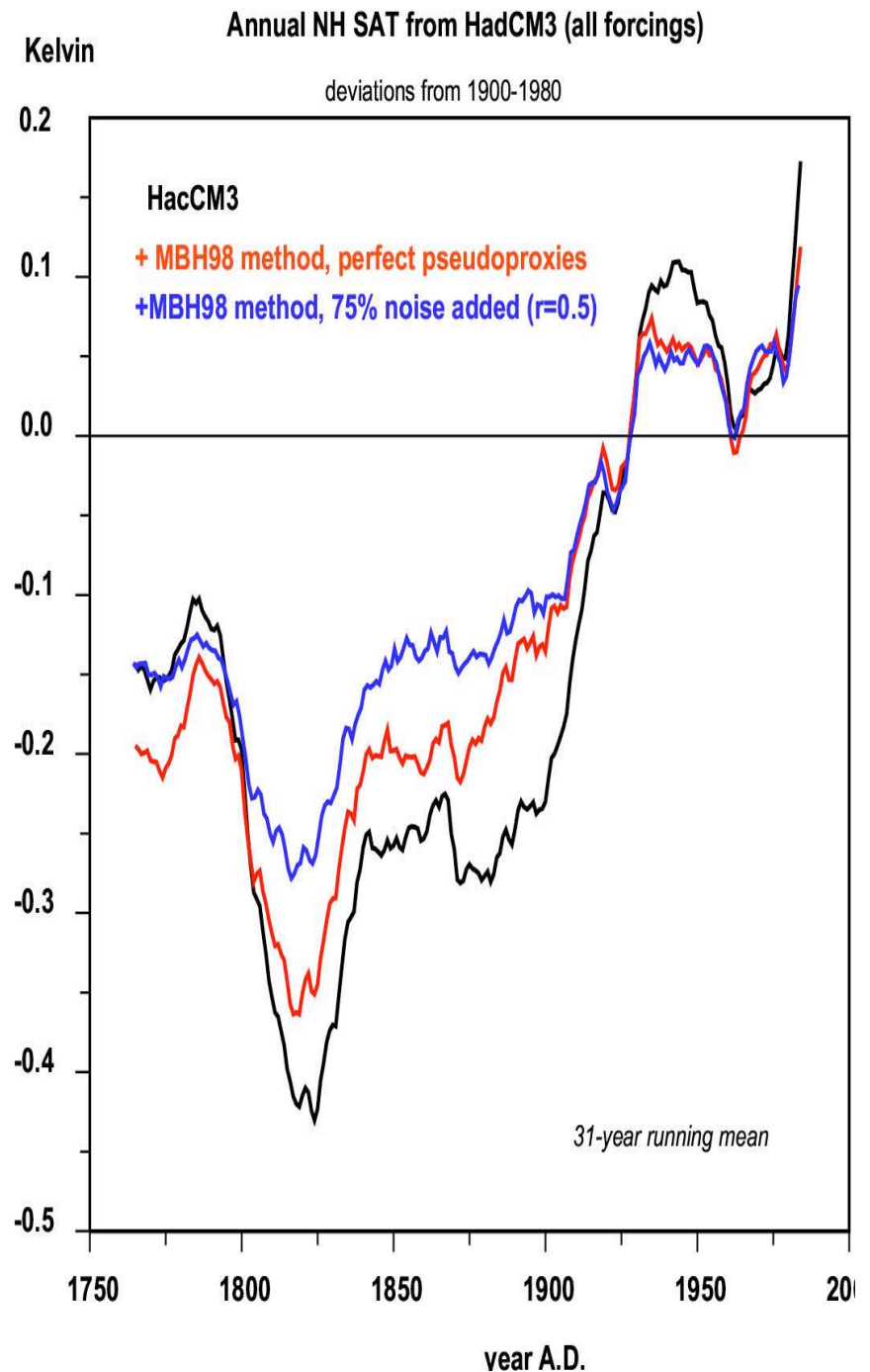
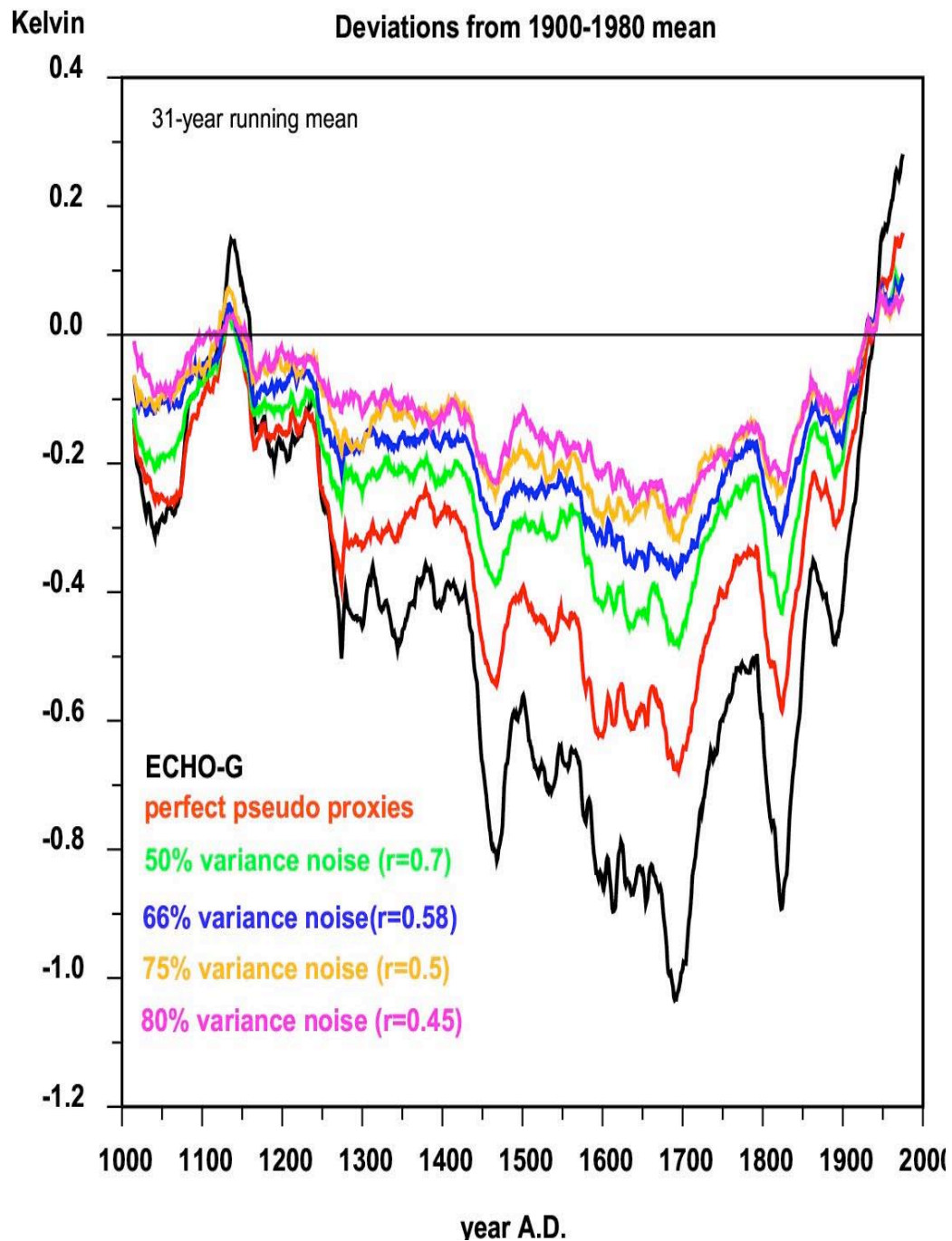
The historical development of air temperature during the past 1000 years resembles a hockey stick – with a weak ongoing decline until about 1850 and a marked increase thereafter.

