Scaling Climate, Scaling Human Social Responses: 尺度气候，尺度人类社会响应

a philosophical analysis on the scale issues of climate/culture, politics and society relationship

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1 Introduction

Recent years, a great proportion of quantitative and qualitative studies concerning the climate change and human response relationships in the past have been published, following my pioneering work in China and world. The researches found that there is a strong association between climate change and war frequencies in history . Such association exists in history of different civilizations and countries ranging from Middle Holocene to recent history. Other researches at local and regional levels show that there is no correlation between climate change and wars (e.g. Halvard Buhaug 2010,Scott Gates and Christopher, K Butler 2012, Wario R Adano, Ton Dietz, Karen Witsenburg, Fred Zaal, 2012 Rune T Slettebak 2012), most of which used the cases in Africa in recent years.

The difference on the research results show that these studies are quite different in terms of both the temporal-spatial scales and the hierarchies of causal linkage (levels of quantitative association).

A. What are the scale issues in climate/human responses studies

The spatial, temporal, or analytical dimensions used to measure and study the phenomenon ,

Resolution: precision, smoothing or moving average

Hierarchies:

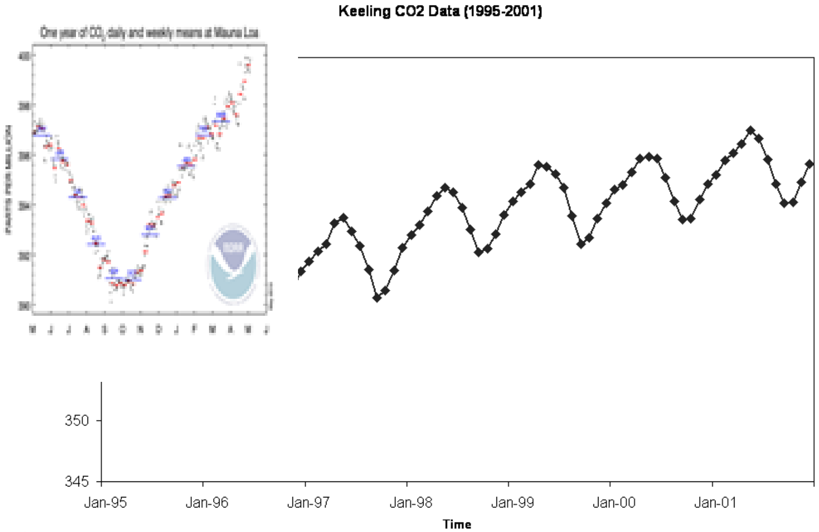
Causal, constitutive, inclusive and exclusive hierarchies (Gibson et al 2000)

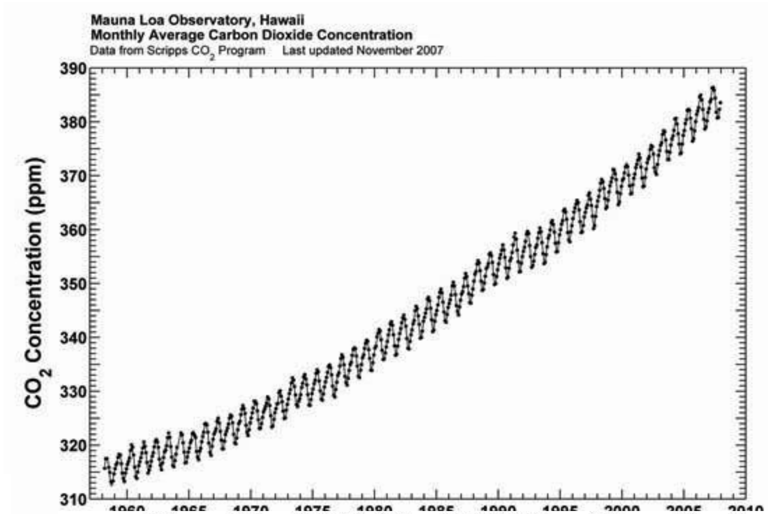
B. Philosophical meaning of scales (Temporal-spatial scales)

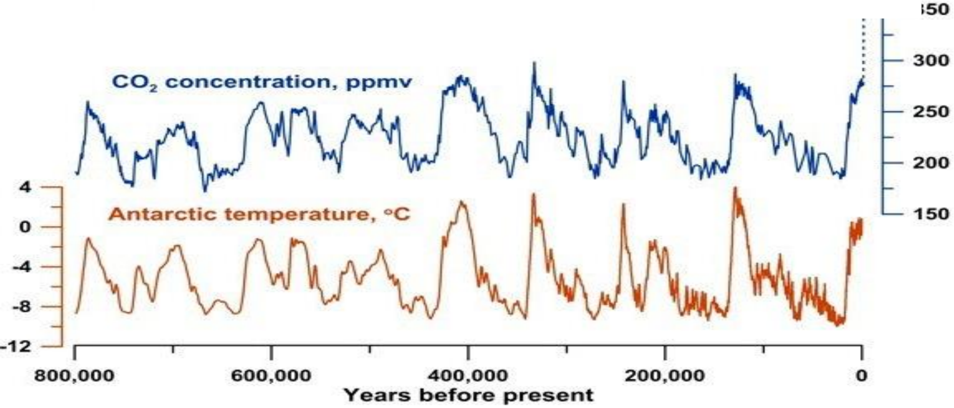
The issues related to the scale of climate/human response relationship in history are fundamental importance to their studies. The long-term, cultural political and social processes are embedded in a complex system that includes both natural and social components. **Any complex system is determined by different factors at different spatial-temporal scales** (O'Neill et al. 1989; Norton & Ulanowicz 1992). **At a given spatial-temporal scale, some processes are more fundamental than the rest in the system** (Tilly 1984). Therefore, I believe that the consequences of climate change on human cultural, social and politics can be measured at different levels and along multiple scales. And human cultural , social and political changes at different scale units might have different causes.

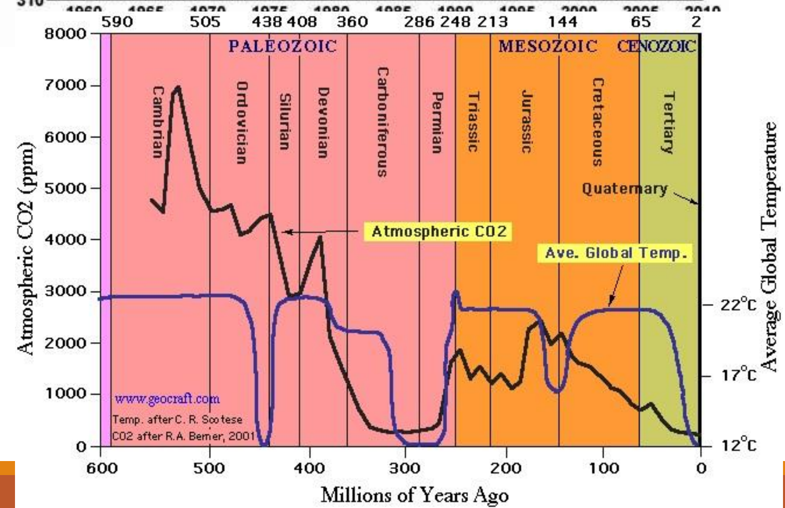
Example

Different causes that determine the CO2 variations at different temporal scales: A. annual variation caused by seasonal change of vegetation (1995-2001); B. the trend of the last 50 year (1958-2008) cause by human activities; C. 100,000 year cycle cause by temperature change; and D. 100 million years cycle caused by multiple factors.

