Testimony of Edward J. Wegman

I would like to begin by circumscribing the substance of our report. We were asked to provide an independent verification by statisticians of the critiques of the statistical methodology found in the papers of Drs. Michael Mann, Raymond Bradley and Malcolm Hughes published respectively in *Nature* in 1998 and in *Geophysical Research Letters* in 1999. These two papers have commonly been referred to as MBH98 and MBH99. The critiques have been made by Stephen McIntyre and Ross McKitrick published in *Energy and Environment* in 2003 and in *Energy and Environment* and in *Geophysical Research Letters* in 2005. We refer to these as MM03, MM05a, and MM05b respectively. We were also asked about the implications of our assessment. We were not asked to assess the reality of global warming and indeed this is not an area of our expertise. We do not assume any position with respect to global warming except to note in our report that the instrumented record of global average temperature has risen since 1850 according to the MBH 99 chart by about 1.2º centigrade. In the NAS panel Report chaired by Dr. North, .6º centigrade is mentioned in several places.

Our panel is composed of Edward J. Wegman (George Mason University), David W. Scott (Rice University), and Yasmin H. Said (The Johns Hopkins University). This Ad Hoc Panel has worked pro bono, has received no compensation, and has no financial interest in the outcome of the report.

[Go to Figure 1]

MBH98, MBH99 use several proxy indicators to measure global climate change. Primarily, these include historical records, tree rings, ice cores, and coral reefs. More details of proxies are given in the report and mentioned in the written testimony. [The width and density of tree rings vary with climatic conditions (sunlight, precipitation, temperature, humidity, and carbon dioxide and nitrogen oxides availability), soil conditions, tree species, tree age, and stored carbohydrates in the trees. The width and density of tree rings are dependent on many confounding factors, making isolation of the climatic temperature signal uncertain. It is usually the case that width and density of tree rings are monitored in conjunction in order to more

accurately use them as climate proxies. Ice cores are the accumulation of snow and ice over many years that have recrystallized and have trapped air bubbles from previous time periods. The composition of these ice cores, especially the presence of hydrogen and oxygen isotopes, provides a picture of the climate at the time. The relative concentrations of the heavier isotopes in the condensate indicate the temperature of condensation, allowing for ice cores to be used in global temperature reconstruction. In addition to the isotope concentration, the air bubbles trapped in the ice cores allow for measurement of the atmospheric concentrations of trace gases, including greenhouse gases carbon dioxide, methane, and nitrous oxide.]

[Go to Figure 2]

Some examples of tree ring proxy series are given in Figure 2. Most of the proxy series show little structure, but the last two show the characteristic ‘hockey stick’ shape. The principal component-like methodology in MBH 98/99 preferentially emphasizes these shapes as we shall see.

Principal component analysis methodology is at the core of the MBH98/99 analysis methodology. Principal component analysis is a statistical methodology often used for reducing datasets with many variables into datasets with fewer, but composite variables. The time series proxy data involved are transformed into their principal components, where the first principal component is intended to explain most of the variation present in the data variables. Each subsequent principal component explains less and less of the variation. In the methodology of MBH98/99, the first principal component is used in the temperature reconstruction.

[Go to Figure 3]

Two principal methods for temperature reconstructions have been used; CFR (climate field construction used in MBH98/99) and CPS (climate-plus-scale). The CFR is essentially the principal component based analysis and the CPS is a simple averaging of climate proxies. The controversy of the MBH98/99 methods lies in that the proxies are incorrectly centered on the mean of the period 1902-1995, rather than on the whole time period. The proxy data exhibiting the hockey stick

shape are actually decentered low. The updated MBH99 reconstruction is given in Figure 3. This fact that the proxies are centered low is apparent in Figure 3 because for most of the 1000 years, the reconstruction is below zero. Because the 'hockey stick' proxies are centered too low, they will exhibit a larger effective 'variance', allowing the method to exhibit a preference for selecting them as the first principal component. The net effect of this decentering using the proxy data in MBH98 and MBH99 is to produce a 'hockey stick' shape. Centering on the overall mean is a critical factor in using the principal component methodology properly.

[Go to Figure 4]

To illustrate this, we consider the North America Tree series and apply the MBH98 methodology. The top panel shows the result from the de-centering. The bottom panel shows the result when the principal components are properly centered. Thus the centering does make a significant difference to the reconstruction.

[Go to Figure 5]

To further illustrate this, we digitized the temperature profile published in the IPCC 1990 report and applied both the CFR and the CPS methods to them. The data used here are 69 unstructured noise pseudo-proxy series and only one copy of the 1990 profile. The upper left panel illustrates the PC1 with proper centering. In other words, no structure is shown. The other 3 panels indicate what happens using principal components with an increasing amount of de-centering. Again, the single series begins to overwhelm the other 69 pure noise series. Clearly, these have a big effect.

It is not clear that Mann and associates realized the error in their methodology at the time of publication. Our re-creation supports the critique of the MBH98 methods.

In general, we found the writing in MBH98 and MBH99 to be somewhat obscure and incomplete and the criticisms by MM03/05a/05b to be valid. The reasons for setting 1902-1995 as the calibration period presented in the narrative of MBH98 sounds plausible, and the error may be easily overlooked by someone not

trained in statistical methodology. We note that there is no evidence that Dr. Mann or any of the other authors in paleoclimate studies have had significant interactions with mainstream statisticians.

Because of this apparent isolation, we decided to attempt to understand the paleoclimate community by exploring the social network of authorships in temperature reconstruction.

[Go to Figure 6]

We found that at least 43 authors have direct ties to Dr. Mann by virtue of coauthored papers with him. Our findings from this analysis suggest that authors in the area of this relatively narrow field of paleoclimate studies are closely connected. Dr. Mann has an unusually large reach in terms of influence and in particular Drs. Jones, Bradley, Hughes, Briffa, Rutherford and Osborn.

[Go to Figure 7]

Because of these close connections, independent studies may not be as independent as they might appear on the surface. Although we have no direct data on the functioning of peer review within the paleoclimate community, but with 35 years of experience with peer review in both journals as well as evaluation of research proposals, peer review may not have been as independent as would generally be desirable.

[Go to Figure 8]

Figure 8 is a graphic that depicts a number of papers in the paleoclimate reconstruction area together with some of the proxies used. We note that many of the proxies are shared. Using the same data also suggests a lack of independence.

The MBH98/99 work has been sufficiently politicized that this community can hardly reassess their public positions without losing credibility. Overall, our committee believes that the MBH99 assessment that the decade of the 1990s was the likely the hottest

decade of the millennium and that 1998 was likely the hottest year of the millennium cannot be supported by their analysis.

Recommendations

Recommendation 1. Especially when massive amounts of public monies and human lives are at stake, academic work should have a more intense level of scrutiny and review. It is especially the case that authors of policy-related documents like the IPCC report, *Climate Change 2001: The Scientific Basis*, should not be the same people as those that constructed the academic papers.

Recommendation 2. We believe that federally funded research agencies should develop a more comprehensive and concise policy on disclosure. All of us writing this report have been federally funded. Our experience with funding agencies has been that they do not in general articulate clear guidelines to the investigators as to what must be disclosed. Federally funded work including code should be made available to other researchers upon reasonable request, especially if the intellectual property has no commercial value. Some consideration should be granted to data collectors to have exclusive use of their data for one or two years, prior to publication. But data collected under federal support should be made publicly available.

Recommendation 3. With clinical trials for drugs and devices to be approved for human use by the FDA, review and consultation with statisticians is expected. Indeed, it is standard practice to include statisticians in the application-for-approval process. We judge this to be a good policy when public health and also when substantial amounts of monies are involved, for example, when there are major policy decisions to be made based on statistical assessments. In such cases, evaluation by statisticians should be standard practice. This evaluation phase should be a mandatory part of all grant applications and funded accordingly.

Recommendation 4. Emphasis should be placed on the Federal funding of research related to fundamental understanding of the mechanisms of climate change. Funding should focus on interdisciplinary teams and avoid narrowly focused discipline research.

