INSTITUTE FOR MONGOLIAN STUDIES
National University of Mongolia

Vol.15 (411) 2014 85-88

Response of Mongolian Nomads to Climate Change during the past 800 years: Stochastic Proxies for Reconstruction

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Background

Mongolians are one of the few ancient traditional nomads in Asia. The extreme climate of Mongolia may have led nomads to migrate for looking for a new adaptable nature and for motivating them to reshape the approaches towards active lifestyle. Ecological changes during the late Holocene may have contributed to three major human events of global significance (Ana and Feng, 2004): (1) the Hsiung-nu Empire between 3rd century BC and 1st century AD, (2) the invasion of China and Europe by nomadic tribes from Mongolia between 311 and 589 AD, and (3) the expansion of Mongolian Empire across the Europe between 1206 and 1405 AD. In addition, according to the many scientists, including of Joerg Schaefer, explored the advancement of glaciers starting in the 14th century affected various cultures in the world. Many questions remain about the global patterns of civilizations induced by the nature and causes of climate changes over the last millennium. Here, this study focuses on how Mongolian nomads experienced the multiple fluctuations of climate change during the historical periods, and how to adapt for the further challenges of rising temperature or global warming. Although lots of independent studies are related to geography, geology, history, archeology, meteorology and etc., it is important for understanding the relationship between human and nature with combined studies among the scientific fields mentioned above. Because human's life, society and economy are not only dependent on climatic and environmental conditions, as like as that David Putnam noted that human societies are quite sensitive to climate change, but human society is capable of shaping its geographical environment.

Global Trend of the Solar Activities

Factors that can shape climate include variations in solar radiation, biotic processes, variations in the Earth's orbit, plate tectonics, volcanic eruptions and changes in greenhouse gas concentrations. Solar cycle apparently affects terrestrial climate, and rises and falls with an 11-year cycle of sunspots (Figure 1) that affects us with increased extreme ultraviolet and x-ray emissions from the Sun. Although the change in the total solar irradiance seems too small to produce significant climatic effects, there is good evidence that, to some extent, the Earth's climate heats and cools as solar activity rises and falls (Haigh, 2007). The 11-year cycle of solar activity is characterized by the rise and fall in the numbers and surface area of sunspots (Hathaway, 2010). Sunspots were almost certainly seen by prehistoric humans viewing the Sun through hazy skies. The earliest actual recordings of sunspot observations were from China over 2000 years ago (Clark and Stephenson, 1978; Wittmann and Xu, 1987). Yet, the existence of spots on the Sun came as a surprise to westerners when telescopes were first used to observe the Sun in the early 17th century. In 1610, shortly after viewing the sun, Galileo Galilei made the first European observations of sunspots with his new telescope. The solar cycle has a period of about 11 years but varies in length with a standard deviation of about 14 months, and each cycle appears as an outburst of activity that overlaps with both the preceding and following cycles by about 18 months (Hathaway, 2010). At any time, one hemisphere may dominate over the other but the northern and southern hemispheres never get completely out of phase. Sunspots erupt in groups extended in longitude but more constrained in latitude with one magnetic polarity associated with the leading spots and the opposite polarity associated with the following spots. Solar cycle amplitudes exhibit extended periods of inactivity like the Maunder Minimum (1645-1715). Predictions for the amplitude of a cycle based on the Sun's polar field strength or on geomagnetic activity near cycle minimum are significant, i.e., solar activities are responsible for numerous reactions such as the Mongolian Empire in the 13th century and civil revolutions (American, French, Scottish, etc.) in the 16th-17th century which may have been corresponded with high and low solar activities, respectively.

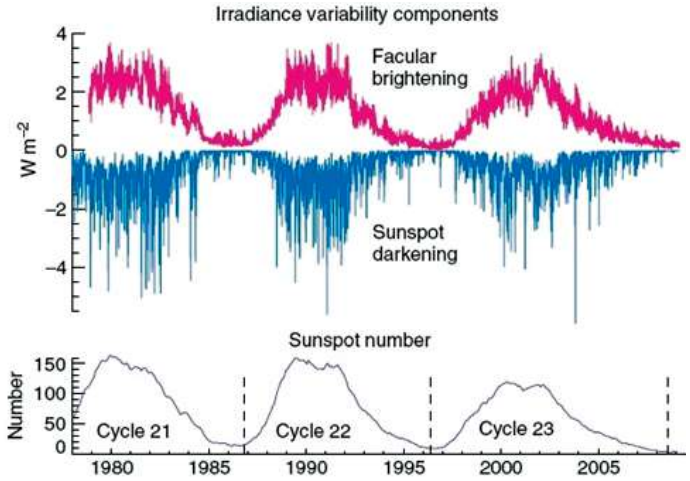

Figure 1. Solar Activity Proxies based on Sunspot Number (*Source*: NOAA).

