CLIMATIC PULSATIONS DURING HISTORIC TIME IN CHINA

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THE question of climatic change in historic times has called forth investigations in many regions. Recently the writer has made an examination of Chinese archives for material bearing on the problem.

Exact meteorological observation goes back only a short time in any country; but, in the absence of rain-gauge and thermometer readings, we may resort to records of the frequency of floods and droughts, the number of severe winters, the dates when the rivers were frozen over, etc., for hints regarding the climate of the time. It was partly on such data that Brückner based his well-known monograph on "Klimaschwankungen." In dealing with the records in Chinese history there is one advantage which is probably not possessed by any of the European countries, i. e. the length of time for which they are available.

Droughts and Floods

The number of droughts and floods recorded during the time considered have been tabulated first according to Chinese dynasties, Tables I and II, and then according to centuries in the Christian era, Tables III and IV. Since Chinese dynasties are not of equal length, in order to make them comparable the data in Tables I and II have been reduced to droughts and floods per century. The data for the Ming Dynasty (1368–1643) and earlier dynasties are taken from the Tu Shu Tsi Cheng (Chinese Encyclopedia),[1] while those of the Manchu Dynasty are obtained from Tung Wah Loh. In the Tu Shu Tsi Cheng a distinction is made between floods directly due to excessive rain and those caused by the inundation of rivers or overflow of ocean and seas. In Tung Wah Loh no such demarcation can be made out. It is largely due to this difference that the floods recorded under the Manchu Dynasty (1644–1911) as shown in Tables II and IV are especially numerous.

[1] A brief account of this work is given by Hosie, who also has tabulated the droughts and floods. However, he does not make a detailed computation of the geographical distribution—a difficult matter, because the boundaries of the Chinese provinces changed very often from one dynasty to another (Alexander Hosie: Droughts in China, A. D. 620 to 1643, *Journ. North China Branch of the Royal Asiatic Soc.*, Vol. 12, 1877, pp. 51–89. See also "Floods in China 630–1630," *China Rev.*, Vol. 7, 1878–79, pp. 371–372).

The number of droughts and floods in each dynasty or century should indicate to a certain extent the relative deficiency or excess of precipitation at that period. However, beside the point mentioned

TABLE I—NUMBER OF DROUGHTS PER CENTURY OBSERVED DURING DIFFERENT DYNASTIES IN CHINESE HISTORY

DYNASTY	TANG	FIFTH DYNASTY AND NORTH SUNG	SOUTH SUNG	YUEN	MING	MANCHU
Christian Era	*618–907*	*908–1126*	*1127–1279*	*1280–1367*	*1368–1643*	*1644–1847 1861–1900*
Capital	*Chang-an Shensi*	*Kai-fung Honan*	*Hangchow Chekiang*	*Peking Chihli*	*Peking Chihli*	*Peking Chihli*
Chihli . . .	2.1	9.1	9.9	29.9	5.1	26.9
Shangtung .	3.4	3.7	6.6	8.1	4.0	19.0
Shansi . .	4.5	2.3	5.3	19.6	13.8	7.3
Honan . .	4.2	24.2	5.3	21.9	2.9	12.4
Shensi . . .	4.5	6.9	5.3	12.7	7.3	9.5
Kansu . .	0.4	1.4	0.7	5.8	0.7	7.0
Szechwan . .	1.7	—	9.2	2.3	1.5	0.4
Hupei . . .	1.7	2.3	4.6	12.7	16.0	11.2
Hunan . .	1.7	2.7	4.0	6.9	5.1	8.7
Kiangsi . .	1.7	0.9	6.6	3.5	4.4	13.6
Anhwei . .	4.5	7.8	9.9	4.6	2.2	14.5
Kiangsu . .	4.2	4.1	14.5	10.4	3.3	15.7
Chekiang .	3.1	4.1	15.2	6.9	16.7	13.9
Fukien . .	1.4	1.4	5.9	4.6	7.6	3.7
Kwangtung	—	—	1.3	4.6	2.9	0.8
Kwangsi . .	—	0.5	—	6.9	4.7	2.1
Yunnan . .	—	—	—	—	6.5	0.8
Kweichow .	—	—	—	—	1.1	—
Manchuria .	—	—	1.3	2.3	—	2.1