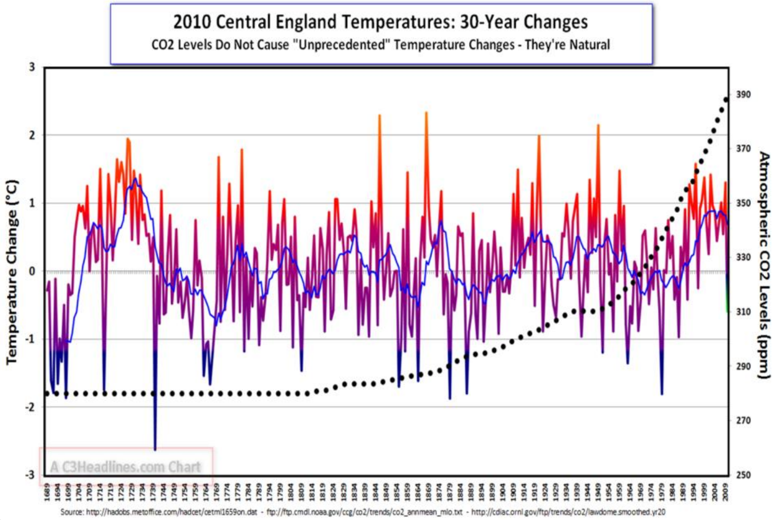


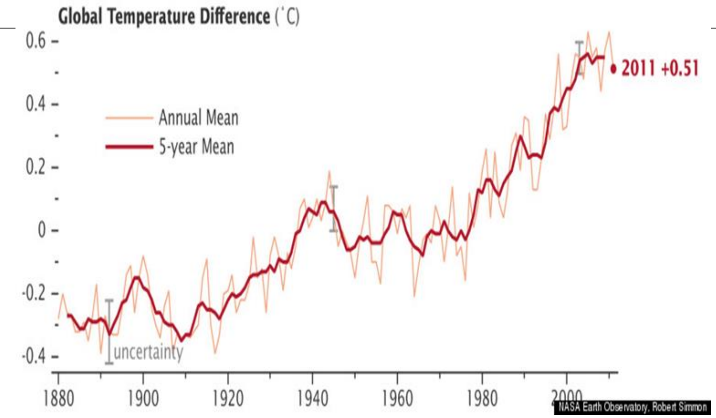


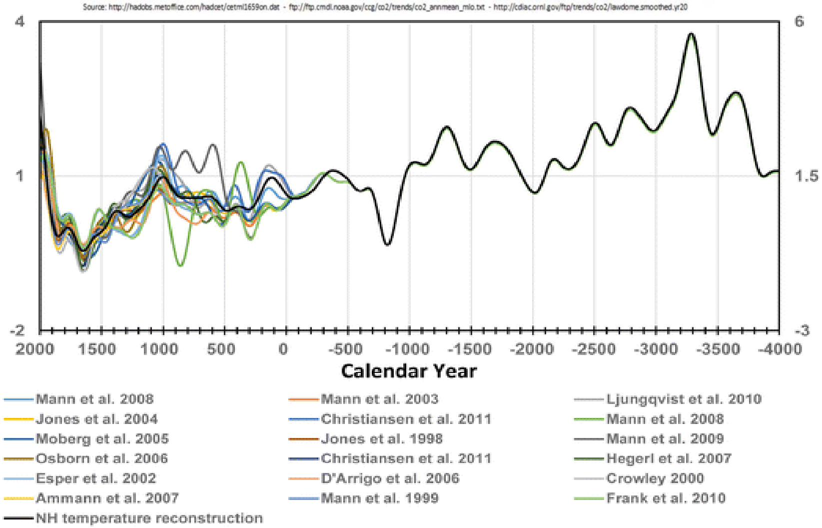


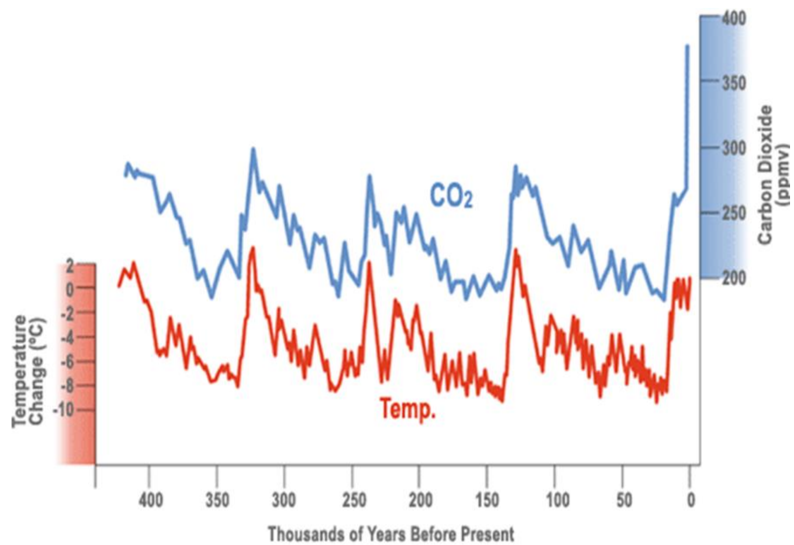


C. Scales of climate (Temporal scales)









C. Definition of climate change

The term of climate change has been misused in many literatures. The most general definition of climate change refers a change in the statistical properties of the climate system when considered over long periods of time, regardless of cause.[1] Similar definition also appears in climatology and IPCC's report. Generally, the long period refers the period ranging from several decades to millions of years

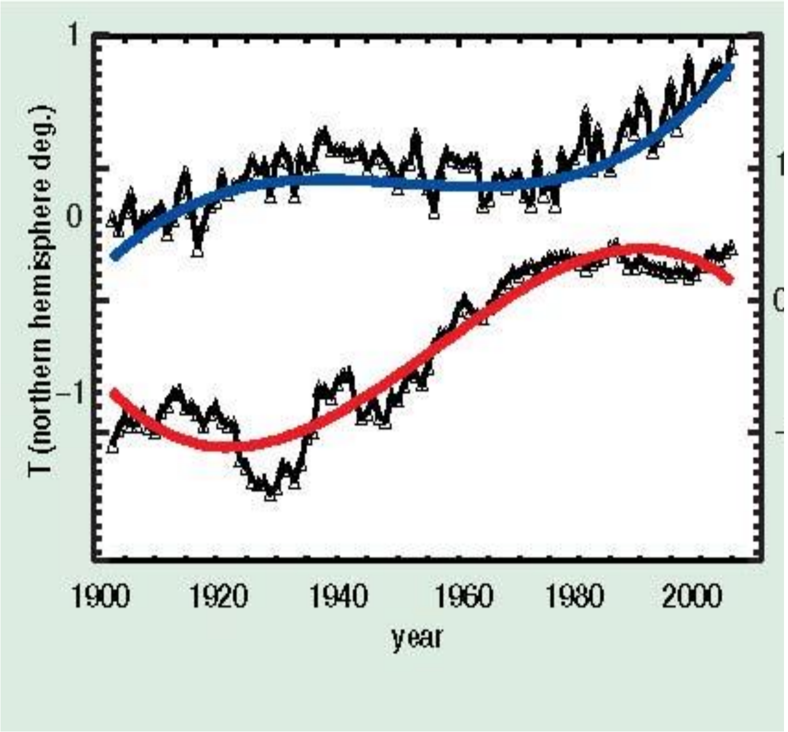
At least the changes at decadal-centennial scale

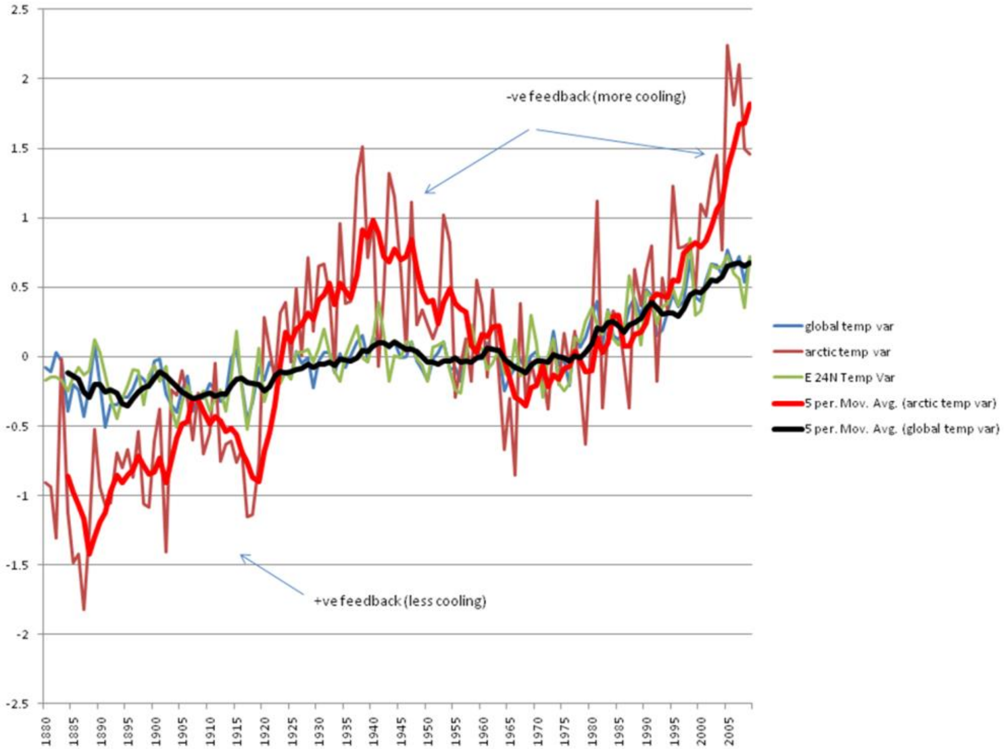
Fluctuations over periods shorter than a few decades, such as El Niño, short-term temperature or precipitation variations (less than 30-year cycle) and climate extremes, such as flood, drought and cold or heat waves, should not be called as climate change

Therefore, the studies based on the times series of several decades are not enough to reflect a full climate cycle. Any statistical analysis based on such short period is less meaningful in term of climate change/war relationship because it cannot reveal a full cycle situation and is difficult eliminates possible impacts of other factors.

D. Spatial scales

Left: Difference of temperature change between SH and NH during the last 100 years
Right: Global (Black) and Arctic (Red) temperature variations from 1880-2010





E. Scales of social responses

It is very difficult to define the temporal scale of a social phenomenon. However, it is easy to identify the temporal scale of many social phenomena by using big data and statistics.

Problems on the issues of scale:

Match and mismatch of the scales

Time-lag: Unlike animal world, the human buffering mechanisms (social and technological) could delay, , the political process could

2. Evidence how climate variation and climate change at different scales were associated with social, cultural, political and economic phenomena

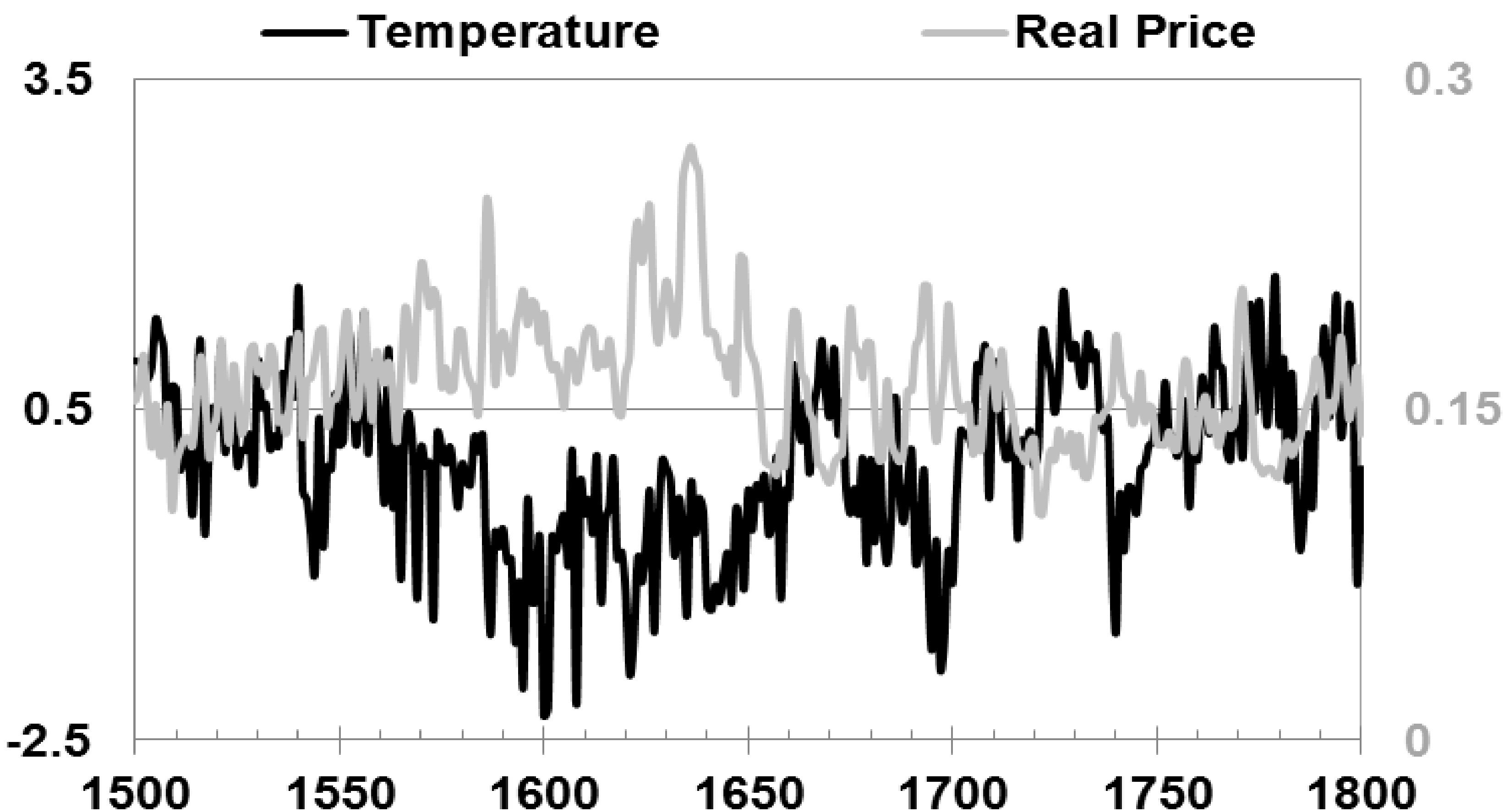
A. Temporal scales: Annual, Decadal, Multi-decadal, Centennial, Multi-centennial,Millennial, Orbit-scale.

