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THE OBSERVATIONS OF THE HUANGHAI SEA, BOHAI SEA AND THE SEA OF JAPAN HIGHS AND THE HEAVY RAIN IN NORTH CHINA IN SUMMER

by

Chao Shuyi

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THE OBSERVATIONS OF THE HUANGHAI SEA, BOHAI SEA AND THE SEA OF JAPAN HIGHS AND THE HEAVY RAIN IN NORTH CHINA IN SUMMER

/162*

Chao Shuyi

ABSTRACT

This article makes use of day by day 500hPa circulation charts for summers (June-August) 1966-1987. It takes high pressure processes occurring in the range 30-50°N, 110-140°E and divides them into five types in accordance with their formation properties, that is, the five types of high pressure processes--westerly high pressure, plateau high pressure, subtropical high pressure, combinations of westerly high pressure and subtropical high pressure, as well as combinations of plateau high pressure and subtropical high pressure. It analyzes time periods associated with the five types of high pressure processes described above as well as the geographical distribution of climatic characteristics. In conjunction with this, it points out that, in the North China region in the height of summer (July and August)--in particular, in the eastern sections of the North China area and the southern Manchuria region--there is an extremely close relationship existing between rainstorm and heavy rainstorm weather processes which appear and these stable high pressure configurations.

I. INTRODUCTION

Each year from June to August--in particular, the high summer months of July and August--in the middle layers of the troposphere, the East Asian area often sees the appearance of relatively strong high value systems. Generally, they are capable of lasting 3 to 5 days. The high value systems which appear along the coastal regions of China north of the Yellow Sea, the Bohai, the Sea of Japan and the Yangtze possess definite blocking functions. They are one of the main circulation forms associated with the East Asian region. They also influence precipitation in the North China flood season, and, in particular, are one of the key systems associated with North

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* Numbers in margins indicate foreign pagination. Commas in numbers indicate decimals.

China rainstorms [1][2]. This article uses day by day 500hPa circulation graphs for summer seasons in the 22 years from 1966-1987, analyzing characteristics associated with high pressure activities in the regions in question. In conjunction with this, it does detailed analysis of relationships with North China region rainstorms.

II. DEFINITION AND CLASSIFICATION OF HIGH PRESSURE PROCESSES

1. Definition

Within the range 30-50°N, 110-140°E, there are closed high pressures or high pressure circulation centers. The center strengths are at 576 geopotential decameters or above. Moreover, areas are not smaller than 5x5 latitude longitude intervals and are the Huanghai, Bohai, and Sea of Japan high pressure systems. These high pressure systems persisting for over 3 days (including 3 days) are figured to be an instance of high pressure process.

2. High Pressure Process Classifications

In accordance with differences in formation properties of Huanghai, Bohai, and Sea of Japan high pressures, it is possible to divide them into five classes. /163

The first class is called westerly high pressure processes. This class of high pressure develops from westerly perturbations. Long wave or short wave ridges develop and grow stronger, forming closed high pressure or high pressure circulation (Fig.1a). Often, a long wave trough is set up and develops along a northeast-southwest direction from the Ural Mountains to the Black Sea. In front of the trough, in the region from the Aral Sea to Lake Balkhash, there is the formation of a high pressure ridge, leading to the low trough which was originally on Lake Balkhash to move east to the west side of the Great Bend of the Huanghe. Correspondingly, there is high pressure formation on the east side of the Great Bend. This type of high pressure can also appear within a Eurasian range in a two ridge one trough

formation. East Asia is a high pressure ridge area. From the Ural Mountains to Lake Baikal is a low pressure trough. When this long wave trough replaces it or develops and deepens, in the East Asian ridge area in front of it, there is the formation of closed high pressure circulation. There is also a portion of high latitude closed high pressure on the north side of the area in question positioned at Lake Baikal or the north side of China's Manchuria region (generally, the area is not large). Due to the fact that from Novaja Zemlya Island to the Tajmyr Peninsula or Lake Baikal area there are low pressure troughs that weaken and move east, this forces high pressure to weaken and go south, entering the area in question. Westerly high pressure center strengths are generally smaller than 588 geopotential decameters.