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Archive	Minimum Sampling Interval	Temporal Range (order:yr)	Potential Information Derived
Historical records	day/hr	~10^3	T, P, B, V, M, L, S
Tree rings	yr/season	~10^4	T, P, B, V, M, S, C_A
Lake sediments	yr to 20 yr	~10^4-10^6	T, B, M, P, V, C_W
Corals	yr	~10^4	C_W, L, T, P
Ice cores	yr	~5 x 10^4	T, P, C_A, B, V, M, S
Pollen	20 yr	~10^5	T, P, B
Speleothems	100 yr	~5 x 10^5	C_W, T, P
Paleosols	100 yr	~10^6	T, P, B
Loess	100 yr	~10^6	P, B, M
Geomorphic feat.	100 yr	~10^6	T, P, V, L, P
Marine sediments	500 yr	~10^7	T, C_W, B, M, L, P

Characteristics of Natural Archives

T = temperature
C = chemical composition of air or water
V = volcanic eruptions
L = sea level
P = precipitation, humidity, water balance
B = information on biomass, vegetation patterns
M = geomagnetic field variations
S = solar activity

After Bradley and Eddy (1991)

FIGURE 1

Sample Proxy Series

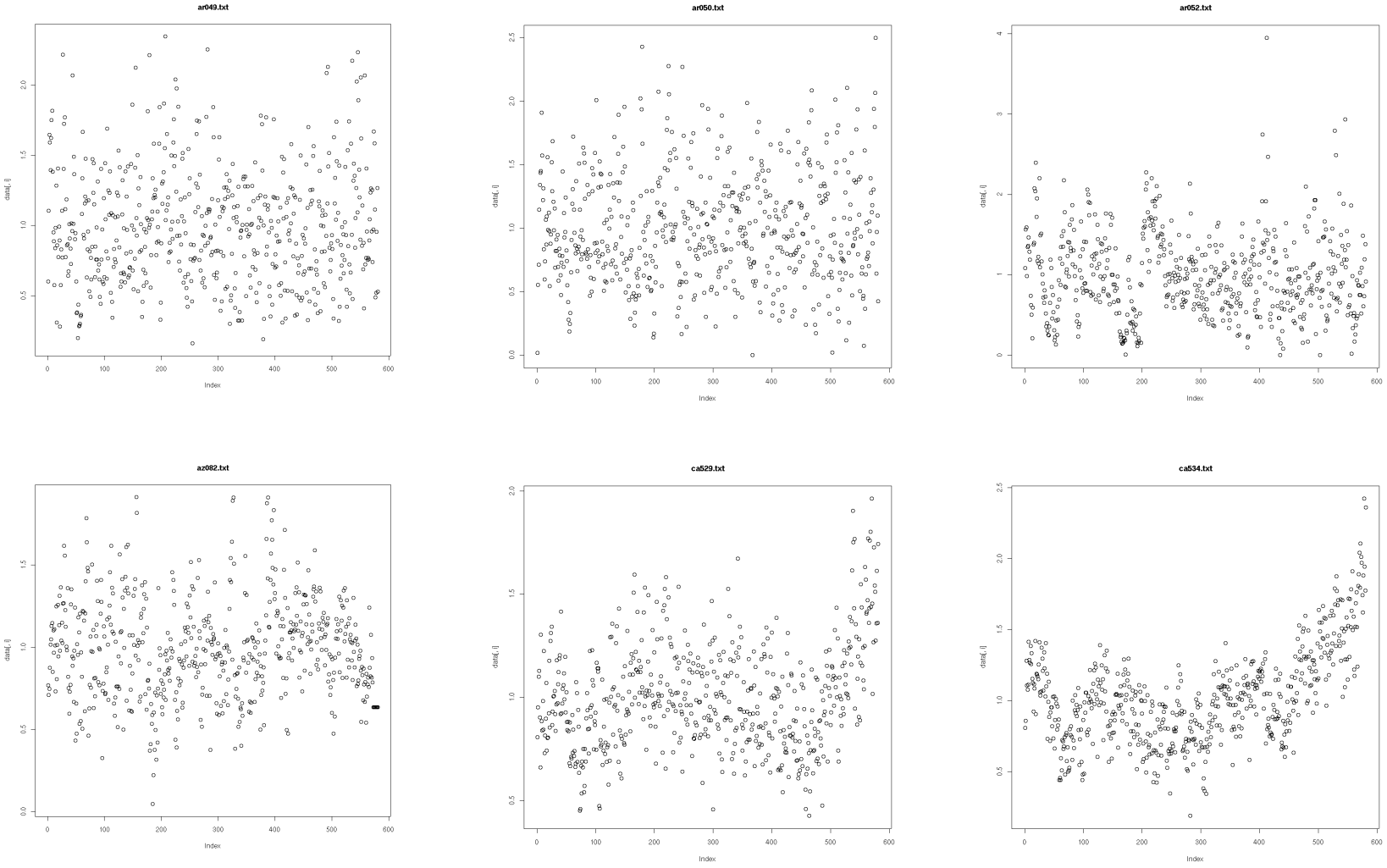
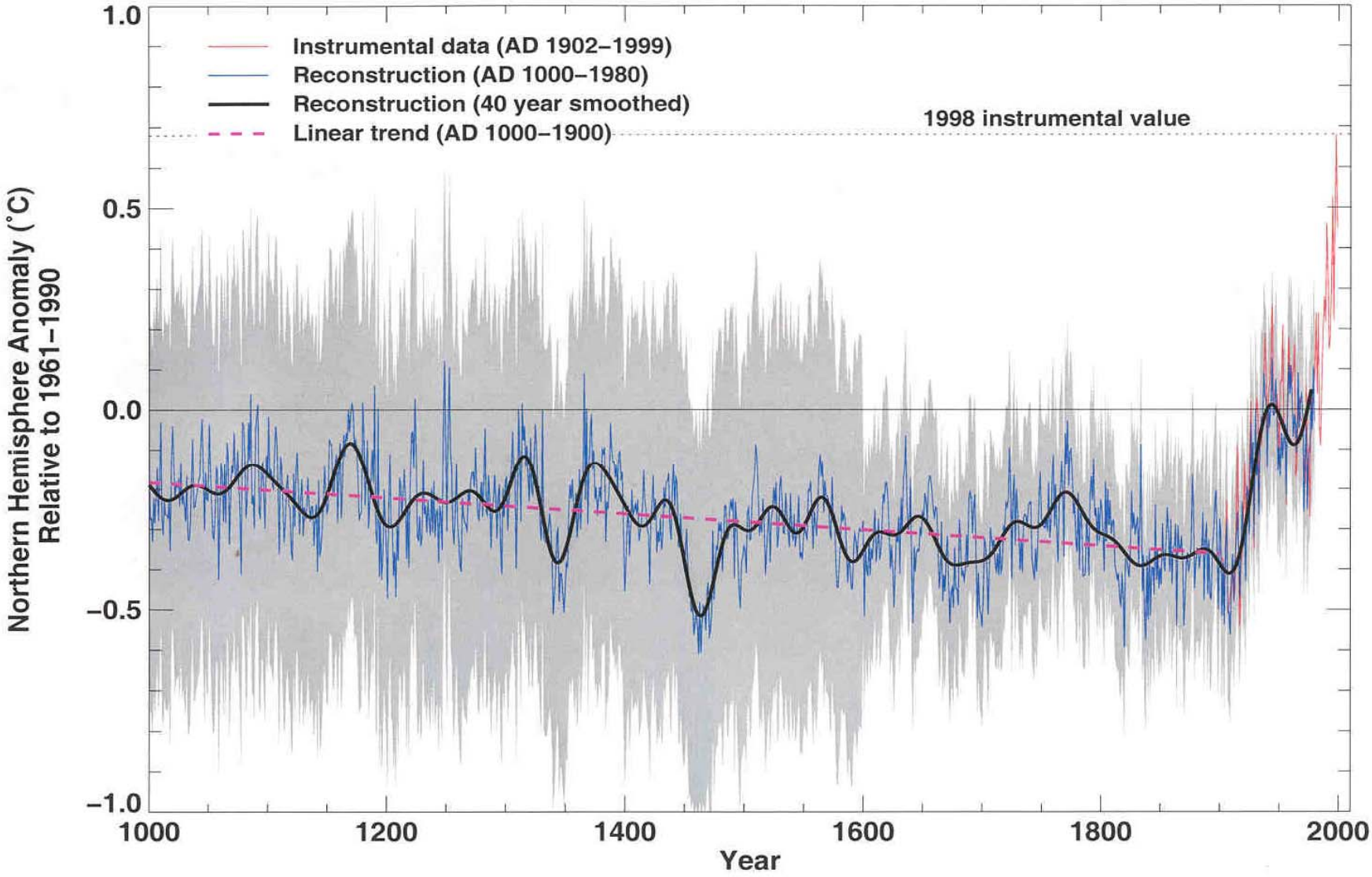
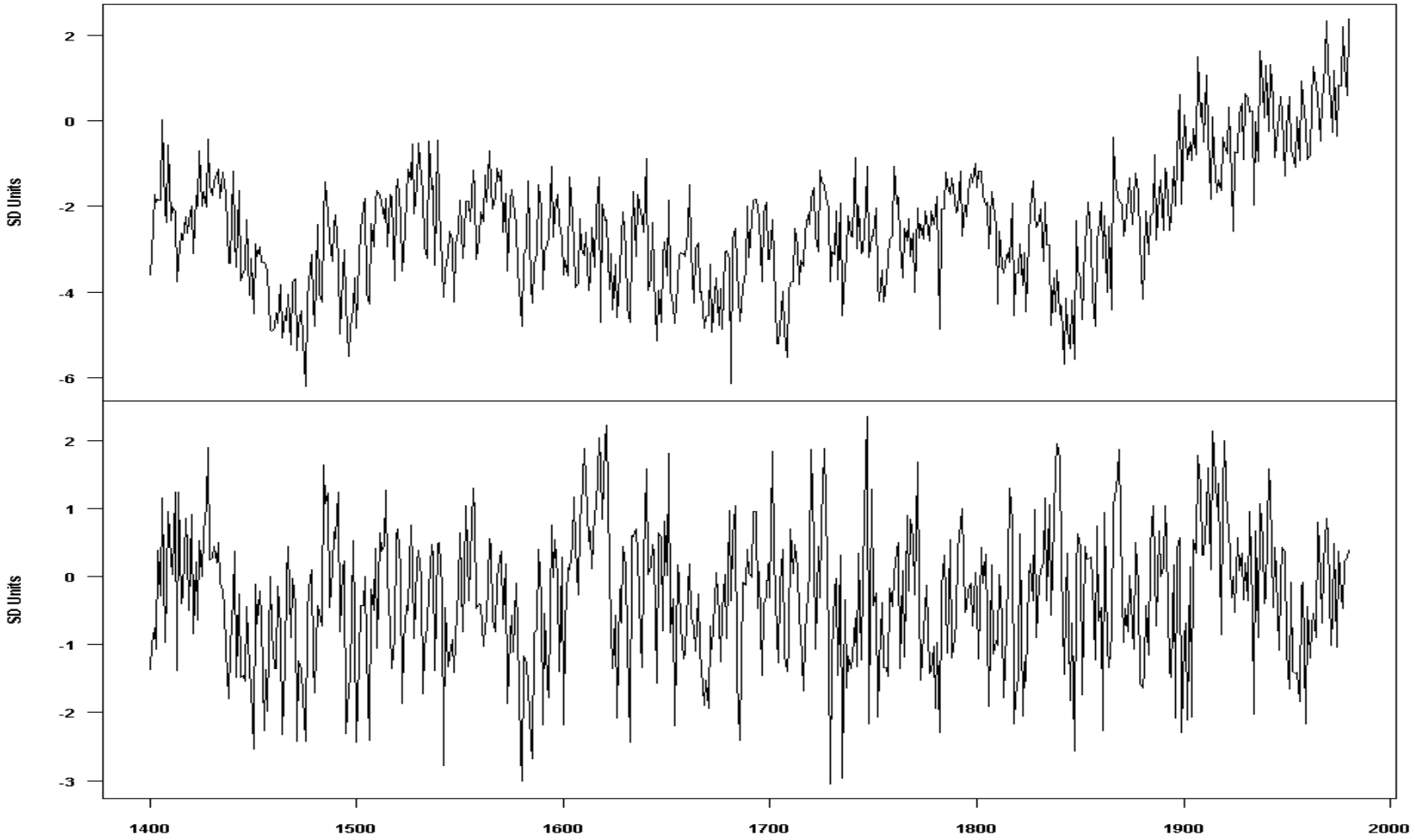