Testing the MBH method

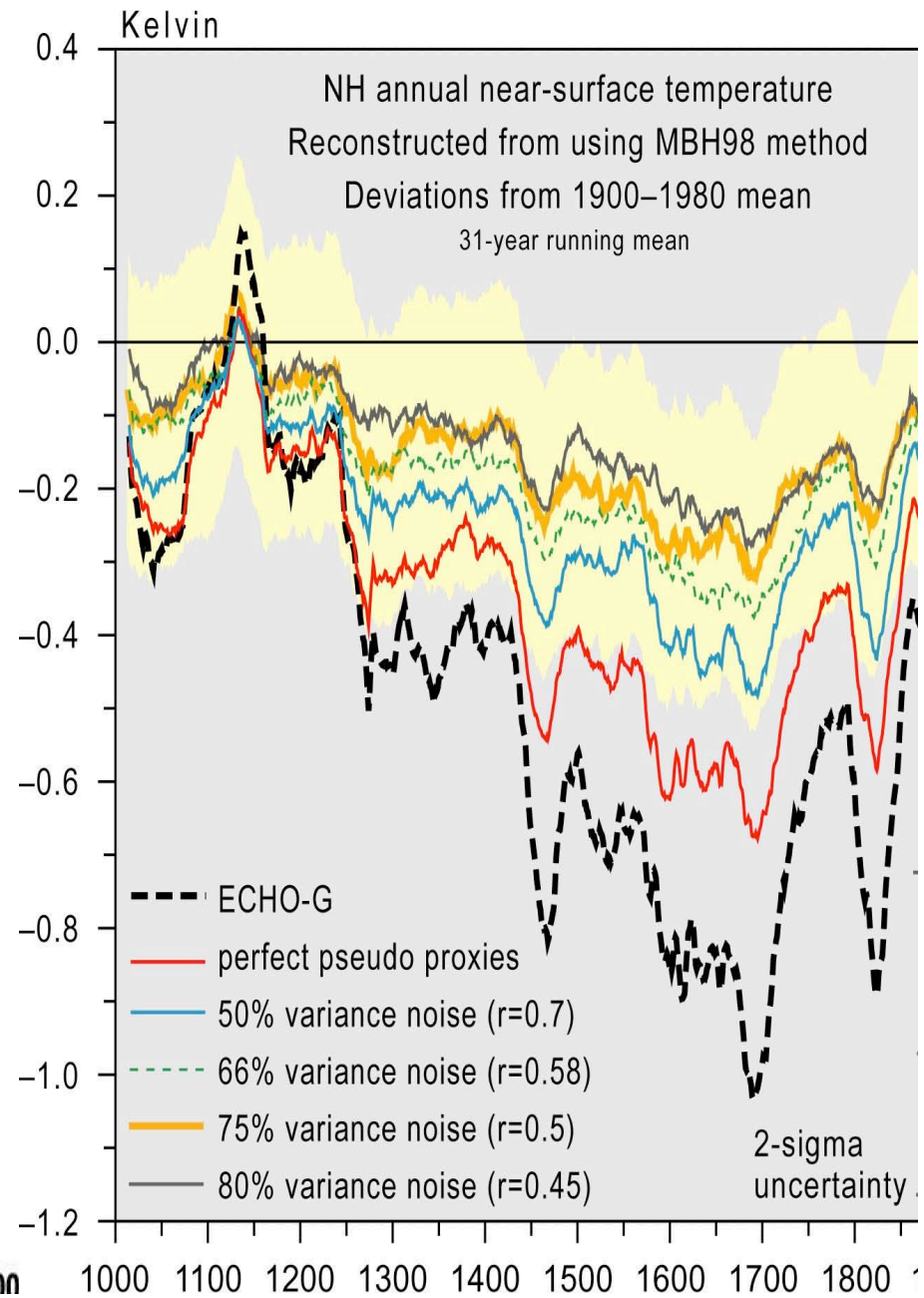
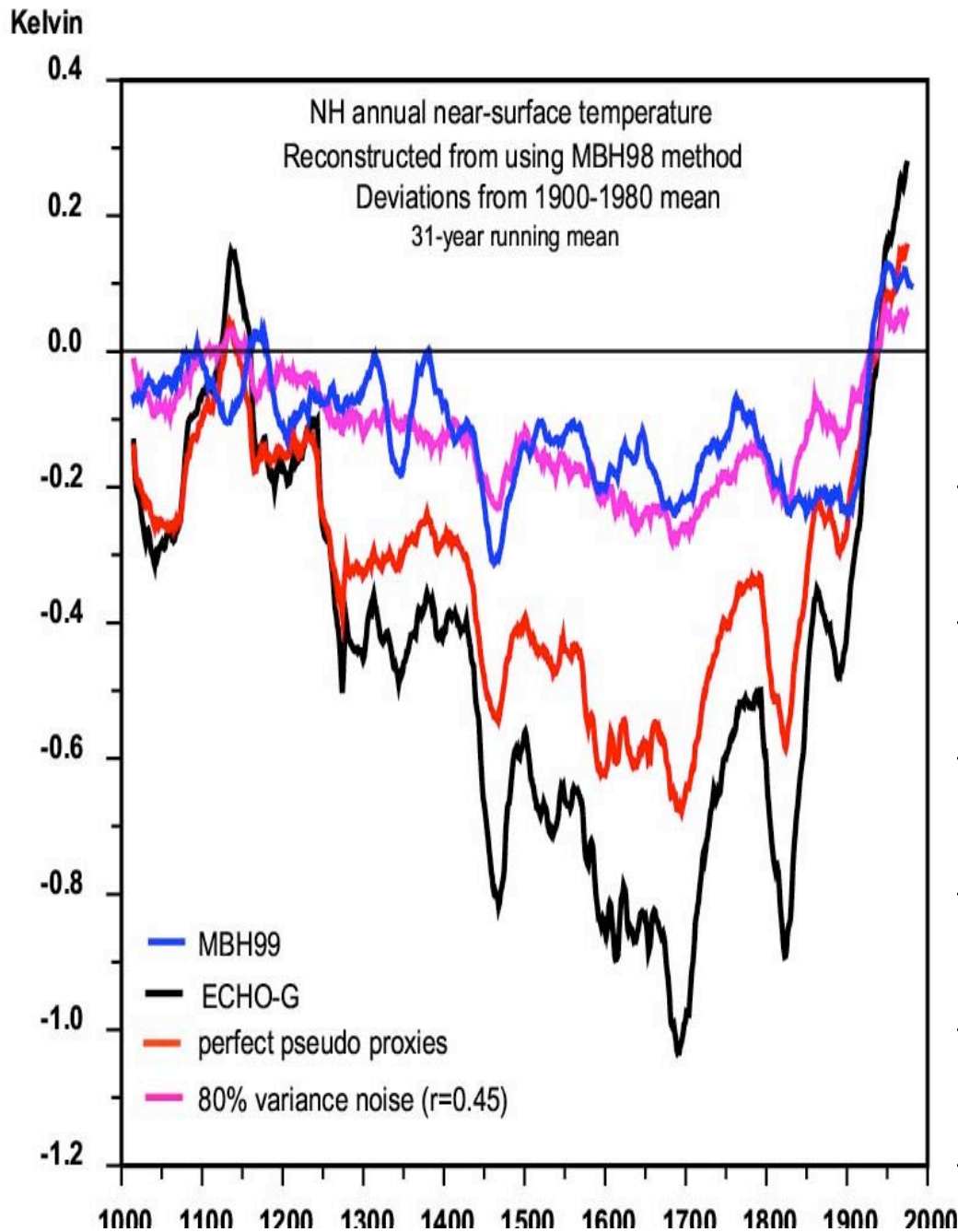


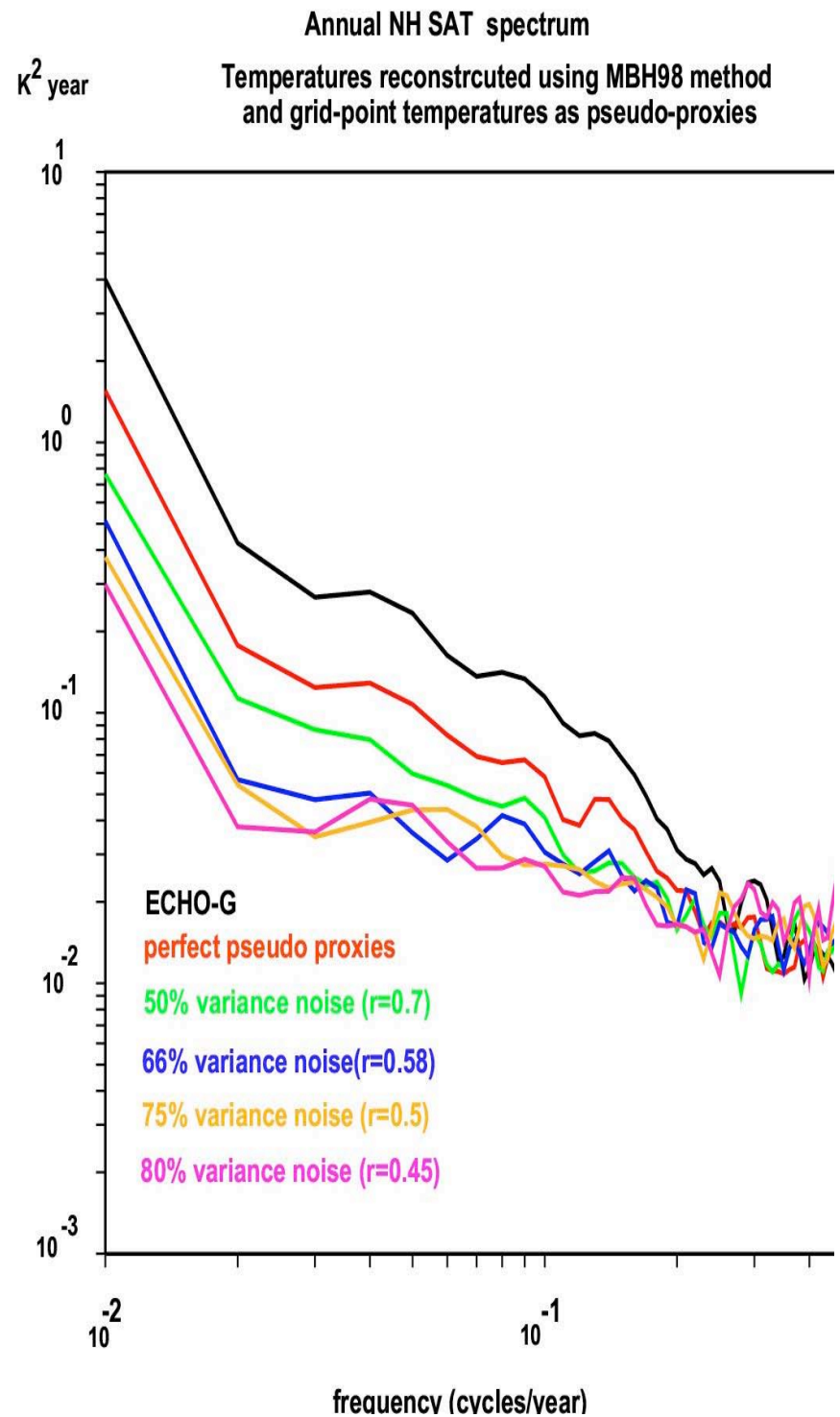
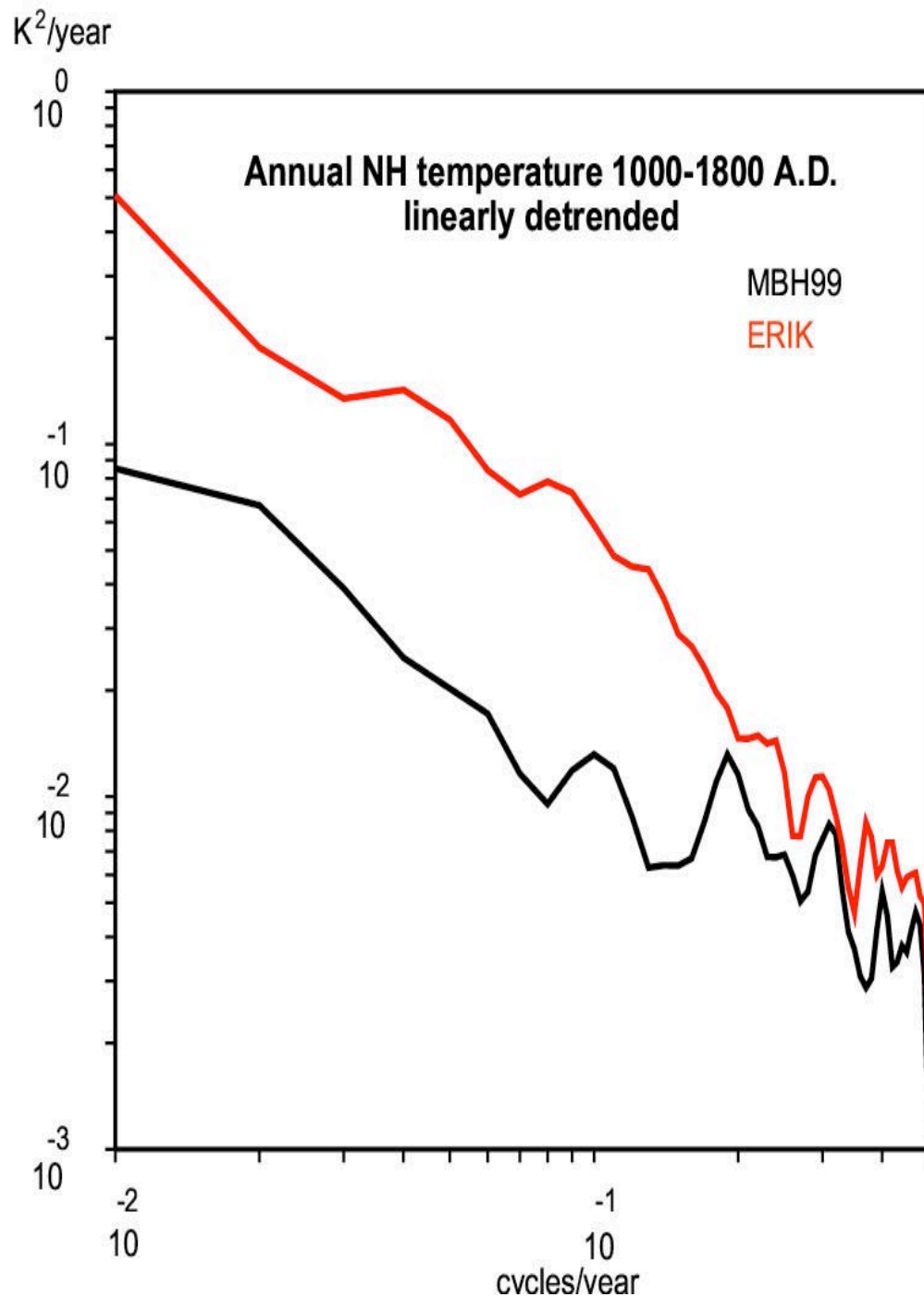
pseudo-proxies: grid point SAT plus white noise
(largest sample available to MBH)