TABLE II—NUMBER OF FLOODS PER CENTURY OBSERVED DURING DIFFERENT DYNASTIES IN CHINESE HISTORY

DYNASTY	TANG	FIFTH DYNASTY AND NORTH SUNG	SOUTH SUNG	YUEN	MING	MANCHU
Christian Era	*618–907*	*908–1126*	*1127–1279*	*1280–1367*	*1368–1643*	*1644–1847 1861–1900*
Capital	*Chang-an Shensi*	*Kai-fung Honan*	*Hangchow Chekiang*	*Peking Chihli*	*Peking Chihli*	*Peking Chihli*
Chihli . . .	2.1	6.9	3.9	25.3	1.8	43.7
Shangtung .	1.7	5.5	0.7	20.7	2.2	27.7
Shansi . .	0.7	2.3	—	4.6	7.3	12.3
Honan . .	4.2	17.8	1.3	34.4	2.2	26.0
Shensi . . .	9.1	1.8	3.9	4.6	2.2	11.6
Kansu . .	0.3	1.8	1.3	5.7	—	8.3
Szechwan .	0.7	—	2.6	—	1.1	2.9
Hupei . . .	0.3	0.9	4.6	4.6	0.7	26.2
Hunan . .	—	1.4	—	3.4	1.1	20.6
Kiangsi . .	0.7	1.4	5.9	4.6	1.5	21.8
Anhwei . .	0.7	3.7	5.9	4.6	—	36.3
Kiangsu . .	1.4	2.7	9.9	3.4	1.5	43.8
Chekiang .	1.4	1.4	17.8	4.6	4.0	22.7
Fukien . .	—	0.9	4.6	4.6	3.3	6.5
Kwangtung	—	0.5	0.7	2.3	1.5	7.0
Kwangsi .	—	0.5	—	1.2	0.7	1.6
Yunnan . .	—	—	—	—	6.9	2.5
Kweichow .	—	—	—	—	—	2.5
Manchuria .	—	—	—	3.4	0.7	7.8

TABLE III—NUMBER OF DROUGHTS IN DIFFERENT PROVINCES OBSERVED DURING HISTORICAL TIMES IN CHINA*

(By Centuries)

A. D.	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–1000	1000–1100	1100–1200	1200–1300	1300–1400	1400–1500	1500–1600	1600–1700	1700–1800	1800–1900	
Chihli	—	—	2	1	—	1	3	2	1	6	14	3	23	16	7	5	13	8	47	*152*
Shangtung	1	—	1	1	—	—	5	1	3	5	2	4	8	6	5	4	11	8	30	*95*
Shansi	—	1	1	1	—	1	4	1	5	5	1	1	12	10	7	8	17	3	12	*90*
Honan	5	14	—	—	2	1	3	1	8	30	23	2	12	12	4	3	9	2	20	*151*
Kiangsu	—	1	—	3	6	1	1	2	9	4	2	17	10	6	3	4	11	5	24	*109*
Anhwei	—	—	—	—	—	—	1	2	10	5	7	18	2	4	3	2	9	5	22	*90*
Kiangsi	—	—	—	—	—	—	—	—	5	1	1	5	6	2	2	9	21	—	12	*64*
Chekiang	—	—	—	1	—	—	—	1	8	2	4	19	7	6	14	22	20	8	15	*127*
Fukien	—	—	—	—	—	—	—	1	3	—	—	6	6	4	4	13	6	5	2	*50*
Hupeh	—	—	—	—	—	—	2	—	3	2	2	5	5	10	15	23	17	4	14	*102*
Hunan	—	—	—	—	—	—	—	1	4	2	2	7	2	5	9	4	11	—	11	*58*
Shensi	—	—	2	—	1	4	5	5	3	6	8	6	6	9	7	9	9	1	16	*97*
Kansu	—	—	—	1	—	—	—	1	—	—	—	4	—	5	1	1	1	6	9	*29*
Szechwan	—	—	2	—	—	—	5	—	—	—	2	10	4	2	2	2	—	1	—	*30*
Kwangtung	—	—	—	—	—	—	—	—	—	—	—	—	3	3	2	6	1	—	2	*17*
Kwangsi	—	—	—	—	—	—	—	—	—	1	—	—	—	5	2	7	3	1	4	*23*
Yunnan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	10	6	—	1	*19*
Kweichow	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	*3*
Fengtien	—	—	—	—	—	—	—	—	—	—	—	2	1	1	—	—	—	1	4	*9*
Kirin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Helungkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	*3*
Sinkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	*2*
Mongolia	—	—	—	—	1	—	—	—	—	—	—	—	3	—	—	—	—	1	—	*5*
Kokonor	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	*2*
All China	25	35	24	41	37	41	43	41	43	64	69	58	77	60	54	84	82	36	70	*984*

*In some cases the phenomenon covers more than one province, while there are a few cases where location is not given; hence the sum for the different provinces in a century is not identical with the number given for the entire country.