FIGURE 2



Last Updated in August 2000 by Ian Macadam.

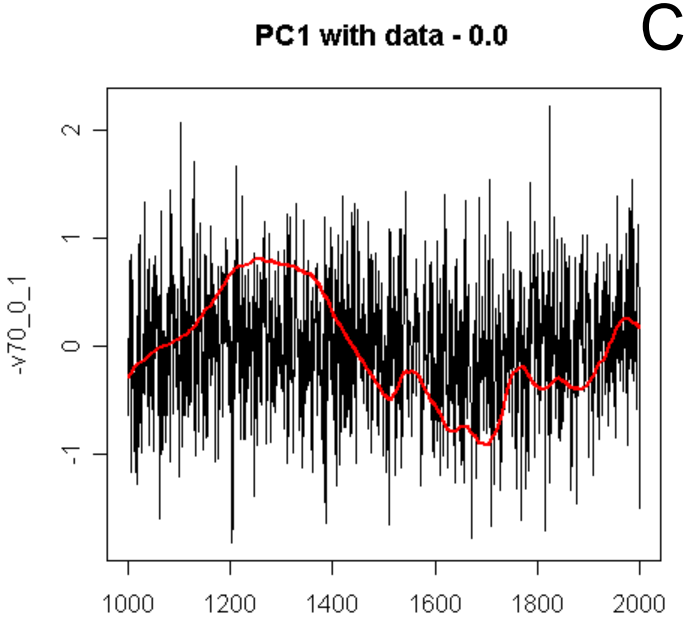
FIGURE 3

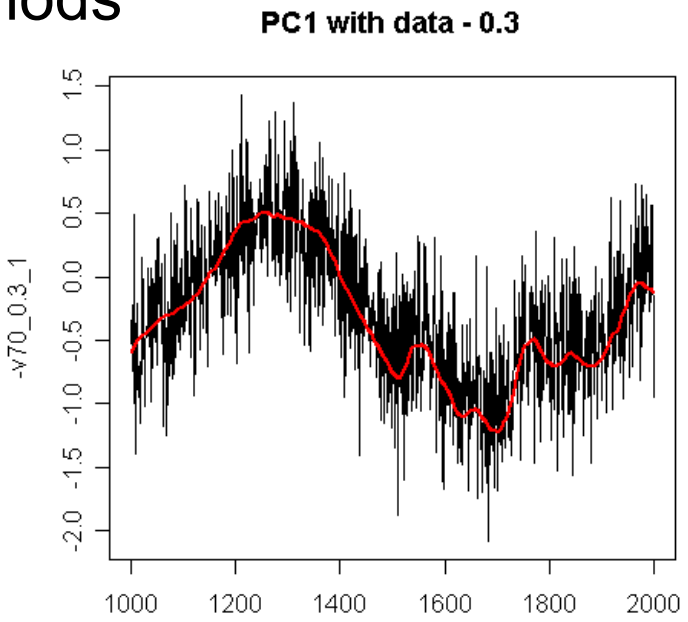


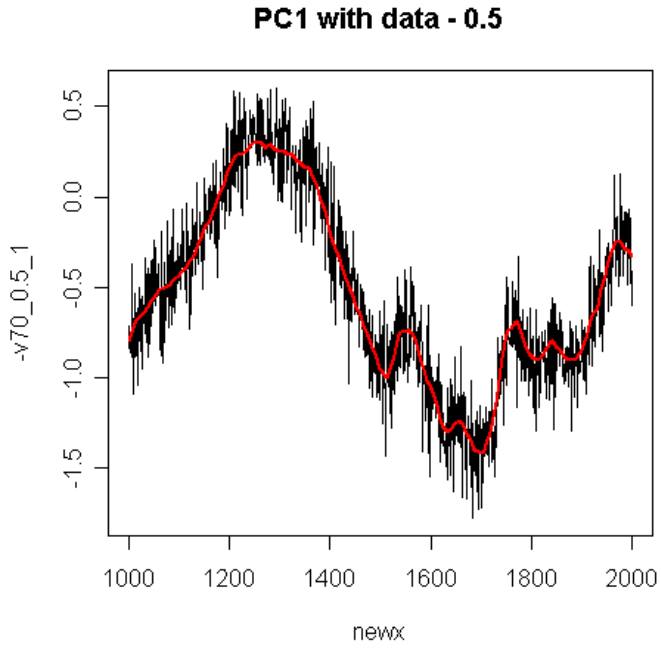
Top Panel is the MBH98 reconstruction
Bottom Panel is the centered PCA reconstruction

