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CLIMATIC CHANGES DURING HISTORIC TIME IN CHINA.

By Coching Chu

I. INTRODUCTION.

While variation of climate from one geological era to another has been established beyond any doubt, the question of climatic changes during historical period is still controversial. Recently, however, a large amount of valuable work has been published dealing with this mooted problem, which tends to prove that there is at least a moderate variation in the amount of solar radiation during the last three or four thousand years.[1] The change may not have been progressive, but it came in the form of pulsations, one century or millennium got drier or warmer than the preceeding, while the succeeding century or millennium may again become humid or cold, something similar to the vicissitude of weather from one day to another.

In depicting the climatic conditions in China during the past ages, there are four main sources from which we may draw material; (1) Phenological records in the Chinese classics, (2) accounts of floods and droughts in the Chinese annals, (3) date of the earliest frost and snow and number of severe winters kept in old chronicle and (4) instrumental meteorological records. Climatic events recorded in old chronicles and classics are necessarily sporadic, but with careful interpretation, proper inferences may be drawn from them. We will now proceed to discuss these items in turn.

II. PHENOLOGICAL RECORDS IN CHINESE CLASSICS.

Phenology has been defined as the science treating of the influence of the climate on the recurrence of the annual phenomena of animal and vegetable life.[2] The influence of match of seasons upon animal and vegetable life must have been noticed

by the ancient men and the dates of sowing and harvesting of farm crops appear in the old chronicles of various people. Chinese classics are particularly rich in phenological records, a whole chapter on monthly calendar of flora and fauna (月令) in Li Ki or the Book of Rites is practically devoted to it, similar mention of the proper time for the first appearance of migratory birds, the blooming of certain species of trees and the like, appear in Huai-Nan-Tze (淮南子) (chap. 5), Annals of Lu (呂氏春秋) and the Book of Chow Kung (汲冢周書). The four books mentioned above agree substantially on the date when a certain phenological events should occur. It is beleived that the chapter on Monthly Calendar of flora and fauna in the Book of Rites was derived from "Annals of Lu," written shortly after the establishment of Ching (秦) dynasty (246 B.C.). Huai-Nan-Tze was written at the early part of Western Han dynasty about 120 B. C., and the book of Chow Kung probably came still a little later, although reputed to be written by Chow-Kung himself. Now in this period of two hundred years (250 B. C.—50 B. C.) or so, the middle basin of the Yellow River, especially the provinces of Shensi and Honan, was holding the center of stage of civilization in China, and the phenological records mentioned in these books must be construed as pertaining to this region.

By comparing the records contained in these classics with the present phenological data we can obtain some idea of lateness or earliness of season at the beginning of the Christian era. Three of the four classics mentioned above used the lunar calendar in reckoning phenological occurences which fact would make strict comparison between these records and modern data difficult. But in the fourth one, the Book of Chow Kung, the solar calendar was followed throughout beginning the year with 立春 (February 5 or 6).

Of seventy two entries in the meteorological calendar of this book, no less than 52 were of phenological significance. Of these some were based on mistaken ideas like the change of hawk into cuckoo in the spring, while others had names of plants and animals the species of which were hard to identify. For the

present only three phenological events will be discussed: i.e., the blooming of the peach trees (prunus persica), the commencement of song by the cuckoo (cuculus micropterus and cuculus canorus telephonus), and the first appearance of the house swallow (Hirundo rustica gutturalis). These three are chosen, firstly because their identity are least doubtful, and secondly because their recurrences in the spring are still watched at some meteorological stations in China.

At present, very few places in China make phenological observation. The most extensive collection of phenological records of present day in China is probably to be found in Father H. Gauthier "La Temperature en Chine"[3] in which more than dozen places have remarks on phenological happenings day by day. According to these records the house swallow first appears in Ningpo by the middle of March, in Shanghai and Wuhu by the end of March, and in Chefoo by the tenth of April. The Peach blossoms in Shanghai on March 25, in Wuhu about April first, in Pei-Hsien in northern part of Kiangsu about April 6, and in Chefoo and Hwang Hsien about April 24. The Indian cuckoo begins to sing in the lower Yangtze Valley by the beginning of May, followed by the common cuckoo two weeks later. Since the year 1929 the Institute of Meteorology at Nanking is also keeping phenological records. For the past two seasons the house swallow was first seen in the capital about April 9, and departed by the end of August or the beginning of September[4] and Indian cuckoo was first perceived in the spring on or about May 5.

