

## PROFESSOR ZHU KEZHEN OPENING UP A PATH FOR RESEARCH ON CLIMATIC CHANGE IN CHINA

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**ABSTRACT:** Professor Zhu Kezhen (Co-Ching Chu, 1890-1974) was an outstanding scientist and educator. His research covered three fields including meteorology, geography and history of natural science. He published about 300 papers related to these fields. The historic climatic change in China was a subject which he most intensively studied. Eight papers related to this subject were published by Professor Zhu Kezhen from 1925 to 1972. The last brilliant paper on the title, "A Primary Study on Climatic Change in Past 5000 Years in China" reconstructed the climatic change history based on temperature index, particularly on winter temperature index. He concluded that the temperature was 2°C higher in 5,000-3,000 a B.P. than at present and temperature in January was 3-5°C higher then. He found that, in the latest 3000 years, there were major cycles of 400-800 years with an amplitude of 1-2°C and small cycles of 50-100 years with an amplitude of 0.5-1°C. The temperature curves of the past 5,000 years which Zhu Kezhen reconstructed in China basically alike the  $\delta^{18}\text{O}$  record from camp Century Ice Core in Greenland. He was particularly good at analysing and summarizing historic data of phenology, archeology and meteorology and comparing with that at present. He also closely followed the international progress in science and technology. He considered that the study of historic climatic change was very useful to the forecast of future climatic change. His method in research and achievement opened up a new path for study of the climatic change in China.

**KEY WORDS:** Prof. Zhu Kezhen, climatic change, climate research, meteorologist

## I. INTRODUCTION

Prof. Zhu Kezhen (1890–1974) was one of a few distinguished leaders of science and education in contemporary history of China. He had been successively a professor, institute director, university president and vice president of the Chinese Academy of Sciences for 56 years. He applied himself with enthusiasm wisdom, democratic and innovation spirits, to promote the development of Chinese sciences and education, and hence enjoys high prestige among the intellectuals in China. His research fields directly covered meteorology, geography and the history of natural sciences. He was the author of about 300 papers related to typhoon, monsoon, synoptical meteorology, agrometeorology, regional climate, phenology, natural division, comprehensive investigation of natural resources and environments, history of astronomy and earth sciences and science popularization. However his most favorable research topic was historical climatic changes in China. From 1922 to 1972, he published 8 papers, 6 in Chinese and 2 in English in this field. They are as follows:

1. Estimation of Climate in China during the South Song Dynasty (1127–1279). *Kexue (Science)* 1925, Vol.10, No.2 (in Chinese).
2. Climatic Change during Historical Time in China. *Dong Fang Za Zhi (East Journal)* 1925, Vol.22, No.3 (in Chinese).
3. Solar Spots and Global Climate. *Kexue (Science)* 1925, Vol.10, No.6 (in Chinese)
4. Drought Variation in China's History. *Shi Di Xue Bao (Jour. of History and Geography)* 1925, Vol.3, No.6 (in Chinese)
5. Climatic Pulsation during Historical Time in China. *Geographical Review*, 1926, Vol.16, 174–282.
6. Climatic Change during Historic Time in China. *Cerlands Beitrage Zhr Geophysik Bd.(Koppen Dand 1)* 1931, 32, 29–31.
7. Global Climatic Fluctuations during Historical Time. *Acta Meteorologia Sinica*, 1962, Vol.31, No.4 (in Chinese).
8. Preliminary Study on Climatic Change during Last Five Thousand Years in China. *Acta Archeologia Sinica*, 1972, No.1, (in Chinese).

Though there were no thesis published during the period of 1932–1961, he was carefully collecting information, closely following the research progress abroad, and probing scientific methods. There were a great deal of research notes published in 5 volumes “Zhu Kezhen Notes” (1984 and 1990).

Through several years of preparation and modification, at his 82 age, he published formally the thesis “The Preliminary Study on Climatic Changes during the Last 5,000 Years in China”. Though he modestly called this complex subject “preliminary study”, in

fact this was the summation of his decades thought and laid the foundation of contemporary research of climatic changes in China. This masterpiece has been widely cited and compared by colleagues at home and abroad. It should be noted that even though in the period of so-called "cultural revolution" in China he was suffering severely from a lingering illness and political uneasiness, he completed the research with his amazing will power. After then no more than two years this famous scientist passed away on Feb. 7, 1974.