FIGURE 4

CFR Methods







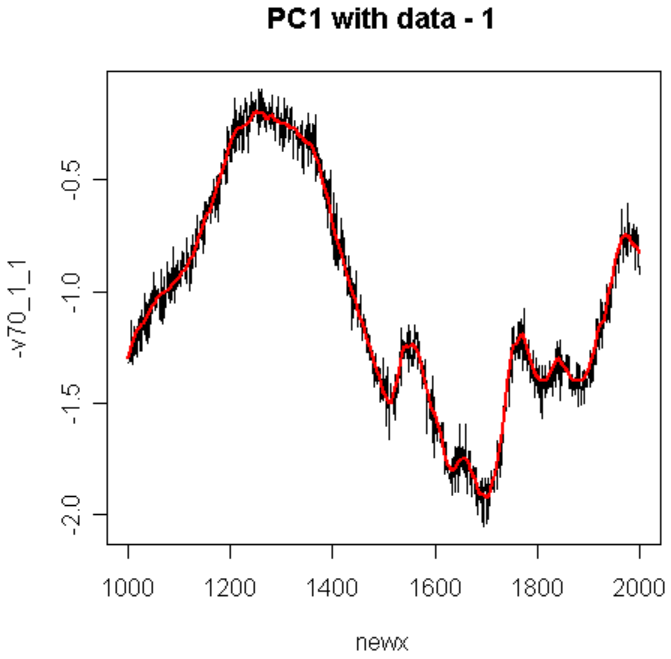
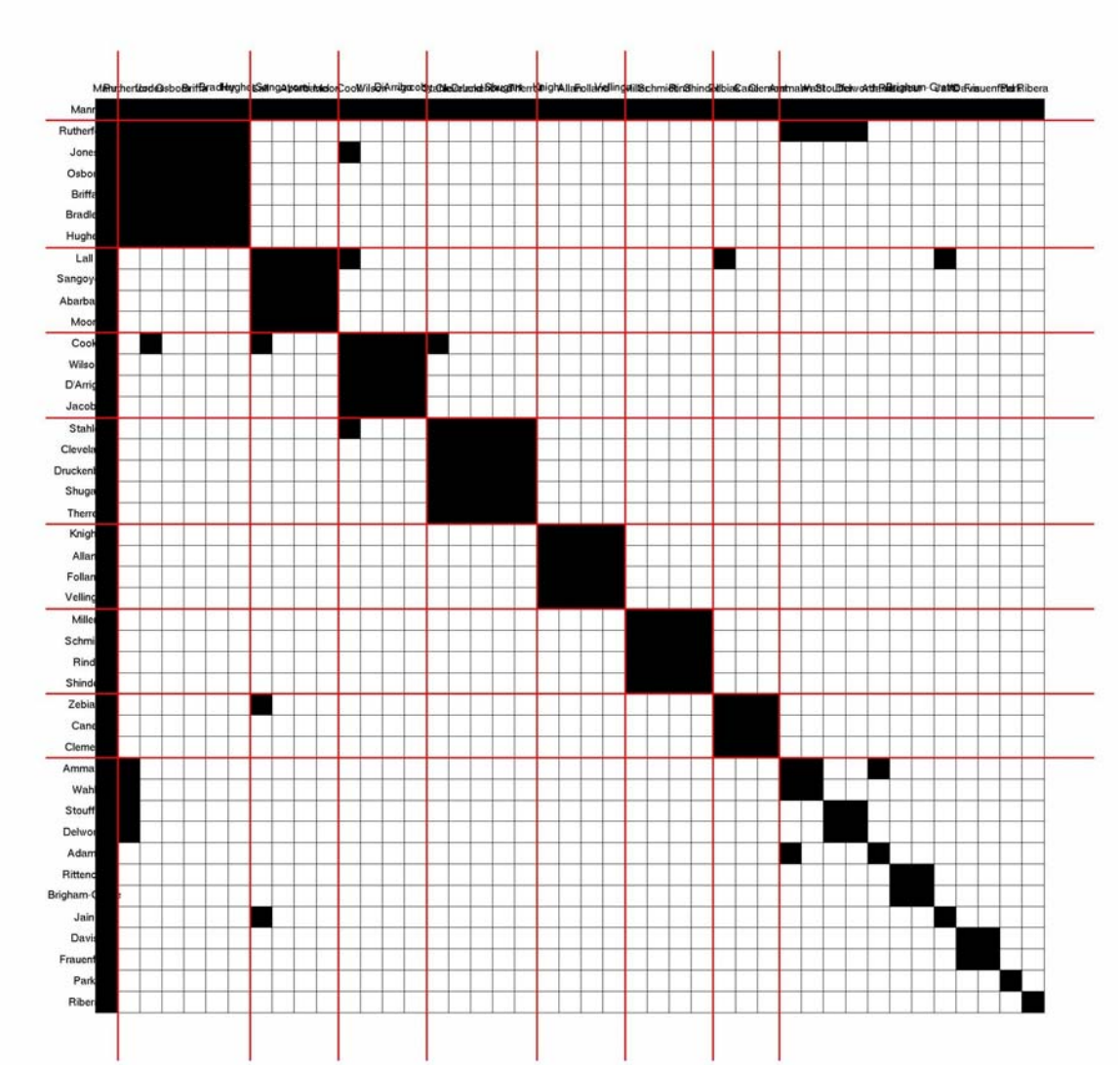
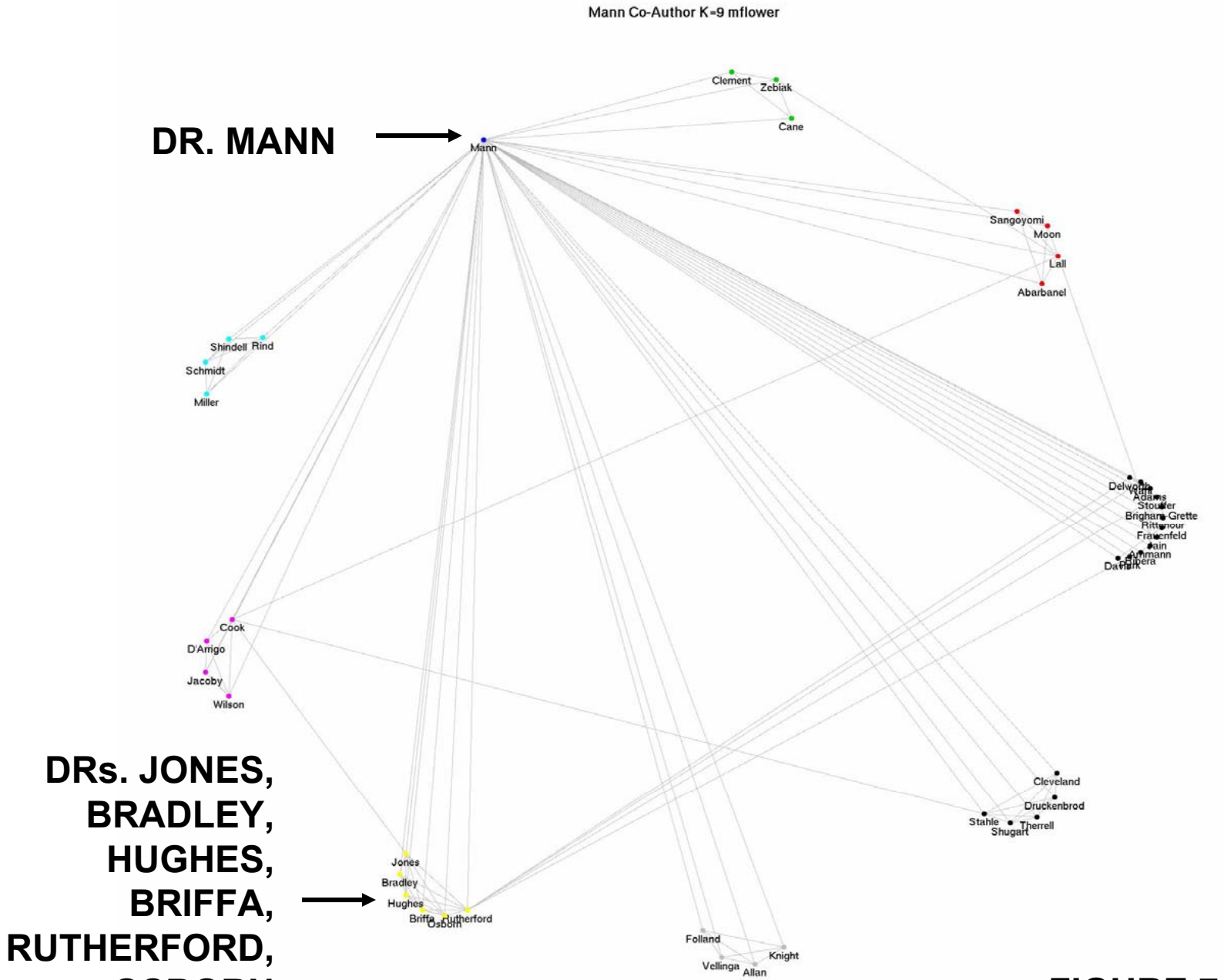


Figure 5



Mann-Rutherford-Jones-Osborn-Briffa-Bradley-Hughes

FUGURE 6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Jacoby
Wilson
Cleveland
Druckenbrod
Stahle
Therrell
Shugart
DRs. JONES, BRADLEY, HUGHES, BRIFFA, RUTHERFORD, OSBORN
Jones
Bradley
Hughes
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Rutherford
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Folland
Knight
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FIGURE 7