The second type is called plateau high pressure processes. This type of high pressure process is very rare. All of them are due to the development and deepening of low pressure troughs from the Black Sea to the Caspian Sea. This causes Iranian high pressure to develop toward the east or northeast direction expanding to the Qinghai-Tibet Plateau. In the area 30-40°N, there forms an east-west pressure belt. After that, when--in the vicinity of the Lake Balkash region--there are westerly troughs invading the Qinghai-Tibet Plateau. Pressure on the plateau breaks up and moves east, entering the area described above. The high pressure center strength can reach 588 geopotential decameters or more (Fig.1b).

The third type is called the subtropical high pressure type (simply called the subtropical type). It is the west Pacific subtropical high pressure strengthening and stretching westward or lifting north to enter the regions described above and form (see Fig.1c). High pressure center strength generally is at 588 geopotential decameters or above. When strongest, it is capable of reaching 596 geopotential decameters.

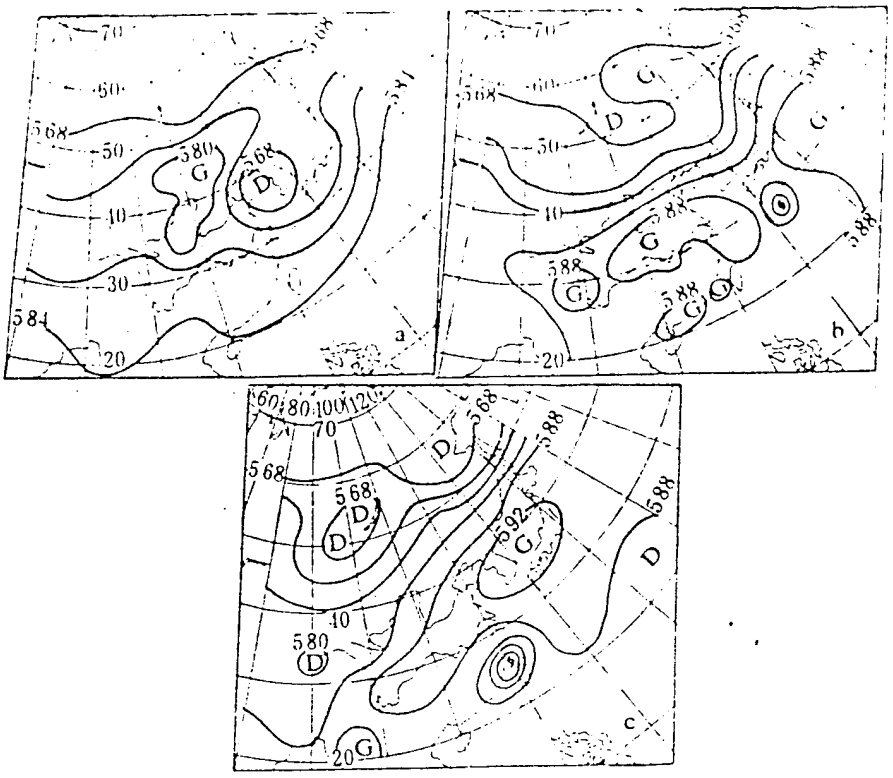

Fig.1 Schematic Diagrams of Huanghai, Bohai, and Sea of Japan High Pressure (a) Westerly High Pressure (1986 June 5) (b) Plateau High Pressure (1985 August 5) (c) Subtropical High Pressure (1985 August 23)

The fourth type is a process associated with the mutual combining of westerly high pressure eastern movement (or southern movement) and subtropical high pressure western advance (or northern lift).