B. Spatial scales: Continental and Regional

C. Time-lags and different spatial scales

A. Different temporal scales

Temperature and Price Fluctuations from 1500-1800 (annual). Correlation: Annual no, decadal yes



Comparison of the same set of data using different filters (different expressions on temporal scale)

Visualization of the Causal Linkages in the Conceptual Model of raw data, low-pass filtered data, and high-pass filtered data for climate change and economy in Europe.

Column I represents raw data (mostly annual to decadal); Column II represents low-pass filtered data (multi-decadal); and Column III represents high-pass filtered data (annual). Row (a) represents Temperature; (b) Precipitation; (c) Grain Yield; (d) Grain Price; (e) CPI; (f) Real Wage; and (g) Population. Variables with obvious long-term trends, such as grain price, CPI, real wage, and population size were linearly detrended.

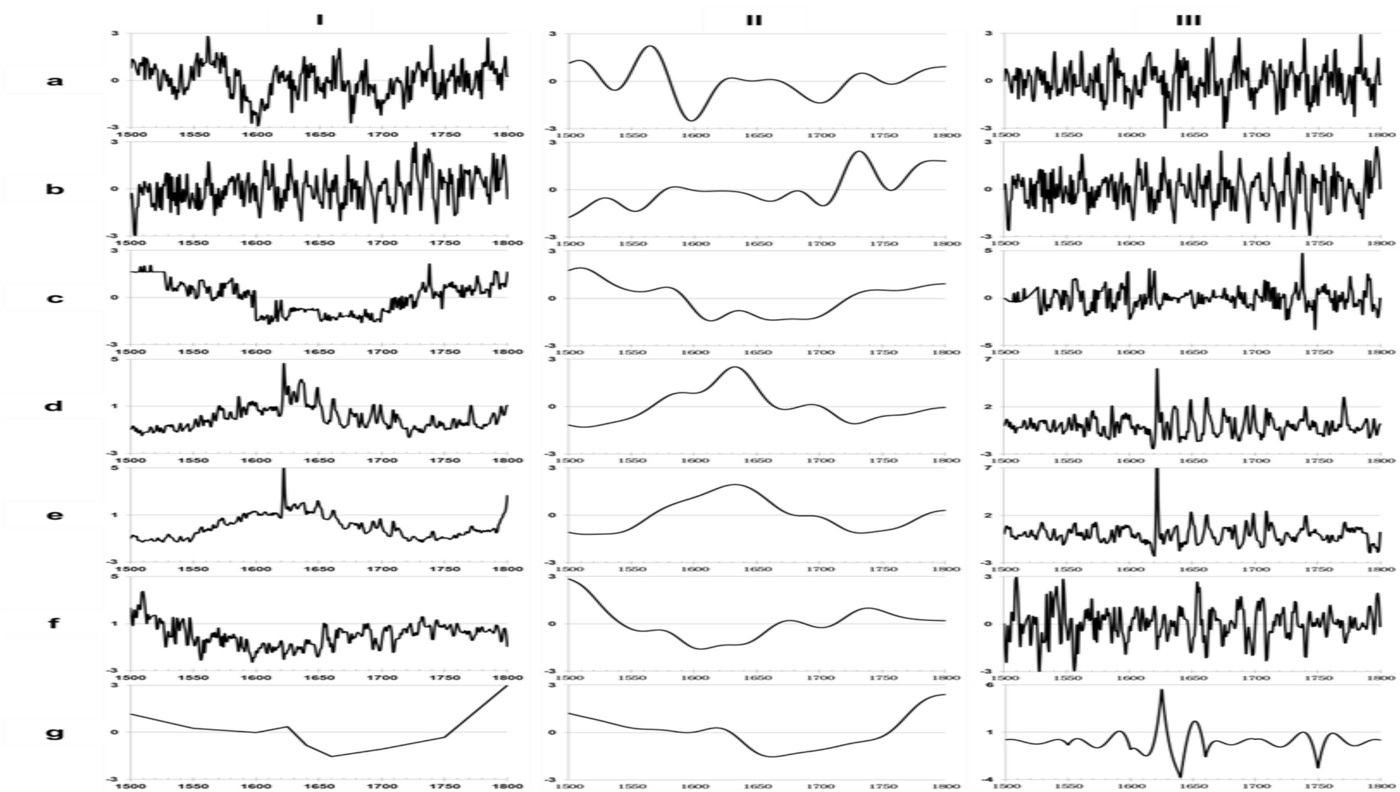


Table 1. Correlation Analysis Results of Causal Linkages in Figure 1

	Raw Data	Low-pass Data	High-pass Data
[Group 1]			
(1) Temperature– Grain yield	0.356**	0.533**	0.060
(2) Precipitation – Grain yield	0.032	0.092	0.020
(3) Grain yield – Grain price	-0.491**	-0.632**	-0.114*
(4) Population size– Grain price	-0.134*	-0.212**	0.126*
[Group 2]			
(5) Grain price– CPI	0.919**	0.968**	0.824**
(6) Grain yield – Real wage	0.524**	0.697**	-0.001
(7) CPI– Real wage	-0.745**	-0.841**	-0.588**
(8) Real wage– Population size	0.222**	0.273**	-0.049

Notes: Variables with obvious long-term trends, such as grain price, CPI, real wage, and population size, were linearly detrended. All data series were filtered by 40-yr Butterworth low-pass filter prior to statistical analysis. Significance (2-tailed): $*p < 0.05$, $**p < 0.01$.

Multi-decadal Temperature & violent conflicts in Europe

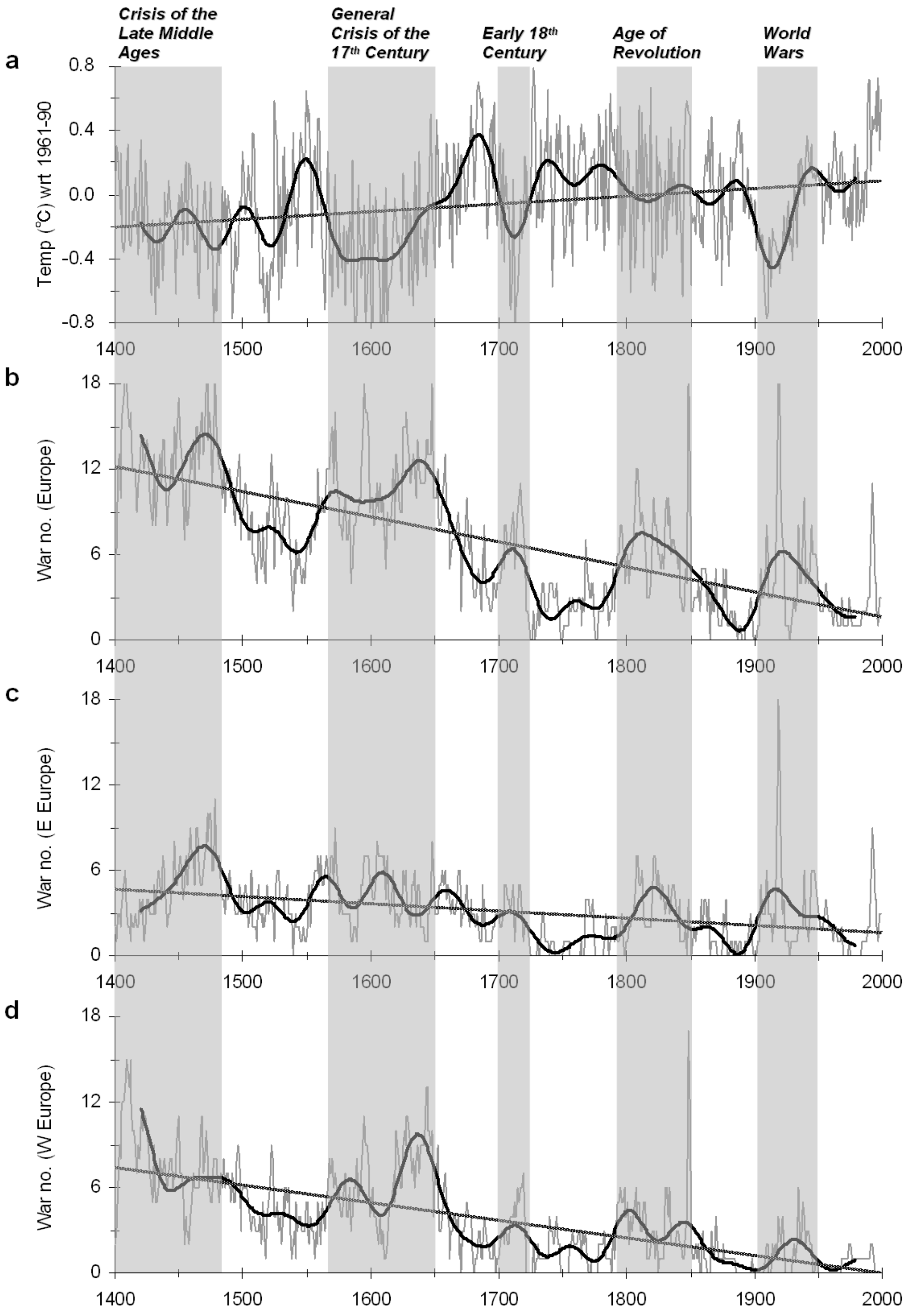
a) Temperature anomaly

b) Violent conflicts in the whole of Europe

c) Violent conflicts in Eastern Europe

d) Violent conflicts in Western Europe

Solid black lines = 40-yr cycle of the original data (elicited via Butterworth low-pass filter)



