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Relationship between climate change and wars between nomadic and farming groups from the Western Han Dynasty to the Tang Dynasty period

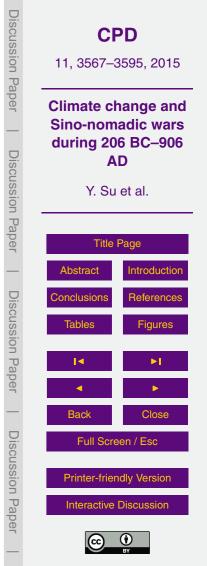
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Abstract

In ancient China, the change in regional agriculture and animal husbandry productivity caused by climate change led to either wars or peaceful relations between nomadic and farming groups. From the Western Han Dynasty to the Tang Dynasty there were

- ⁵ 367 wars between the two groups. The nomadic people initiated 69 % of the wars, but 62.4 % were won by the farmers. On a 30 year-period timescale, warm climates corresponded to a high incidence of wars. The conflicts between the nomadic and farming groups took place in some areas which are sensitive to climate change. During the cold periods, the battlefields were mostly in the southern regions. The main causes
- which leading to the above results are following: (1) warm climate provided a solid material foundation for nomadic and farming groups, especially contributed to improve the productivity of nomadic group; meanwhile, the excessive desire for essential means of subsistence in nomadic group could led to wars. (2) During the cold periods, people of farming group moved to the south and construct the south, meanwhile, nomadic group
- ¹⁵ occupied the central plains, thus the battlefields also changed. As the background, climate change plays an indirect role in wars between groups.

1 Introduction

The association between violent conflicts and environmental change has attracted much research attention recently. Since 2007, more systematic research on the ef-

- fect of climate change on security issues has emerged. The theoretical model linking climate change to intrastate conflict incorporates case studies as well as conflict statistical studies. Three effects of climate change (natural disasters, sea-level rise, and increasing scarcity of resources) may lead to loss of livelihood, economic decline, and increased motivation for instigating violence (Halvard et al., 2008). Climate change is
- a contributing factor to conflict (Collier and Hoeffler, 2005; Homer-Dixon et al., 1993; Maxwell and Reuveny, 2000), acting in many cases as a "threat multiplier". The latest



research, published in Science in August 2013, has found that even minor changes in climate are linked to increases in violence and warfare in human populations (Hsiang et al., 2013).

The key factors in conflicts stemming from climate change vary from region to region.
Webster's study of historical societies suggested that warfare is an adaptive ecological choice under the conditions of population growth and resource limitation (Webster, 1975). In Africa, most studies of influencing factors have focused on the role of precipitation in explaining the incidence of conflict, finding that modern conflicts are more likely in drier years or during prolonged droughts (Held et al., 2006; Hendrix and Glaser, 2007). Over the last millennium, conflicts were more prevalent during colder periods not only in Europe (Tol and Wagner, 2010), but also in China (Zhang et al., 2006), because

reduced thermal energy input during a cold phase lowers the land-carrying capacity in a traditional agrarian society.

The impact process of climate change on conflict varies in different regions. Zhang (2006) concluded that in China the frequency of war varied in the last millennium according to geographical locations (northern, central vs. southern China) because of differences in the physical environment and hence differential responses to climate change. This study also concluded that variations in the frequency of rebellion in China were highly correlated with climatic changes. The conflicts were more prevalent during

colder periods. However, in northern China, the aberrant peaks, overshadowed by this correlation, were mainly due to instigations by nomadic invaders from the north (Zhang et al., 2006). This leads to the question of whether conflicts are more prevalent during colder periods when factors relating to regional divisions or types of violent conflicts are considered. This paper focuses on the relationship between climate change and wars
 of invasion between nomadic and farming groups in northern China in 206 BC–906 AD.

of invasion between nomadic and farming groups in northern China in 206 BC–906 AD. Rotational grazing and sedentary farming were two of the most important modes of economic production in ancient societies. These subsistence techniques gave rise to two groups: nomadic and farming groups. The nomadic group comprised a number of nomadic minorities, such as the Huns, Xianbei, Xiqiang, Khitan and Turks. The farming



group was predominantly of Chinese Han ethnicity, and was a combination of ancient Huaxia people and other ethnic groups. The main tribes of the Huaxia were the Huang Di, Yan Di, and Chi You. The history of the exchanges and collisions between these two groups is an important part of Chinese civilization (Tian and Ma, 2008). In China,

- ⁵ the northern nomadic tribes moved from place to place in search of water and grass for their herds. Nomadic settlements in the vast temperate arid or semi-arid steppes offered harsh conditions; cold in winter and infrequent rainfall. In contrast, the farmers mainly of Chinese Han ethnicity adopted a self-sufficient way of production and distributed themselves in the eastern monsoon region, where the rainfall and high tem-
- peratures were synchronous, with relatively abundant precipitation. The natural climate conditions in these areas were comparatively favorable (Fig. 1). Therefore, the farming group was mainly engaged in agricultural production and living a sedentary life.