The fifth type is a process associated with the mutual combining of plateau high pressure eastward movement and subtropical high pressure. /164

III. HIGH PRESSURE PROCESS CHARACTERISTICS

1. Various Types of High Pressure Process Time Distribution Characteristics

Characteristics of Huanghai, Bohai, and Sea of Japan high pressure processes from June to August 1966-1987. In 22 years, there were a total of 107 instances of high pressure processes--an average of approximately 5 instances each year. However, annual variations are very large (table omits). For example, the year 1973 showed the appearance of 7 instances of high pressure processes. They lasted a total of 62 days and accounted for 67% of the entire summer season. However, the year 1987 only showed the appearance of 2 instances of high pressure processes--only 6 days--accounting for 2% of the summer season. Among five types of high pressure processes, westerly high pressure processes are most numerous--an average of 2 instances each year. The most numerous year showed the appearance of 4 instances (1974). Next are subtropical high pressure type high pressure processes--an average of 1.5 instances each year. The most numerous year showed the appearance of 5 instances (1966). The fourth and fifth types of high pressure processes averaged 1 instance and 0.5 instances per year respectively. Plateau high pressure processes are the rarest. However, the status of appearance of the various types of high pressure processes in various months as well as the probability of appearance of high pressure centers on land and sea are each different. Below respective discussions are made.

TABLE 1 VARIOUS TYPES OF HIGH PRESSURE PROCESSES FOR JUNE - AUGUST 1966-1987

月份 \ 类型 (1)	(2) 一		二		三		四		五		合计	平均
	过程次数	持续天数	过程次数	持续天数	过程次数	持续天数	过程次数	持续天数	过程次数	持续天数		
6	18	4.5	1	3.0			1	3.0			20	0.9
7	15	1.8			15	4.7	10	10.0	5	6.6	45	2.0
8	5	1.0	2	3.5	19	6.7	11	9.8	5	9.2	42	2.0
合计	38		3		34		22		10		107	4.9
平均	1.7		0.1		1.5		1.0		0.5			

Key: (1) Type (2) 1 (3) 2 (4) 3 (5) 4
(6) 5 (7) Total (8) Average (9) Number of Processes
(10) Number of Days Sustained (11) Month

(1) Number of instances of the appearance of various types of high pressure in each month. July high pressure processes were most numerous. There were 45 instances. There were approximately 2 instances of appearance each month. August had 42 instances, only second to July. June had the fewest--only 20 instances--an average of only 1 instance of appearance each month. Looking from the viewpoint of the number of instances of appearance of the five types of high pressure in various months, westerly high pressure was the most numerous in June, somewhat reduced in July, and rarest in August. The third, fourth, and fifth types of high pressure processes, by contrast, are the opposite. Moreover, the third and fifth types of high pressure processes only appear in the two months of July and August.

(2) As far as the time periods the various types of processes are sustained are concerned, the one with the longest number of days sustained is the fourth type of high pressure process. The average was sustained 10 days. The longest was sustained 20 days (1977 July 18 to August 3). Second is the fifth type of high pressure process. The average was sustained from 7 to 9 days. The longest was 16 days (1984 July 28 to August 12). The third is subtropical type high pressure. The average is sustained 5 to 7 days. The longest is 14 days (1969 July 16 to 19). Time periods during which westerly high pressure processes are maintained are relatively short. The average is 4 to 5 days. The process with the shortest time periods of sustainment is plateau high pressure. They only have 3 to 4 days. Obviously, high pressure process sustainment periods are longest for combination types of subtropical high pressure and westerly or plateau high pressure.

2. Geographical Distribution Characteristics Associated with Various Types of High Pressure Centers

We took a small region constructed from a 5°x5° latitude longitude interval in order to calculate the frequency of appearance of various types of high pressure centers within a range 30-50°N, 110-140°E. Westerly high pressure type high pressure centers within the regions described above basically present a uniform distribution. However, in June and July, the number of appearances in the northern part of North China and the northern part of Manchuria tend toward being relatively more numerous (chart omits). Subtropical types of high pressure are primarily active above the surface of the sea south of 40°N and east of 120°E. In August, the probability of appearance of this type of high pressure above the ocean in China's Yellow Sea and over the southern part of Japan's Honshu Island (35-30°N--120-125°E as well as 130-135°E) obviously increases (Fig.2a). /165 Moreover, the fourth and fifth type of high pressure (Fig.2b,c)

appearance probabilities on the Chinese mainland and the ocean are almost the same. This is related to westerly high pressure and plateau high pressure coming from the western part of the mainland in these two types of high pressure processes. There is also a primary concentration in the area south of 40°N. Only August No.4 type high pressure has relatively frequent activity north of 40°N.