## **II. PROF. ZHU KEZHEN'S CONTRIBUTION TO RESEARCH ON CLIMATIC CHANGES IN PAST 5,000 YEARS IN CHINA**

Prof. Zhu Kezhen drew a primary conclusion on climatic change in past 5,000 years in China as follows:

1. Between 5,000–3,000 a. B.P. the climate in China was warmer than that of present by  $2^{\circ}\text{C}$ , and about  $3\text{--}5^{\circ}\text{C}$  in January. There was a secondary fluctuation in that period, but it was difficult to discuss it further at that time owing to lack of more detailed data.

2. Since 3,000 a B.P. a series of climatic variations have occurred. 1,000 B.C., 400 A.D., 1,200 A.D. and 1,700 A.D., may be the lower temperature times. By this deduction, we can determine several quasi-cycles with a period of 400–800 years and a temperature amplitude of  $1\text{--}2^{\circ}\text{C}$ .

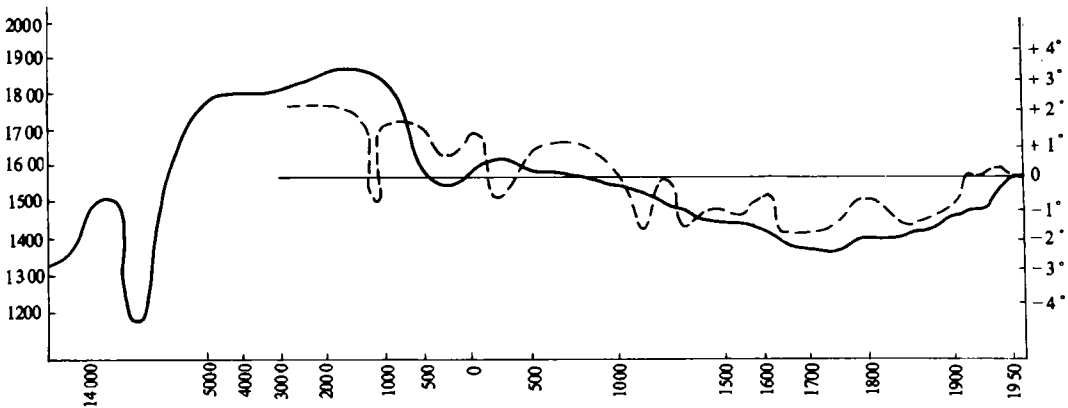
3. Each quasi-cycle can be distinguished some smaller cycles, and each about 50–100 years with temperature amplitude of  $0.5\text{--}1^{\circ}\text{C}$ .

4. It seems that all of the lower temperature times started from the Pacific coast, then moved westwards the Atlantic coast of Europe and Africa.

Fig.1 and Fig.2 show the comparison of temperature variations in China between the results from Prof. Zhu Kezhen and the results from some western scientists.

How did Prof. Zhu Kezhen draw the above-mentioned conclusions from historical literature of China? Although there were many records of the meteorology and the phenology in Chinese literature, it scattered widely in historical documents, travel notes and personal diaries. It was very difficult by oneself to sort out these records as proxy data which could be compared with modern climatological data. Most of classic scholars understood historical literature well but did not know modern climatology so much, while the modern climatologists are not expertise in finding scattered climatic records in ancient literature. Only Prof. Zhu Kezhen was good at both of them, he studied alone in the historical litera-

ture of China with great forwardness and willpower. Based on the rigorous scientific methods, he opened up a new path for revealing the regularity of climatic change.



**Fig. 1** Comparison between the temperature fluctuations during the past 5,000 years in China (broken line) and the altitude variations of the snow line during the past 10,000 years in Norway (solid line)

1. After some trial researches in the early 1920s, Prof. Zhu Kezhen recognized that there was a high variability of precipitation in East Asia monsoon area, and that both drought and flood occurred in the same time in two neighboring areas. Although precipitation is an important factor, it is not a good criterion of climatic change in a big region. However, temperature changes synchronously in a large area especially the winter temperature of China, which is controlled by Siberian High, and gets its changes considerably, so it could be a major criterion for defining climatic fluctuation in China.