Now according to the meteorological calendar in the "Book of Chow Kung", the blossoming of peach was put down at March 5, the first appearance of swallow at March 21, and the first singing of the cuckoo at April 26. The departure of the house swallow was said to happen on September 12.[4] These dates in the spring when compared with present records are anywhere from one week to one month too early, and bearing in mind that these old records are most probably valid for the central Yellow River Valley, it seems that the season during the beginning of Christian era in China must be more open than it is now.

The mildness of climate of this period was suspected by early Chinese writers such as King-Lu-Siang (金履祥) of Yuan dynasty.[5] Recently a writer in Historical Journal of China also maintains that the climate of the Yellow River Valley during Han dynasty was warmer and wetter than it is today, basing his argument on the extensive cultivation and use of bamboos and mulberries.[6]

III. ACCOUNTS OF FLOODS AND DROUGHTS IN CHINESE HISTORY.

It was Mr. Alexander Hosie who first made an examination of number of floods and droughts contained in Chinese chronicles from Tang to Ming dynasty, the results of which were published in the China Review and the Journal of North China Branch of the Royal Asiatic Society.[7] Some years ago the writer with the help of his colleagues in the Department of History of Southeastern University of Nanking, made another analysis of these records in a paper published in the Geographical Review[8] This analysis reveals that the ratio of number of droughts to the number of floods is great in the fourth, sixth and seventh centuries and again in the fifteenth, while it is comparatively small in the twelfth and fourteenth, indicating the former periods as predominantly dry, and the latter periods wet as shown in the following table:—

Table 1.—Ratio of Droughts to Floods in China.

Period A. D.	Ratio of Rainness	Remarks.
100-200	1.98	
200-300	1.60	
300-400	8.20	Dry
400-500	2.06	
500-600	4.10	Dry

600-700	3.30	Dry
700-800	1.32	
800-900	1.80	
900-1000	1.80	
1000-1100	1.70	
1100-1200	1.04	Wet
1200-1300	1.80	
1300-1400	1.05	Wet
1400-1500	2.25	Dry
1500-1600	1.95	

According to Dr. C. E. P. Brooks of London Meteorological Office [9] "if a considerable number of droughts were recorded in one century, the rainfall of that century was abnormally low; similarly a large number of floods and storms suggests a heavy rainfall". The absolute number of floods and droughts per century, however, does not mean much, it is the ratio between the two that is of significance.

In this connection it may be mentioned that extensive emigration took place from China during the two dry periods mentioned above, namely in the seventh and fifteenth centuries. Recently in an article on "Changes of Climate in the Old World", Dr. C. E. P. Brooks has shown that the dry period of the fourth to eighth centuries, and the wet period of the twelfth to fourteenth were not limited to China alone, but synchronous to several areas in the old world [10].

IV. DATE OF LATEST SNOWFALL AND NUMBER OF SEVERE WINTERS.

In the Chinese Encyclopedia Tu Shu Tsi Cheng, there are three chapters devoted to the records of damaging frosts, severe colds, and the like. These data have been embodied in the following table along with those of Europe as given by E. Brückner [11] from 500 to 1600 A.D.

Table 2.—Number of Severe Winters in Europe and China.

Periods A. D.	CHINA	EUROPE
500-600	19	
600-700	11	
700-800	9	
800-900	19	11
900-1000	11	11
1000-1100	16	16
1100-1200	24	25
1200-1300	25	26
1300-1400	35	24
1400-1500	10	20
1500-1600	14	24

The number of severe winters per century in China decreases from the sixth century to the eighth, rises to a maximum between the twelfth and the fourteenth, and decreases again in the fifteenth, thus showing the period from 1100 to 1400 A.D. to be particularly cool. The rigors of winter during these centuries can be confirmed by the date of spring snowfall recorded in the History of Southern Sung dynasty from 1131 to 1260 A.D. at Hangchow, then the Capital of South China. The average date of latest snowfall for each decade of years during that period was April 9, almost a month later than the date of latest spring snowfall during the period 1905-1914.