The evolution of inter-group relations in China has a long and complex history, which, when combined with long-term historical documentation, is conducive to the relation-

- ship studies between climate change and group conflicts. Hinsch (1998) referred to the climate change in East Asia, Europe, and North America and discussed the relationship between Chinese history and different climate change periods. He pointed out that China was traditionally an agrarian society, which was particularly vulnerable to the effects of climate change. He also summarized the periodic changes of warm and
- ²⁰ cold periods in China, and described the competition and integration of the ecological environment of the nomadic and farming civilization. Based on the ancient administrative divisions in the *Historical Atlas of China* (Tan, 1982), Wang (1996) studied the latitude change of the southern boundary of the national regime established in the southward migration process of the northern nomadic groups starting with the Qin and
- Han Dynasties. From this, he concluded that in warm periods, the nomadic and farming groups maintained a peaceful relationship, while in cold periods, the nomads moved southward, leading to instability of the Central Plain regime and confrontations between the two groups (Wang, 1996).



Research on the relationship between climate change and different community group relations should involve not only empirical cases, but also the construction of proxy indicators and sequences. By conducting quantitative studies, we can better understand the impact of climate change. However, because the evaluation of different community group relations is complicated, there is a lack of reconstruction of long-term, continuous

community group relation sequences with high resolution.

The period this paper examines (206 BC–906 AD) spanned 1112 years and underwent eight major dynasties, in which the Western Han Dynasty (206 BC–24 AD), the Eastern Han Dynasty (25–220 AD), the Western Jin Dynasty (265–316 AD), the Sui

- ¹⁰ Dynasty (581–617 AD), and the Tang Dynasty (618–906 AD) managed to unite the region by politically ruling both the southern and northern parts of China. In contrast, during the Three Kingdoms (220–280 AD), the Eastern Jin Dynasty (317–420 AD), and the Southern and Northern Dynasties (420–589 and 386–581 AD, respectively), China was in turmoil. In the Eastern Han Dynasty and the Southern and Northern Dynas-
- ties, nomadic groups conquered the Central Plain and occupied the northern part of China. This paper focuses on the period from the Western Han Dynasty to the Tang Dynasty, constructs the sequence of the inter-ethnic wars at this time based on historical documents, and compares this sequence with that of simultaneous climate changes obtained from historical documents to analyze the influence of climate change on these
 wars.

2 Data and methods

2.1 Construction of the sequence of wars between nomadic and farming groups

To exchange and obtain natural resources and products, nomads and farmers traded with each other, leading to migration, population mixing, and even cultural blending. However, there were also disputes, conflicts, and wars. National cohesion was eventu-



ally achieved either through peaceful communication or conflicts between the nomadic and farming groups.

Data relating to the wars between nomadic and farming groups were obtained from the *Chronology of Wars in Chinese History* (The Chinese Military History editorial, ⁵ 2003), collected and edited by the Compiling Group of Chinese Military History from Nanjing Academy of Military Sciences. This book includes a chronological table of all the wars in China's history from the Spring and Autumn periods (769 BC) to the Qing Dynasty (1911 AD).

Based on the records in this book, we classified and selected 367 wars between nomadic and farming groups from the Western Han Dynasty to the Tang Dynasty. We noted: the year that the war occurred, the name of the war, the initiator, the victor, the major battlefield, and the location of the battlefield (its present name, latitude and longitude position).

The selection of the records was based on the following criteria:

- we used only wars between the northern nomadic group and farming group who established a regime in central China. We excluded: wars between nomadic ethnicity regimes or tribes, wars between nomadic groups and separatist groups, peasant uprisings within the Central Plain regime that were established by the farming group, and wars between minority ethnic groups in the southwest and farmers or foreign countries.
 - 2. If a war lasted for more than 1 year, the initial year was recorded according to the chronology.
 - 3. In 363 cases (98.91 % of the data) it was clear who initiated the war. In four cases (1.09 %) farming groups lent assistance (in the form of troops) to nomads embroiled in civil strife. In these instances, the farming groups were regarded as the initiators.
 - 4. In 355 cases (96.72%), it was clear who were victorious. For 12 cases there was no information on who won; among these cases, seven (1.91%) described



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one side as "effective defense" or "effective counterattack", or described the other side as "unable to conquer the adversaries" or "attempted attack failed". In these cases, the defending side was categorized as the victor. In three cases (0.82%), one side begged for truces or made peace by marriage, and we considered them to be the losing party. The other two cases (0.54%) were related to wars that involved multiple battlefields and varying outcomes of different wars. For these, we classified the outcome according to the last war.