Correlation between temperature & violent conflicts in Europe using different cycle lengths

The cycles were elicited by Butterworth low-pass filter

Autoregressive disturbances in time-series were corrected by the Prais-Winsten estimation method

* = $p < 0.05$

** = $p < 0.01$

*** = $p < 0.001$

Region	Cycle length	1400–1999	1400–1699	1700–1999
Whole of Europe	0-yr	0.020	–0.028	0.058
	10-yr	–0.076	–0.122*	–0.056
	20-yr	–0.110**	–0.096	–0.078
	30-yr	–0.500***	–0.414***	–0.586***
	40-yr	–0.534***	–0.420***	–0.694***
Eastern Europe	0-yr	0.002	–0.041	0.044
	10-yr	–0.056	–0.091	–0.047
	20-yr	–0.016	–0.044	0.035
	30-yr	–0.448***	–0.406***	–0.477***
	40-yr	–0.501***	–0.278***	–0.711***
Western Europe	0-yr	0.020	–0.004	0.041
	10-yr	–0.057	–0.083	–0.030
	20-yr	–0.145***	–0.078	–0.190**
	30-yr	–0.262***	–0.209***	–0.346***
	40-yr	–0.193***	–0.236***	–0.252***

Multi-decadal change of temperature and war number in China

Time series of temperature change & war and dynastic responses in China, AD1000–1911

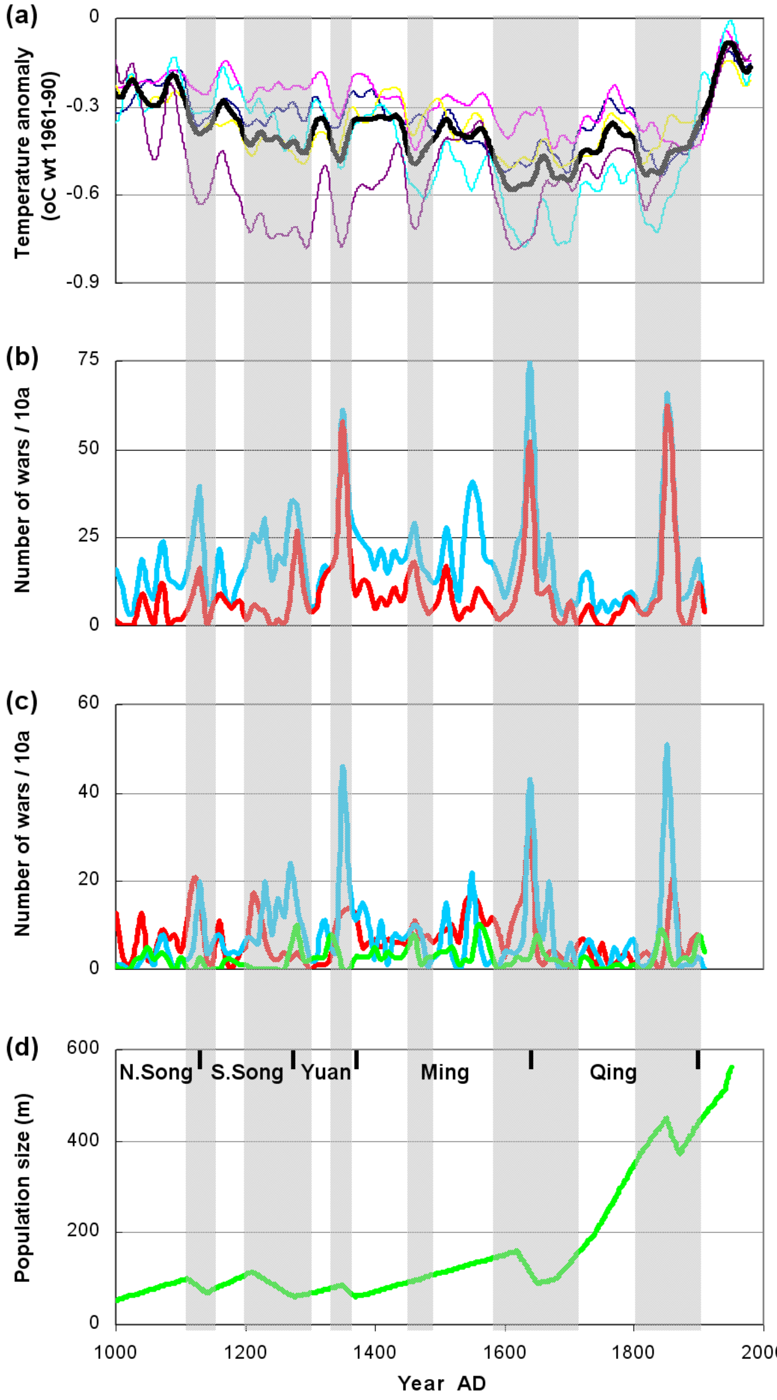
(a) NH temp anomaly

(b) Total no. of wars & rebellions

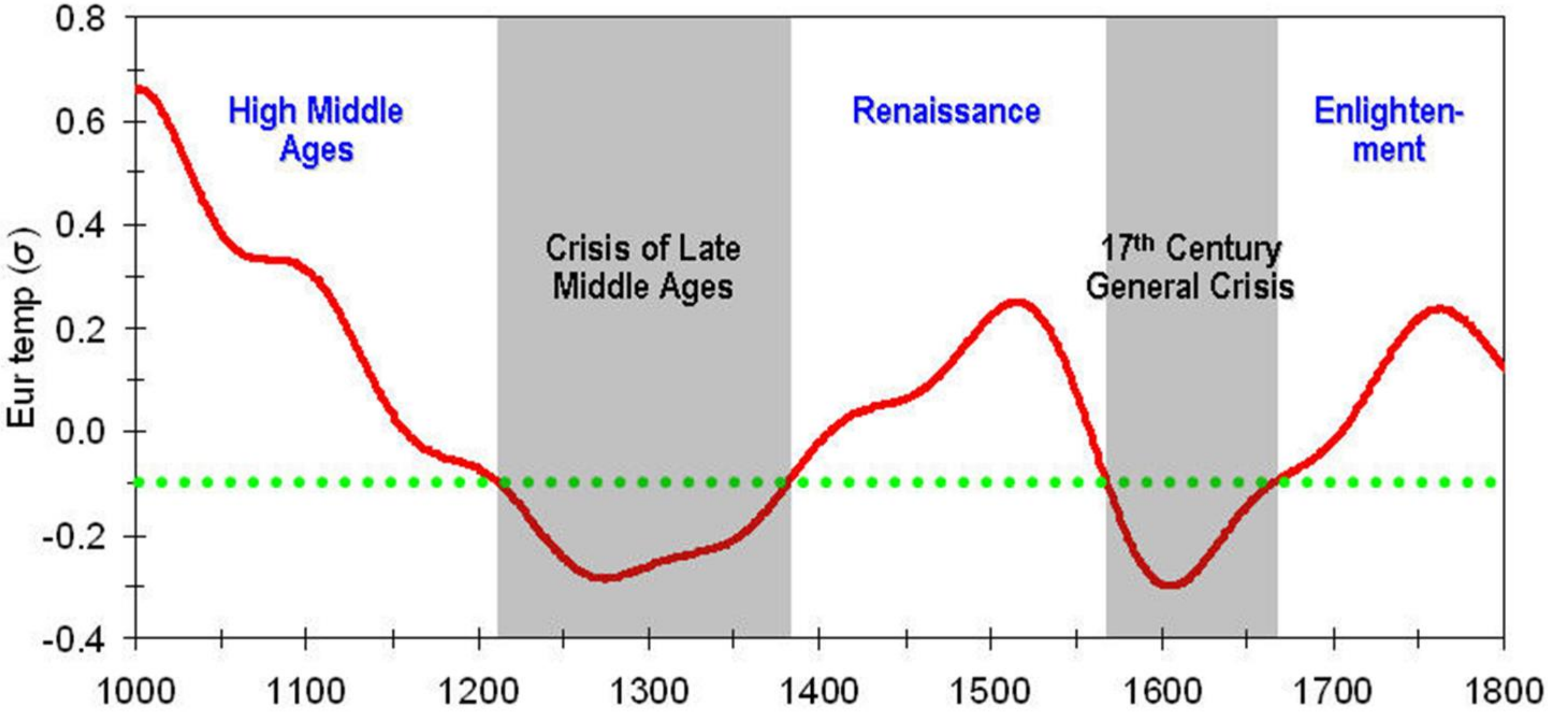
(c) No. of wars in Northern China, Central China & Southern China