In a diary kept by one Kuo Tien-Si[12] from the ninth of September 1308 to the second of December, 1309, various notes on current weather were entered. On October 7,[13] 1308, the diarist arrived at Hangchow by midnight, and made this entry "Air frosty under moonlight bitingly cool" (霜月皎潔寒氣侵人). (Snow was first noted at Hangchow on December 14, and then again on 15.) On January 1, 1309, the diarist went from Wusih to his home at Tang Yang, it snowed on the way, and by January

3, the boat was frozen thick in the river and was covered with icicles, so that he was obliged to go on horse back. Snow was entered on February 3-10, 1309, and again on March 9-11 of the same year. While the record of one season at one place cannot give any indication to the general run of climate of a country in a certain period, the winter of 1308-09 happened to be one of more than average rigor in the lower Yangtze valley, for rivers around Wusih seldom freezes to such an extent as to stop communication.

V. INSTRUMENTAL RECORDS.

Rainfall measurement was made in China as early as Han dynasty, mentions of it appear in various Chinese literatures, but unfortunately no numerical data have been preserved. The earliest instrumental meteorological record in China, that covers any length of time, does not go back more than one hundred years. The most valuable collection of early Chinese meteorological record along modern lines was probably to be found in the researches of Dr. H. Fritsche, Director of the Russian Observatory at Peking. His long series of observations made at Peking, from 1841-55, 1860-61 and 1869-74 covering altogether twenty-three years, is particularly valuable.

It will be interesting compare this series of observations with the data kept at the Central Observatory of Peking for the period 1915-1924 [15] as shown in the following table.

Table 3.—Meteorological Data of Peking for the Period 1841-1874 *and* 1915-1924.

Mean Temperature (C.)

Month / Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1841-1874	-4.6	-1.4	5.1	13.8	19.9	24.3	26.1	24.6	20.1	12.5	3.8	-2.4	11.81
1915-1924	-4.6	-1.3	5.3	13.9	20.1	24.8	26.3	25.3	19.8	12.5	3.9	-2.8	11.93

Range of Temperature (C.)

1841-1874	7.4	4.7	9.7	10.4	10.7	10.8	7.5	7.6	8.6	9.9	7.5	7.5	8.8
1915-1924	11.3	10.7	12.0	12.0	13.3	12.8	9.8	9.3	10.9	12.7	11.4	10.0	11.6

Relative Humidity (%)

1841-1874	58	59	54	49	51	61	76	76	68	60	58	58	61.0
1915-1924	62	56	52	48	51	59	76	78	71	66	60	62	61.6

Prevailing Wind Direction

1841-1874	NW	NW	NW	S	S	S	S	N	NW	NW	NW	NW
1915-1924	N	N	N,SW	SW	N	SW	S	N	N	N	NNW	N

Extreme Temperature (C.)

	Absolute Maximum	Absolute Minimum
1841-1874	36.3	-15.3
1915-1924	37.9	-16.3

Rainfall (mm.)

1841-1874	2.8	5.1	7.1	14.0	42.1	89.4	237.2	152.1	73.0	17.5	8.7	2.9	651.9
1915-1924	1.3	2.5	6.5	5.8	32.4	61.0	259.3	144.5	36.2	14.4	8.1	3.5	575.5

Rainy Days

1841-1874	2.0	3.0	4.0	4.0	7.0	11.0	14.0	11.0	8.0	3.0	3.0	2.0	72.0
1915-1924	3.4	2.6	5.0	5.5	9.3	13.3	17.6	14.3	9.8	5.6	4.0	3.1	93.5

Absolute Variability of the Amount of Precipitation.

(mm.)

1841-1874	29	28	27	56	104	195	497	347	286	46	32	20	822
1915-1924	3	6	14	21	113	127	580	310	117	52	27	7	804

Cloudiness (%)

1841-1874	20	24	32	39	40	45	54	47	35	24	23	18	33.8
1915-1924	24	28	36	42	46	50	53	49	40	27	27	28	37.5

Amount of Precipitation and Number of Rainy

Days in Peking, 1915-1924.