- 5. For 351 cases (95.64 %) the location of the war was given. In two special situations, there was no relevant information, and we thus used other criteria. There were 11 cases (1.99 %) that recorded the battlefield location as "on the border". In this situation, we referred to the *Historical Atlas of China* (Guo, 1996) and used the middle point of the border as the battlefield location. In five other cases (1.36 %), as only the information of the armies involved was recorded, we used the locations of army camps as the battlefield location.
- We calculated the total number of wars, the average latitude of the battlefields, the frequency of nomadic vs. farming groups' initiation of the conflict, and the dates of their victory, on a 10 year period timescale. We reconstructed the timeline of community group wars from the Western Han Dynasty to the Tang Dynasty. By analyzing the variation characteristics of the sequences, we divided up the historical periods into several stages, drew a scattergram of the major battlefield distribution, and made a spatial
- analysis of the transfer and distribution of the conflicted regions. We also analyzed the possible relationship between the sequence of wars, the distribution of conflicted regions, and climate change.

2.2 Climate change sequences

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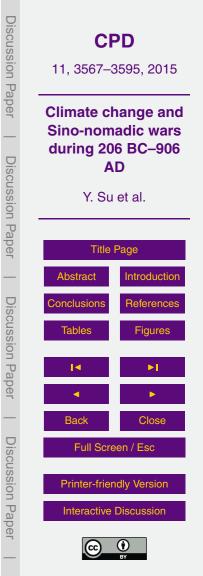
²⁵ Currently, two high-resolution quantitative temperature series provide data to cover both the study period and the study areas. One series, which was reconstructed from stalagmite data from the Beijing Shihua Cave (Tan et al., 1997), indicates temperature



changes in August. The other series, which was reconstructed based on historical documents, shows the winter half-year temperature departure series in eastern China over the past 2000 years (Ge et al., 2003, 2010). Chu Kochen (1973) pioneered the research of Chinese past climate change and his results on climate series reconstruction have

- ⁵ been widely accepted (Gribbin, 1973). The series of the temperature discrepancy of the winter half-year (from October to April) was constructed based on historical documents that were closely related to agricultural production. The resolution is on a 30 year period timescale. The winter half-year temperature departure series in eastern China over the past 2000 years (east of 105° E, 25–40° N) reflects the temperature variation in the
- farming regions. This series also encompasses environmental incidents (Shi, 2000; Cui and Song, 1992; Xia, 1996), such as glacial advancement in West China, and periglacial and paleosol development in the northern regions. Shao's tree-ring studies show a trend between the temperature characteristics in arid or semi-arid zones in northwest China and the temperature change in the Northern Hemisphere (Shao
- et al., 2007; Liu et al., 2004). In the nation of Mongolia, located to the North of China, the temperature series over the past 1738 years was reconstructed from tree-ring data from the Hangai region; the results show that the temperature changes in Mongolia are similar to the temperature changes in polar regions, Europe, and the rest of the Northern Hemisphere (Jacoby et al., 1996; D'Arrigo et al., 2001). Climate changes in the Northern Hemisphere are telepenaeted (D'Arrige et al., 2000). This selected series of the Northern Hemisphere are telepenaeted (D'Arrige et al., 2000).
- Northern Hemisphere are teleconnected (D'Arrigo et al., 2000). This selected series of the mean temperature departures for winter half-years from the Western Han Dynasty to the Tang Dynasty (30 year period timescale) (Ge et al., 2003, 2010) also reflected the temperature change in the northern pasturing areas of China.

For the dry/wet ratio series, we adopted the "dry/wet ratio series of eastern China over the past 1500 years" (Zheng et al., 2006). This series reconstructed the dry/wet ratio from 105 AD to 2000 AD in eastern China (range: east of 105° E, 25–40° N) based on Chinese historical records and data generated from measurements. The resolution is on a 1 year period. The farming-grazing transitional zones are more sensitive to climate change. The development of these transitional zones is related to the change



of the dry/wet ratio. High-resolution data are conducive to the research on the impact of dry/wet ratio on the relationship between the nomadic and farming groups.

3 Analyses

3.1 War sequences between nomadic and farming groups

5 3.1.1 War frequency

A total of 367 wars (average 3.3 times per 10 years (3.3 wars (10 yr)⁻¹)) occurred between the farming and nomadic groups from the Western Han Dynasty to the Tang Dynasty (Fig. 2). The wars between the two groups were concentrated in different periods. Wars were more frequent (14 wars (10 yr)⁻¹) within three periods (111–120 AD, 311–320 AD, and 621–630 AD). Based on the descending order of the frequency of war in each dynasty, the first 15% of periods with a frequency of more than (or equal to) 7 wars (10 yr)⁻¹ were regarded as high incidence. There were 18 such periods that accounted for 169 wars. In other words, during 16% of the time span (1112 years), 46% of the wars occurred. The last 15% of the periods, which witnessed wars less than (or equal to) 1 war (10 yr)⁻¹, were regarded as a low incidence. In these 41 periods, only 20 wars occurred (36% of the time span, 5% of the wars). Periods of no wars occurred mainly in the late period of a dynasty or during periods between dynasties in the Central Plain, when there was no extra power to initiate wars or resist enemies. However, we do note that during periods between dynasties there is a lack of records.