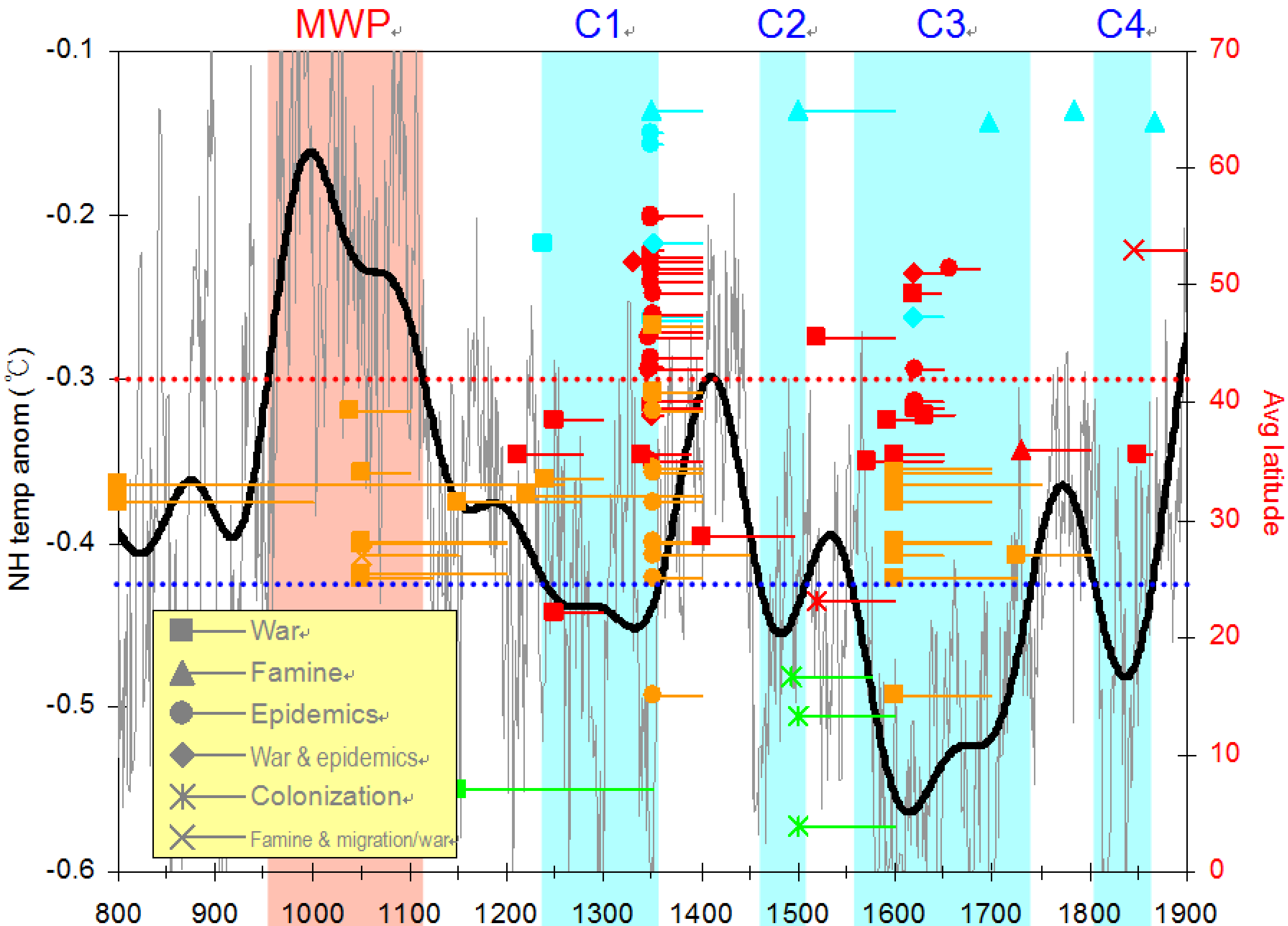
(d) Dynastic changes & population size

Gray strips represent cold phases

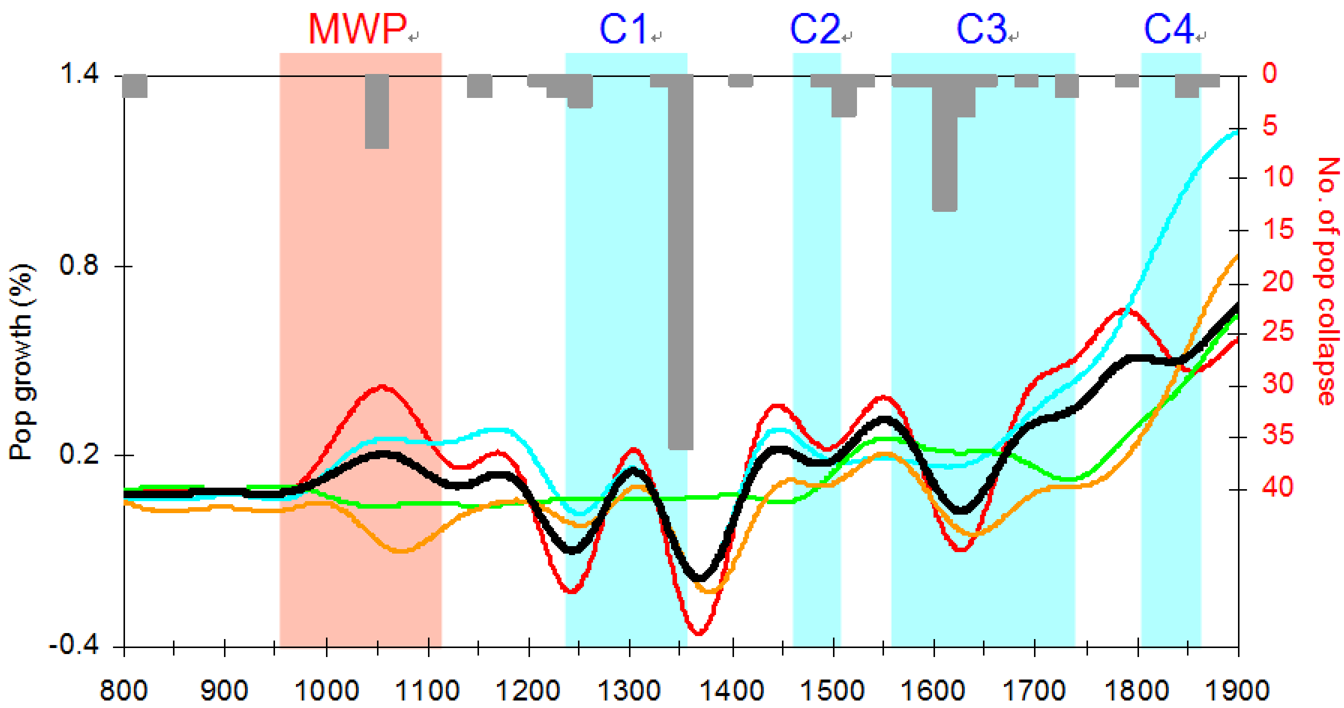


Centennial variability (low frequency) of temperature and the alternation of golden and dark ages in Europe. Europe was in dark ages when temperature dropped below the threshold (i.e., σ < -0.1)