TABLE IV—NUMBER OF FLOODS IN DIFFERENT PROVINCES OBSERVED DURING HISTORICAL TIMES IN CHINA*

(By Centuries)

A. D.	0–100	100–200	200–300	300–400	400–500	500–600	600–700	700–800	800–900	900–1000	1000–1100	1100–1200	1200–1300	1300–1400	1400–1500	1500–1600	1600–1700	1700–1800	1800–1900	
Chihli	—	2	2	—	—	—	2	2	2	5	9	4	7	18	3	1	24	31	52	*164*
Shangtung	—	3	2	1	2	1	1	1	3	8	4	—	2	17	2	2	14	20	35	*118*
Shansi	—	1	—	—	1	—	—	1	1	1	4	—	1	3	5	12	6	2	24	*62*
Honan	2	10	7	1	1	—	3	6	3	15	19	5	6	26	3	2	14	19	31	*173*
Kiangsu	—	—	1	1	10	—	1	1	2	3	3	13	2	3	3	2	28	37	41	*151*
Anhwei	—	—	2	1	1	—	1	1	—	4	4	6	3	4	—	—	15	31	42	*115*
Kiangsi	—	—	—	—	—	—	1	1	—	—	3	8	2	4	—	1	19	8	28	*75*
Chekiang	—	—	—	—	2	—	1	1	2	—	2	18	10	5	3	4	13	16	27	*104*
Fukien	—	—	1	—	—	—	—	—	—	—	2	6	1	2	4	3	8	2	8	*37*
Hupeh	—	3	2	—	—	—	—	1	—	2	—	5	2	4	—	2	13	14	36	*84*
Hunan	—	3	—	1	—	—	—	—	—	3	—	—	—	4	—	2	10	7	33	*63*
Shensi	—	2	1	—	—	1	4	13	8	1	3	4	3	3	—	6	9	5	14	*77*
Kansu	—	1	—	—	—	—	—	—	—	3	—	3	—	5	—	—	1	2	17	*32*
Szechwan	—	—	1	—	—	—	1	—	1	—	—	4	—	—	1	—	4	—	5	*17*
Kwangtung	—	—	—	—	—	—	—	—	—	1	—	—	1	1	1	3	1	7	9	*24*
Kwangsi	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	1	1	—	3	*6*
Yunnan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	12	4	2	4	*25*
Kweichow	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	*5*
Fengtien	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	2	—	—	17	*22*
Kirin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	9	*10*
Helungkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	3	*5*
Sinkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	*1*
Mongolia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	*2*
Kokonor	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
All China	4	18	15	5	18	10	13	31	24	36	41	56	43	57	24	43	67	72	81	*658*

*See reference to Table III.

above, there are others which must be taken into consideration. The droughts and floods recorded are not equal in intensity; and there is wide difference in the extent of area affected, sometimes the whole of China, at others only a few districts. The apparent increase in the number of droughts and floods from ancient to modern times is due to the fact that we have more records of recent happenings. Because of the ease of communication droughts and floods in places within a short distance from the capital of the empire easily attract attention, while calamities of the same or greater intensity occurring in distant provinces often escape notice. Tables I and II show that practically in every dynasty except the Ming the number of droughts and floods of the metropolitan province exceeds that of any other. Factors other than decrease or increase of precipitation may favor or check the occurrence of droughts and floods. It is well known to the Chinese historians that during the Yen Dynasty the Mongol invaders demolished the drainage system in the Yellow River valley, and consequently at that period both droughts and floods were particularly numerous in the provinces along the Yellow River.

The factors mentioned should, however, affect the number of droughts and floods alike. If there is a rapid rise in the number of droughts accompanied by a sudden drop in the number of floods at the same time, a drier climate is probably indicated; and, conversely, a marked decrease in the number of droughts followed by an equally marked increase in the number of floods means a moister climate.