- ²⁰ Statistical classification of wars in different dynasties suggested that in a 10 year period during the Eastern Han Dynasty, the Western Jin Dynasty and the Eastern Jin Dynasty, the frequency of war was far higher than the average (3.3 wars (10 yr)⁻¹), and these dynasties were the periods with a high incidence of group wars (Table 1). There were 14 high-incidence periods of wars within these three dynasties, making up 78 %
- $_{\circ}$ of all the high-incidence periods. In other dynasties, the frequency of wars, on a 10 year



period timescale, was lower than the average, and were considered to be low-incidence periods.

3.1.2 Initiators and the victors

Table 2 shows the frequency of initiation and victory for farming and nomadic groups. The nomadic groups were dominant in initiation, while the farming groups were dominant in victories. This distribution was particularly distinct in politically united dynasties (the Western Han Dynasty, the Eastern Han Dynasty, the Sui Dynasty, and the Tang Dynasty). During the Western and Eastern Han Dynasties, the farming groups initiated far fewer wars but achieved most of the victories. This pattern persisted until the Sui and Tang Dynasties, in which the wars initiated by farming groups slightly increased, but in most cases they were still victorious. In contrast, the nomadic groups were mainly the instigators, and they achieved victories only during periods of political turbulence (i.e., the Western Jin Dynasty, the Eastern Jin Dynasty, the Southern and Northern Dynasty). However, during the Three Kingdoms, the farming groups initiated most of

the wars but achieved few victories.

3.1.3 Classification of war periods

We divided the changes in the frequency of war into three periods based on the frequency of war in different dynasties (Fig. 2).

The first period includes the Western and the Eastern Han Dynasties (206 BC–220 AD), with a low incidence of wars in the beginning of this period (Western Han Dynasty) and high-incidence in the latter portion (Eastern Han). There were 148 wars (40% of the total), with an average of 3.4 wars(10yr)⁻¹, increasing to 5.3 wars(10yr)⁻¹ in the late period. Farming groups initiated 21.6 % of the conflicts during this period and were victorious 71.6 % of the time.

²⁵ The second period includes the Three Kingdoms, the Wei Dynasty, the Jin Dynasties, and the Southern and the Northern Dynasty (221–580 AD). There were 130 wars in



total (36 % of the total, 3.6 wars $(10 \text{ yr})^{-1}$). The frequency of wars initiated by the farming groups in this period was significantly higher than that of the earlier period, rising to 38.5 % of the total, but they achieved only 42.3 % of the victories.

The third period was the Sui Dynasty and the Tang Dynasty (581–906 AD), which ⁵ was a low-incidence period. In this period, there were 89 wars in total (24 % of the total, $2.7 \text{ wars} (10 \text{ yr})^{-1}$). Besides the high incidence of wars during the alternation periods of different dynasties, the frequency of war decreased overall. As in the first period, the farming groups initiated fewer conflicts (34.8 % of the total), but won most of them (76.4 %).

10 3.2 Distribution and change in the conflict regions between farming and nomadic groups

The wars in the first period (206 BC–220 AD) mainly occurred between an ethnic group (such as the Hun, Qiang, Xianbei, or Wuhuan) and the farming group who established the Western and Eastern Han Dynasty. The border between the Hun, Wuhuan, and Xianbei ethnic groups' territory and the Han Dynasty was located at approximately 44° N, and extended to 41° N to the southeast (Guo, 1996). The main conflict regions were from 33 to 42° N and from 100 to 118° E, and distributed along the Hexi Corridor, on the Loess Plateau south of the Yellow River and north of the Qin Mountains (high-incidence regions), in the regions from the east of the Plain and Step Lands to the west

²⁰ of the Taihang Mountains (high-incidence regions), and regions along the Great Wall in the north of the North China Plain. In summary, the major battlefields were mostly in the border regions (Fig. 3a).

In the second period (221–580 AD), wars mainly broke out between the ethnic Xianbei and the Hun against the Western Jin Dynasty, as well as between the Eastern Jin

²⁵ Dynasty and the nomadic tribes that invaded the Central Plain. During the Western Jin Dynasty, the border between the two groups ran from the northeast of the Tianshan-Hexi Corridor, 36° N north of the Qin Mountains, the Yellow River to the Great Wall of

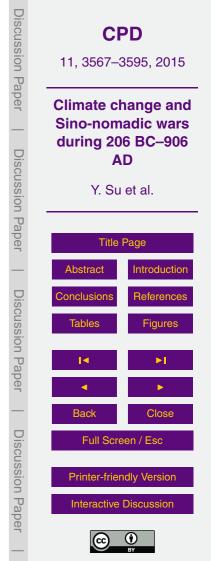


that time (40° N). During the Eastern Jin Dynasty, the border was near the Qing Mountains and the Huaihe River, around 33° N (Guo, 1996). The main battlefields were at 105–120° E, 30–38° N and scattered along the Qin Mountains, the North China Plain and the Huanghuai Plain west of Shandong Peninsula (Fig. 3b), which shows that these latitudes were notably to the south (around 3–4 latitudes).