The Medieval Maximum Period and the Little Ice Age

Several reconstructions of large-scale climate changes made with various sets of paleoclimate data from lacustrine sediments (Prokopenko et al., 2007; Kashiwaya et al., 2010; Orkhonselenge et al., 2013), tree rings (Jacoby et al., 1996; D'Arrigo et al., 2001; Pederson et al., 2014), ice cores of corals (Greer and Swart, 2006), and historical records (Lattimore, 1938) review the climatic fluctuations during the Pleistocene and Holocene, and they point a general decline in temperature from ~1000 to ~1900 A.D (Figure 2) with rapid warming from around 950 to 1250 A.D (Mann et al., 2009) and over the last century that has no counterpart in the millennial record. During the Medieval Warm Period (MWP), Europe entered a warm spell, while episodic droughts hit the southwestern U.S. Some additional data predict the MWP: high-precision borehole temperature measurements from Greenland, and some from Antarctica, do point to warmer conditions around 1000 A.D. than in recent decades. Because the MWP is often pointed to as proof that there were periods of naturally warm, without anthropogenic influences. Cosmogenic isotope data (^{10}Be and ^{14}C) point to relatively high levels of solar activity around 1000 A.D., when slightly higher insolation was also suggested with orbital considerations. It may have been predicted that the Mongolian Empire took place at peak of its power during the MWP.

The Little Ice Age (Figure 2), the first post medieval advance of glaciers, was the last period of extreme cooling prior to the climatic conditions we know today. There is some dispute among scientists as to when the Little Ice Age began, somewhere between 1100 and 1300 A.D., but it is more widely believed to have ended by 1850 A.D. As Putnam noted, the Little Ice Age started it all for the Mongolians some 800 years ago is debatable, and he supports the earlier start, related to the Mongolian expansion, while Joerg Schaefer offers findings to support the later onset. By the mid-16th century, global temperatures were colder than in previous centuries, and alpine glaciers around the world, a sensitive bell of temperature change generally advanced. Hessl pointed out, in the face of apparently severe climate conditions, the Mongolian Empire did not collapse, instead, they restructured and diversified energy sources, and still, a favorable climate and abundant energy would have helped the ruler consolidate Chinggis' power (Mara, 2012). That intriguing possibility could reshape our understanding of seeds of the Mongolian Empire, i.e., Mongolian nomads are skillfully adaptable to any climate that has been reliably proving by Mongolians who have distributed all over the globe in the past and today.

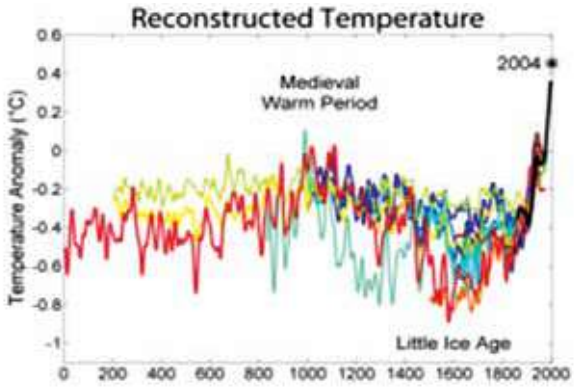

Figure 2. The Medieval Warm Period and the Little Ice Age (*Source*: Mann et al., 2009).

How have the Mongolian Empire responded to the climate changes?

Much of what historians know about the ascent of the Mongolian Empire is based on a single source: *The Secret History of the Mongolia,* but while rich with details about Chinggis Khaan's life and folklore, and it says nothing about resource use or climate during the period of the leader's rise. Some historians have explained the Mongolians' achievements as a product of superior military tactics, proposing that because Chinggis Khaan's troops grew up hunting and riding horses they had an advantage over sedentary armies. In exploring why the Mongolians managed to rule over a large empire, scholars have pointed to an innovative leadership style.

