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WAR AS A SOCIAL-ECOLOGICAL RESPONSE TO CLIMATE CHANGE IN ANCIENT CHINA

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ABSTRACT: In recent years scientists have studied the phenomenon of climate change intensively and its implications for the future of the human race. By contrast, there has been little study on the dramatic effects of climate change upon human society in history. In this study we explore the relationship between climatic change and war in China, by comparing high-resolution paleoclimatic reconstructions with the known incidence of war in China over the past millennium. We demonstrate a remarkable correlation between climatic change and the incidence of war. Wars broke out more frequently during cold phases. We suggest that the reduction of thermal energy input during cold phases resulted in the shrinking of livelihood resources in the traditional agrarian society, which in turn led to armed conflicts or wars between states, tribes and peoples on the lands with different carrying capacity.

Keywords: climate change, war, ancient China, temperature anomaly, correlation, agricultural production

1. Introduction

The idea that climate change can produce important social, cultural and economic changes in human society is not new. As wars are socially-organized armed conflicts, and often have economic or cultural causes, it should not be surprising that climate changes, which can seriously affect the level of food production, have been an important cause of war. However, the assumed relationship between climate change and war has not yet been substantiated with scientific evidence. Historians have often looked for political, social or economic causes of wars (Evera, 1999;Seabury and Codevilla, 1989) but the relationship between climate change and war has never been systematically examined.

Over the last thirty years, scientists around the world have carried out intensive research on past climate changes. Research in the last decade, in particular, has yielded significant improvements in high-resolution paleoclimatic reconstructions of the last millennium, using multi-proxy data networks with a focus on a global-warming trend. The conclusion is that the last century was the warmest in the last millennium (Jones et al., 2001; Mann et al., 2003). These refined paleoclimatic records provide a strong base for analyzing climatic change and war associations. Meanwhile, in the course of China's long history of civilization, voluminous documentation in the palace archives of different dynasties, dating back to 880 B.C., systematically recorded all major events. This valuable and comprehensive documentary repository provided a rich database for studying wars.

2. Methods

In this research, we use four independent sets of data, covering climate change and the incidence of warfare respectively in China during the last millennium, to investigate the influence of climate change on warfare. Briffa and Osborn (2002) have chosen the five most representative and recent climate series of the last millennium in the northern hemisphere to discuss the differences between the records of various independent studies (Figure 1A).

Despite the diverse sources of data, all five high-resolution climate records register a close match between their warm and cold phases and highly significantly correlated with each other. Such congruence of data acquired independently by different authorities suggests a high degree of accuracy with reference to both temperature and timing. These climate series provide a rather reliable basis to investigate the relationship between climate changes and historical events, in this case, wars in China. The records from A.D.1000 to 1980 have been adopted as the standard climate variations in this study.

These records were reconstructed by using multi-proxy data, which were achieved from tree ring, coral, ice-core, borehole and historical document studies, including those from China. The data were recalibrated with linear regression against the 1881-1960 mean annual temperature observations averaged over the land area north of 20 degrees North and the results smoothed with a 50-year Gaussian filter. Those recalibrated records were then averaged in order to quantitatively define the boundaries of the cold and warm phases. A cold or warm phase was determined whenever an average temperature anomaly had an amplitude exceeding 0.14 degrees Celsius. This delimitation enabled the authors to equalize total lengths of cold and warm phases during the last millennium.

