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STUDY ON CLIMATIC CHARACTERISTICS OF CHINA-INFLUENCING TYPHOONS AND THE INTERRELATIONS BETWEEN THEM AND THEIR ENVIRONMENTAL FACTORS

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Abstract: Climatic characteristics of China-influencing typhoons (CIT) were analyzed in this paper. Main characteristics include: (1) CIT season is May-November, especially from July to September. (2) Frequency of the CIT shows a decreasing trend during 1951 – 2004, especially after the late period of the 1960s. (3) Strong CIT also shows an obvious decreasing trend. Meanwhile, there exist obvious interdecadal variations in the CIT genesis, being more southward and eastward than normal in 1960s – 1970s, and more northward and westward than normal in the 1980s. In addition, the interrelations between CIT and its environmental factors show that CIT has close relationships with sea surface temperature and East Asian summer monsoon; the structure of the circulations in frequent CIT years is much different from that in infrequent CIT years.

Key words: China-influencing typhoons; climatic characteristics; interdecadal variations; environmental factors

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1 INTRODUCTION

In recent years, quite a number of meteorologists have studied the ways in which typhoons are formed over the northwest Pacific[1-6] but have not worked much on the climatological characteristics of the typhoons exerting influence (mainly on precipitation). It is then necessary to study it. By definition, the typhoons that affect China (hereafter shortened as "affecting typhoons") are those, including tropical depressions, which form over the northwest Pacific, including the South China Sea, and bring precipitation to either of the Chinese continent or one of its two main islands of Taiwan and Hainan, regardless of making landfall or being active offshore. An improved method of objectively separating typhoon-inflicted precipitation has been used to isolate the affecting typhoons objectively[7, 8]. On the basis of it, the climatological characteristics have been discussed before a brief analysis of the interconnection between the affecting typhoons and Pacific sea temperature / summer monsoon circulation system in East Asia.

2 CLIMATOLOGICAL CHARACTERISTICS OF THE AFFECTING TYPHOONS

2.1 *Variation of the frequency*

Of a total of 1845 typhoons were generated over the northwestern Pacific region for the time from 1951 to 2004, 928 of them affected China, averaging at 17 per year. The frequency of affecting typhoons has been declining since 1951 by a rate of 0.9 typhoon / 10 years, which passes the test of 0.05 significance level (Fig.1). Significant interdecadal changes have taken place in the frequency of the affecting typhoons. It is anomalously more for the 1960s but reduces significantly after the mid-1970s. The past 10 years is the time that sees the least frequency. As shown in some studies, supertyphoons (U>51 m/s) have the largest drop in the frequency, showing a tendency of decreasing 0.7 typhoon / 10 years, which passes the test of 0.001 significance level.

2.2 *Variation of the source areas*

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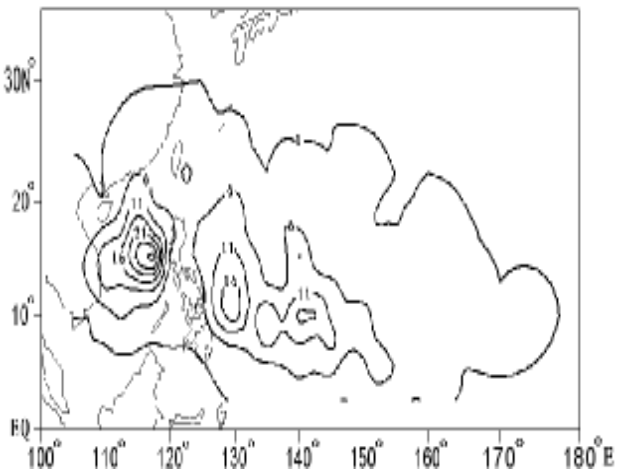

Fig.1 Geographical distribution of the frequency of source areas for the affecting typhoons for 1951 – 2004.

As shown in a statistical summary of the frequency of source areas of the affecting typhoons in a mesh composing 2.5°×2.5° gridpoints from 1951 to 2004 (figure omitted), most of the typhoons bringing precipitation to China have cyclogenesis over waters west of 170°E and between 5°N and 25°N. They are not formed over areas north of 30°N. There are three centers of source areas, which are over the South China Sea, the Philippines islands and Mariana Islands, and the South China Sea, an region being the closest to China of the three, has the most affecting typhoons.