2. If any record from instruments could be available, he preferably used it. For example in Shanghai, since the late last century, there has been a systematic meteorological record between 1880–1960, the average value of winter temperature (Dec., Jan., Feb.) was 4.6°C. It was very cold at the end of the 19th century with temperature lower than the average value by 0.5°C, and then turned warm, with a temperature higher by 0.6°C in 1945–1950. Later it got cold again and backed to the average value in 1960. In ancient China there were no instrument data of temperature but records on snowing and freezing. For example in the South Song Dynasty (1131–1260 A.D.), snowing season was longer than that at present by three weeks in Hangzhou. In the year 1111 the weather was so cold that the Tai Lake south to the Changjiang River was frozen and vehicles could travel on the lake ice. Therefore the 12th century may be a cold period and its temperature was about

1°C lower than that at the beginning of the 20th century, perhaps 1–2°C lower in April. There were some records about the Grand Canal freezing at the beginning of the Qing Dynasty from the tourist Tan Chan's "Bei You Lu" (North Travels). In 1656 the freezing period in Beijing was 107 days, twice as that at present. From this and other evidences of phonological records, it is true that the 17th century in Beijing was the coldest period in "Little Ice Age" with a winter temperature 2°C lower than that at present.

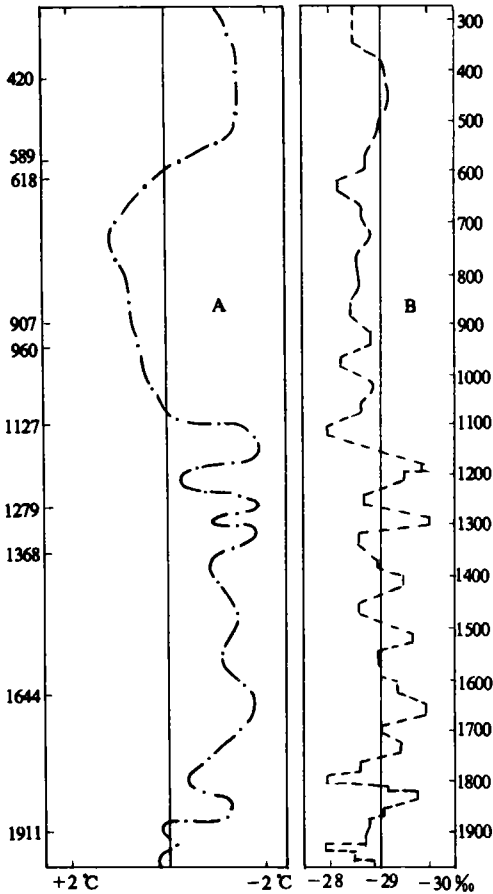


Fig. 2 Comparison between the temperature fluctuation of China (A) and oxygen isotope temperature variation from ice core Greenland (B) during last 1700 years

3. There are a great amount of phenology in Chinese literature. Prof. Zhu said: "Phonological phenomena, like auxodrome of trees, blossom of flowers and migrant activities of seasonal brides etc., should be as the mark of climatic condition". "The peach blooming, willow getting green and swallow coming are not only the marks of the weather that time but also an integrator of the weather past time". From his famous work "Phenology" we can see that Prof. Zhu Kezhen is a profound scholar with respect to this field. He inferred historical climate mainly from phonological records. For example, he estimated the temperature in Tancheng country of present Shandong Province, was 1.5°C higher during 3000–4000 a B.P. than that present according to the fact that the time of swallows *Hirundo rustica gutturalis* arriving in Tancheng is the same as the time their arriving in Shanghai at present, and believed that the tempera-

ture of January was 4.6°C higher than that at present. Mengzi and Xunzi, both lived in the Zhanguo (Warring States) Age (480–200 B.C.), said that the farmers of Shandong had double harvests each year, but now a days there are three harvests for two years. So it is sure during that time, climate was much warmer than now. The famous historian Sima

Qian, in his masterpiece "Shi Ji" (Records of History), mentioned that the subtropical plants as the mandarin orange, lacquer, mulberry, hemp and bamboo distributed farther north than now, even to the Huanghe (Yellow) River basin. This fact also indicates that North China was warmer and wetter than the present. After 155 A. D., these subtropical crops were on the decline, merely blooming but no harvesting. This shows that the climate became cooler and dropped to the lowest in 400 A.D.