Year	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	Mean
Amount of P.	655	422	781	513	566	277	255	838	379	1059	575.5
Rainy Days	90	99	97	94	90	100	76	97	97	84	93.5

First take temperature, the mean annual differs only by one tenth of a degree centigrade, the Central Observatory series being the higher of the two. With regard to the mean monthly, the second period was warmer in spring and summer from March to August inclusive and also in November but colder in the months of September, December and February, the difference being greatest in the month of August amounting to 0.8 C. The range of temperature is not comparable for the reason that the Russian series used periodic maxima and minima, while Central Observatory series used non-periodic, with the consequence that the second series has a range much greater than the first.

With regard to the mean annual relative humidity, no appreciable difference exists between the two series. The monthly means, however, differ slightly, the second series is drier in the months of February, March, April and June, but wetter from August to January inclusive. It seems therefore, the climate of Peking during the first part of twentith century is slightly cooler in autumn and winter, but a little warmer in spring and summer than the middle of the ninteenth century; or in another word, the climate of Peking is becoming a little more continental during the last ninty years or so.

The rainfall data seem to confirm this conclusion. The amount of mean precipitation decreases by 12% in the second period but the July rainfall, which occupies more than 40% of the total in both series, actually increases by 10%. Although the first period covers twenty three years and the seond period only ten, yet the absolute variability of the latter period is really greater when we take into consideration of the fact that the second period has less rainfall than the first. All this goes to show that climate in Peking in the beginning of the twentith century fluctuates more, hence is more liable to go to the extremes. For the present, we cannot make any comparison between numbers of rainy days of the two series, for we do not know exactly just what constitutes a rainy day in the Russian series. Another point to be noted is that even though the first period has more rainfall in every month except July, yet the reverse is the case with the cloudiness.

In making such a comparison difference of exposure and instrumental error must be taken into consideration. In the present case, however, it is not the difference of mean temperature or total amount of precipitation which attracts our attention, but rather, it is the seasonal distribution of each element which concerns us the most. Any instrumental error should affect the data of all seasons alike, while the defect in exposure would make its presence felt most seriously at least in the case rainfall, in the total value.

Several recent writers have alluded to the evidence of desiccation of North China. Thus Sir Aurel Stein has found in drying up of bed of Etsingol and the abandoned city of Ḵhara-Khoto the unmistakable evidence of desiccation of northern Kansu since late medieval times,[16] and Mr. Sowerby of China Journal also alleged the approaching desert condition of North China on the ground of enchroachment of sand within city walls of Yuling Fu in Shensi[17]. While the comparison made above shows no indication for any drastic change of climate, it does seem to prove that the degree of continentality in North China has been gradually increasing during the last ninty years.

NOTES.

(1) G. C. Simpson, "Past Climate" Nature, London, December 28, 1929, pp. 988 991.

(2) According to Whitney's "Century Dictionary" quoted in F. J. Wright "The New Nature Study", London, 1929, p. 259.

(3) H. Gauthier "La Temperature en Chine", Shanghai, 1918.

(4) In Shanghai the house swallow remains until August or later, and in Nanking swallow are rarely seen in September. See E. S. Wilkinson "Shanghai Birds", Shanghai, 1929, p. 143.

(5) 秦嘉謨編月令粹編,二十三卷,月令孟春之月蟄虫始振句下,嘉慶十七年本.

(6) Historical Journal of China, Vol. 2 Nos. 3 and 4, Sept., 1930. On Past Climate of North China by Mon Wen-Tung.

史學雜誌二卷三四合期,蒙文通著"中國古代北方氣候攷略"

(7) "Droughts in China A. D. 620-1643", Journal North China Branch of the Royal Asiatic Society Vol. 12, 1877, pp. 51-89. "Floods In China 630-1630", China Review, Vol. 7, 1878, pp. 371-372.

(8) Coching Chu "Climatic Pulsations during Historic Time in China" Geographical Review, Vol. 6, No. 2, April 1926, pp. 274-282.

(9) C. E. P. Brooks "Climate through the Ages", London, 1926, p. 328.