It is shown from the mean location of source areas for the affecting typhoons in different decades (Tab.1) that it is averaged at 132.5° E, 14.4° N and the source area experiences significant interdecadal variation over the past 50 years, shifting from westward, eastward to westward again, and from southward to northward.

Tab.1 Mean location of source areas of the affecting typhoons in different decades

Decades	long./ °E	lat./ °N	State
1950	130.7	14.4	Westward
1960	134.8	13.6	Eastward, southward
1970	132.8	14.0	Slightly eastward, southward
1980	132.5	15.0	Northward
1990	131.7	14.8	Westward, northward
1951 – 2004	132.5	14.4	

3 CORRELATION BETWEEN THE AFFECTING TYPHOONS AND ENVIRONMENTAL FIELD

To reveal the environmental factors that play a major role in the affecting typhoons, 74 characteristic circulation quantities, index of SST in Niño regions, PDO index, QBO index and correlation coefficients of the frequency of the affecting typhoons are computed. Results with the most correlation are used to list in Tab.2. The numerals show that the variation of the central and eastern Pacific SST, subtropical high and polar vortex play an important role in the frequency of the affecting typhoons.

3.1 *Possible effect of North Pacific SST on the affecting typhoons*

It is seen from the curves showing the variation of PDO index and frequency of the affecting typhoons that the latter is correlated (coefficient being -0.46) well with the reverse phase variation of the former. Before the mid-1970s, PDO is in a cold phase that corresponds to more frequency of the affecting typhoon; after the time, PDO changes to a warm phase that accompanies a time of less frequency of the affecting typhoons.

From an analysis of the corresponding relation between the frequency of the affecting typhoon and ENSO episode (figure omitted), it is known that there are altogether 13 El Niño years and 15 La Niña years for the time of 1951 – 2004. In 10 out of the 13 El Niño years, the number of the affecting typhoons is relatively small with the probability being 77%; in 11 out of the 15 La Niña years, however, the number is relatively large with the probability being 73%. It shows that they are well correlated.

The years of high PDO index (and most of which are the El Niño years) and those of low PDO index

(and most of which are the La Niña years) are separately selected. When El Niño and La Niña are in phase with PDO respectively, significantly different characteristics can be found in the source area and track of the affecting typhoons (figure omitted). For the years with high PDO index, the source areas are in a stripe shape that covers a more eastward region and extends the northern border more to the south; for the years with low PDO index, the source areas are in a lump shape that covers a more westward and northward region. The distribution of the track also varies with the value of PDO. When PDO is in a high-value year, the affecting typhoon mainly moves westward to migrate into the South China Sea or turns the direction of movement over offshore waters. After the turn, the affecting typhoons usually enter the Sea of Japan while few make landfall on the coast of East China and advance deep inland. When PDO is in a low-value year, however, the affecting typhoon shows complicated patterns of track and can make landfall in coastal areas south of the Shandong Peninsula. It also moves deep into southeastern China and other inland areas in large numbers. When it turns the direction of movement, it is usually more northward and westward.

Tab.2 Coefficients of the simultaneous correlation between the frequency of the affecting typhoon and environmental factors

	SST index		Area index	Intensity index
Niño1+2	-0.57	North Africa subtropical high	-0.51	-0.49
Niño3	-0.61	North America subtropical high	-0.43	-0.36
Niño4	-0.49	Northern Hemisphere subtropical high	-0.40	-0.37
Niño3, 4	-0.54	South China Sea subtropical high	-0.41	-0.37
		West Pacific subtropical high	-0.38	-0.34
		North America polar vortex	0.33	0.35

Note: All correlation coefficients listed in the table have passed the significance test.