Arnold J. Toynbee may have been the first to point to a possible climate connection, and proposed that a push exerted by the climate of the steppes implicitly an inhospitable climate may have propelled nomadic armies in Mongolia to venture out for resources due to drought in the 12th and 13th centuries. The prevailing Mongolian Empire, some 800 to 900 years ago, around the Khorgo Volcano have been reviewed by the lava field's stressed trees acutely sensitive to changes in moisture levels. The preliminary climate record that the period from 1211 to 1230 A.D., when Chinggis Khaan was in heyday, Mongolia took abundant rainfall, apparently more than in any other 20-year stretch over the past 800 years. The grasses and other vegetation in the steppe would have flourished, allowing the Mongolians to raise more livestock and giving them more horsepower for conquests. In addition, the tree-ring data show that in the late 12th century, Mongolia was wracked by intertribal warfare, the area did experience a cold, dry period. But a few decades later, as Chinggis Khaan began consolidating power, weather conditions appear to have substantially improved and to nomads who rely on access to lakes for watering animals. In times of abundant rain, pastoralists thrive, If more rainfall boosted grassland productivity and overall energy output, that could help explain why the Mongolians were able to transition from a chieftain society, where positions are hereditary to managing a complex state covering a vast empire. The horses and food accumulated on the steppe would have enabled the Mongolians to set out in pursuit of gold and silk to more distant lands. Climatic shifts may be responsible for its scale and grandeur, the expanded Mongolian Empire was remarkably short-lived. As Mara suggested, around 1258, after an unidentified volcano unleashed a massive eruption that spewed sulfur and ash into the stratosphere, a cool, dry climate returned. Thereafter, Khubilai Khaan moved the Mongolian capital to Beijing and the Mongolians' power had begun to wane.

What can Mongolian nomads do for the further climate changes?

Climate changes in the future will call new challenges for Mongolian nomads. Because up to one-third of total population in Mongolia lives as nomadic herders who rely upon grazing livestock, even small changes in ecology could have a profound effect on the nation. The traditional nomadic way of life and associated socioeconomic activities based on the unique geographical and climatic conditions in Mongolia imply their sensitiveness to the impacts of climate changes. For predicting the further trends on climate changes, reconstructing the paleoclimatic changes in Mongolia, based on fluvial and lacustrine terraces (^{14}C, OSL, etc.), erosional and depositional surfaces on moraines (^{26}Al, ^{10}Be, etc.), loess-paleosols (MS, TL, etc.), and the fossils (charcoals, caves, shells, peats, etc.) from the historical facts throughout country, would be one of the most beneficial ways. In addition, it is necessary to understand how climate sets under the Milankovitch cycles of precession, obliquity and eccentricity due to magnetic fields and tectonic movements. If today's warming in the Holocene (MIS 1) is reshaped as similar to that in an unusual prolonged interglacial period (MIS 11), which is an interval corresponding to a small insolation minimum (Kashiwaya et al., 2010), what to be done is to find holistic approaches for overcoming the global warming. In other words, it contributes to take into account the more detail investigations and precise predictions based on the advanced scientific methods mentioned above.

Summary

It reviews how paleoclimatic changes played an important role in the civilizations of Mongolian nomads and expansion of empire. The climatic variations might add impetus and emphasis to either dispersal or concentration of nomads, but it can be much less the sole agent, in any period of which we have any historical knowledge. Because it apparently shows Mongolian nomads are the pure nomads, best able to survive under the strictest conditions of the climate, and at the same time, best able to evolve into new adaptable ways of life. Today, or in the 21st century, we can see the real traditional nomadic life outside of capital of Mongolia as like as that in the 13th century! It means that nomads have not altered the specific life through the serious climatic fluctuations including of glaciations and warming during the over past 800 years. For Mongolians, it would have historically, culturally and economically been one of the few peculiar sights for not only scholars of various fields on geography, history, archeology, etc., but a thousand of tourists from all over the world, in the future, as a natural museum in Central Asia.

Abstract

This reviews how climate change affects the Mongolian nomadic cultures during the past over 800 years and how Mongolian Empire spreads across the Eurasia in a period of less than 100 years. Paleoclimatic proxy records imply the sunspot cycles of 11 years and glacial-interglacial transitions are predicted to have been relatively effective on rise and fall of human societies including of the Mongolian Empire and civil revolutions in Europe. Apparently, a famine that spread death and crisis across Europe is widely recorded in historical records of the early 1300s and linked to the start of the Little Ice Age. Therefore, it has been inferred to be compared climate change findings with historical accounts of famine and societal struggle in order to detect how the climate change impacted on the human societies. There would be a big challenge for Mongolian nomads for resolving how to adapt the further rising temperatures and new catastrophic events on the Earth, i.e., it requires a necessary of more empirical studies for reconstruction paleoclimate changes and of precise approaches for further predictions.

Keywords: Mongolian Nomads, Sunspots, Climate Change, Little Ice Age, Medieval Warm Period.

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