NH annual near-surface temperature Reconstructed from using MBH98 method, 99 pseudoproxies



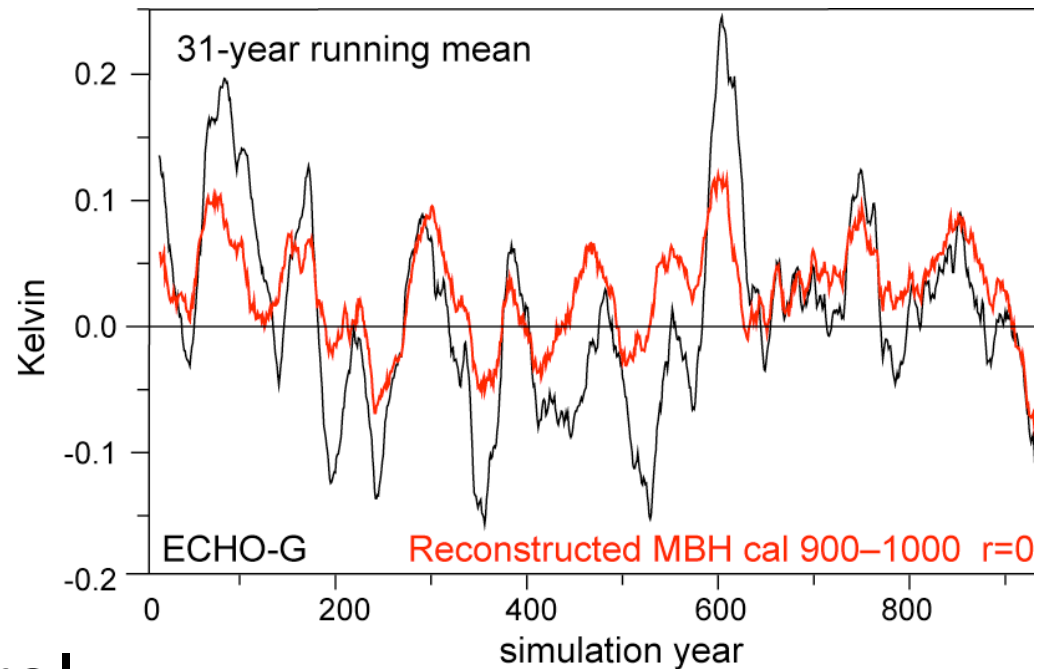
Mimicking MBH?





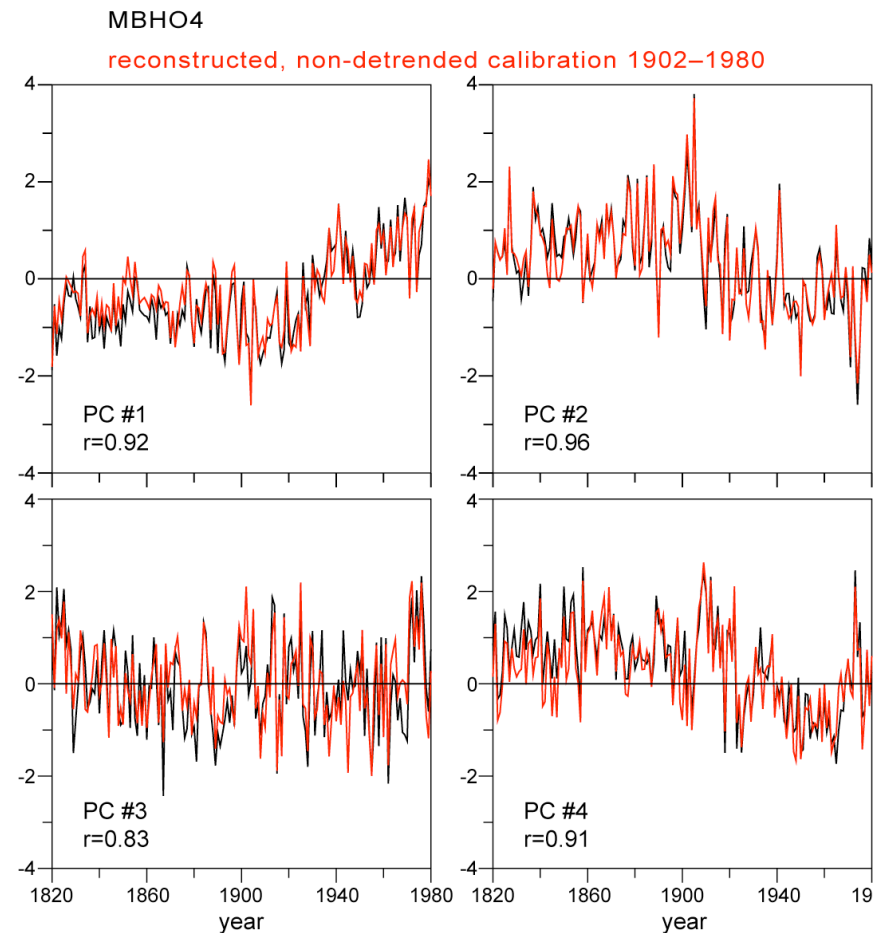
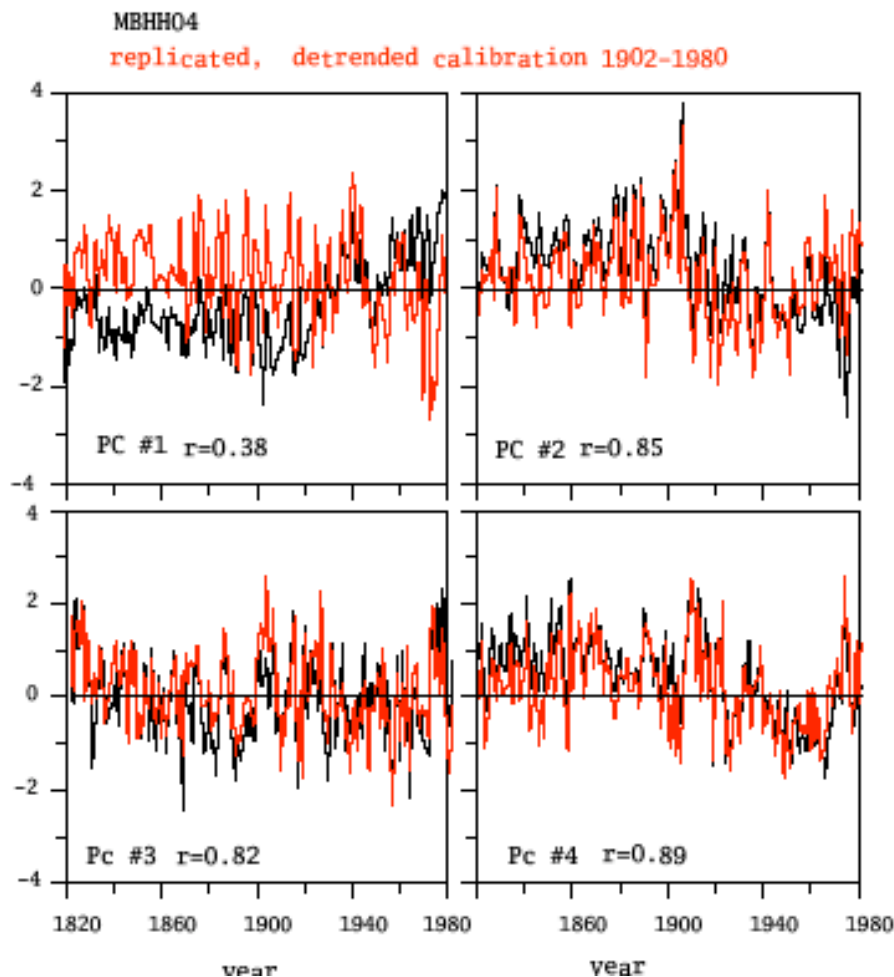
Discussion

- Claim: MBH was not built for such large variations as in ECHO-G
- But – the same phenomenon emerges in a control run.