Wars in the third period (581–906 AD) were mainly between the nomadic groups like the Tuyuhun, Turk, Khitan, Tibet, and Uyghur tribes, and the Sui and Tang Dynasties. The border between the minorities in the north and the dynasties in the Central Plain was along the 42° N region (Guo, 1996). The conflicts were widely distributed within 98–113° E, 33–42° N, mainly in the northwestern region. Furthermore, some of the wars extended to present-day Kazakhstan and Kyrgyzstan, with scattered sites in the Tianshan Mountains, Hexi Corridor (high-incidence regions), the Loess Plateau south of the Yellow River and north of the Qin Mountains, regions east of the Plain and Step Lands and west of the Taihang Mountains, and regions along the Great Wall north of the North China Plain (Fig. 3c).

An overall examination of the these periods showed that the battlefields were mainly distributed in the Hexi Corridor, the Loess Plateau south of Yellow River and north of Qin Mountains, and the whole North China Plain. These regions were the adjoining areas of the nomadic and farming groups in the semiarid ecological transitional band. Meanwhile, they were on the fringes of the agricultural production areas. This region corresponds to the location of the 400 mm isohyets, the demarcation line between the monsoon region and non-monsoon region and the Great Wall, which are all extremely sensitive to climate change.

The battlefields in the first period (the Western and the Eastern Han Dynasties) and the third period (the Sui and Tang Dynasties) were far away from the capitals of the farming regime and mainly in the north. In contrast, the battlefields in the second period (the Three Kingdoms, the Western and Eastern Jin Dynasties, and the Southern and Northern Dynasty) were near the capitals of the farming areas, even directly south of the capital.



3.3 Impact of the climate on the ethnic wars

3.3.1 Climate change from the Western Han Dynasty to the Tang Dynasty

There were warm periods during the Western and Eastern Han Dynasties, and in the Sui and Tang Dynasties; and cold periods in the Wei and Jin Dynasties, and in the Northern and Southern Dynasties. Dryness and wetness variations fluctuated periodically (sequence a and b in Fig. 2). During the Western and Eastern Han Dynasties the annual change of temperature reached its maximum in the middle stage and relatively cold periods occurred in the later stages. The Wei and Jin Dynasties and the Northern and Southern Dynasties were colder and drier, and the coldest period took place in the Northern and Southern Dynasties. The climate became warmer from the late Northern and Southern Dynasties and reached its warmest period in the mid-Tang Dynasty. Al-

and Southern Dynasties and reached its warmest period in the mid-Tang Dynasty. Although the humidity of this period fluctuated slightly, it rarely went beyond the normal level.

3.3.2 Ethnic wars and climate change

On a centennial or longer scale, there was no significant difference between the number of wars and climate change (Fig. 2, Table 3). However, in terms of the spatial variable, group wars between farmers and nomadic tribes corresponded to climate changes (Figs. 2f and 3). In warm periods, the battlefields were mostly in the northern areas (average latitude 38.92° N). In the cold period, the battlefields were in the southern parts (average latitude 34.66° N).

On a 30 year period scale, a warm climate corresponded to a high incidence of wars, while a cold climate corresponded to a low incidence of wars. During the warm climate of the Western and Eastern Han Dynasties, the correlation index between the frequency of the wars and climate change was 0.143, and the correlation index was 0.577 during the Sui and Tang Dynasties (cold climate). In the cold period of the Wei

²⁵ 0.577 during the Sui and Tang Dynasties (cold climate). In the cold period of the Wei and Jin Dynasties, the correlation between the frequency of wars and climate change



was negative (-0.223). The number of wars decreased to its lowest point in the cold period of the late Tang Dynasty. The highest frequency of wars was 14 times higher during the warm period of the Western Han Dynasty (111–120 AD, the temperature departure was 0.4 °C), the cold period of Wei and Jin Dynasties (311–320 AD, the temperature departure was -0.5), and the warm period of the Sui and Tang Dynasties (621–630 AD, the temperature departure was 0 °C). In the 18 high-incidence periods of group wars, 13 of them (72 %) broke out in a warm period, with an average temperature departure of 0.28 °C. 20.6 % of the warm periods were also high-incidence periods of group wars.

There was no significant correlation between the frequency of wars and the dry/wet series. Only the longest drought period, 302–421AD, corresponded to the high incidence of wars in the Eastern Jin Dynasty. The peak of the war frequency saw about 20–30 years' delay compared with that of the extreme drought.

The farming groups maintained a low frequency of initiation, with no correlation to climate change, while the nomadic groups were always the aggravating party. The peak of the frequency of war almost corresponds to that of the temperature departure, and reaches a maximum value in the cold period of the Eastern and Western Jin Dynasties.

The farming groups had a greater chance of winning, especially in the warm period. However, in the cold period, the two groups had almost the same chance of winning the wars, with the nomadic groups gaining the upper hand.