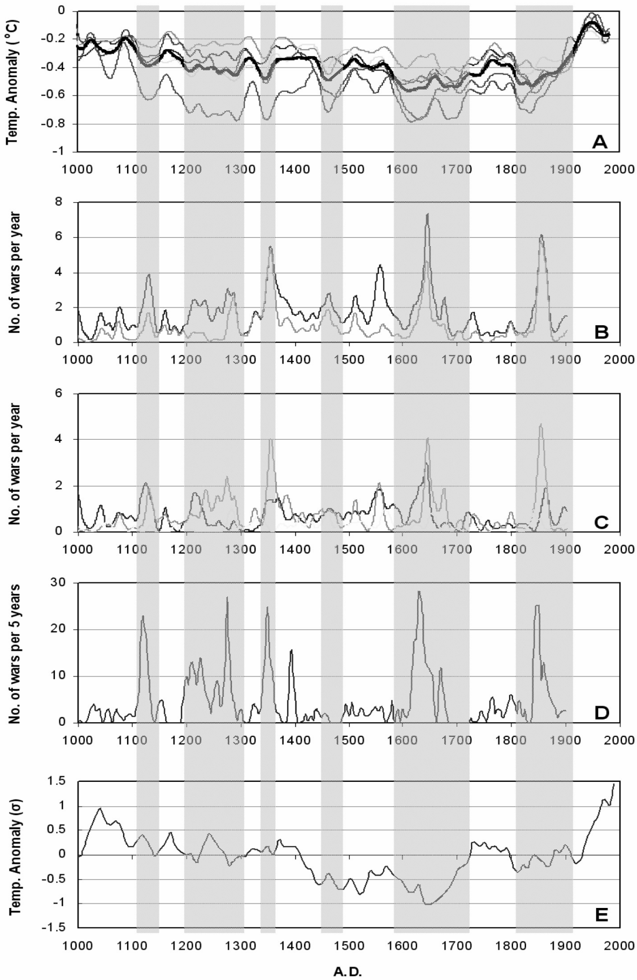

FIGURE 1

Climate changes and incidence of wars in China during the last millennium.

A. Normalized temperature change records for the last millennium for land areas in the northern hemisphere north of 20 degrees: Mann (1998,pink); Briffa (2000, turquoise); Jones (1998, dark blue); Cowley and Lowery (1997, dark red); Esper (2002, blue); and the average of these five normalized series (black). Cold phases are shaded as gray strips. **B.** Frequency of all wars (dark blue) and frequency of rebellions (pink). Data is smoothed by Gaussian 50-year lowpass filter. **C.** Frequency of wars, in North China (dark blue); in Central China (pink); and in South China (yellow). Data is smoothed by Gaussian 50-year lowpass filter. **D.** Number of wars per five years in China recorded by Lee (1931). E. Temperature anomaly data of China reconstructed by Yang et al (2002).

Six major cycles of warm and cold phases between A.D. 1000 and 1911 are identified. The boundaries between warm and cold phases were delineated at the mean temperature point between minimum and maximum values of two contiguous phases on the averaged reconstruction. The warm phases are A.D. 1000-1109, 1153-1193, 1303-1333, 1360-1447, 1488-1582, 1718-1805 and the cold phases A.D. 1110-1152, 1194-1302, 1334-1359, 1448-1487, 1583-1717 and 1806-1911. The aggregated duration of the cold phases is 459 years and of the warm phases 453 years. Similar cycles have been shown in many other reconstructions of climate change both in China and in the northern hemisphere generally (Mann et al., 2003; Zhang, 1981; Wang, 1990; Ge, et al., 2002).

The latest record with a lower resolution of a 10-year scale for China was also chosen for comparison between local record and those of the land area north of 20°N (Figure 2E) (Yang 2002). The series is only used as a comparison due to its lower resolution. The record also approximately agrees with those of hemisphere scale. However, half of the cold phase during 1200-1300 A.D. was a warm phase (>0 sigma units) in this reconstruction.

Our data on the incidence of warfare was derived from a multi-volume compendium that exhaustively catalogues all known wars in China between 800 B.C. and A.D. 1911 (ECCMH, 1985). This compendium lists a total of 1,672 wars between 1000 and 1911, and these were used as the database for this study. Only the year of inception, number, participants and location of the wars from this authoritative treatise are used as reliable data for scientific analysis in the present study in order to avoid bias that might result from the diverse sources of information. Based on the identity of the participants in a particular conflict, we classified wars into two groups: rebellions and others (state wars and tribal wars).