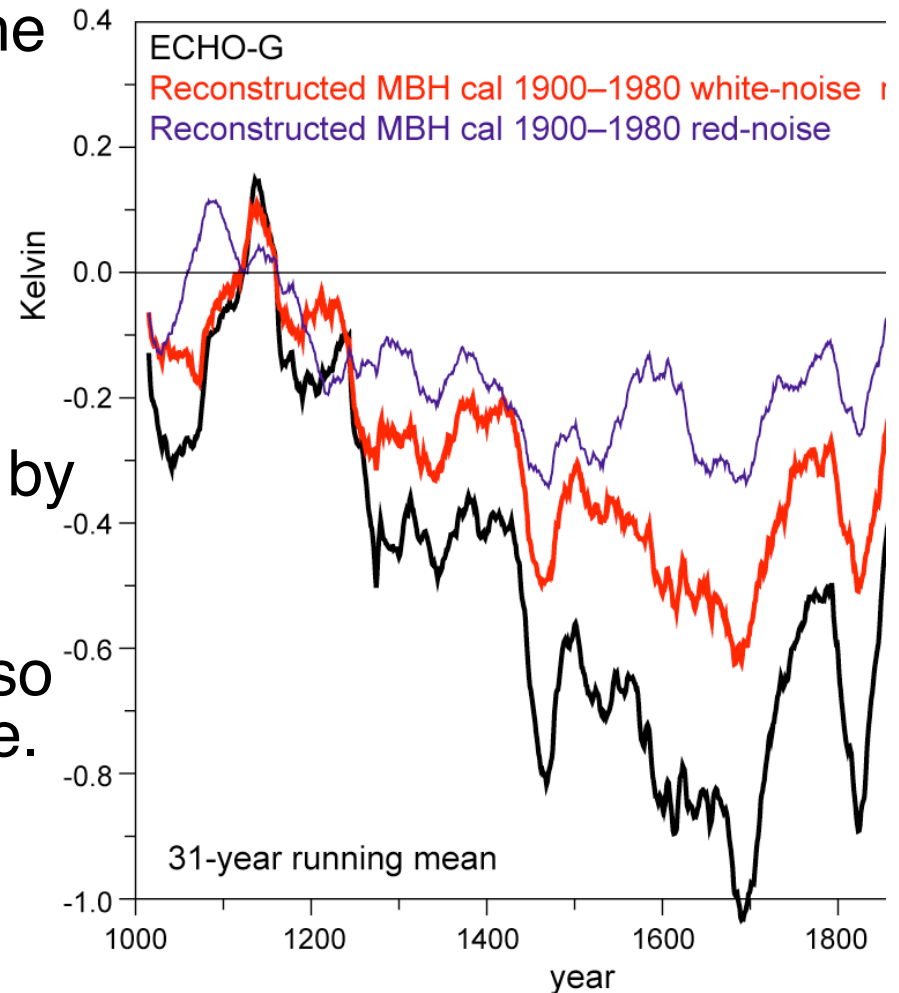
Discussion

Training MBH with or without **trend** in calibration period.
Statistical meaningful is the exclusion of the trend, but MBH seems to exploit the trend.



Training with or without trend

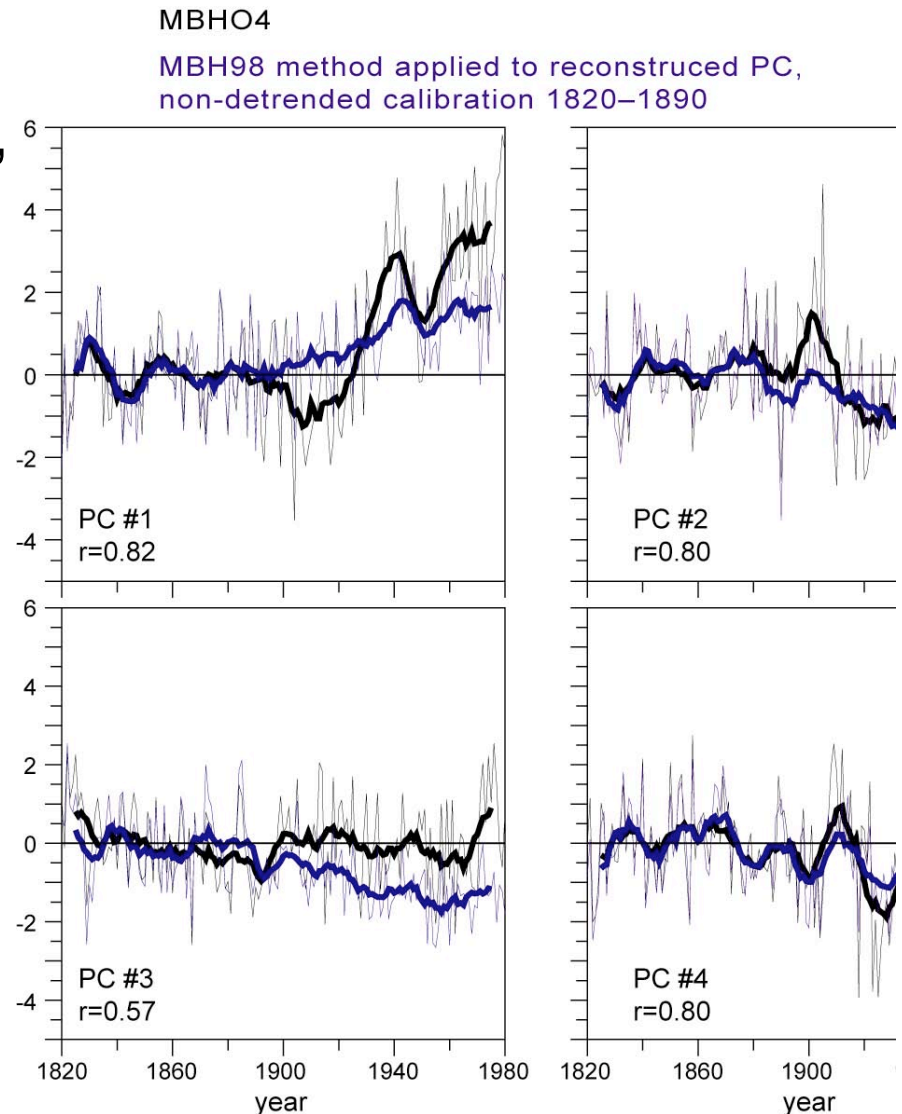
- In our implementation of MBH, the trend in the calibration period is taken out.
- When the trend during the calibration period is used as a critical factor in the empirical reconstruction model, then the contamination of the proxy trend by non-climatic signals must be mimicked.
- Thus, apart of white/red noise also error on the centennial time scale.
- Here: 50% centennial, 75% white noise.
- Again heavy underestimation of long-term variability.



Trend – does it really help ?

- If R is the reconstruction method, and S the sampling operator, then we want
$$R \cdot S = 1$$
- We used the original MBH result M , given by the first 4 EOFs, and derive the MBH operator R from samples of this 1820-1890 history, including the trend.
- Then we compare $R(S(M))$ with M . The difference is significant.
- In case of MBH

$$R \cdot S \neq 1$$



Conclusion

- MBH algorithm does not satisfy the basic requirement
$$R \cdot S = 1$$
- Instead MBH underestimates long-term variability
- But $R(S(E)) \approx M$, with M representing MBH and E the millennial simulation “Erik de Røde”.