4 Mechanism of the impact of climate change on the wars between the farming and nomadic groups

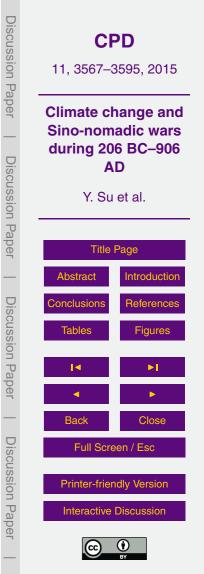
Our conclusions that groups wars were more prevalent during warmer periods are different from those of the study conducted by Zhang Dian (Zhang et al., 2006), who concluded that the frequency of wars in cold periods was higher than that of warm periods. One possible reason is that the frequency of war in our study only accounts for wars between the nomadic and farming groups without considering any other types



of war (e.g., civil wars in cold periods lead to insufficient food). From Table 3 we can see that the vast majority of all wars were initiated by nomadic group and the frequency of war initiated occupy a large proportion in the total war frequency, however, farming groups got more victory; and the location of the key battleground also changed with climate. Why do the above aspects of wars change, what role does the climate play?

Firstly, nomadic economy was single and vulnerable, and the war plunder which cost less but obtained more was a way of getting a variety of agricultural products and wealth for nomadic group. Northern nomadic groups and farming groups varied greatly in their culture and economic stability. The nomadic economy relied highly on nature and ap-

- plied few technologies to the production of goods. In addition, their simple socioeconomic structure was more vulnerable to natural disasters. There were few opportunities for internal trade, therefore the nomadic groups traded with farming groups (He, 2003). These differences between the two groups resulted in an unbalanced complementary relationship in their product structures, such that the nomadic economy depended on
- the farming economy. Therefore, the nomadic groups had to resort to mutual trade and wars to obtain agricultural products and crafts from the farmers, which made them the primary initiators of wars. The purpose of nomadic groups waging war was to open commodity circulation channels and ensure continuous access to more agricultural products. Compared with farming group, in the cold-weapon age, one of the important
- ²⁰ characters of nomadic group was a combination of military and production. Advantages which fighting on horses and the accuracy of shooting with the bow in nomadic group can get training in daily life, and farming group can not do this (Zhao and Yu, 2013). Therefore, nomadic group often became the part of launching in wars. Nomadic group which living in the cold condition had the character of advocating force, and during the
- ²⁵ period of strong of nomadic group (warm periods) wars which was predatory and expansionary were brought to the central plains by the nomad (Ma, 2011). The purpose of the most wars was to get necessary survival items and luxury goods, and the way they took usually was robbing. It was just because they did not intend to obtain a large area of land and cities, they just wanted to use the lower cost to get higher interests



through wars. Due to strong ability of plunder, the wealth of nomadic group increased sharply. This became a kind of the most effective means of gaining wealth, and became a dynamic to inspire people in nomadic group to plunder (Cui, 2011).

- Secondly, warm climate provided a good environmental conditions for developing
 economy in both groups. Good economic conditions in nomadic group can enhance the strength to against farming group, and also provide a solid material foundation for waging wars (Wu et al., 2009). In the cold periods, to some extent, strength of both groups was weakened, and extreme cold would weakened the ability to attack by damaging nomadic livestock (especially horses); two groups presented concessions in the
- ¹⁰ cold periods. In the case of good climate condition, nomadic group was enough to live comfortably and livestock could proliferate more than double with abundant precipitation, lush grass in a few years (Xiao, 1972). By studying the history of vicissitude of nomadic group, results indicate nomadic empire can often rise rapidly with strong horses and armies (Wu et al., 2009). Besides, high frequency of launching does not
- ¹⁵ mean winning. The results of wars depend not only on the strength of nomadic offensive capability, but also on the ability to figh back of farming group. For example, in the Western and the Eastern Han Dynasties warm period, farming area had erupted a large flood which spread to many other areas, and even a sea overflow appeared. Due to the fact that the Han government failed to completely solve the serious conse-
- quences caused by the flood, and the fact made the social conflicts intensified (Duan, 2002), and turbulent situation in farming group was a good time for nomadic group to attack. Thirdly, nomadic population increased rapidly in warm periods, and the thirst for necessaries of life led to wars. As is known to all, the characteristics of the monsoon climate of China are warm and wet over the same period, cold and drought in the
- same period, and so is the historical period (Wang, 1996). In the warm and wet period, nomads had relatively few natural disasters and lush, at this time, population tended to increase rapidly. On the one hand, nomadic group unilaterally pursued the quantity or the scale of the livestock in order to maintain the basic livelihood, and eventually caused the imbalance of the grassland ecosystem and grassland degradation in some



areas (He, 2002). Some regions near the 400 mm rainfall line are the transition areas, namely, semi-arid ecological transition zone. On account of feasibility of agricultural and nomadic in these regions, contending for the areas intensified the conflict between both groups. On the other hand, with the growing demand of nomadic group for subsis-

tence, food, cloth and other agricultural products had become necessary supplements and these can only obtain from the farming group (Wei, 2011). By studying the Huns' population in Western Han Dynasty, Shang (2006) shows that the Huns'period with the largest population is the ones which are from Modu period to Junchen period. During the period, Huns often plundered wars against foreign and robbed a large number of population and wealth.