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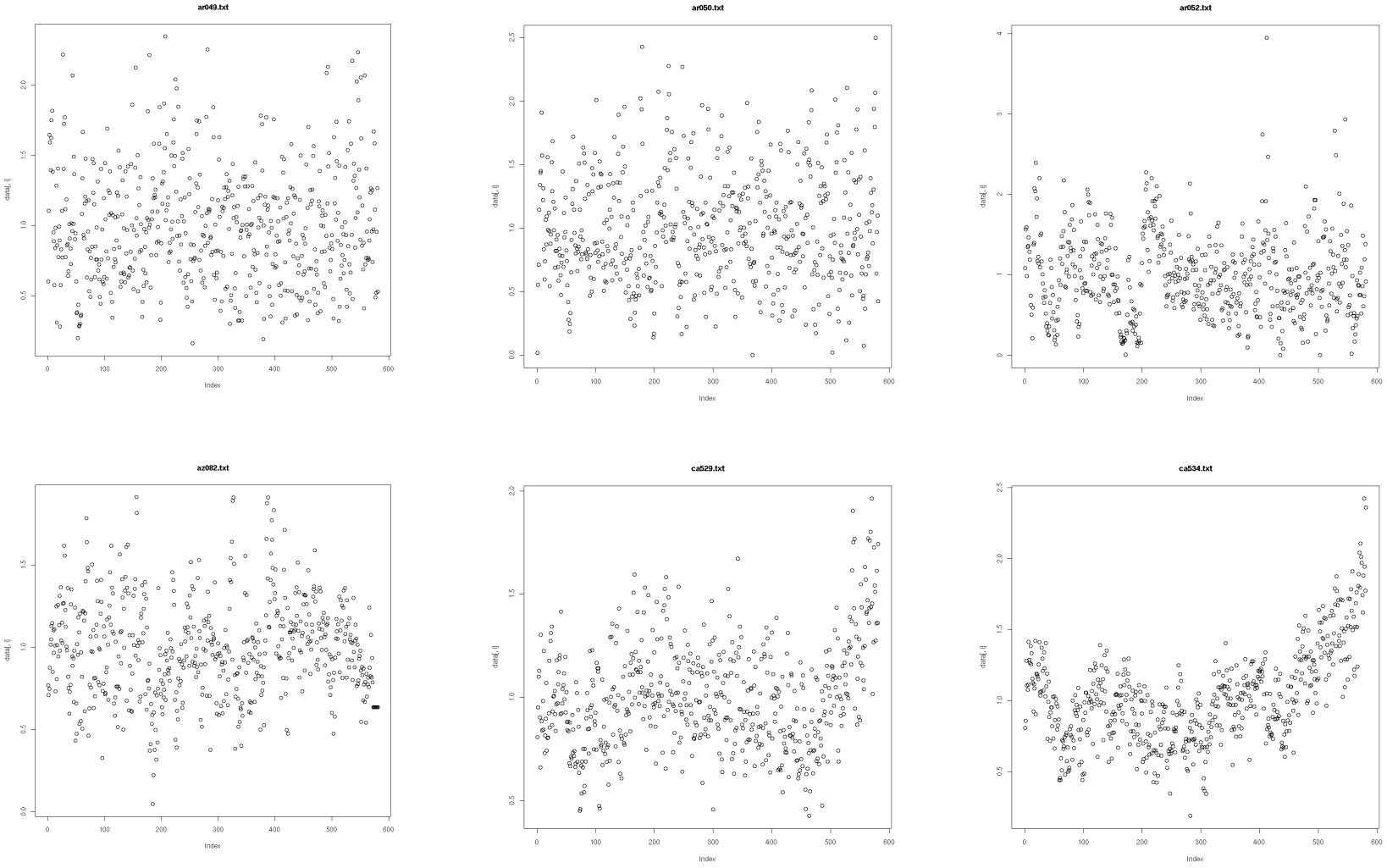

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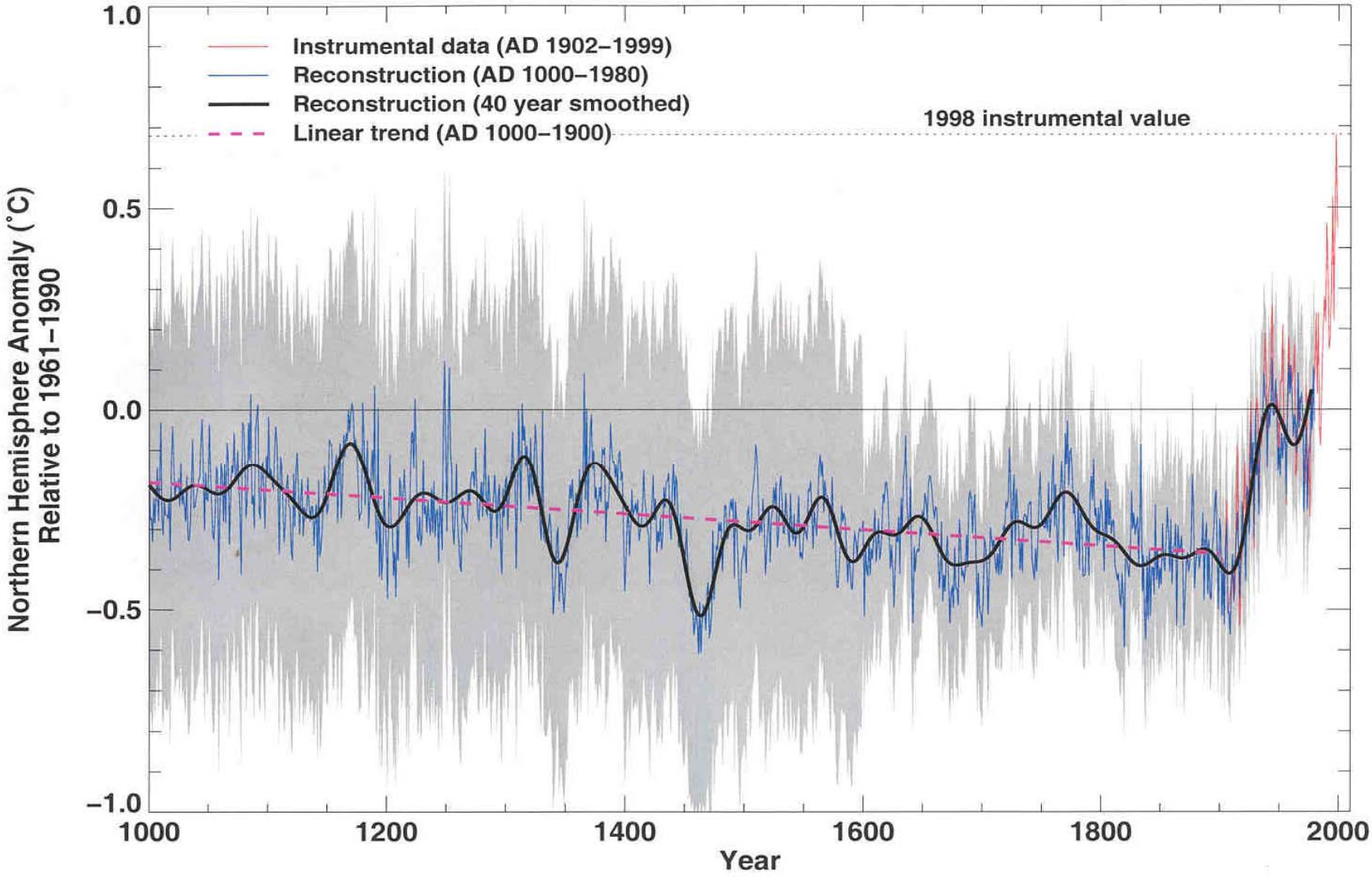

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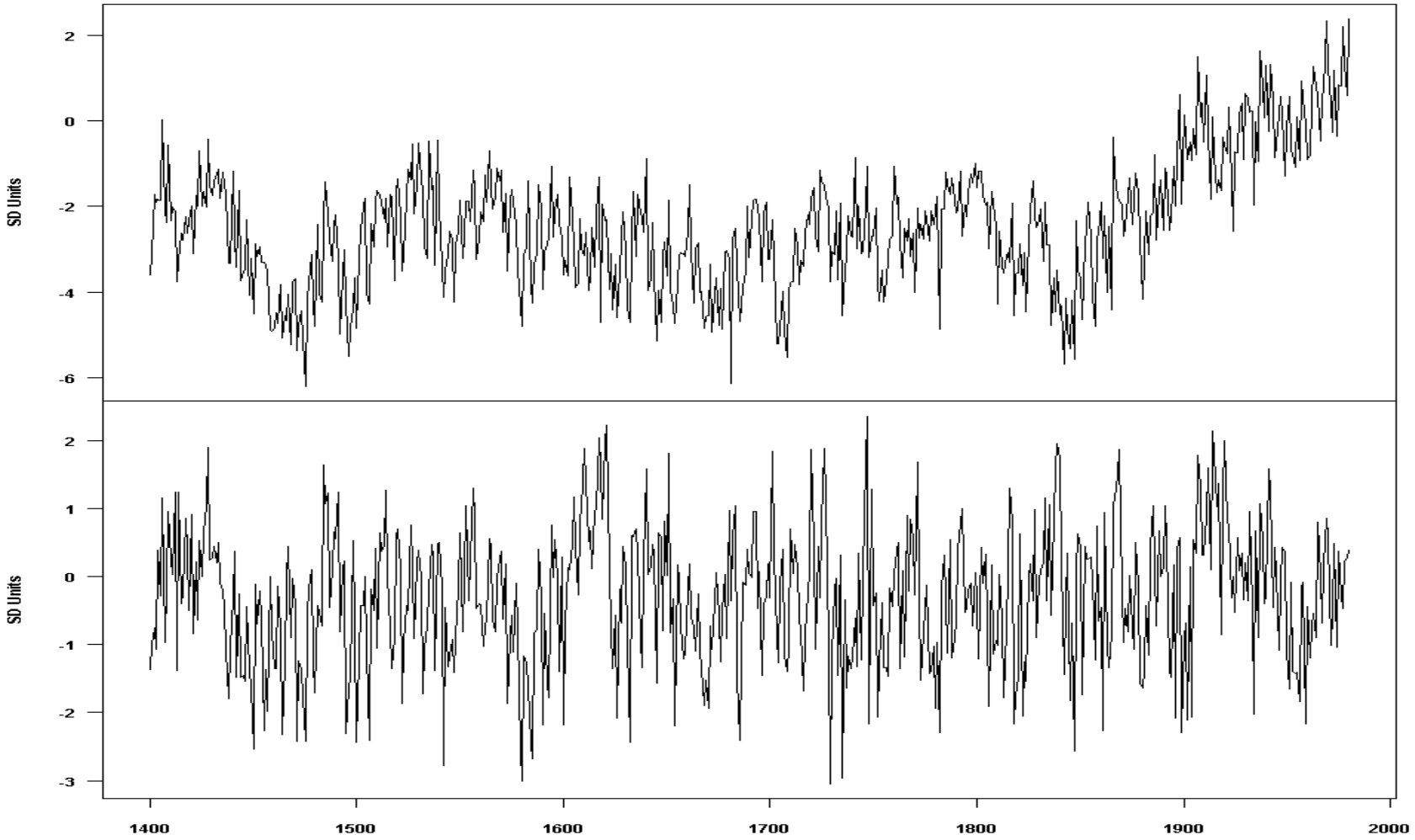