Testing Claims - #2

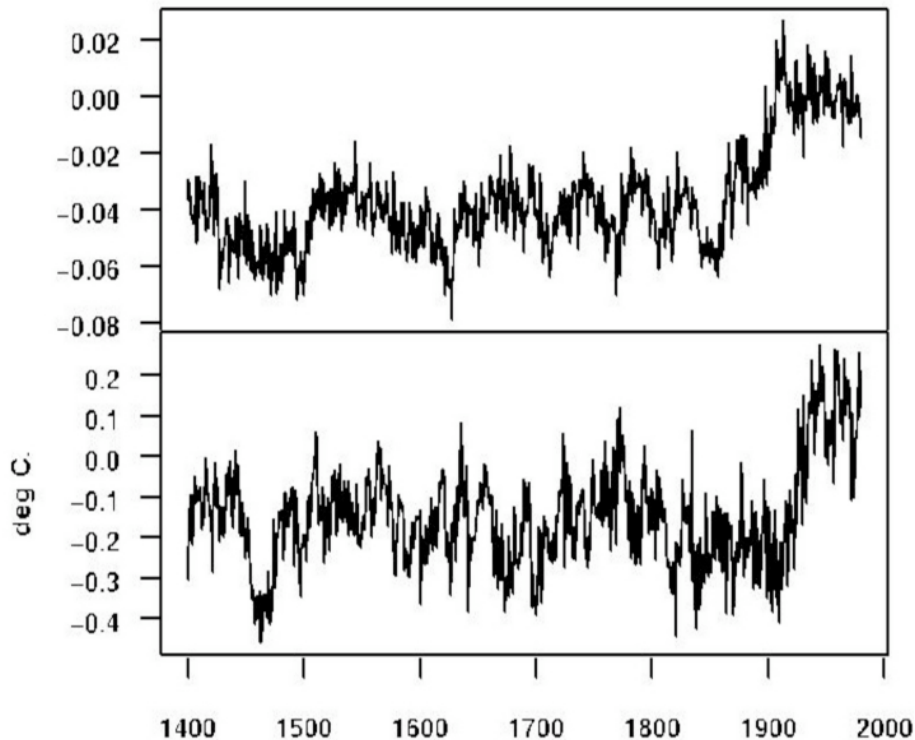
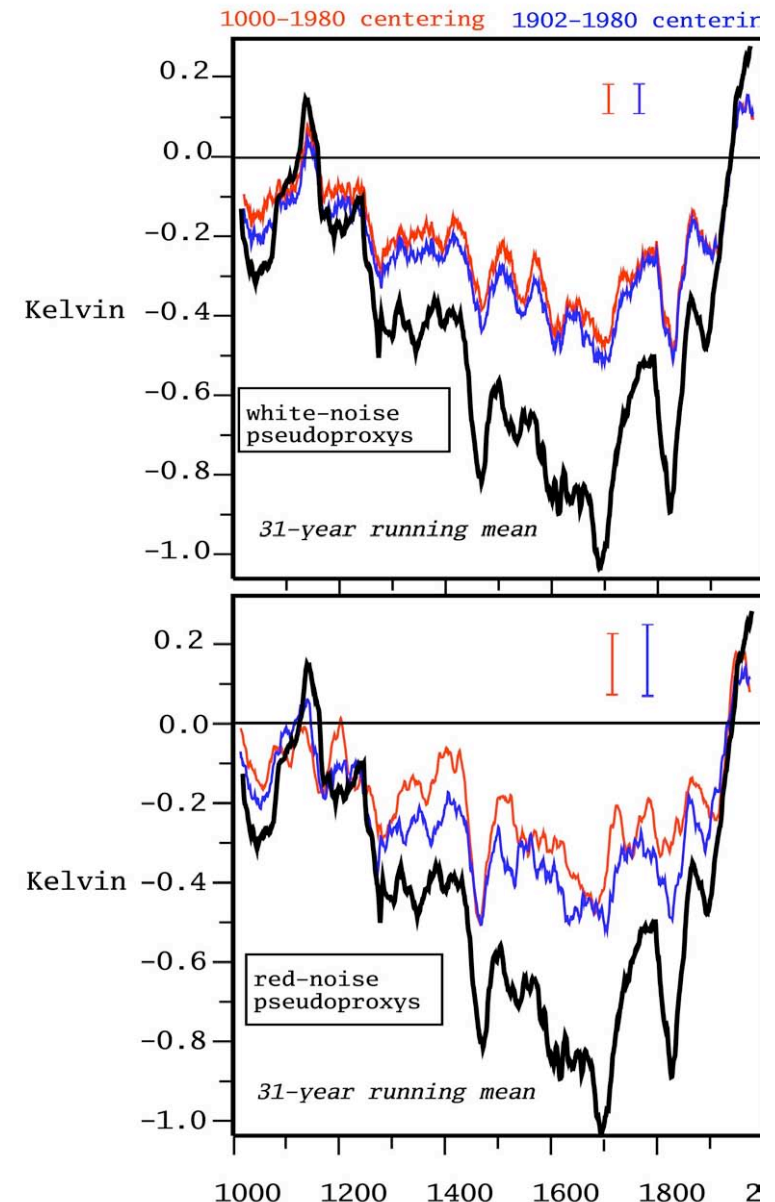


Figure 1. Simulated and MBH98 Hockey Stick Shaped Series. Top: Sample PC1 from Monte Carlo simulation using the procedure described in text applying MBH98 data transformation to persistent trendless red noise; Bottom: MBH98 Northern Hemisphere temperature index re-construction.

- McIntyre, M., and R. McKittrick, 2005: Hockey sticks, principal components and spurious significance. *Geoph Res. Letters* 32
- Claim: Partial centering generates PC coefficients with a hockey stick pattern from red-noise random time series fields.
- Claim is valid – but does it matter when deriving historical reconstructions?
- Not included in our original analysis as we have well separated grid boxes and not clusters of proxy data (effect is potentially misleading only with respect to proxy data)

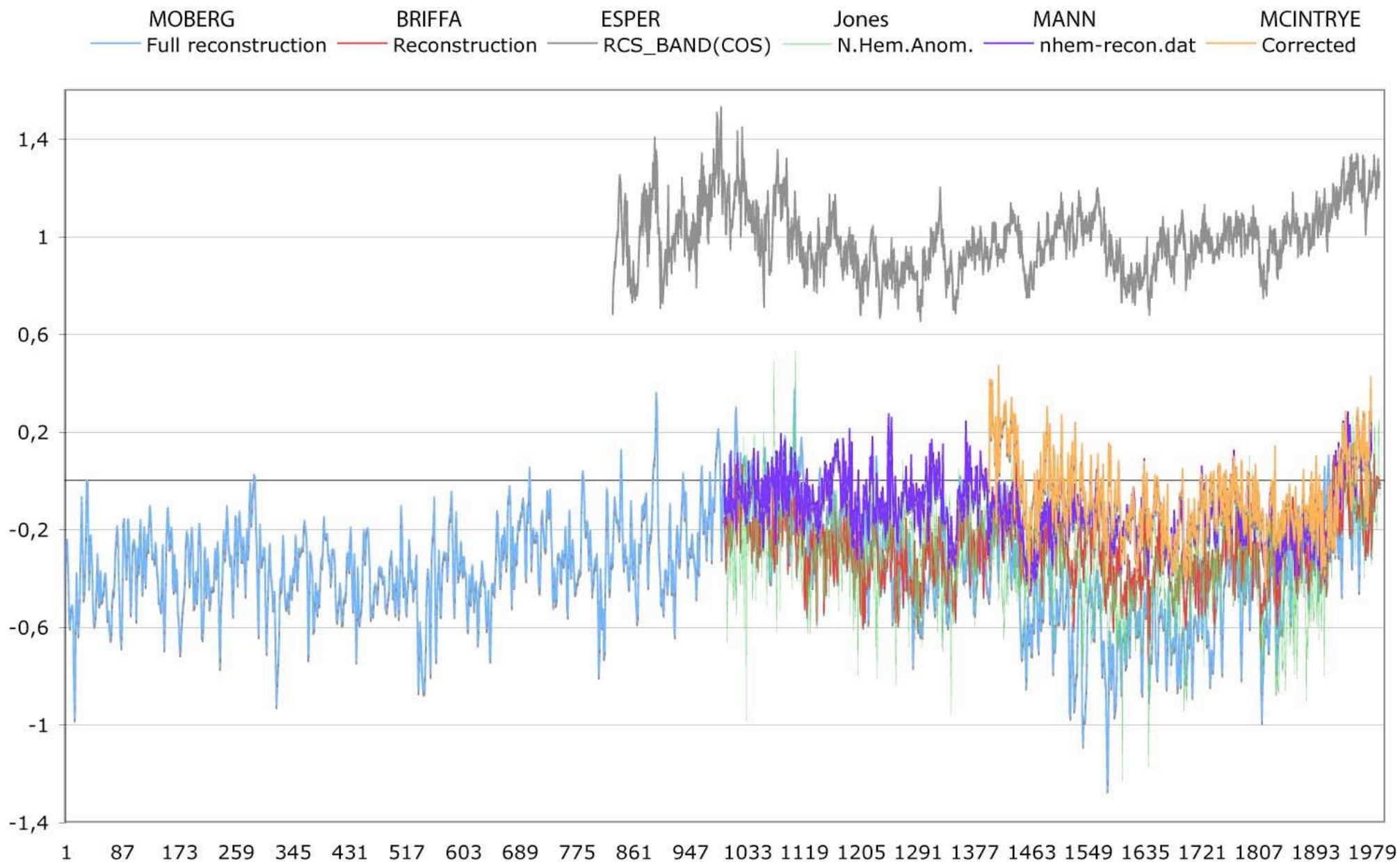
Conclusion

- Resulting from the application of the MBH98 algorithm to a network of pseudo-proxies.
- The variance of the pseudoproxies contains 50% noise (top panel: white noise; bottom panel: red noise with one-year lag-autocorrelation of 0.8).
- The pseudoproxies were subjected to separate PCA in North America, South America and Australia with **full** (1000-1980; red) or **partial** (1902-1980; blue) centering.
- **This specific critique of McIntyre and McKittrick is irrelevant for the problem of reconstructing historical climate.** (Other aspects may be, or may be not, valid.)



Overall Conclusions

1. Millennial simulations are useful laboratories to test empirical methods, which can not be really validated with reliably recorded data.
2. The MBH method is associated with a systematic underestimation of long-term variability.
3. The fundamental test of reproducing the known temperature history in any millennial simulation is failed by MBH for long-term variations.
4. The McMc-phenomenon of “artificial hockey sticks” (AHS) due to unwise centering of EOFs does not cause harm for the overall process.