(10) C. E. P. Brooks "Changes of Climate in the Old World", Quar. Jour. of the Royal Meteorological Society, Vol. 57, London, January, 1931, pp. 13-30.

(11) Eduard Brückner "Klimachwankungen seit 1700 nebst Bemerkungen über die Klimaschwankungen der Diluvialzeit" Abhandl. herausg. von A. Penck, Vol. 4, No. 2, Vienna, 1890, p. 268.

(12) 元郭天錫日記,至大元年戊申八月廿七至二年己酉十月卅日

(13) The dates were originally in Chinese calendar, but transformed into the Julian Calendar by the aid of Pierre Hoang's "Concordance des Chronologies Néoménique Chinoise et européenne", Shanghai, 1910.

(14) H. Fritsche "The Climate of Eastern Asia", Journal N. China Branch of Royal Asiatic Society" Vol. 12, 1878, pp. 127-335.

(15) Taken from Tsing Hua Weekly, Vol. 32, No. 6, pp. 8-12, "The Climate of Peking" by S. C. Hwang.

清華週報三十二卷六期黃廈千著,北平之氣候

(16) Sir Aurel Stein "Innermost Asia", Oxford, 1928, Vol. 1 pp. 459-460.

(17) Arthur de Sowerby, Approaching desert Conditions in North China, "China Journal of Science and Arts", August, 1924.

THE FISSURAL PATTERNS OF CHINESE BRAINS

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There are three chief races in the world, the black, the white, and the yellow. Their organic characteristics differ with different races, and the difference in their brain structure would naturally be a very interesting problem for physical anthropologists as well as neuroanatomists. Here we are dealing with the Chinese brain, and also in comparison with the black and the white brains.

The study of the Chinese brains is not absolutely nothing in the literature. Thirty or forty years ago, when the Western anatomists were studying the gross structure of human brains, they were using materials of their own, i.e., the white race. Occasionally there were some Chinese brains, but they made only some general observations, not strictly scientific, owing to the fact that the materials were either in poor condition, or in very small amount. Therefore those studies were only fragmentary and incomplete; and their conclusions are not final, sometimes quite prejudicial. Recently a German author, Dr. Kurz ('24), has published some detailed descriptions of the fissural patterns of three adult Chinese brains and seven children. His observations are so far the best, though from quite a small amount of materials. He has mentioned the sloping condition of the orbital surface, a distinct rostrum, a pronounced curvature of the frontal lobe, a strong curvature of the temporal poles and a strong mesial concavity of the temporo-occipital lobe. He has found steep occipital lobe with a steep gyrus hippocampi, a partly exposed insula Reilli, a narrow fossa interpeduncularis, and a not very obtuse angle between the medulla oblongata and the basis cerebri. In the general fissural pattern, he was struck by a number of transverse anastomosis on the frontal lobe, a long sulcus frontalis medius, a sulcus frontalis inferior, either merging into the sulcus

frontalis orbitalis or developing in that direction, a very frequent division of the strongly arched sulcus intraparietalis in its three constituents, a simian sulcus which he describes in a similar way as Bushmakin does in Buriates, not refering to Elliot Smith's lunatus. The gyrus frontalis superior and pars superior of gyri frontalis medii, have only a few accessory convolutions, the operculum triangulare is not so well separated from the pars orbitalis, and there is a certain lack of accessory convolutions in the upper part of the temporal lobe. Also the sulcus centralis indenting the mesial margin only in 15%. With these peculiarities, he inclines to believe that the Chinese spring from an orangoid ancestor.

Some of these peculiarities have been observed also by Dr. Kappers ('29), but some of these are not. Dr. Kappers has sixty Chinese brains. We would rather believe the latter author's observations than Kurz's, who has such a small amount of materials. I myself had the pleasure of staying in Amsterdam with Dr. Kappers for a few weeks, and took that opportunity to observe the sixty Chinese brains collected there. Most of them were presented by Dr. Shellshear in Hongkong. Strictly speaking, they could only represent the Southern Chinese, not the whole group. In spite of that, we have observed the followings:

1, more brachencephalic;
2, smaller interpeduncular fossa;
3, smaller stem angle;
4, corpus callosum higher at its middle;
5, area splenialis more pressed;
6, sulcus calcarinus more curved;
7, orbital rostrum larger;
8, tentorial surface of the cerebral hemispheres more curved downward;
9, inward curvature of the lower part of the blunt temporal pole;
10, bulging parietal lobe;
11, a steep calloso-marginal fissure;
12, a steep uncus.