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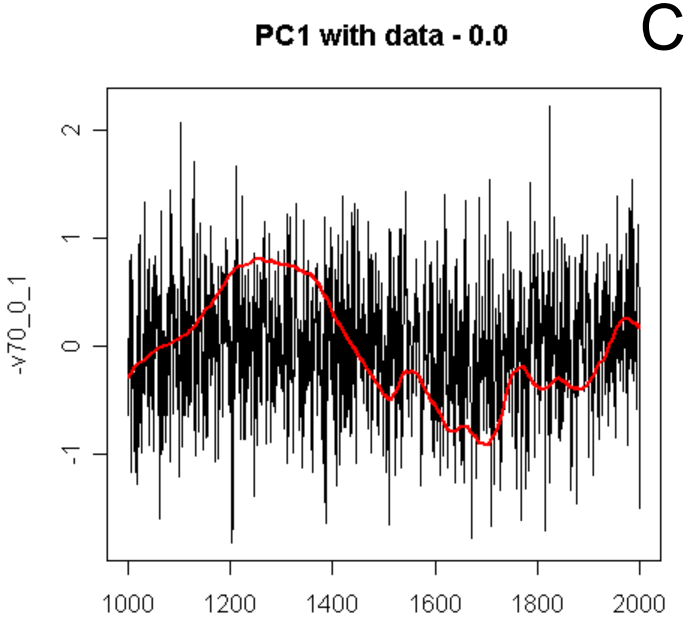