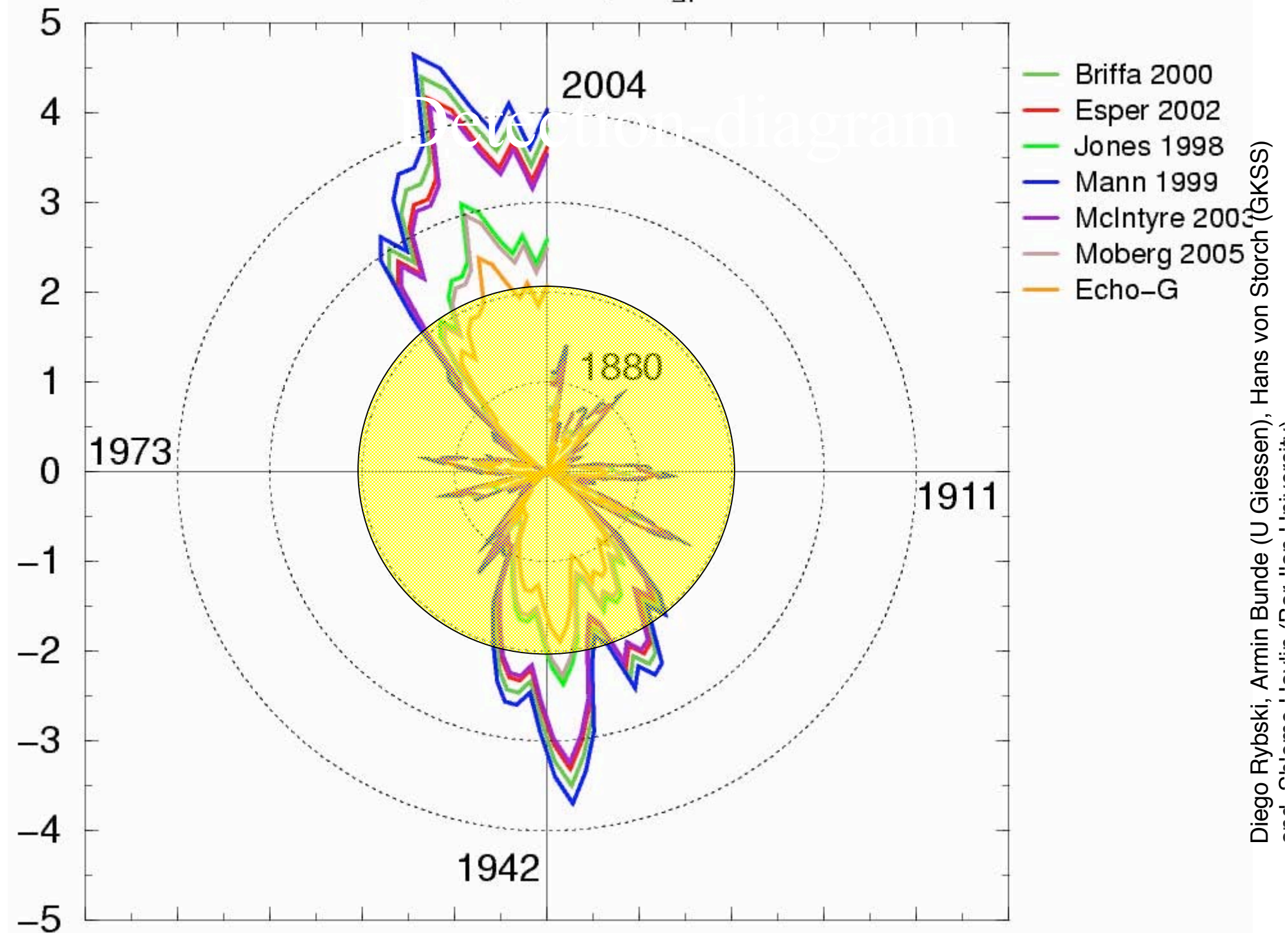


Diego Rybski, Armin Bunde (U Giessen), Hans von Storch (GKSS)
and Shlomo Havlin (Bar-Ilan University)

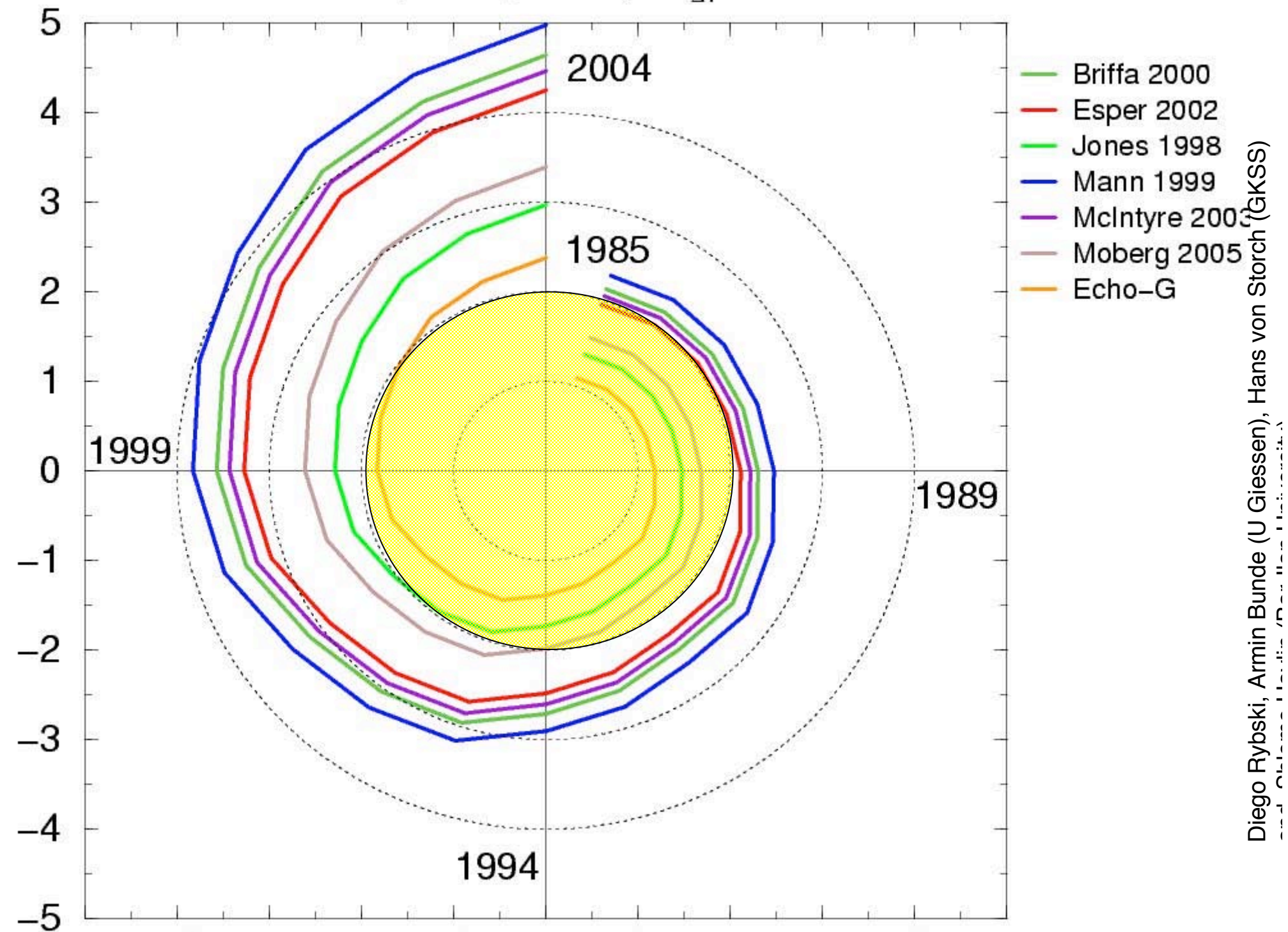
Historical Reconstructions – their significance for “detection”

- Historical reconstructions are academically interesting and of significance of assessing the “normality” of the most recent warming.
- Work in progress, with D. Rybsky & A. Bunde (U Giessen), S. Halvin (Bar-Ilan University) – results likely will need revision.
- Statistics of $\bar{T}_{L,m}$, which is the difference of two m -year temperature means, which are separated by L years.
- Temperature variations are modelled as Gaussian long-memory process, fitted to the various reconstructions.

$$\Delta T(m=5, L=20) / \sigma_{\Delta T}$$



$$\Delta T(m=30, L=100) / \sigma_{\Delta T}$$



Part I

with
Eduardo Zorita



Do not believe
advanced complex methods when
they are advanced as magic bullets.

Part II



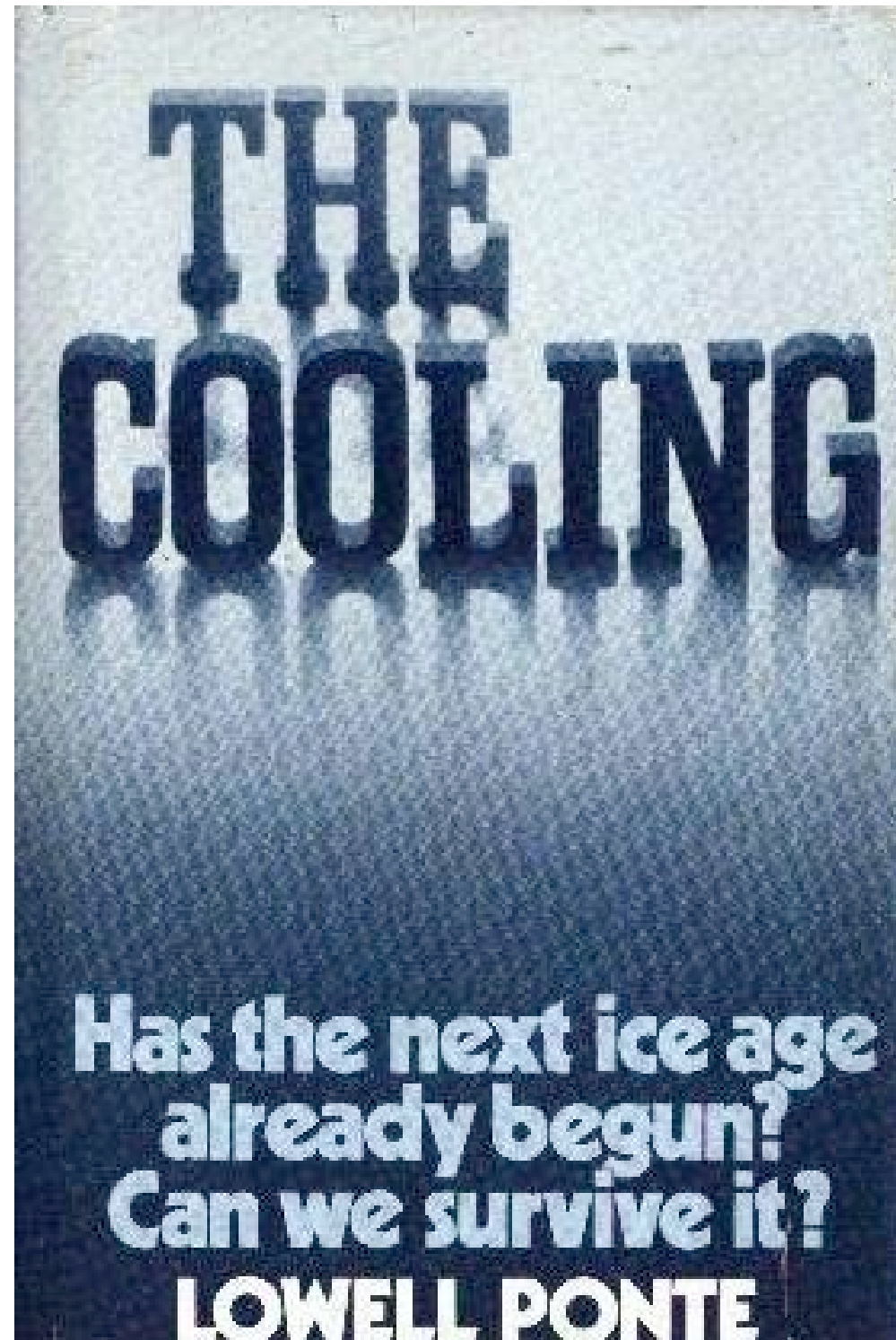
Subjective,
possibly biased, polemic
– but needed.