4. Chinese archeology has been developed greatly in recent decades. Prof. Zhu Kezhen used the materials which was discovered in culture horizon to deduce paleo-climate. Subtropical animals such as *Hydropotes inermis* (a kind of deer) and *Rhizomys sinensis* (bamboo rat) had been found in Xi'an Banpo paleorains dated 5,600–6,080 a B.P. and the *Tapirus indicas cuvier* in Anyang paleorains of the Yin Dynasty (3400–3100 a B.P.), in addition it has been found that the limit of bamboo distribution was 1–3 ° altitude farther north than that at present. The above-mentioned facts indicate that north China was much warmer at 6000–3000 a B.P. than that at present and could be compared with the climatic optimum in the middle Holocene, it is inferred from bamboo distribution that the annual mean temperature was higher than that at present by 2°C and the temperature of January by 3–5°C .

5. Prof. Zhu Kezhen always paid attention to the development of new technology and the progresses of the other countries in paleoclimatology. In the paper titled Global Climatic Fluctuations during Historical Time (1962), Prof. Zhu quoted 43 references including 29 foreign works which were published in the 1950s. In the paper titled Preliminary Study on Climatic Changes in Last 5,000 Years in China (1972), he referred not only a great amount of footnote on ancient literature but also 46 modern references including 20 foreign papers. Prof. Zhu Kezhen attached importance to the application of new techniques such as oxygen isotope analysis, dendrochronology, spore-pollen analysis and <sup>14</sup>C dating method, and encouraged to develop and apply these techniques in China. Prof. Zhu Kezhen thought that the historical climatic research in China should have our own distinctive features, that is the combination of historical phenology and historical climatology, and also should refer to the latest achievement abroad. He was very glad to see that historical temperature curves of China are generally accord with oxygen isotope temperature curve from ice core in Greenland which was reconstructed by W. Dansgard et al. (1969, 1972). This proves that Prof. Zhu Kezhen's methods by using phenological data from historical documents are effective.

6. Prof. Zhu Kezhen had a clear social aim for studying paleo-climate, that is for the prediction of future climate. He said "it is useful to know the objective law of historical climatic change to help the prediction of future climate" and "it would be successful to specu-

late future climate using the periodicity which may be able to describe from a great amount of Chinese phenological records and archaeological records". Though Prof. Zhu Kezhen had no work on the speculation, yet he pointed out the destination of paleo-climatic studies. When his last paper was published in 1972, which exerted tremendous influence in China, Premier Zhou Enlai congratulated him and hoped that he would write more papers on this subject and popularize them. It was great promoting for studying climatic change in China at that time.

### **III. ETERNAL TO PROF. ZHU KEZHEN'S SPIRIT**

It has been 20 years since Prof. Zhu Kezhen passed away in 1974. The study on climatic change, which were initiated and laid the foundation by him, has been developing rapidly; some dozens of institutes and colleges go in for this work on different scales. The research field has been greatly enlarged. It includes not only the meteorological and phenological notes from the historical literatures, but also the proxy data from various Quaternary deposits (loess, lake and oceanic sediments, glacial and periglacial sediments and lava ash.). The experimental means including pollen and micro-paleontological analyses, isotopic dating, tree rings, oxygen and carbon isotopic analyses and geochemical analyses etc. have become common. We have also made encouraging progress in numerical modeling on climatic changes. The rapid increase of content of CO<sub>2</sub> and other trace gases, the wide destruction on forest and other natural vegetations, the changes of the ecosystem and environment and the global temperature and the sea level rising are all urging us to fulfil the pressed and earnest task i.e. the accurate prediction of future climate and environment. We should remind Prof. Zhu Kezhen's warmheartedness, unswerving determination and the spirits of pursuing for truth, and carry forward the cause pioneered by Prof. Zhu Kezhen and forging ahead into the future.