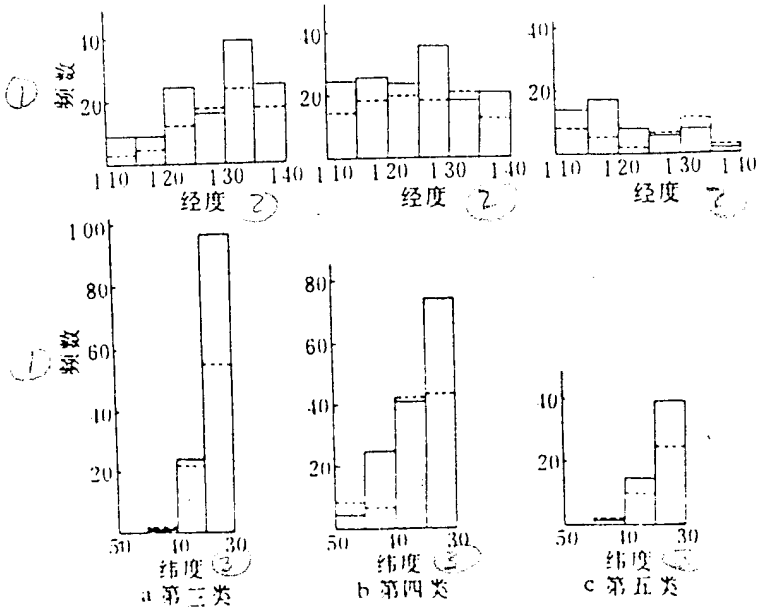

Fig.2 1966-1987 August (Solid Lines) and July (Dotted Lines) High Pressure Center Frequency Distributions (a) No.3 Type (b) No.4 Type (c) No.5 Type (1) Frequency (2) Longitude (3) Latitude

IV. HIGH PRESSURE PROCESSES AND NORTH CHINA PRECIPITATION

1. North China Precipitation Segments

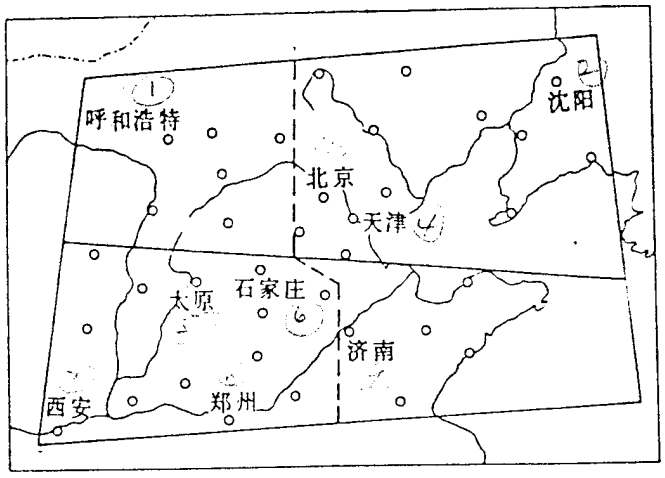

Fig.3 July North China Precipitation Segments

Key: (1) Huhhot (2) Shenyang (3) Beijing (4) Tianjin (5) Taiyuan (6) Shijiazhuang (7) Xian (8) Zhengzhou (9) Jinan

/166

This article makes use of day by day precipitation data for June to August 1966-1987 from 37 representative stations in the southern part of the North China and Manchuria region. Calculations were done by month for the relevant coefficients associated with amounts of precipitation at the various stations.

On the basis of the relevant coefficients, it is possible to take North China and divide it into northern segments and southern segments or eastern segments and western segments. The number of stations in the various segments is basically the same. Fig.3 gives segment status for July. June and August are analogous.