Science is a social process.

Can we organize climate science in a sustainable manner?

Postnormal science

- Science no longer curiosity-driven but potentially of great importance for policy definition and social practice.
- High stakes, high uncertainty.
- Other motives than quest for “truth”.



Climate science ...

- ... is definitely in a post-normal stage.
- It is heavily politicized.
- The distinction between activists and scientists is blurred.
- The community is split between a large majority of “pro’s” and a small minority of “con’s”.
- The “con’s” are **EVIL**.
- ... is it also in a post-sensible phase?
- Dennis Bray defines post-sensible science as follows; “when moral entrepreneurship begins to infuse the objectivity of scientific thought. This is not limited to any particular perspective but rather to the process of dissemination of scientific information excessively shaped by any moral persuasion.”

"Global warming 'worse than Hitler'"

<http://news.scotsman.com/scitech.cfm?id=512592005>

JOHN ROSS

THE advance of global warming is a greater threat than was the rise of Hitler in the 1940s, a leading supporter of renewable energy has claimed. Dr Jim Hunter, a former chairman of Highlands and Islands Enterprise, said alternative energy schemes were needed to tackle the problem, and he attacked those who opposed wind farms.

His remarks mirrored those of Sir David King, the government's chief scientific officer, who said recently climate change was a more severe problem than the threat of terrorism. ...

He said: "Global warming is a more insidious and longer-term danger than Hitlerism, but it's one that could be far more deadly. Ultimately, it might extinguish humanity itself."



The Committee on Energy and Commerce

Joe Barton, Chairman

U.S. House of Representatives

Letters Requesting Information Regarding Global Warming Studies

[Letter to IPCC Chairman Rajendra Pachauri](#),
requesting information regarding global warming
studies.

[Letter to National Science Foundation Director Arden
Bement](#), requesting information regarding global
warming studies.

[Letters to Dr. Michael Mann](#), requesting information
regarding global warming studies.

[Letter to Dr. Malcolm K. Hughes](#), requesting
information regarding global warming studies.

[Letter to Dr. Raymond S. Bradley](#), requesting
information regarding global warming studies.

####



The Committee on Energy and
Commerce
2125 Rayburn House Office Building
Washington, DC 20515
(202) 225-2927
[Contact Us](#)

The Committee concluded that:

The science of climate change leaves considerable uncertainty about the future.

The balance between mitigation and adaptation needs to be re-examined. The costs of mitigation are uncertain, as are the benefits which are also more distant. Adaptation – including for instance flood defences and water conservation – has recognisable costs and calculable benefits.

Because the Kyoto Protocol will make little difference to rates of warming and because a continuation of the same approach focusing excessively on emission reductions is likely to fail, the UK should take a lead in exploring alternative approaches based on agreements on carbon-free technology and its diffusion.

There are concerns about the objectivity of the IPCC process and about the IPCC's crucial emissions scenario exercise.

Positive aspects of global warming appear to have been downplayed in IPCC reports. The Government should press the IPCC to reflect the costs and benefits of climate change in a more balanced way.

HOUSE OF LORDS

Select Committee on Economic Affairs

2nd Report of Session 2004-05

The Economics of Climate Change

Volume I: Report

Ordered to be printed 21 June 2005 and published 6 July 2005

Published by the Authority of the House of Lords

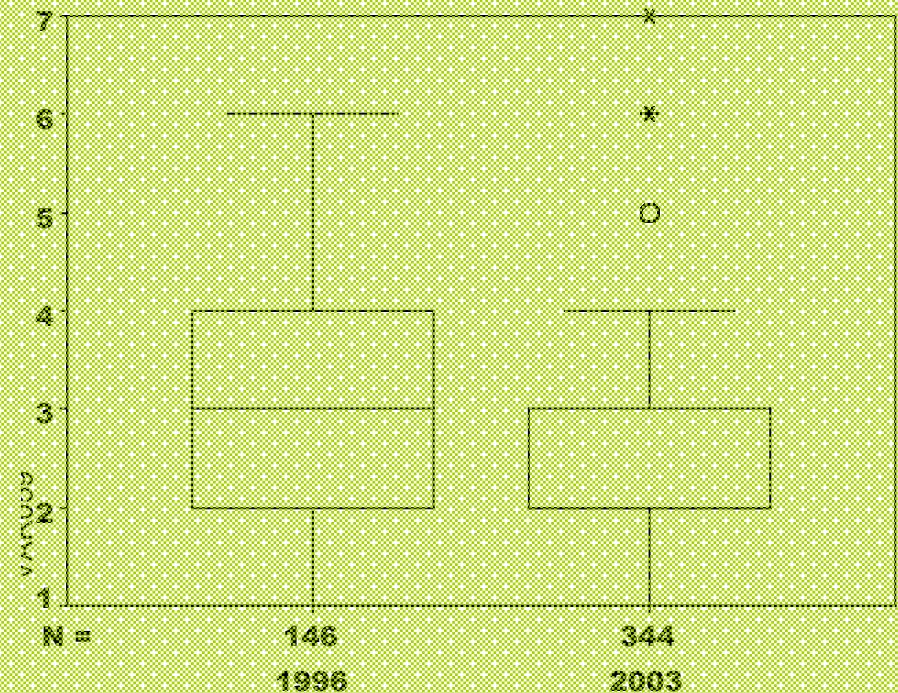
London: The Stationery Office

Overselling

- Spiral of ongoing practice of slight exaggeration results in the formation of significant misinformation in the public realm.
- Scientists are part of the public realm, and experts only in a rather narrow field.

To what extent are those who present the extremes of the climate debate, for example, those presenting the worst case scenarios or those claiming that climate change is a hoax, the people most likely to be listened to by those involved in making policy decisions?

1 = a great extent 7 = none at all; don't know no answer



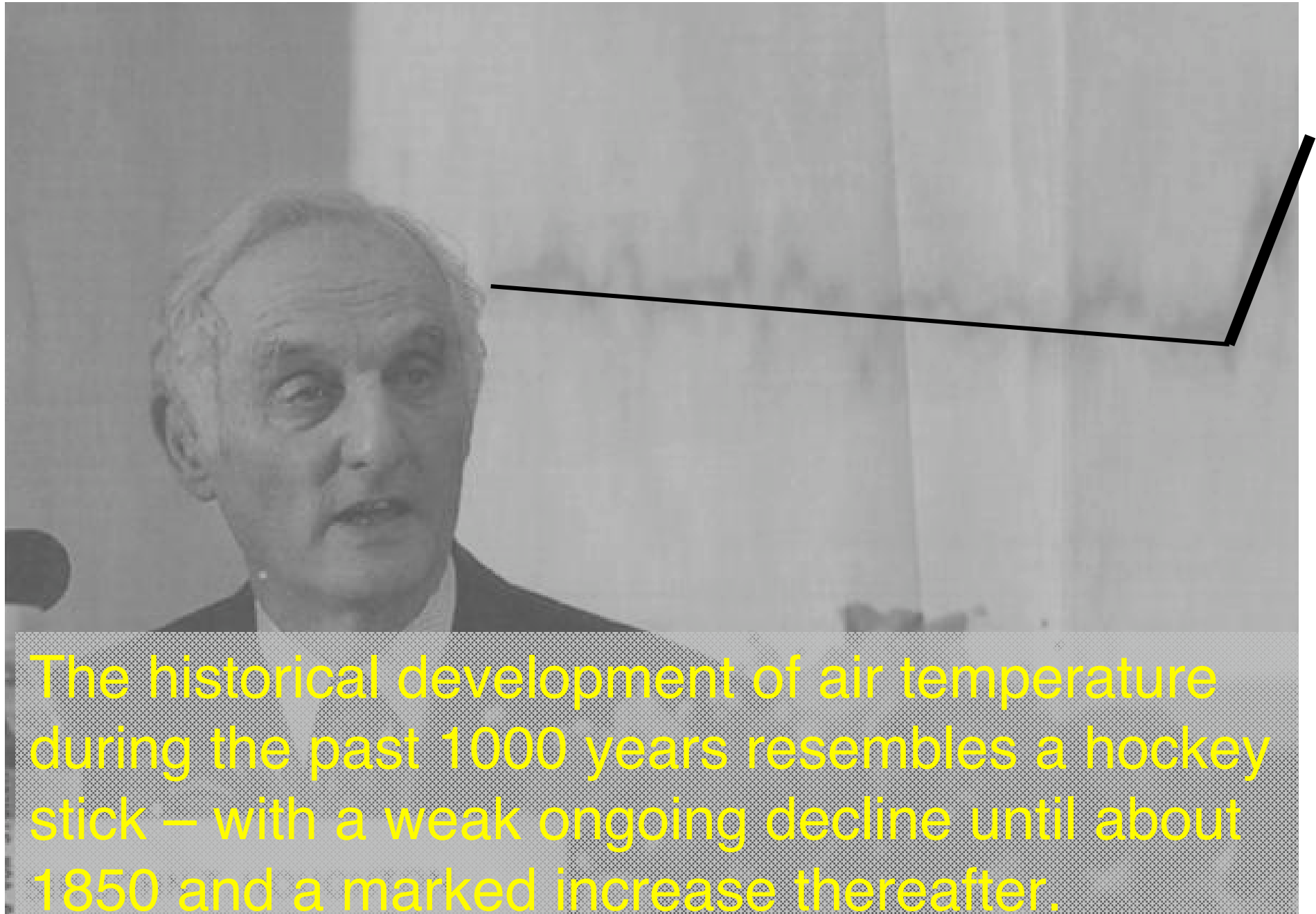
Bray and von Storch, 1996, 2003

Examples of overselling premature claims

The hockey stick

The link of disaster damages and ongoing climate change.