With this as a criterion we note several points in Tables III and IV. The data before the Christian era are too scanty to be utilizable. During the fourth century the number of droughts greatly exceeds those of the preceding or the following centuries and is accompanied by very few occurrences of flood. A less marked but similar condition prevailed in the seventh century. In the twelfth century and again in the eighteenth there is a marked decrease in the number of droughts together with an equally marked increase in the number of floods. In the fifteenth century there were very few cases of floods, while droughts were quite frequent. If we divide the total number of droughts of each century by the total number of floods during the same interval, we have the ratios appearing in Table V. The data for the seventeenth century and later have not been computed, for, as has been already remarked, the method of enumeration is not the same as in the preceding periods.

In a recent bulletin published by the U. S. Department of Labor Ta Chen has found that Chinese migration can be grouped into three periods: those of the seventh, fifteenth, and nineteenth centuries.[2] During the first period Chinese migrated to the Pescadores and For-

[2] Ta Chen: Chinese Migrations, With Special Reference to Labor Conditions, *Bull. U. S. Bur. of Labor Statistics No. 340*, Washington, 1923, p. 4. Noted in the *Geogr. Rev.*, Vol. 15, 1925, pp. 144–145.

mosa; in the second period, to Malaysia; and in the third, about 1860, the third oversea migration started with destinations in Hawaii, North America, and South Africa. Mr. Chen found that the most significant causes of emigration are pressure of population and droughts and famines; while during the last century Chinese emigration was much accelerated by the ease of communication and by the demand for labor to open up new lands. Such, however, cannot be said of the seventh or fifteenth century. Mr. Chen has tabulated the number of droughts that occurred in four provinces of China, where the over-

TABLE V—RATIO OF DROUGHTS TO FLOODS BY CENTURIES

PERIOD	RATIO	REMARKS
A. D.		
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	

sea laborers are usually recruited (Chihli, Shantung, Fukien, and Kwangtung), from 1369 to 1596, without however being able to point out that droughts were especially numerous in the fifteenth century.

SEVERE WINTERS

With regard to temperature it is possible to follow one of the methods Brückner used in his "Klimaschwankungen," i. e. tabulation of the number of severe winters. There are three chapters in Tu Shu Tsi Cheng entirely devoted to the records of severe frost, great colds, and the like, observed in Chinese history. In Table VI the years with severe frost and great cold have been tabulated for the period 500–1600 A. D. along with those given by Brückner[3] and by C. E. P. Brooks[4] for Europe in the same period.

[3] Eduard Brückner: Klimaschwankungen seit 1700 nebst Bemerkungen über die Klimaschwankungen der Diluvialzeit, *Geogr. Abhandl. herausg. von A. Penck*, Vol. 4, No. 2, Vienna and Olmütz, 1890, p. 268.

[4] C. E. P. Brooks: The Evolution of Climate, London, 1922, p. 155.

Considering the divergent sources from which the data were obtained, the number of severe winters in China and in Europe agrees remarkably well, particularly in showing that the fifteenth century was relatively mild while the period 1100–1400 was comparatively cool. In the last column of Table VI the number of years in which sun spots were observed in China has been added. The sun-spot records are taken from Tu Shu Tsi Cheng and from the standard histories of different dynasties.[5] As is well known, the curve of sun-spot numbers and that of earth temperature follow each other in a general way in the sense that the temperature is lower at sun-spot maxima. The Chinese of these early days had no telescopes, but the occurrence of large sun spots observable by the naked eye is some indication of the intensity of solar activity. It is therefore interesting to find in Table VI that the number of years with records of sun spots increases as the number of severe winters increases.

TABLE VI—NUMBER OF SEVERE WINTERS IN EUROPE AND CHINA

PERIODS	CHINA	EUROPE	SUN-SPOT YEARS (CHINA)
500–600	19		7
600–700	11		0
700–800	9		0
800–900	19	11	8
900–1000	11	11	1
1000–1100	16	16	3
1100–1200	24	25	16
1200–1300	25	26	6
1300–1400	35	24	9
1400–1500	10	20	0
1500–1600	14	24	2

LATE FROSTS AND SNOWFALLS

Another indication of temperature conditions in past times is obtained from the dates of frost and snowfall Now the Chinese calendar fixed the date of the first frost in autumn as October 24, which is probably the mean date of the first frost in the Yellow River valley 2000 years ago. To be comparable with recent data the old records must be exact as to the date of occurrence and location and numerous enough to make certain that the case is not an exception. Also the phenomena must have occurred in a region from which we have records today.