Based on a conventional classification of China's physical regions (Zhao, 1986; and Ren et al., 1985), we divided the wars into three different geographical regions for this study as shown in Figure 2: (1) North China, which is characterized by continental semi-humid, semi-arid and arid temperate climates and economic activities that were mainly pastoral agriculture; (2) Central China, which has a subtropical climate dominated by monsoons and has historically served as China's major rice producing area; and (3) South China, which has both southern subtropical and tropical climates and cultivation that enjoys a long growing season with double- or triple-cropping in a year.

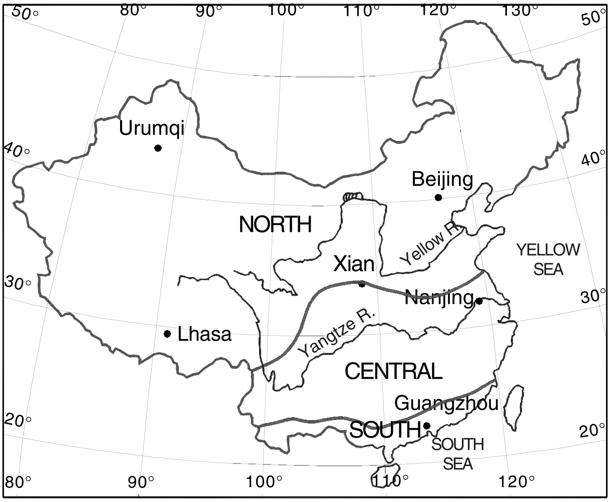

FIGURE 2

Physical regions of China.

In the statistical and frequency analysis, the war data were smoothed by a Gaussian filter with a 50-year interval in order to make it comparable to Briffa's temperature series. Another set of war data (Lee, 1931) provides a diagram of war frequency over time. The war frequency from 1000-1910 A.D. on the diagram was reproduced for this study. As the exact number of wars cannot be retrieved from the diagram, it is only used as a comparison figure to our primary statistics of war frequency (Figure 1D).

3. Results

As with variations in climate, war frequency in China also demonstrates a cyclic pattern. Typically, a turbulent period is followed by a relatively tranquil one (Figure 1B). Eight out of the ten peaks with a high frequency of wars (above 2 wars per year) coincide with the cold phases. The three highest peaks stand out well above the others. Two of these occurred in the coldest phases (< –0.5 degrees Celsius), and the third may represent a carry-over from the previous long cold phase (only a 30-year warm phase separated two cold phases). All cold phases have one or two high frequencies of war. Only two high war frequency peaks fall outside the cold phases (both during the sixteenth century). The two aberrant peaks were mainly the result of wars against pirates intruding from overseas and nomadic invaders from the north. Pirate raids accounted for around 50% of the total incidence of wars in the 1550s (ECCMH, 1985). Rebellions appear to be the dominant category of war in the record (Figure 1B).

The incidence of rebellions is highly correlated with climate changes, and all high frequency rebellion incidences fall in the cold periods. In warm and wet South China, variations in the incidence of wars were less sensitive to changes in temperature (Figure 1C). The outbreak of wars in North China often had a close association with cold phases. All seven highest war frequencies (>2 wars per year) in Central China occurred in cold phases and the peaks neatly followed the cold phases. It is also interesting to note that wars in North China broke out immediately after the onset of a cold phase, except during the cold phases in the fourteenth and nineteenth centuries, when China was ruled by northern nomadic peoples (the Mongols and the Manchus respectively). Compared to war frequencies from Lee (1931) (Figure 1D), of the 9 highest war peaks (10 wars per 5 years), 8 fall in the cold phases.

To compare with Yang's complete China temperature series, 8 out of 10 high frequencies of total war (>2 wars per year) and 4 out of 5 rebellion high war peaks fall in cold times. In Central China, 5 out of 6 high war peaks occurred in the cold periods. For Lee's war series, only 5 high peaks are in Yang's cold periods.