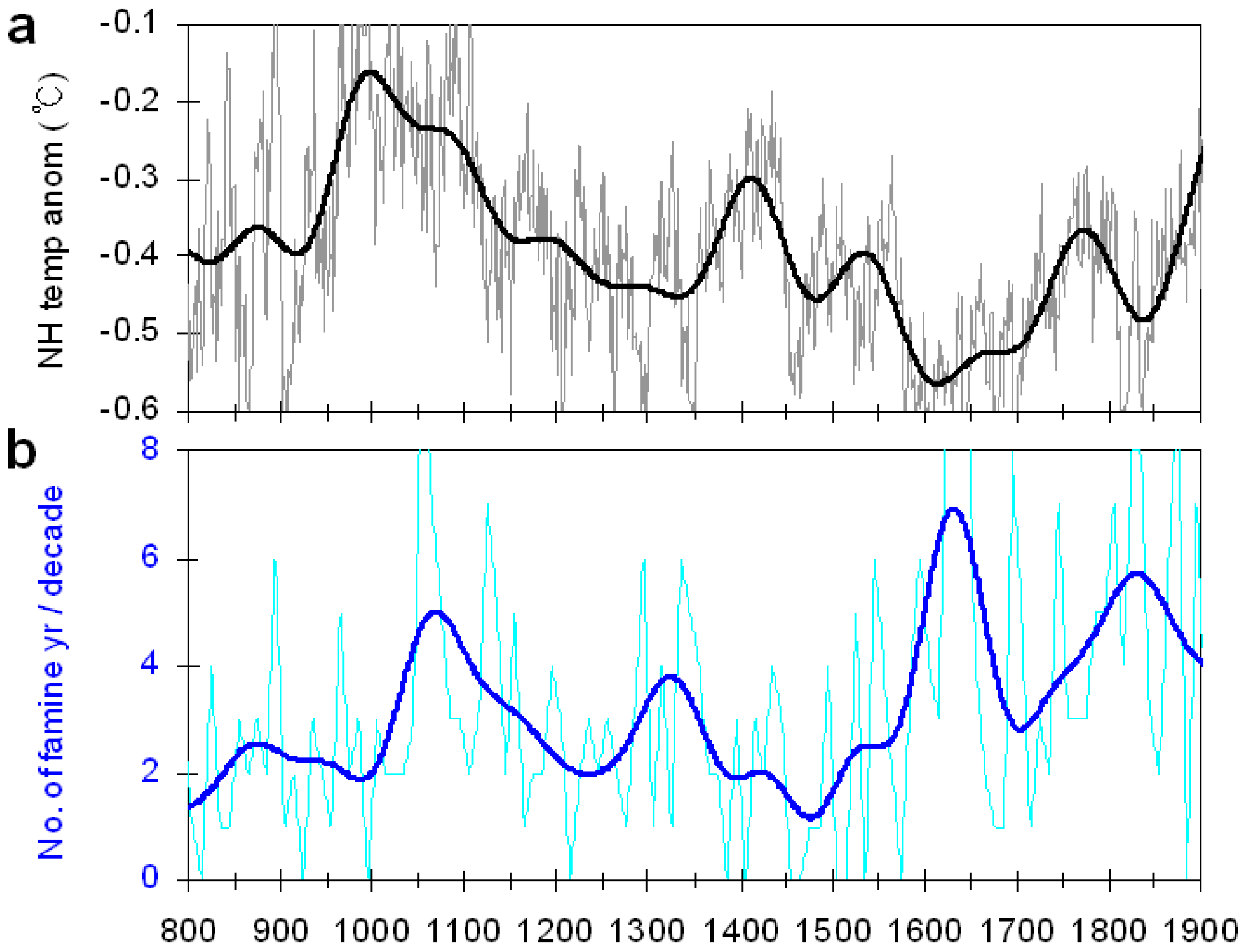




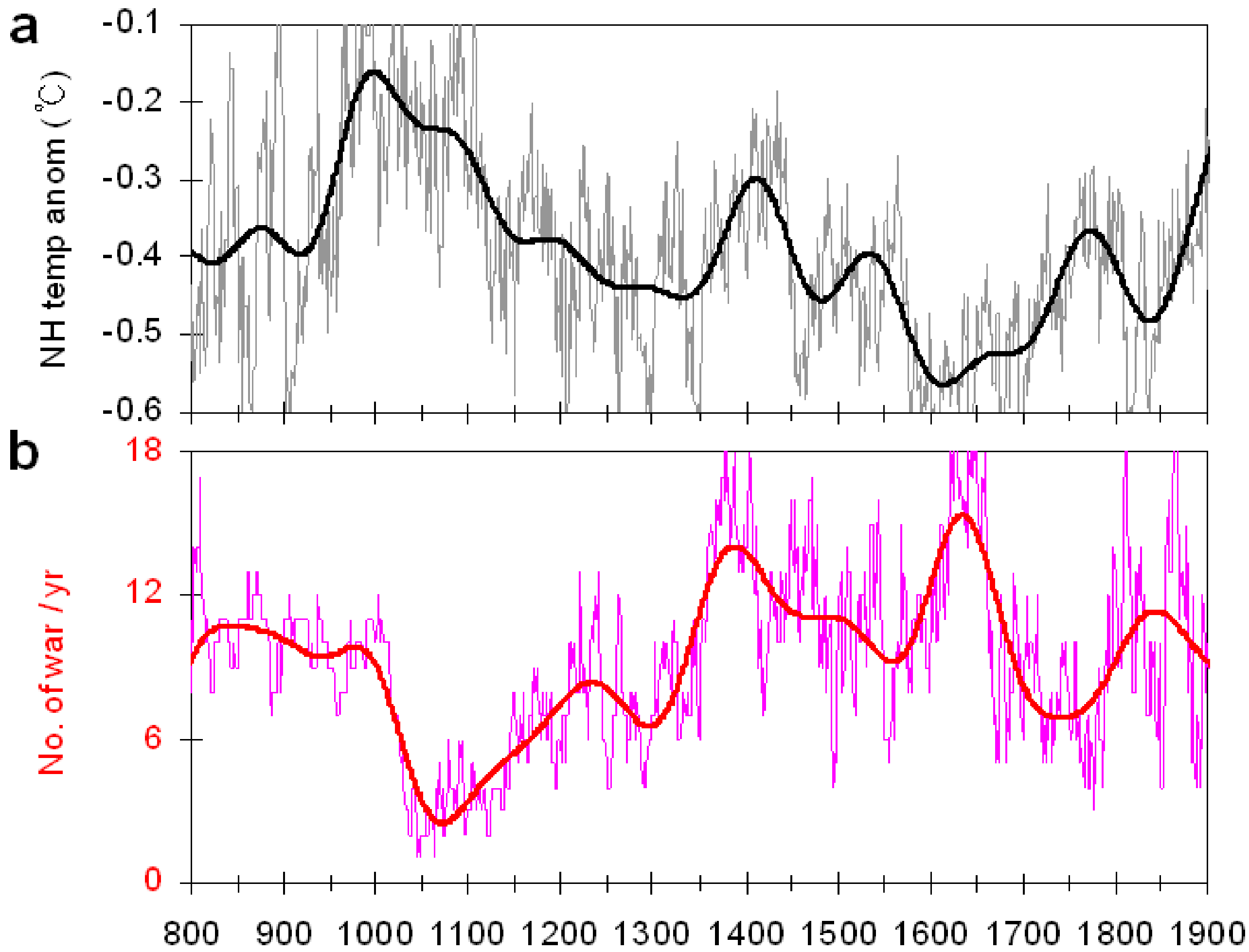
Centennial scale NH temp anom (˚C) from the 1961–90 mean & pop collapse. Temp series (grey line) has been smoothed by Butterworth **100-year low-pass** filter (bold black line). Red & blue dotted horizontal lines denote warming threshold (> -0.3 ˚C) & cooling threshold (< -0.42 ˚C). Average latitude of the relevant country/region corresponds to right Y-axis & the associated climatic zone is identified by color (red, WH; turquoise, CH; bright green, TH; orange, D); cause is represented by symbol; duration is revealed by the length of line.



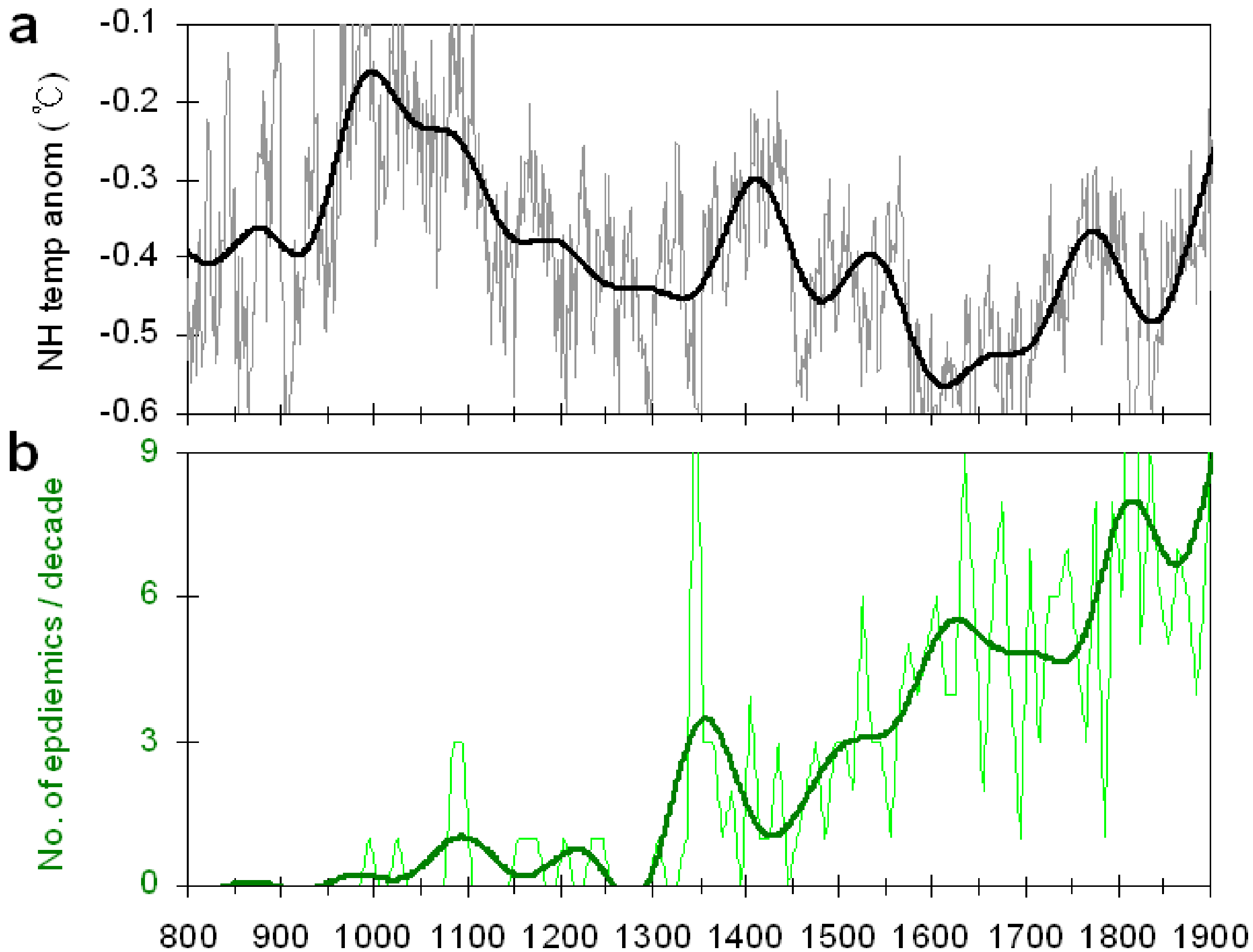
Centennial scale: Population collapse & population growth rate in Northern Hemisphere. The grey bars represent the no. of population collapses in 20-year units, which corresponds to the right Y-axis (inverted). Population growth rate in different climatic zones is identified by color (red, WH; turquoise, CH; bright green, TH; orange, D), and bold black (NH). The red shaded area represents the warm phase in the MWP, while the blue shaded area represents the cold phases in the LIA (C1–C4).