[5] See also Alexander Hosie: Sunspots and Sun-shadows Observed in China, B. C. 28–A. D. 1617, *Journ. North China Branch of the Royal Asiatic Soc.*, Vol. 12, 1877, pp. 91–95.

Fortunately in the history of the South Sung Dynasty (1127–1279) there were forty records of spring snowfall in the capital (Hangchow) with the exact date in the Chinese calendar.[6] The first record was entered in the year 1131, and the last in 1264. According to the meteorological records made during the ten years 1905–1914 in Hangchow, the mean date of the last snowfall in spring during that period was found to be February 23, and the latest date March 15. Of the 40 records of spring snowfall registered in the South Sung Dynasty all

TABLE VII—LATEST SPRING SNOWFALL OBSERVED IN HANGCHOW BY DECADES

DECADE	DATE	DECADE	DATE
1131–1140	April 11	1211–1220	March 30
1141–1150	April 19	1221–1230	May 15
1151–1160	April 13	1231–1240	May 16
1161–1170	April 19	1241–1250	March 8
1171–1180	March 26	1251–1260	April 11
1181–1190	March 26	Mean	April 9
1191–1200	April 2		
1201–1210	March 9	1905–1914	March 15

save two came later than February 23, while there were twenty of them that came later than March 15.

If we take the 39 records made in the period of 130 years from 1131 to 1260 and divide them into 13 groups, each consisting of the records of a decade, it will be seen that the latest date of spring snowfall in each decade occurred later than March 15 with the exception of the periods 1211–1220 and 1241–1250, as shown in Table VII.

The recent snowfall observation in Hangchow covers only a period of ten years, which is too short. According, however, to the observation made at Zi-ka-wei Observatory near Shanghai about a hundred miles northeast for the thirty years 1873–1902, the latest date for the last snowfall in spring during that period was found to be April 4 (1882)[7], which is early compared with the snowfall records in Hangchow during the twelfth and thirteenth centuries. As Shanghai is north of Hangchow by a degree of latitude and is more than one degree Centigrade colder in mean annual temperature, it would seem safe to assume that the latest date of spring snowfall in Hangchow for the last three decades of the nineteenth century was still earlier. This occurrence of snow in Hangchow in the late spring during the twelfth and thirteenth centuries would suggest a severer climate and thus

[6] The Chinese calendar was first transformed into the Julian calendar by the aid of Pierre Hoang's "Concordance des chronologies Néoménique chinoise et européenne" (Shanghai, 1910), and seven days were added to each in order to make comparable with the Gregorian calendar.

[7] J. de Moidrey: Notes on the Climate of Shanghai 1873–1902, Shanghai, 1904, p. 31.

confirms the conclusion we have drawn from a comparison of the severe winters.

The snowstorms in Hangchow and in the lower Yangtze valley as a whole are usually caused by a certain type of weather, a well-developed anticyclone in Siberia and a low center passing south of the Yangtze valley approaching the Eastern Sea. The wind backs from southeast to northeast and then to northwest, accompanied by a considerable drop in temperature. Practically all of the winter precipitation of the lower Yangtze valley is derived under this type of pressure distribution, although the amount is not heavy when compared with that obtained from the summer showers. On the other hand, if the Siberian anticyclone is weak or has disappeared, the depression, if there is any, will pass north of the Yangtze valley. The wind will then veer from southeast to southwest and then to northwest. It may cause a dust storm (although never so severe in the Yangtze valley as in North China), but no rain or snow is produced; the drop in temperature, while usually noticeable, will not be so large as in the former case.

According to the investigation of C. J. Kullmer, "when sun-spots are few in number cyclonic storms move in a great variety of tracks, but when spots are numerous the storms tend to confine themselves to a few well-defined tracks, so that storminess is more or less restricted to certain areas within which it is highly concentrated."[8] Since according to records of Chinese history during the twelfth and thirteenth centuries the sun spots observed were particularly abundant, we should expect a concentration of storm tracks. If they should take place in the southern part of the Yangtze valley it would have the effect of making the lower Yangtze valley cool and damp. In this connection it may be noted that, according to Table IV, during the twelfth and thirteenth centuries the floods in the lower Yangtze provinces were especially numerous—indeed, there were more floods then than in any other century except in the Manchu Dynasty—while the provinces along the Yellow River were almost exempt from them.

[8] Ellsworth Huntington: The Climatic Factor, *Carnegie Instn. Publ. No. 192*, Washington, 1914, p. 253, note.