2. North China Rainstorm Distribution Characteristics

(1) Time Period Distribution Characteristics: Table 2 gives distribution status for the number of summer rainstorm days from 1966 to 1987. From the table, it is possible to see that June rainstorms are the rarest (75 days). Rainstorm days with 3 or more stations involved in one day were the rarest (10 days). July rainstorm day numbers abruptly increase to 244 days. August and July are about the same. However, rainstorm days with 3 or more stations forming a segment increase from 48 days to 58 days.

TABLE 2 NORTH CHINA RAINSTORM DISTRIBUTION STATUS JUNE-AUGUST 1966-1987

(1) 项目 / (4) 月份	(2) 暴雨天数		(3) 暴雨站点分布机率(%)			
	(5) 1个站	(6) 3个站	(7) 北片	(8) 南片	(9) 西片	(10) 东片
6	75	10	39	60	33	67
7	244	18	41	56	29	71
8	240	58	49	51	38	62

Key: (1) Item (2) Number of Rainstorm Days (3) Rainstorm Station Point Distribution Probability (%) (4) Month (5) 1 Station (6) 3 Stations (7) North Segment (8) South Segment (9) West Segment (10) East Segment

(2) Geographical Distribution Characteristics: In accordance with north south segments and east west segments, respective statistical calculations were done for probabilities of the appearance of rainstorms (Table 2). It is not difficult to see that, in the two months of July and August, north south segment rainstorm distribution is relatively uniform. However, east west segment rainstorm distribution is not uniform. East segment rainstorm stations are quite clearly more numerous than the western section. July is even more obvious. Although June southern segment rainstorms are also more numerous than the northern segment, the eastern segment, however, is even more clearly more numerous than the western segment.

3. Various Types of High Pressure Processes and North China Rainstorms

(1) General Survey of High Pressure Process Precipitation: Statistical calculations were done of the number of rainstorm days appearing in the North China region during the five types of high pressure processes as well as of the percentage of the total number of rainstorms they account for in the region in question (Table 3). It was obtained that, in June, during the five types of high pressure configurations, rainstorms produced accounted for 24-18% of the total rainstorm days, which is definitely a minority. July rainstorm day ratios follow upward to be approximately 45%. August proportions continue to rise to over 60%. Rainstorm day ratios associated with 3 or more stations reach higher than 76%, revealing the fact that July and August have near majorities and large majorities of segment forming rainstorm processes which are produced under the five classes of high pressure configurations. Besides, analyzing the number of North China rainstorm days in the flood season of each year and the number of days with the occurrence of high pressure (table omits), one gets all the years when the number of rainstorm days was 25 or more. The majority of the years in question also had

many days associated with the five classes of high pressure processes--generally more than 32 days (75%). The converse is also true (60%). Because of this, these five classes of high pressure are extremely important atmospheric circulation systems influencing precipitation in the broad range of North China in flood seasons.

TABLE 3 NORTH CHINA RAINSTORMS UNDER HIGH PRESSURE PROCESSES

月份 \ 项目 (1)	(2) 1个站		(3) 3个站以上	
(4) 份	天数	(6) 百分率(%)	(5) 天数	(6) 百分率
6	18	24	2	18
7	113	46	21	44
8	145	60	44	76

Key: (1) Item (2) 1 Station (3) 3 Stations or More
(4) Month (5) Number of Days (6) Percentage

(2) Time Period Distribution Characteristics Associated with Various Types of High Pressure Rainstorms: It is stipulated that high pressure processes which simultaneously do not show the appearance of rainstorms among the 37 representative stations described above are non-rainstorm processes. However, processes associated with the appearance of rainstorms or heavy rainstorms at one station on any one day are rainstorm processes. After/167 that, rainstorm statuses associated with various types of high pressure processes are calculated by month and set out in Table 4. In No.2, No.3, No.4, and No.5 class high pressure processes, rainstorm processes account for over 80%. Among these, No.2 class and August No.4 and No.5 class high pressure processes, in every case, correspond to an instance of rainstorm or heavy rainstorm production (100%). This is in line with maximum ratios

for rainstorm days produced by August high pressure processes in Table 3. However, among westerly high pressure processes, there were only approximately 80% of processes in July that showed the appearance in North China of rainstorms or heavy rainstorms (this fact also cannot be ignored). June and August rainstorm processes were clearly on the rare side.