To refine this analysis, the number of wars and their occurrences and the war ratios in both cold and warm phases are shown in Table 1. Their relative distribution shows a pattern consistent with the above observation. The Pearson's correlation coefficients between war frequency and temperature anomalies have been calculated at the annual scale. The Pearson's correlation coefficients between war frequencies and temperature anomalies have been calculated at the phase, decadal and annual scales. The highest frequency of total wars, rebellion wars and wars in Central China in each climatic phase are significantly correlated with the lowest temperature and mean temperature in the phase. The numbers of total wars, rebellion wars and wars in Central, South and North China are all significantly correlated with the temperature variation of the Northern Hemisphere in the annual scale (Table 2), which also indicates that the most highly correlated war categories are the wars in Central china and rebellion wars.

Table 1 Number of wars and ratios of wars in cold and warm phases in different war categories

	TOTAL	REBELLION	CENTRAL	NORTH	SOUTH
Cold phases (459 years)	994	536	462	351	116
Warm phases (453 years)	678	275	237	278	110
Ratio of wars (cold/warm)	1.45	1.92	1.94	1.25	1.04

Table 2 Pearson's correlation coefficients between number of wars and the temperature anomaly from AD 1000 to 1911 in China

	N = 902 (LAG = 0 YRS)	N = 897 (LAG = 0 YRS)	N = 892 (LAG = 0 YRS)	N = 887 (LAG = 0 YRS)	N = 882 (LAG = 0 YRS)	N = 877 (LAG = 0 YRS)	N = 872 (LAG = 0 YRS)
Total	-0.223***	-0.264***	-0.285***	-0.285***	-0.265***	-0.231***	-0.190***
North	-0.106**	-0.144***	-0.153***	-0.135***	-0.096**	-0.041	+0.018
Central	-0.225***	-0.269***	-0.299***	-0.310***	-0.303***	-0.285***	-0.261***
South	-0.112**	-0.087**	-0.070*	-0.067*	-0.078*	-0.092**	-0.100**
Rebellion	-0.247***	-0.279***	-0.297***	-0.297***	-0.280***	-0.254***	-0.228***

• = P<0.05, ** = P<0.01, *** = P<0.001.
War Data is smoothed by Gaussian Filter (year = 50)

The correlations were also run for different time lags at the annual scale in order to gauge how the delayed climate impact upon agricultural production was reflected socially in the form of wars. The highest correlation coefficients for the four war categories have a time lag of 10-15 years, except for south China where war occurrence had no time lag. Compared to the wars in Central China, wars in North China are only significantly correlated with the temperature anomalies with a shorter time lag of 10 years. It appears that climate change caused a more rapid social response (war) in North China than in Central China. Less significant correlations were found for South China. The outbreak of wars led to the collapse of dynasties during A.D. 1000-1911. All dynastic changes following high war frequencies in the study period basically occurred in cold phases, except the collapse of the Yuan Dynasty which happened just a few years after the end of a short cold phase. Of the six cold phases, five led to dynastic collapses during the last millennium.

4. Analysis

The high degree of match between war frequencies and cold phases, higher war ratios in cold phases, and the significant correlations between war frequency and temperature fluctuations in the last millennium seems unlikely to be merely accidental. The explanation for this striking correlation may be that the reduction of thermal energy input in cold periods was the root cause of many social unrests and uprisings. China was an overwhelmingly agrarian society throughout this period. Traditional agriculture was very much dictated by the whims of climate and weather conditions.

Any reduction of thermal energy input would impact upon agricultural production. For example, China's agricultural yields between 1840 and 1890 (a cold period) were between 10% and 25% lower than between 1730 and 1770 (a warm period) because of a shortened growing season, an increase in the number of frost days, and frequent cold spells during the cold periods (Gong et al., 1996).