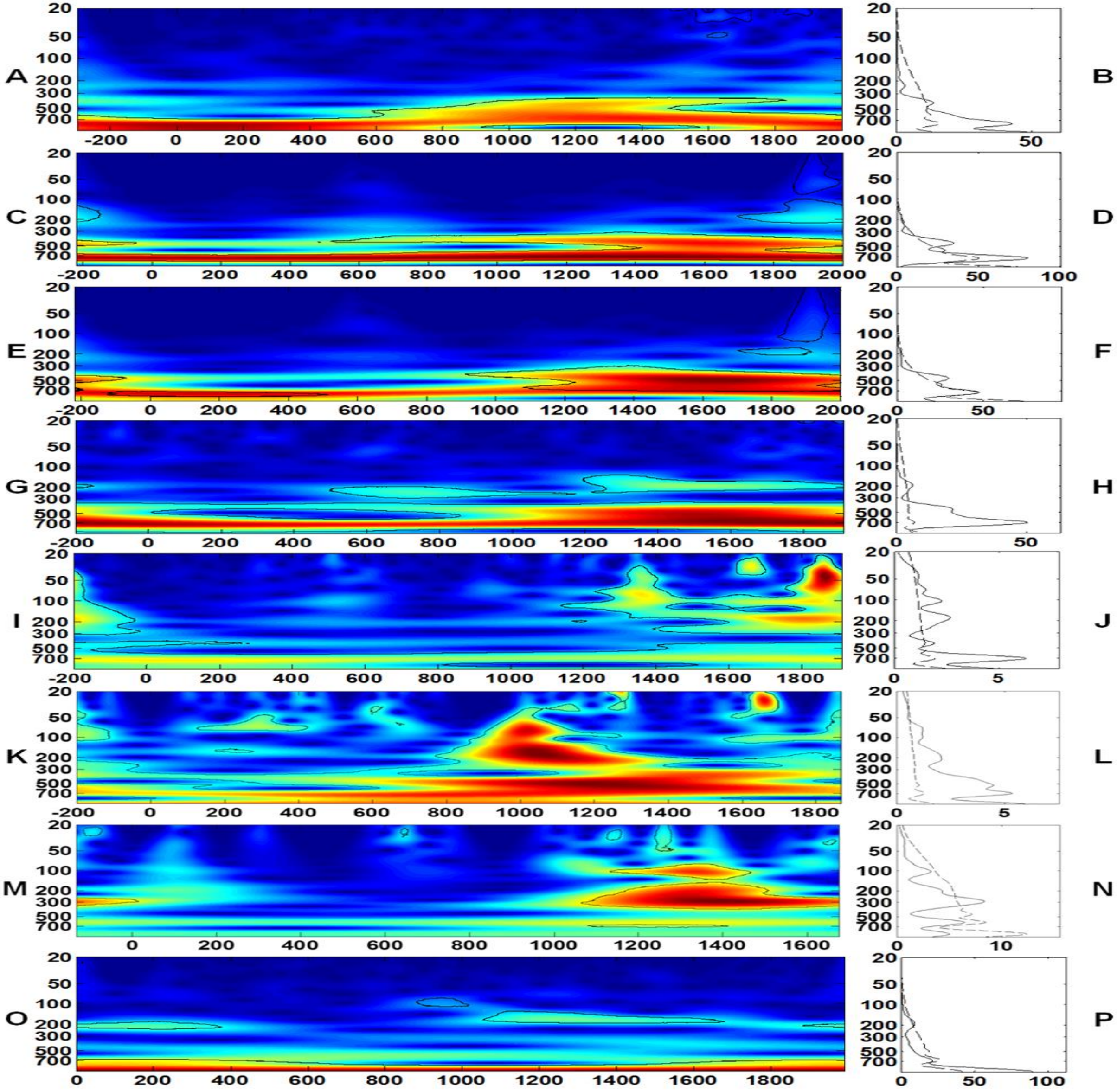
Centennial climate change & famines in the NH in 800–1900. (a) NH temp anom (°C) from the 1961–90 mean. (b) Years with famine per decade. Both series have been smoothed by the Butterworth 100-year low-pass filter (described by the bold curve).



Centennial Climate change & no. of wars in the NH in 800–1900. (a) NH temp anom (°C) from the 1961–90 mean. (b) No. of wars per year. Both series have been smoothed by the **Butterworth 100-year low-pass filter** (described by the bold curve).



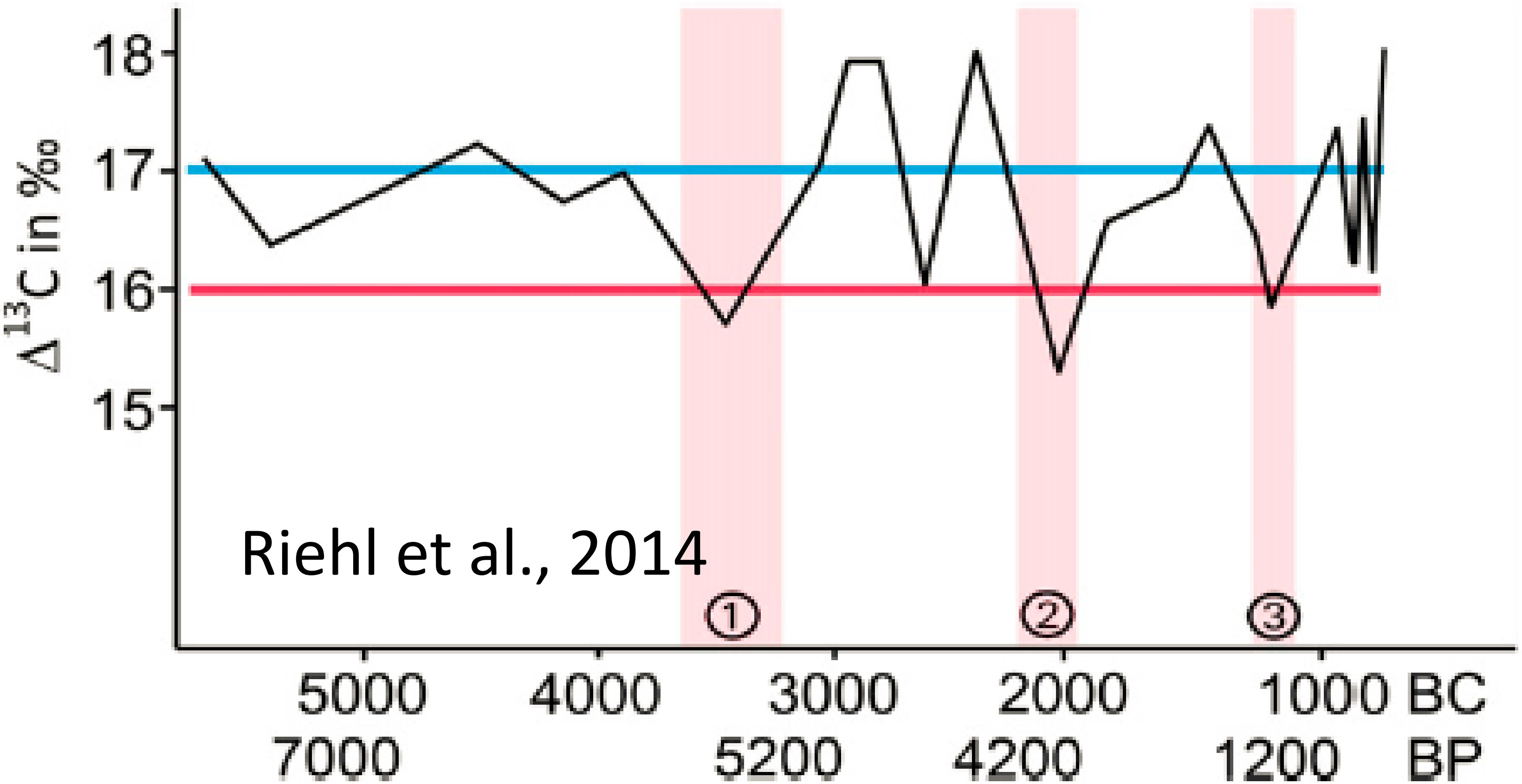
Centennial Climate change & epidemics in the NH in 800–1900. (a) NH temp anom (°C) from the 1961–90 mean. (b) No. of deadly epidemic events of 6 diseases (malaria, plague, typhus, measles, smallpox, dysentery) per decade. Both series have been smoothed by the Butterworth 100-year low-pass filter (described by the bold curve).



Multi-centennial to millennial scale

According to the wavelet analysis, the 700-800y cycle of the precipitation variation (A)largely controlled the frequencies of the geopolitical changes between pastoral and agrarian empires , including boundary latitude (B), size of agrarian empire (C) and the latitude change of the wars between agriculturalists and pastoralists (D) in China during the last 2200 years.

Millennial scale
Drought stress correlated with major climatic fluctuations and affected many agricultural settlements in the ancient Near East