The claim of universal agreement to the IPCC assessment among climate scientists (the Oreskes case)

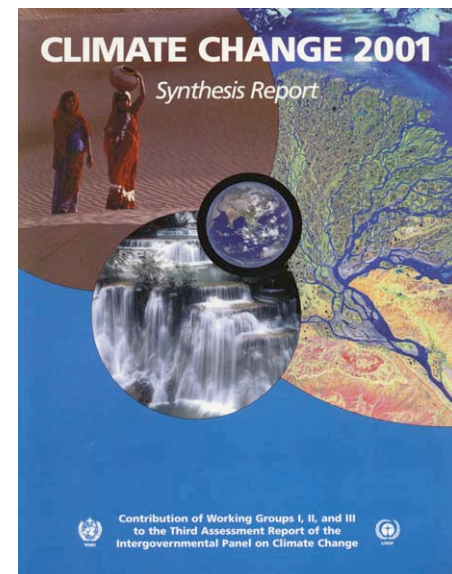


The historical development of air temperature during the past 1000 years resembles a hockey stick – with a weak ongoing decline until about 1850 and a marked increase thereafter.

Misleading exaggerating information by IPCC

Only this
reconstruction
is shown in
the IPCC TAR
Synthesis
Report....

Shown at least three
times, on p. 34, p. 152
and 174



Pachauri in nature

Was it unwise to give Mann's 'hockey stick' so much prominence in the IPCC's summary for policy-makers?

No. It is no exaggeration and it doesn't contradict the rest of the IPCC assessment. Of course you can always argue about details. But we assess all the available literature, and we found the hockey stick was consistent with that.

ASSESSING CLIMATE STABILITY

BAMS, 2004
Leading IPCC authors

BY PAUL R. EPSTEIN AND JAMES J. MCCARTHY

In the past 5 years extreme precipitation events and heat waves, and sequences of extremes (droughts followed by heavy rains), have been responsible for the unprecedented loss of human life worldwide. Hurricane Mitch in Honduras in 1998, with over 11,000 lives lost, severe rains in Venezuela in 1999, and intense flooding and three cyclones over 6 weeks in Mozambique stand out as outliers and events with long-lasting impacts on development. The pace of outliers appears to be quickening; in 1 year (summer 2003–summer 2004) the following occurred: temperatures and impacts associated with the surprisingly intense 2003 European summer heat wave far exceeded any of the model projections (Kalkstein and Greene 1997); intense rains on the island of Hispaniola in May 2004 registered 5 ft of rain in 36 h and killed over 3300; 520 tornadoes battered the middle of the United States in May 2004; 16 in. of rain fell on Guam in 24 h (27 June 2004), shattering the daily rainfall record of 3.16 in. set in 1962; and we just ended the sixth consecutive year of drought (perhaps the most severe in 500 years) in the western United States.

One impact measured by the IPCC—the *economic costs* related to more severe and volatile weather—deserves mention as an integral indicator of volatility. Costs associated with disasters rose from an average of \$4 billion per year in the 1980s to \$40 billion annually in the 1990s (1999 dollars; Vellinga and Mills 2001), and the United Nations Environmental Programme projects that, if current trends continue, the losses will rise to \$150 billion per year within this decade. While coastlines have become more populated and values of built structures on coastal property have risen, the number of extreme weather events has also risen in both hemispheres [see the online Emergency Events Database (EMDAT); www.emdat.net/]. In 2002, 2003, and 2004 the costs continued to rise, and the mounting costs of weather volatility and extremes has created considerable concern in the reinsurance industry (companies that insure the insurers).

Scientific debate constrained by ...

concern for the “evil” “skeptics”, and

concern for the “good” process of “Kyoto”.

Thus, the set of scientific knowledge claims enshrined in the IPCC reports must not be doubted.

Any failure of a key statement of the IPCC assessment reports is made to represent a failure of the entire concept of anthropogenic climate change.

Any statement, which may be used by the skeptics, is fended off.

Socio-politically constrained scientific discourse

The historical lesson of the emergence of new, with the contemporary scientific paradigm hardly consistent evidence, is not acknowledged in favor a socio-political correctness.

Science is downgraded to a repair-shop of contemporary knowledge claims.

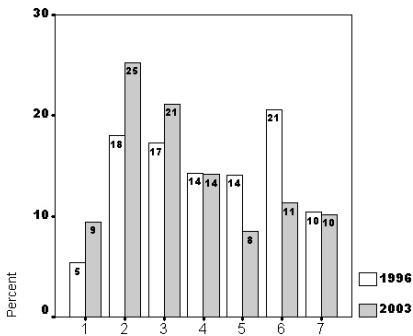
Under the veil of socio-political benevolence, a variety of subjective self-centered agendas are pursued, and deviating, scientifically possible valid approaches are fended off.

This practice is unsustainable and damages the social institution “science”.

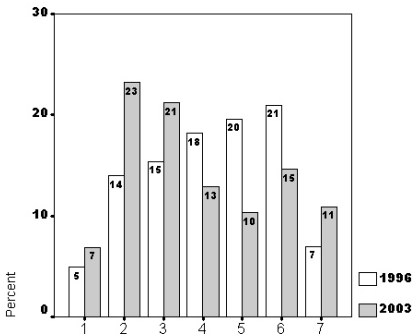
Climate Change is mostly the result of anthropogenic causes

1 = strongly agree
7 = strongly disagree

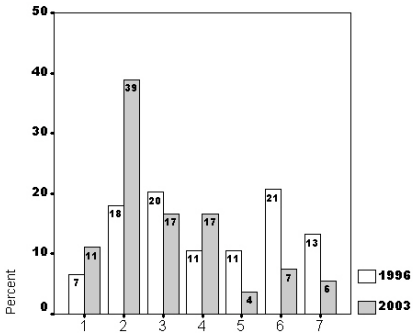
All



USA



Germany

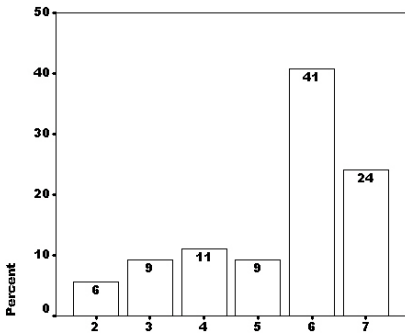
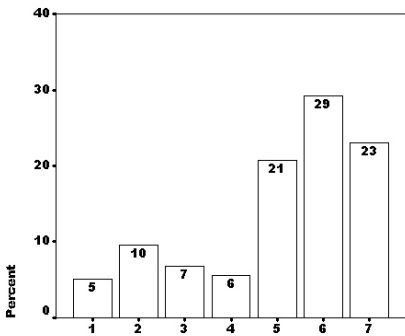
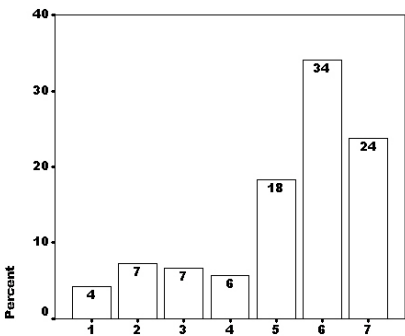


Sample

	1996	Freq	%
USA	49	27.3	
Canada	35	6.4	
Germany	228	41.8	
Italy	73	13.4	
Denmark	33	6.0	

How much does new scientific discovery in the last decade confirm anthropogenic influence on climate

1 = not at all
7 = a significant amount



Country	1996 Freq	1996 %	2003 Freq	2003 %
USA	372	66.7	14	2.5
Germany	56	10	10	1.8
Italy	14	2.5	14	2.5
Poland	1	0.2	1	0.2
Denmark	5	0.9	5	0.9
Netherlands	4	0.7	4	0.7
Sweden	5	0.9	5	0.9
France	5	0.9	5	0.9
UK	18	3.2	18	3.2
Australia	21	3.8	21	3.8
Norway	3	0.5	3	0.5
Finland	3	0.5	3	0.5
New Zealand	6	1.1	6	1.1
Austria	3	0.5	3	0.5
Ethiopia	1	0.2	1	0.2
South Africa	3	0.5	3	0.5
Switzerland	7	1.3	7	1.3
Mexico	3	0.5	3	0.5
Russia	1	0.2	1	0.2
Argentina	1	0.2	1	0.2
India	3	0.5	3	0.5
Spain	2	0.4	2	0.4
Japan	3	0.5	3	0.5
Brazil	1	0.2	1	0.2
Taiwan	1	0.2	1	0.2
Bulgaria	1	0.2	1	0.2
Total	557		557	

The morale of all this?

Science is a social process.

Long-term acceptance of explanations (theories) is mostly based on evidence and logic, but on short time scales, social arguments and pre-scientific contexts are also important.

We need to confront claims-making with the same vigor, independently if the claims serve skeptic's or Kyoto-agendas.

Break the power of “alarmists” disguised as scientists.

Engage “skeptics” in a constructive dialogue.

Just for the fun of it

... who are the beneficiaries when the perception of anthropogenic, catastrophic climate change prevails?

- **climate scientists**, who are rewarded with attention, public recognition, careers and funding.
- **insurance companies**, who find their clients more willing to proactively pay for perceived enhanced risks.
- **green political movements**, who use the threat of severe man-made climatic interruptions as most useful argument to push other environmental agendas as well.

The morale of all this?

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Break the power of “alarmists” disguised as scientists.

Engage “skeptics” in a constructive dialogue.

Implications for detection of abrupt climate change

“Abrupt change” is a non-property, like “non linear”.
Abrupt = not continuous.

A proof of absence of “abrupt change” is not possible, because the rejection of the null hypothesis “continuous change”

“Abrupt change” research is socially rewarded.

Historical reconstructions based on statistical principles can reveal only repeated, similar events. Abrupt changes are often perceived as unique, unprecedented events.

Statistical reconstructions likely underestimate the frequency and intensity of past abrupt changes.