Cold weather resulted in poor harvests, as shown by the history of rice cultivation in the middle and lower reaches of the Yangtze River, where double cropping of rice failed during the cold phases and started again in warm phases (Gong et al., 1996). A reduced food supply would trigger famine, tax revolts, and a weakening of state power. The shortage of livelihood resources would also be aggravated by population growth that had occurred in the preceding warm period. Rebellions would therefore be more likely to break out during cold phases, and it can be seen that the highest three peaks of wars were dominated by peasant wars (ECCMH, 1985). Domestic unrest also opened the gate for foreign invaders and sharpened competition for a shrinking resource base between states, ethnic groups and tribes.

The geographical distribution of wars further supports the hypothesis that climate change has had a major influence on warfare in China (Figure 2C). In wet tropical and subtropical South China, a drop in temperature during a cold phase would often have a less serious effect on agricultural production than other parts of China, and would not have caused the same degree of social unrest. In contrast to South China, Fig 2C reveals a marked increase in wars of Central China in cold phases. However, in Central China wars tended to break out some time after the start of a cold phase and the major outbreaks were characterized by low frequency and high amplitude. The reason is probably because, in Central China (unlike North China), surplus farm products could be stored to serve as a cushion in difficult times and social dissatisfaction therefore would have taken longer to reach a breaking point.

Grazing was the principal means of sustenance in North China, and this was sensitive to a fall in temperature. Sensitive agriculture brought about a quick response (a shorter time lag) of social unrest, many of which were characterized by incursions by desperate nomadic warriors from the Mongolian grasslands into the fertile plains of Central China. Compared with Central China, the outbreaks exhibit a lower amplitude and shorter frequency. The sensitive response, plus the facts that people in the north freely shifted southward (Fang, 1992) and that livelihood resources could be transferred from the south to the north during the northern nomadic occupation (400 years) may explain why the war ratio between cold and warm phases and the correlation coefficients between temperature anomaly and war numbers in North China (Tables 1 and 2) were not high compared with Central China.

In addition to temperature, some authors (Zhang et al., 1997 and Yang and Shi, 2001) considered that the fluctuations of precipitation in history also influenced social evolution. Indeed, the 13th century drought in China may be one of controlling factors on 13th century high war frequency. However, compared with temperature change, the regional differences of precipitation variation were much higher and there is no high resolution precipitation series from multi-proxy records for the last millennium. Therefore, the degree of precipitation impact on war frequency will rely on the completion of high-resolution reconstruction of paleoprecipitation records.

5. Conclusion

The findings of this study are of great theoretical significance. Historians have long tended to look for economic, political, and ethnic explanations or causes for wars. These traditional classifications, however valid the explanations they provide, do not adequately take into account the effects of climate change. Our research indicates that climatic change in China – specifically, a cooling of the climate – has created conditions favorable for the outbreak of wars, and in extreme cases has helped to overthrow dynasties. The ancient Chinese philosopher Mencius (374-288 B.C.) perceptively envisaged a cycle in which a period of order was perforce followed by a period of disorder. The Chinese believed generally that a minor disturbance was expected every thirty years and a major one every hundred years (Hsu, 1995).

Interestingly, during the last millennium the cold phases of the averaged reconstruction could be divided into long ones, each lasting 105-133 years, and short ones of 25-43 years. Lee (1931) also found out such a cyclic pattern of war, but could not explain it. The major disorders often coincided with the collapse of dynasties. Western scholars have described the rise and fall of dynasties as a "dynastic cycle", the study of which has engendered numerous economic, evolutionary and developmental explanations of Chinese history (Elvin, 1973; Hartwell, 1973). These cyclic theories tried to explain the rise and fall of dynasties as the consequence of social evolution or internal mismanagement. The results from this research suggest that climate change is associated with the social unrest and armed conflicts and should therefore be incorporated in cyclic theories.

While wars will always have their specific political, social and economic causes, we should no longer ignore the long-term effects of natural forces on human society. Seen from a broad perspective, Nature appears to have profoundly influenced the course of China's history during the last millennium. The influence of climate change on war adds a new dimension to the classical concept of Darwinism and environmental determinism.

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