Fourthly, in the cold periods, both groups moved to the south, so did political boundaries and conflict zones. In the cold periods, to some extent, strength of both groups was weakened. However, farming group's economy was developed and accumulated abundant supplies, and the disaster areas can be granted subsidies by government

- regulation and control. Nevertheless, due to the unicity of nomadic economy, nomadic group would suffer more losses than farming group in the extreme cold condition, so nomadic group was going to launch wars to farming group under the condition of excessive population and low power. As a result, the main conflict areas moved to south step by step. The strong desire of getting living space by winning in wars also contributed
- to the the tenacious will of nomadic group in the cold periods. Nomadic continuously southward invasion and migration led to the frequent wars in the central plains, and forced agricultural people to move to the Yangtze river and the south. At this time, the cold climatic condition made the south water area reduced, and the large areas of farmland appear, so the environment in the south was more suitable for farming and
- ²⁵ living for human beings (Lan and Jiang, 2005). Farming group brought a large number of labor force and advanced production technology to the south, and these conditions promoted the great development of the economy in the south and then attracted more farming people to migrate to the south. The decreased population of the north and deterioration of agricultural environment brought the more difficulties for supplies



of soldiers and food, so the conflict areas were southward. Warm climatic conditions made the economic recovery of farming group, and the military power of two groups had gradually generated gap. The frequency of victory of farming group was gradually increasing, nomadic group was expelled from the central plains, and the main conflict zone gradually moved to the north again.

5 Discussion and conclusions

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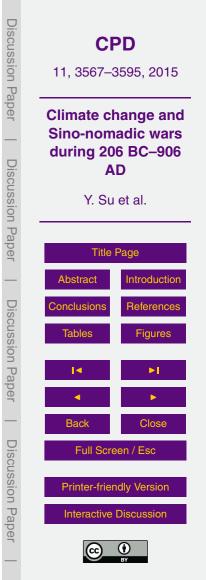
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The reasons for the change in group relations are complex and diverse, and are influenced by political, economic, social, and cultural factors. Climate change also plays a role in promoting change. From the Western Han Dynasty to the Tang Dynasty, the nomadic and farming groups' relationship was affected by climate change as follows:

- wars between the nomadic and farming groups took place with regularity. On a centennial scale, there was no significant correlation between the number of wars and climate change; however, on a 30 year period timescale, a warm climate corresponded to a high incidence of wars, while cold periods corresponded to a low incidence.
- 2. Overall, the nomads initiated the majority of the wars, which had no close relationship to climate change. This reflects the nomads vulnerability, and their dependence on the farming economy. During warm periods, most of the wars were won by the farming groups, which reflected their strong economic strength. However, during the cold periods, both sides won almost the same number of wars, but the nomadic groups had a slight advantage.
- 3. The conflicts between the two groups mainly took place in the Hexi Corridor, the Loess Plateau south of the Yellow River and north of the Qin Mountains, and the North China Plain. The wars mostly took place either at the border of the two groups or in the nomads' territory. As the temperature decreased, the battlefields



expanded into the farming areas, and the involved regions were in the east or the south.

4. The influence of climate change on wars between nomadic and farming groups may be achieved by the following four aspects: (1) under the background of warm climates, the excessive growth of population in nomadic group could bring about desire for essential means of subsistence, and led to wars. (2) Warm climates provided a solid material foundation for nomadic and farming groups, especially contributed to improve the productivity of nomadic group; in addition, compared with cold periods, both groups had the strength to fight in warm periods. (3) The nomadic economy had a strong dependence on the agricultural economy, and plundering by wars was a way of low cost and high income. (4) During the cold periods, people of farm group moved to the south and started to develop and construct the regions south of the Yangtze River, meanwhile, nomadic group occupied the central plains which made the boundary of regime change, thus the conflict area also changed.

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As there are a limited number of documents and quantitative indices, we need other proxy indicators and criteria than data related to wars to gain an in-depth understanding of group relations, especially their power and confrontations. With regard to the distribution of battlefields, some battlefields lie outside the current territory of China. These battlefields have not been included in the analysis.

In addition, we did not cover the 2000 years holistically in this research; therefore, there are temporal limitations in the conclusions about their relationships. Moreover, the construction of the sequence needs to be further extended. After the Tang Dynasty, China's economic center shifted to the south, while the north was the political center, and we suspect that ethnic relations may have changed.

This case study revealed that the socio-economic impacts of climate change are different in different regions and for different aspects. In ancient China, peasant uprisings were greater in colder periods, and ethnic conflicts were more serious in warmer



periods. These results may indicate that multiple mechanisms contribute to the observed relationships and that different mechanisms dominate in different contexts. It seems likely that climatic changes influence wars through multiple pathways. Further research should be to identify these mechanisms.