Orbit-scale climate change

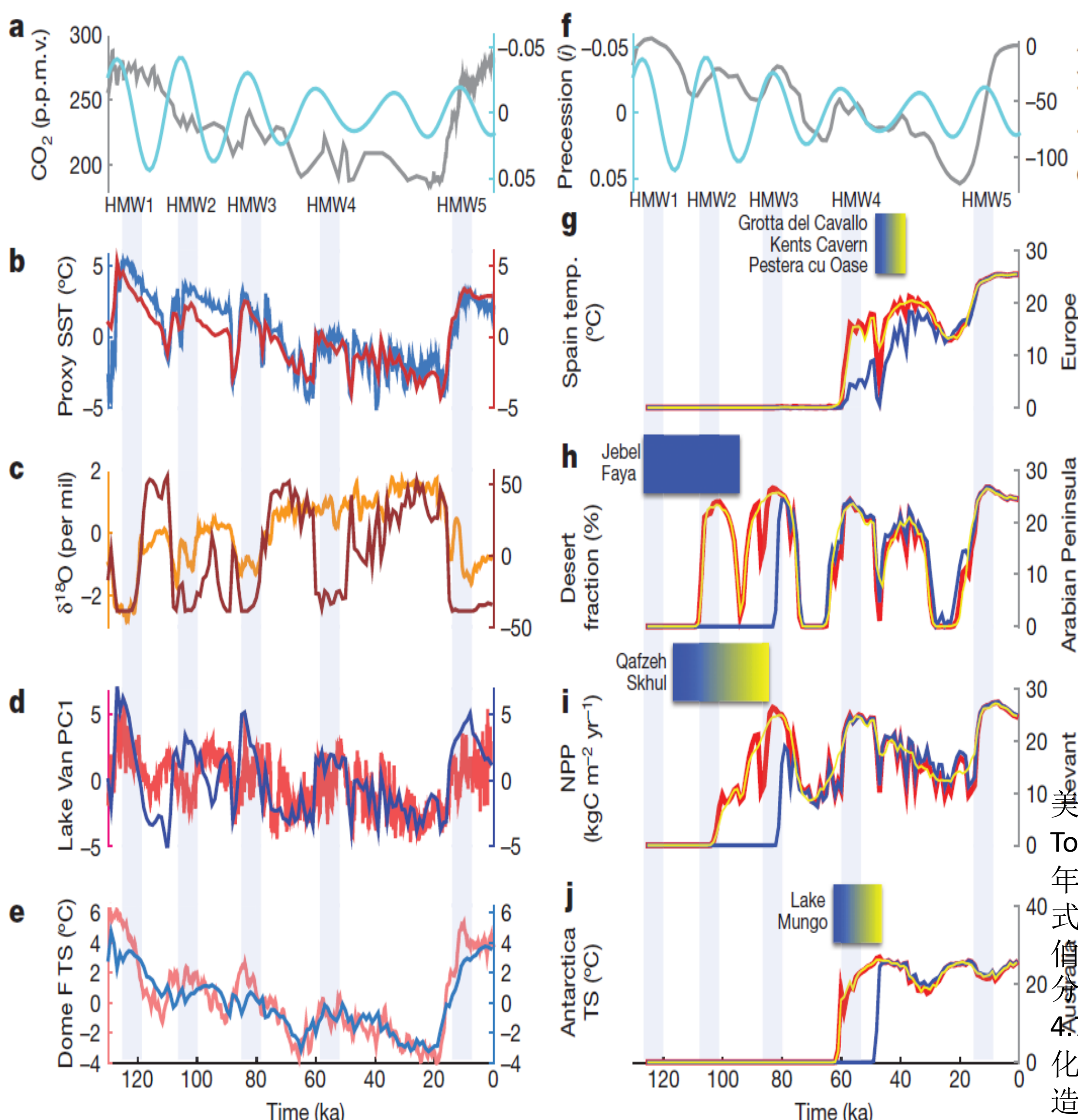


Figure 1 | Climate drivers. a, Precession (cyan) and CO_2 concentrations[24] (grey). p.p.m.v., parts per million by volume. **b**, Reconstructed[25] (blue) and simulated (red) North Atlantic/Spain temperature anomalies (°C) (see Methods). **c**, Israel (Soreq cave) speleothem[26] $\delta^{18}O$ (orange) and simulated Israel desert fraction anomalies (brown). **d**, Turkey hydroclimate reconstruction[27] (red) and simulated Turkey net primary production anomalies (NPP) (blue). **e**, Antarctic (Dome Fuji) reconstructed[28] (orange) and simulated (blue) surface temperature anomalies (TS). **f**, Precession and sea level[10]. **g–j**, Simulated human density (individuals per 100 km^2) for early (red), late (blue) and early-without-Dansgaard–Oeschger events (yellow) exit scenarios in Europe (9.5° E, 48.5° N), Arabian Peninsula (56.5° E, 21.5° N), Levant (37.5° E, 34.5° N) and Australia (144.5° E, 19.5° S). Blue (mixed blue/yellow) boxe indicate archaeological (archaeological and fossil) evidence for *H. sapiens*[18,20,29,30]

美国夏威夷大学马诺阿分校的Axel Timmermann和Tobias Friedrich构建了一个数值模型，对过去12.5万年的时间里气候与海平面变化之于全球人类迁移模式的影响进行量化分析。模型识别出四次横跨阿拉伯半岛和黎凡特地区的明显的冰期人类迁移浪潮，分别发生在10.6万—9.4万、8.9万—7.3万、5.9万—4.7万和4.5万—2.9万年前左右。这些结果与考古和化石数据高度一致发现证明轨道尺度气候变化在塑造全球种群分布中所发挥了关键作用。相反，骤然的千年尺度气候变化的影响较为有限，且是区域性的。模型还显示，约9万—8万年前，智人几乎同时到达了中国南方和欧洲

B. Spatial scale

Spatial scales:
Correlations between climate change & war frequency around the world, AD1500–1900

These figures show several scale problems:
1. The more cases, the higher the correlation in the three types of the world wars (first three rows)
2. Geographical differences: a. New World has no correlation; b. Asia and China areas with large wet tropic zone has lower correlation.

* Less than 5% is by chance
*** Less than 0.1% is by chance

Regions	Correlations
World (>50,000 troops)	-0.26***
World (principal wars)	-0.32***
World (armed conflicts)	-0.36***
Northern Hemisphere (NH)	-0.46***
Southern Hemisphere	-0.48***
Asia	-0.24***
Arid areas in NH	-0.64***
Europe	-0.63***
Western Europe	-0.56***
Eastern Europe	-0.63***
North America	-0.08
South America	-0.12*
West & Central Africa	-0.49***
East & South Africa	-0.55***
China	-0.26***

C. Time-lags and spatial differences

Pearson's *r* between temperature anomalies & war records (decadal scale), AD1000–1911

Time lag (year)	Total wars	Rebellions	North	Central	South
0	–0.179	–0.229*	–0.090	–0.214*	–0.065
10	–0.223*	–0.268*	–0.133	–0.274*	–0.043
20	–0.200	–0.252*	–0.076	–0.271*	–0.065
30	0.122	–0.204	0.024	–0.225*	–0.106

* Significant at 0.05 level (two tailed).

Pearson's *r* between temperature anomalies & the highest war frequencies (phase scale), AD1000–1911

	Total wars	Rebellions	North	Central	South
Avg temp anom	–0.693*	–0.686*	–0.511	–0.666*	–0.525
Lowest temp anom	–0.707*	–0.707*	–0.516	–0.697*	–0.576

* Significant at 0.05 level (two tailed).

Pearson's *r* temperature anomalies & war records in China (annual scale), AD1000–1911

The table show that Total war is correlated wit temperature but North and south China is not correlated. It also show that the most correlated period is 10-15 years, which

Time lag (year)	Total wars	Rebellions	North	Central	South
0	–0.115**	–0.156**	–0.060	–0.133**	–0.034
5	–0.143**	–0.178**	–0.086**	–0.160**	–0.024
10	–0.153**	–0.191**	–0.086**	–0.179**	–0.021
15	–0.152**	–0.192**	–0.073**	–0.183**	–0.023
20	–0.142**	–0.180**	–0.052	–0.178**	–0.033
25	–0.117**	–0.162**	–0.021	–0.163**	–0.042
30	–0.091**	–0.145**	0.012	–0.151**	–0.046

** Significant at 0.01 level (two tailed).

3. Discussion and conclusion

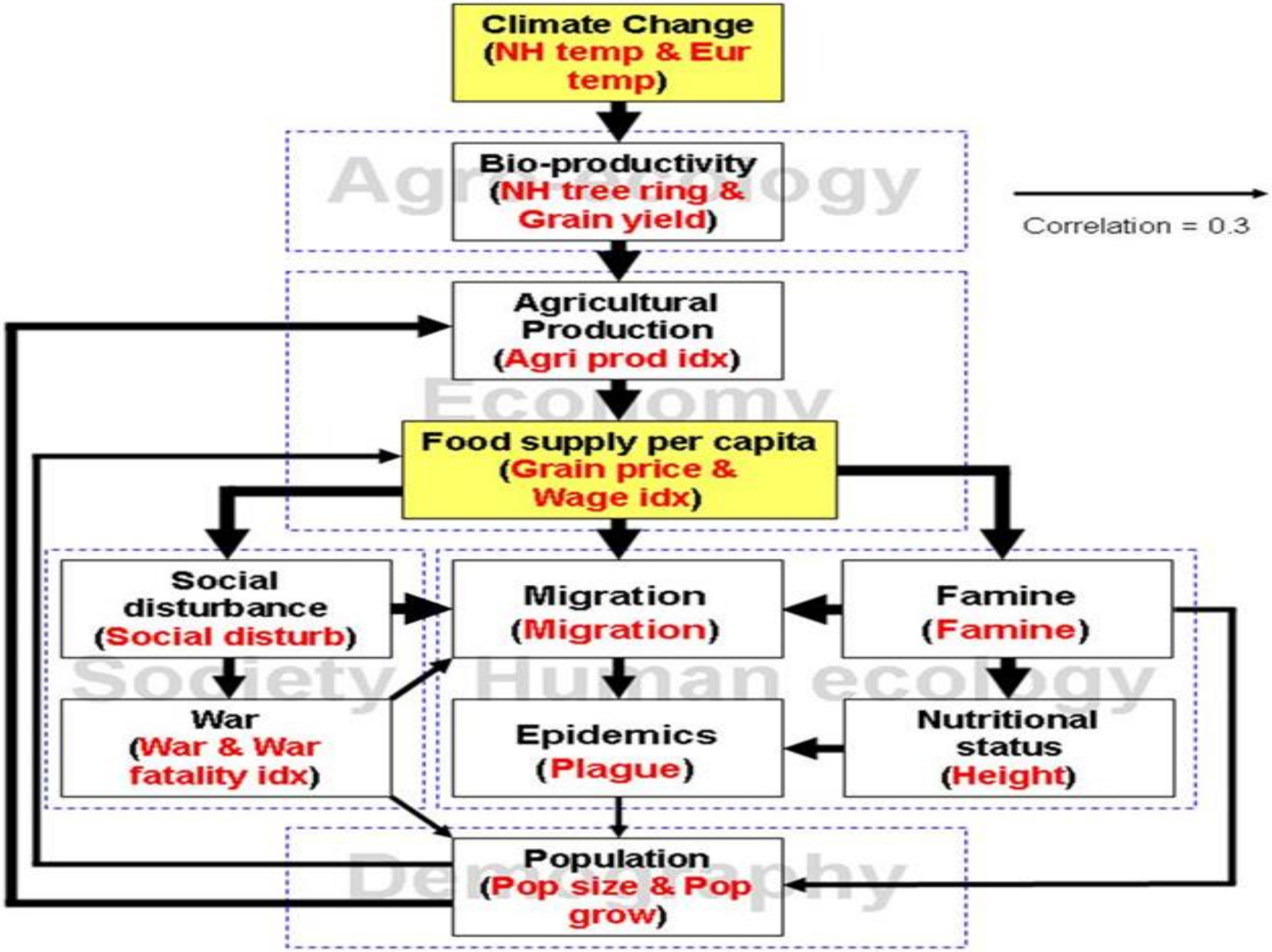
Statistical method is adopted as the official mathematical language of many disciplines to construct the causal relationships by inferring the major connections (Pearl, 2000).
Statistics is a basic research method for modern sciences, even for social sciences. Especially, in the field of study on historical law on the sense of patterns common to all periods and all types of social organization, some scholars have attach great importance to statistical laws, because they involve numerous collections of men and that they do not apply in every single case but in a certain number of cases (Bunge, 2009).

The most of findings in the studies that denied the climate impact in ***Africa*** *have made a series mistakes, mostly in the scale issues, including length of the study period, size and location of the study area and mismatch of temporal and spatial scale.*

The findings of this analysis on the climate/social response relationship do not refute other theories about the causes of social, cultural, political and economic phenomena and the complexity of these phenomena in history. This study is different from its predecessors in terms of both temporal scale and hierarchies of reasoning (levels of quantitative association).

Establishment of conceptual model of causal linkages

Set of causal linkages from climate change to large-scale human crisis in pre-industrial Europe (note: impact transferred form cause to effect at each link point can be buffered by human adaptive capacity in the case of relative slight change)



Thanks!