3.2 *Possible effect of East Asian summer monsoon on the affecting typhoon*

A composite analysis is carried out of the circulation patterns of the period of concentrated typhoon activity (July – September) with more and less affecting typhoons. If the affecting typhoons $\geqslant$23 and landfalls $\geqslant$9, the year is tagged the one with active typhoon activity. If the affecting typhoons $\leqslant$12 and landfalls $\leqslant$8, the year is labeled the one with inactive typhoon activity. The difference is significant, as shown from a comparison of July – September 500hPa geopotential height field between the two types of years, especially so over the Asian continent, Japan – Sea of Okhotsk, Aleutian Islands, eastern coast of north Pacific and polar vortex and the area where the polar vortex is active. During the years with active activity of typhoons, the East Asian continent is controlled by strong negative anomalies, which cover the west Pacific area south of 30°N, areas north of Japan – Sea of Okhotsk are dominated by positive anomalies, with the Aleutian low strengthening and the polar vortex locating more to North America. It is a pattern in which northern cold air is less likely to affect China and a more northward and westward located subtropical high is favorable for typhoons to remain active. During the years with inactive activity of typhoons, however, the circulation is just the reversed. Positive anomalies prevail in the continent of East Asia and west Pacific south of 30°N and negative anomalies are in control over Japan – Sea of Okhotsk. It is a pattern in which the anomalous high pressure ridge west of Lake Baikal is favorable for steering the northwesterly flow to progress south into China and a more southward located subtropical high is not likely to develop over the west Pacific and eastern China.

For analyses of other aspects, refer to the Chinese edition of the journal.

4 SUMMARY

On the basis of typhoon-related precipitation, this work defines the typhoon that affects the region of China and studies the climatological features of these affecting typhoons for the causation of changes. The preliminary efforts have yielded the following conclusions.

(1) Significant changes have taken place in the frequency and source area of the affecting typhoons over the past 50 years. The frequency shows a decreasing trend and the past 10 years become a period with the least frequency. The decreasing trend of supertyphoons is the most obvious among the affecting typhoons in terms of occurring frequency. The main source area of the affecting typhoons is in the South China Sea, which is changing significantly on the

interdecadal scale. It is more eastward and southward for 1960s – 1970s but more northward and westward after the 1980s.

(2) As shown in the studies, the decadal variation of SST in north Pacific (PDO) and SST anomalies in central and eastern Pacific (ENSO episode) are closely linked with the affecting typhoon. When PDO is in the cold phase and La Niña years, there will be more affecting typhoons; when PDO is in the warm phase and El Niño years, there will be less affecting typhoons. When the El Niño episode is in phase with PDO, the source area of the affecting typhoon is more southward and eastward and there will be less typhoons affecting China; when the La Niña episode is in phase with PDO, it is more northward and westward and there will be more typhoons affecting China.

(3) The frequency of affecting typhoons is closely linked with the circulation system of summer monsoon in East Asia. For the years of more (less) affecting typhoons, almost reversed changes are taking place in corresponding circulation situations.

REFERENCES:

[1] CHEN Lian-shou, DING Yi-hui. Introduction to West Pacific Typhoons [M]. Beijing: Science Press, 1979.
[2] ZHANG Guang-zhi, ZHANG Xian-gong, WEI Feng-ying. A study on the variations of annual frequency for tropical cyclone in northwest Pacific during the last hundred years [J]. J. Trop. Meteor., 2000, 11(4): 315-323.
[3] MU Hai-zhen, TU Qi-pu. Climatological characteristics of tropical cyclone activities in the west Pacific [J]. J. Nanjing Inst. Meteor., 2000, 23(1): 81-86.
[4] LEI Xiao-tu, CHEN Lian-shou. The latitudinal distribution of climatic characteristics on tropical cyclone activities in the WNP [J]. Quart. J. Appl. Meteor., 2002, 13(2): 218-227.
[5] CHAN J C L，SHI J E. Long-term trends and interannual variability in tropical cyclone activity over the western North Pacific [J]. Geophys. Res. Lett. , 1996, 23(20): 2765-2767.
[6] LI Ying, CHEN Lian-shou, et al. Statistical characteristics of tropical cyclone making landfalls on China [J]. J. Trop. Meteor., 2004, 20(1): 14-22.
[7] REN F M, WANG Y M, WU G X, et al. Estimating Tropical Cyclone Precipitation from Station Observations [J]. Adv. Atmos. Sci., 2007, 24(4): 700-711.
[8] WANG Yong-mei, REN Fu-min, WANG Xiao-ling, et al. The study on the objective technique for partitioning tropical cyclone precipitation in China [J]. Meteor. Mon., 2006, 32(3): 6-10.

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