TABLE 4 NORTH CHINA PRECIPITATION STATUS ASSOCIATED WITH VARIOUS CLASSES OF HIGH PRESSURE PROCESSES

类型	月份	过程总次数	无暴雨过程		暴雨过程	
			次数	百分率(%)	次数	百分率(%)
一	6	18	8	44	10	55
	7	15	3	20	12	79
	8	5	3	60	2	40
二	6	1	0	0	1	100
	8	2	0	0	2	100
三	7	15	1	7	14	94
	8	19	3	16	16	84
四	6	1	0	0	1	100
	7	10	1	10	9	90
	8	11	0	0	11	100
五	7	5	1	20	4	80
	8	5	0	0	5	100

Key: (1) Item (2) Total Number of Process Instances
(3) Non-rainstorm Processes (4) Number of Instances
(5) Percentage (6) Rainstorm Processes (7) Month
(8) Type (9) I (10) II (11) III (12) IV (13) V

TABLE 5 GEOGRAPHICAL DISTRIBUTION STATUS ASSOCIATED WITH VARIOUS TYPES OF HIGH PRESSURE PROCESS RAINSTORMS AND HEAVY RAINSTORMS

类型 \ 项目 \ 月份		暴雨总站数	北片		南片		西片		东片	
			站数	百分率(%)	站数	百分率(%)	站数	百分率(%)	站数	百分率(%)
一	6	31	4	13	27	87	11	36	20	65
	7	31	15	48	16	52	11	36	20	65
	8	1	1	100	0	0	1	100	0	0
二	6	1	1	100	0	0	0	0	1	100
	8	13	12	92	1	8	5	38	8	62
三	7	59	22	37	37	63	22	37	37	63
	8	122	64	53	58	48	27	33	89	73
四	6	4	3	75	1	25	0	0	4	100
	7	72	37	51	35	49	29	40	43	60
	8	152	61	40	91	60	49	32	103	68
五	7	19	10	53	9	47	7	37	12	63
	8	38	22	58	16	42	12	32	26	68

注:第二类7月,第三、第五类6月无高压过程

Key: (1) Item (2) Total Number of Rainstorm Stations (3) North Segment (4) South Segment (5) West Segment (6) East Segment (7) Number of Stations (8) Percentage (9) Month (10) Type (11) I (12) II (13) III (14) IV (15) V (16) Note: There were no high pressure processes of Type II in July or Types III and V in June.

/168

(3) Geographical Distributions Associated with Various Types of High Pressure Rainstorms and Heavy Rainstorms: Table 5 clearly shows geographical distribution characteristics associated with various types of high pressure rainstorms and heavy rainstorms. Rainstorms produced by No.1 and No.2 type high pressure developed in the interior respectively concentrate in the southern segment and northern segment of the North China region. The south north distribution is very uneven. Moreover,

No.3, No.4, and No.5 types of high pressure--mainly over the ocean--are just the opposite. Rainstorms produced are generally distributed north south in a relatively uniform manner. Rainstorms and heavy rainstorms easily occur in the eastern part of the North China region and the southern portion of the Manchuria area. In particular, August subtropical type high pressure had 73% of rainstorms and June No.4 type high pressure had 100% of rainstorms occur in the eastern segment of North China.

To summarize what was described above, during the height of summer in July and August, there is an extremely close relationship between Huanghai, Bohai, and Sea of Japan high pressure activity and North China region precipitation. As far as North China rainstorms--in particular, disastrous large sectional rainstorms--are concerned, they have even more profound degrees of parallel. Rainstorms produced under this type of configuration are mostly distributed in the eastern part of North China and the southern part of Manchuria. The intermonthly differences are also relatively clear. As far as the revelation of these observed facts is concerned, there is no doubt that they are extremely advantageous to rainstorm forecasts associated with North China flood seasons. With regard to physical mechanisms maintaining the stability of various types of Huanghai, Bohai, and Sea of Japan high pressure systems, the contributions to North China precipitation await further probes hereafter.

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