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Table 1. Frequency of wars between the farming and nomadic groups from the Western HanDynasty to the Tang Dynasty in China.

Dynasty	Total	Frequency $(times (10 yr)^{-1})$	High-frequency periods
Western Han	46	2.00	-130s
Eastern Han	102	5.28	90s–130s, 150s–170s
Three Kingdoms	3	0.66	
Western Jin	38	7.45	270s, 300s–320s, 350s
Eastern Jin	48	4.66	370s
Southern and Northern	41	2.43	
Sui	9	2.50	
Tang	80	2.78	620s, 680s–690 s
Sum/average	367	3.30	

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Table 2. Frequency of war initiation and victories of	of farming and the nomadic groups.
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Dynasty	Farmers Total	Percentage	Total	Percentage	Nomads Total	Percentage	Total	Percentage
	initiation	J	victories		initiation	(%)	victories	(%)
		(%)		(%)				
Western Han	11	23.91	28	60.87	35	76.09	18	39.13
Eastern Han	21	20.59	78	76.47	81	79.41	24	23.53
Three Kingdoms	3	100	1	33.33	0	0	2	66.67
Western Jin	11	28.95	19	50	27	71.05	19	50
Eastern Jin	19	39.58	16	33.33	29	60.42	32	66.67
Southern and Northern	17	41.46	19	46.34	24	58.54	22	53.66
Sui	3	33.33	9	100	6	66.67	0	0
Tang	28	35	59	73.75	52	65	21	26.25
Total/Average	113	30.8	229	62.4	254	69.2	138	37.6

Time	Stage	Cold-warm phase		Frequer	Frequency over 10 year periods			
		fluctuations	Trends	the ethnic wars	wars initiated by farming groups	wars initiated by nomadic groups	wars won by farming groups	wars won by the nomadic groups
210–31 BC	The Western and the Eastern	Warm	Drop in temperature	2.39	0.50	1.89	1.44	0.94
30 BC-30 AD	Han Dynasties warm period	Cold	Drop in temperature	0.50	0.17	0.33	0.33	0.17
31–120 AD	·	Warm	Rise in temperature	5.33	1.78	3.56	4.33	1.00
121–210 AD		Warm	Drop in temperature	5.89	0.56	5.33	4.22	1.67
211–360 AD	The three Kingdoms, the	Cold	Drop in temperature	4.13	1.67	2.47	1.73	2.40
361–390 AD	Wei and Jin Dynasties, and	Warm	Rise in temperature	6.33	2.33	4.00	2.00	4.33
391–510 AD	the Northern and Southern	Cold	Drop in temperature	3.17	0.92	2.25	1.50	1.67
511–570 AD	Dynasties cold period	Cold	Rise in temperature	1.50	1.17	0.33	1.00	0.50
571–720 AD	The Sui and Tang Dynasties	Warm	Rise in temperature	4.13	1.40	2.73	2.93	1.20
721–780 AD	warm period	Warm	Drop in temperature	3.83	1.67	2.17	2.83	1.00
781–906 AD		Cold	Drop in temperature	0.54	0.15	0.38	0.54	0.00

Table 3. Frequency of wars in cold and warm periods.

The warm period in the cold-warm fluctuation refers to the temperature departure that is above or equal to 0 °C, while cold refers to that of lower than 0 °C. The cold-warm trend statistics are generated from comparing them with former phases. Bold values: a larger proportion of wars initiated (or won) by the nomadic and farming groups.





Figure 1. Distribution of the regions of the nomadic and farming groups during the Western Han Dynasty, the Western Jin Dynasty, and the Tang Dynasty (Tan, 1982).

Note: regions where the regime was established by the farming group in different periods are in green. Regions identified with other colors correspond to different regimes established by several nomadic ethnicities.



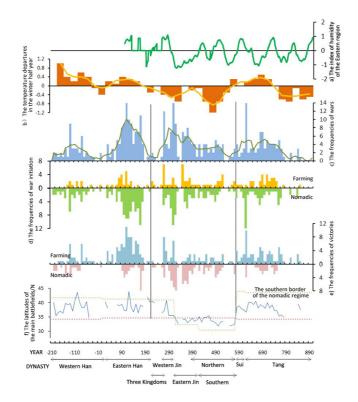


Figure 2. Sequence of wars between the northern nomadic and farming groups. **(a)** Annual humidity index of China from 105 AD to the middle of the Tang Dynasty (Zheng et al., 2006); **(b)** mean temperature departures and three-point moving average curve for winter half-years from the Western Han Dynasty to the Tang Dynasty (30 year period timescale) (Ge et al., 2003, 2010); **(c)** frequency of war and five-point moving average values; **(d)** frequency of wars initiated by the farming and nomadic groups; **(e)** frequency of victories of farming and nomadic groups; **(f)** latitude of the main battlefields (north latitude/N, blue solid line), latitude of the capitals of the farming regime (red dotted lines), changes of the southern border of the nomadic region in each dynasty (green dotted lines) (Huichang, 1996).