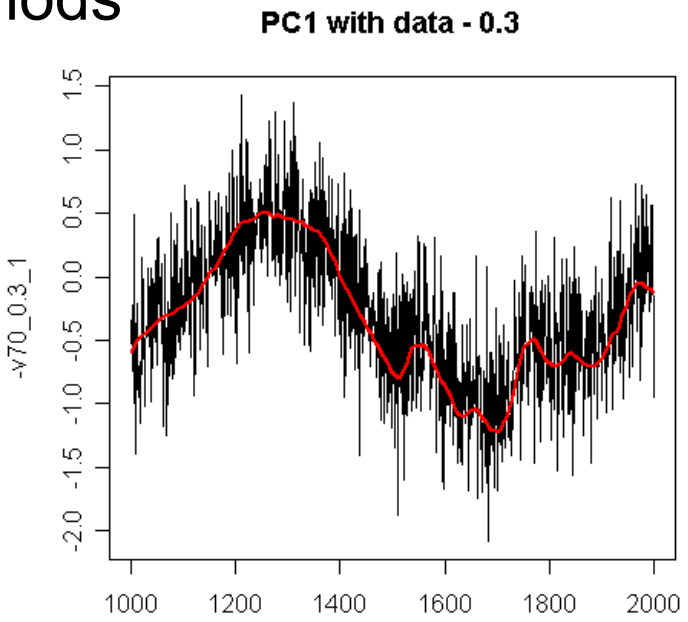

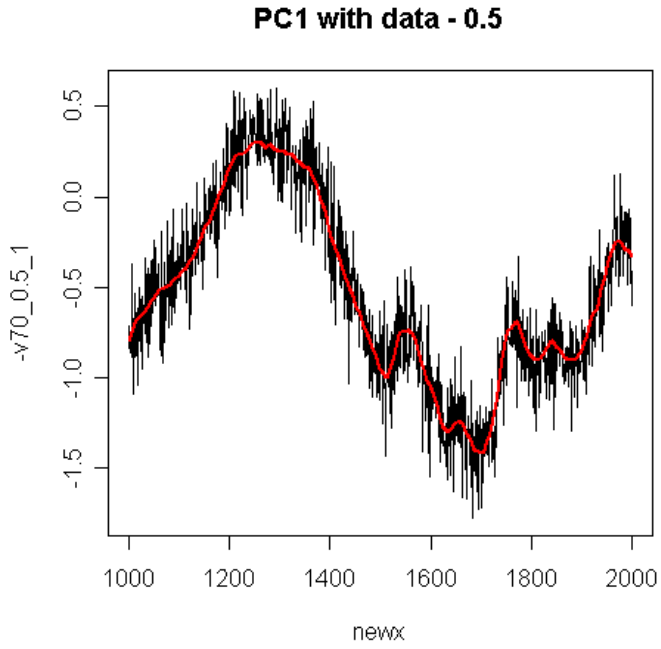

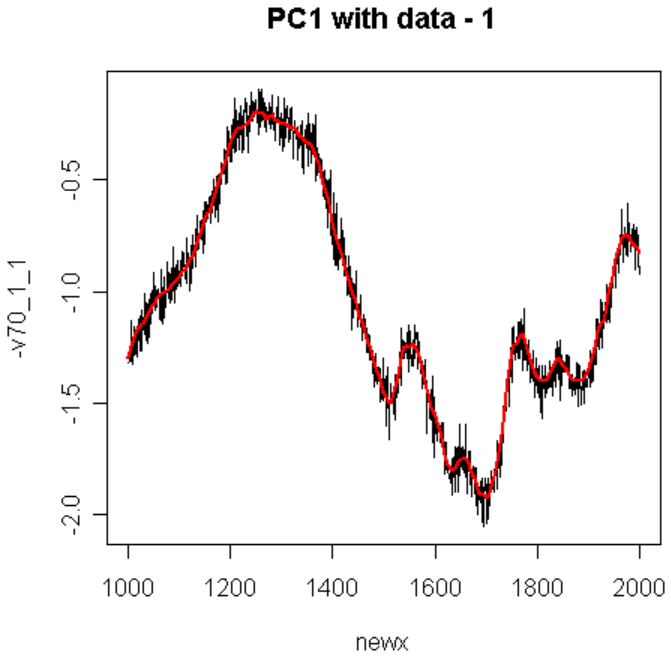

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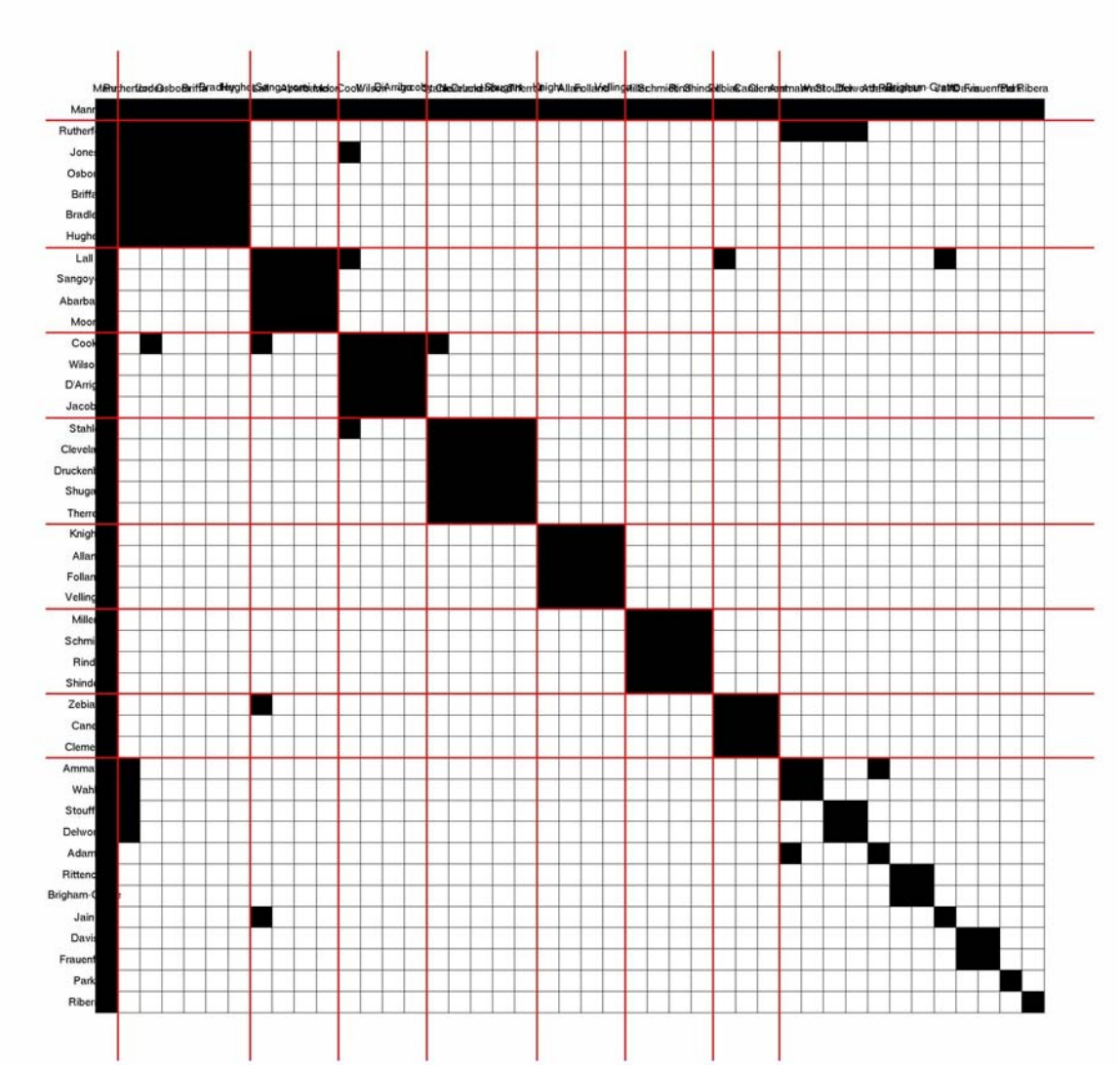

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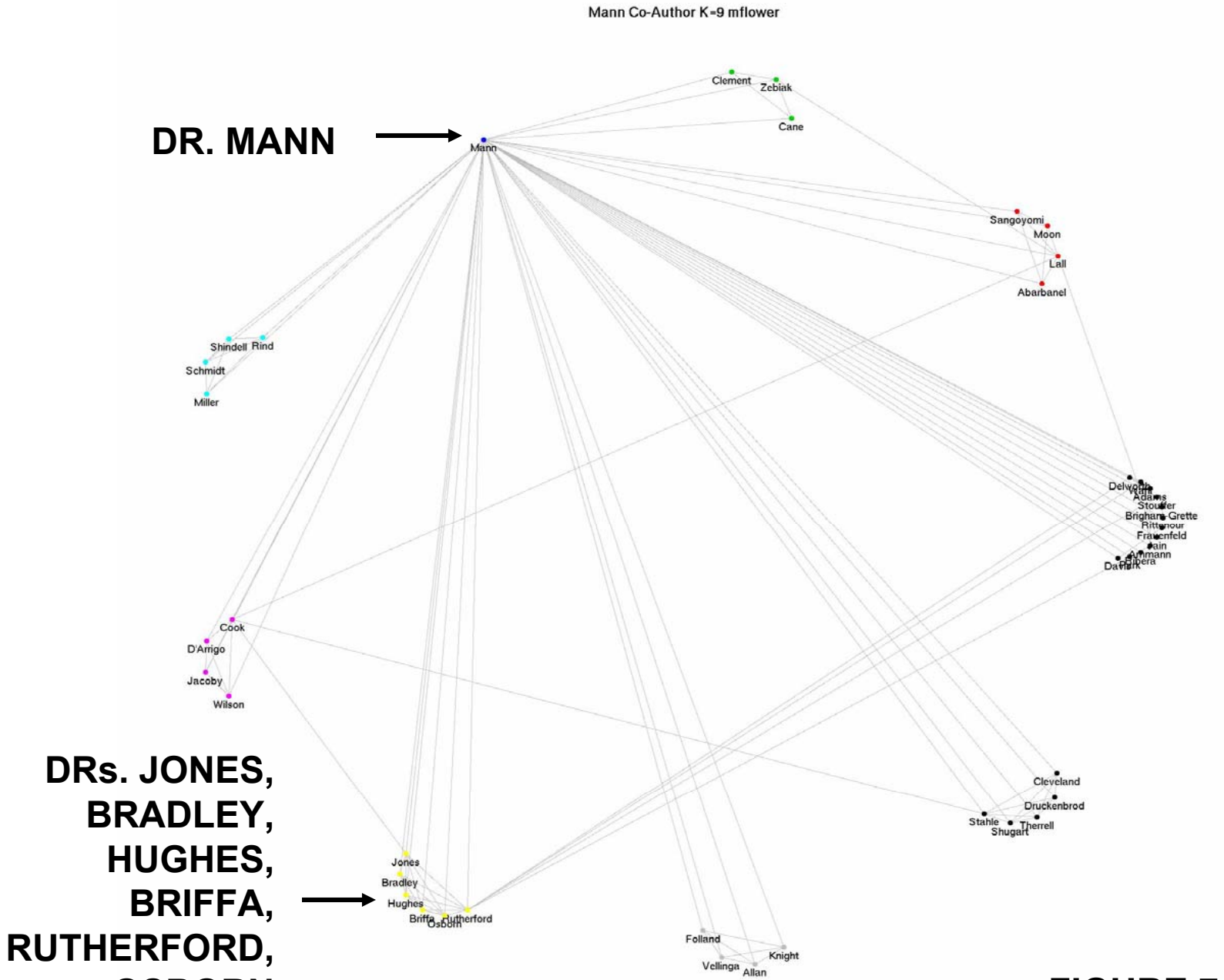
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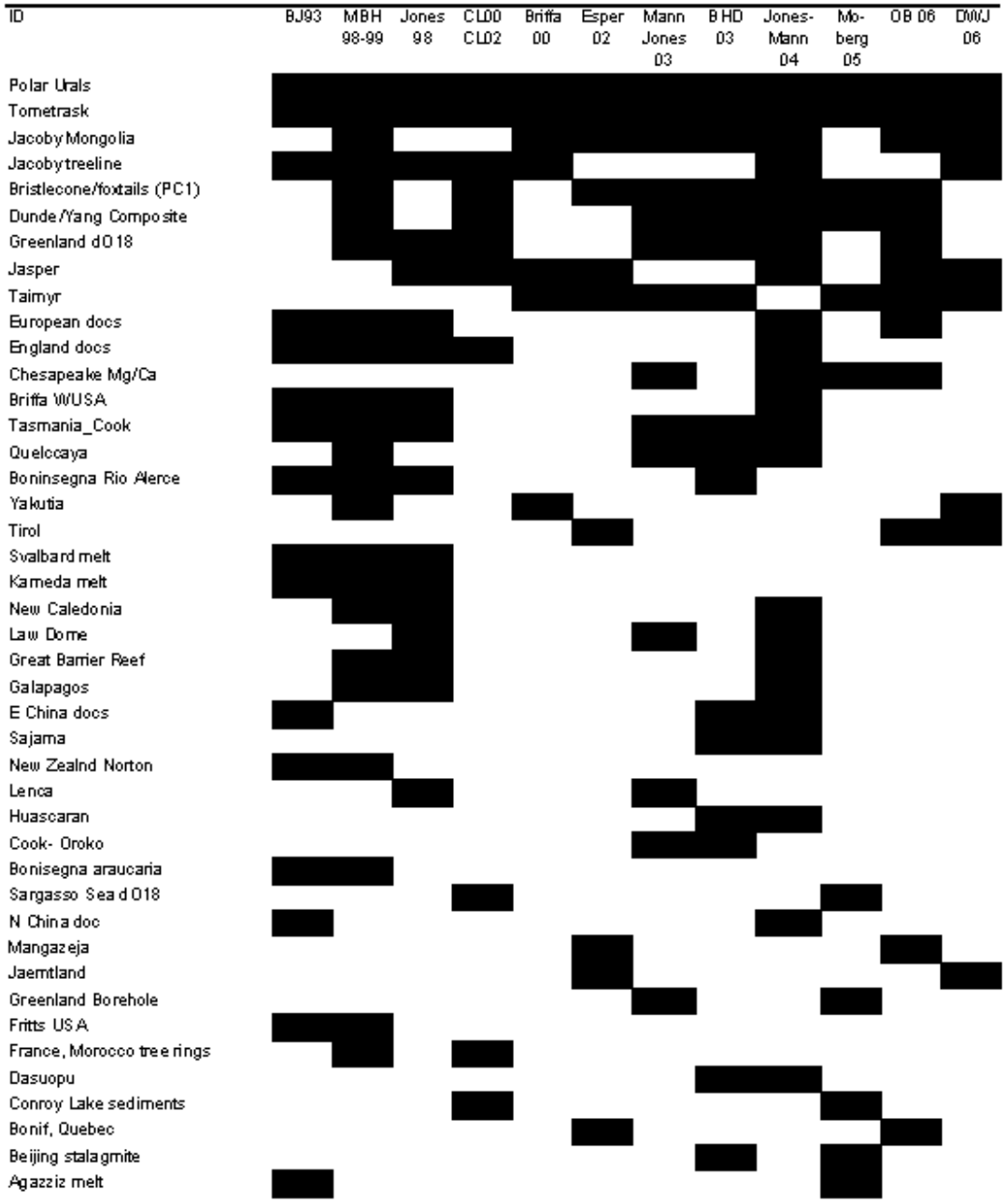