Most of these observations would be reported later in a more elaborated thesis by Mrs. A. J. van Bork. Her opinion was that most of these characteristics were influenced by the brachycephalic skull. Besides these, Shellshear in Hongkong recently also reported in a letter to Dr. Kappers that he has observed 54% of Chinese brains have the sulcus lunatus, a correction of 75% in his published article ('26). My own statistical data on fifty Chinese brains in comparison with fifty negro and fifty white that I have observed during my stay in the Western Researve University, Cleveland, O., U. S. A., with Dr. T. Wingate Todd may be tabulated as following:

RACES	s. intrap.				s. temp. s.				s. fr. s.				s. lun.	
	L		R		L		R		L		R		L	R
	C	D	C	D	C	D	C	D	C	D	C	D		
Negro	30	20	20	30	41	9	46	3	36	14	37	13	14	28
White	29	21	18	32	35	12	41	5	44	6	37	13	15	22
Chinese	28	22	19	31	44	6	49	1	40	10	39	11	31	29

Here s. intrap. represents the sulcus intraparietalis; s. temp. s. the sulcus temporalis superior; s. fr. s. the sulcus frontalis superior; s. lun. the sulcus lunatus; L. means left; R. right; C. continuous; and D. discontinuous.

From these data, we can see that sulcus frontalis superior of the frontal lobe is totally 27% discontinuous with the sulcus precentralis in negro, 19% in white, and 21% in Chinese. The difference between the white and the Chinese is only 2%. The negro brains have higher percentage than both white and Chinese. The sulcus intraparietalis of the parietal lobe is 50% broken in negro, 51% in the white, and 51% in Chinese. This does not indicate any essential difference about the prominent sulcus in the parietal lobe. The sulcus temporalis superior of the temporal lobe is 87% continuous in negro, 76% in white, 93% in Chinese. The sulcus lunatus of the occipital is present in 42% of negro brains, 37% of white, and 60% of Chinese.

Whether the discontinuity of a sulcus is a sign of further development or retardation is a question which can be hardly

answered now. On the one hand, it might be due to the retarded embryonic state; and on the other, it might be due to the extraordinary development of some submerged gyri on the course of the sulcus. The frontal lobe has been regarded physiologically as the association center of the cerebrum. On the frontal lobe, the sulcus frontalis superior is one of the most prominent fissure. In negro brains, there is higher percentage of discontinuous sulcus frontalis superior than the white and the Chinese; but lower percentage of discontinuous sulcus temporalis superior than the white, higher than the Chinese. Can we draw any conclusion that which race is higher or which is lower from these data? Certainly not.

As to the parietal lobe, there is practically no difference between these races. From these data, it seems as if the continuity or discontinuity of the sulcus intraparietalis is merely a matter of chance, i. e., 50% for each. The only peculiar case is the high percentage of presence of the sulcus lunatus of the occipital lobe in the Chinese brains. What does it mean? According to the sense that this name implies (first used by Elliot Smith), it shows the anthropoid character. This made Shellshear ('26) believe that Chinese brains were more anthropoid, because of 75% of the Chinese brains that he examined had this sulcus lunatus, though he did not give any exact figure. As a matter of fact, the occipital lobe as a whole apparently is better developed in the Chinese brains than in both white and negro. We have no histological data to prove that in the Chinese brains, but we can see that the visual area is better developed. Since our Chinese brains are more brachycephalic, naturally the occipital lobe is more pressed toward the longitudinal direction, so that the sulci there are more pronounced. And so does Mrs. Bork believe (personal communication).

Dr. Kappers, who has so rich experience in both anthropological and comparative neurology, drew his conclusion from his extensive measurements that Chinese brains were more fetalised than Europeans, and Bolk's principle of fetalization, which states that some of the adult human organic characters still remain the