Bradley & Jones (1993)

Mann, Bradley, Hughes (1998,1999)

Jones et al. (1998)

Crowley & Lowery (2000)

Briffa (2000)

Esper (2002)

Mann & Jones (2003)

Bradley, Hughes, Diaz (2003)

Jones & Mann (2004)

Moberg et al. (2005)

Osborn & Briffa (2006)

D'Arrigo, Wilson, Jacoby (2006)

FIGURE 8

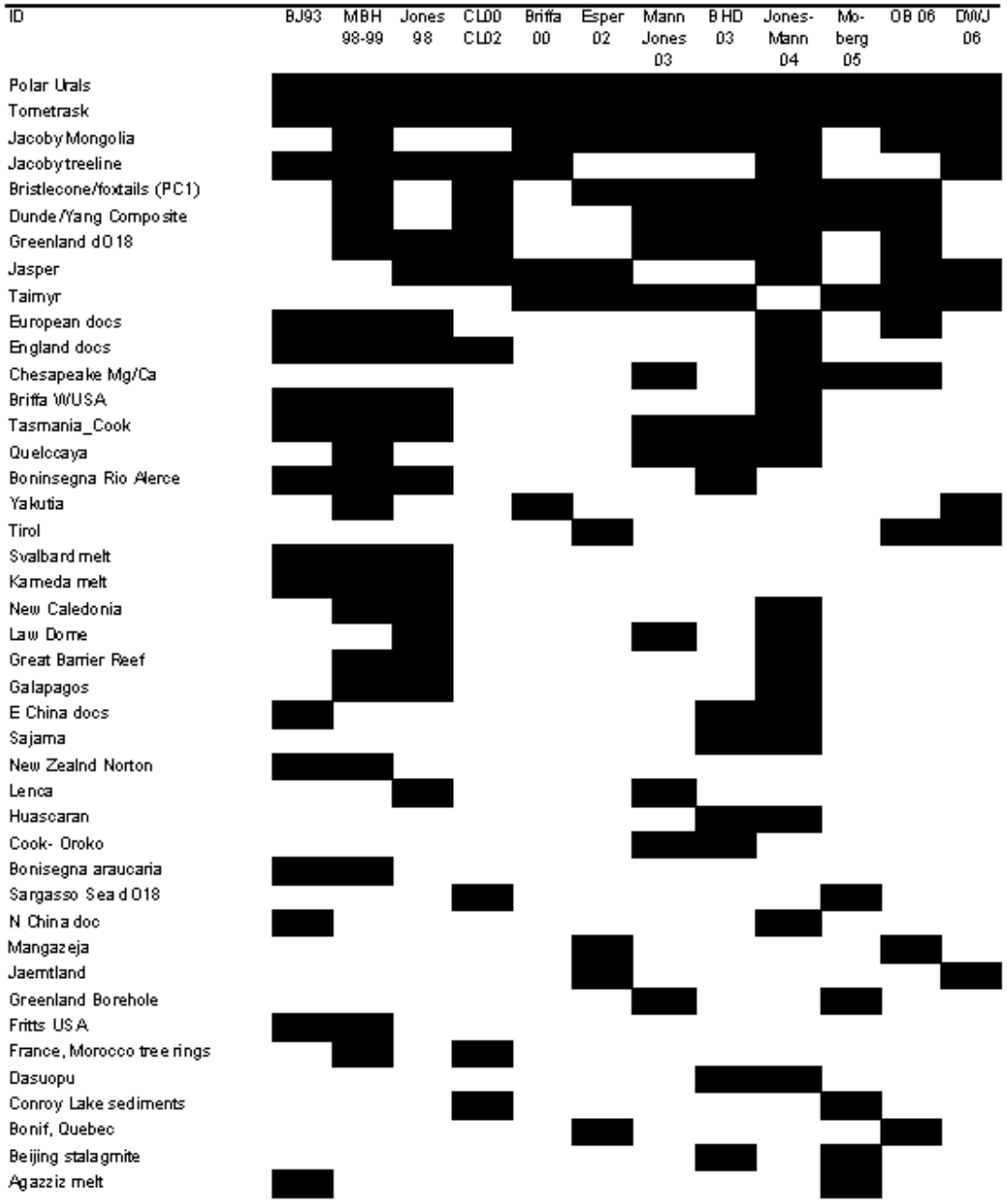

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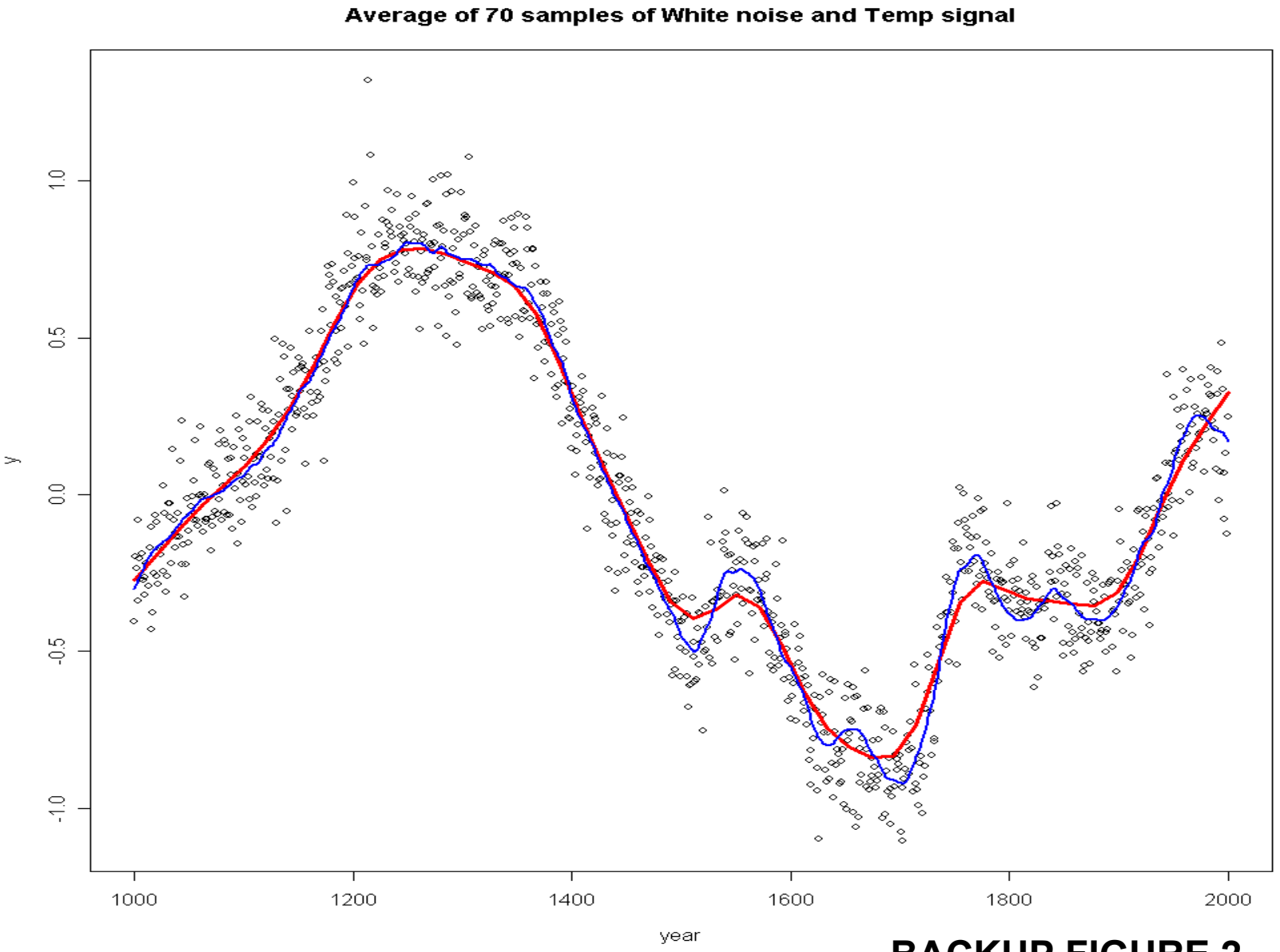
FIGURE 8

Digitized IPCC 1990 Temperature Curve

BACKUP FIGURE 1

CPS Method



BACKUP FIGURE 2