ACTIONS OF TYPHOONS OVER THE WESTERN PACIFIC (INCLUDING THE SOUTH CHINA SEA) AND EL NINO

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ABSTRACT

According to the time cross-section of SST in the equatorial eastern Pacific and the historical data on typhoon actions over the western Pacific (including the South China Sea), a composite analysis of the actions of typhoon over the western Pacific in El Nino year (SST in the equatorial eastern Pacific are continuously higher than normal) and in the inverse El Nino year (there are continuative negative anomalies of SST in the equatorial eastern Pacific) is carried out. The results show that the actions of typhoon are in close relation with El Nino: The annual average number of typhoons over the western Pacific and South China Sea is less than normal in El Nino year and more in the inverse El Nino year; The annual average number of the landing typhoon on the continent of China bears the same relationship with El Nino; The anomalies of typhoon actions mainly occur during July-November and their starting are behind the anomaly of SST in the equatorial eastern Pacific.

Based on the generation and development conditions of typhoons, the circulations and state of the tropical atmosphere and SST in the western Pacific are respectively analysed in El Nino year and in the inverse El Nino year. Then some possible influence mechanisms of El Nino on the actions of typhoons are discussed.

I. INTRODUCTION

In El Nino year, there is a continued anomalous warming phenomenon of sea-water in the equatorial eastern Pacific. It is regarded as a sign of El Nino occurrence that the average sea surface temperature (SST) in the region (0°–10°S, 180°–90°W) is continuously higher than normal. In general, the positive anomaly of SST begins in March–April and continues for about one year or more. If a negative anomaly of SST in the equatorial eastern Pacific takes place continuously, the year is called an inverse El Nino year.

A number of studies in recent years have shown that the appearance of El Nino influences not only the circulation and weather in the tropical atmosphere but also the circulation and short-range climate variation over the global area (Chen 1977, Rowntree 1979, Wallace et al. 1981). For example, in El Nino years, the Pacific-North American (PNA) pattern can be produced and leads to special weather in most parts of the United States; The anomaly of SST in the equatorial eastern Pacific is closely correlated with the precipitation in China during summer. One may then ask what relation exists between the action of typhoon over the western Pacific and El Nino? Studies on their relationship have resulted in different conclusions (Pan 1982, Ramage et al. 1981).

In order to understand exactly the relationship between El Nino and the actions of typhoon over the western Pacific, some statistical analyses are completed, using the typhoon data over the western Pacific and the SST data in the equatorial eastern Pacific during the period 1900–

1979 in this paper. Based on the environmental conditions of the generation and development of typhoon, some possible influence mechanisms of El Nino on the actions of typhoon are discussed.

II. DATA USED

The time cross-section of SST in 1806–1979 provided by Angell (1981) is basic data for analysis. But in order to pledge the reliability of the analyzed results, the SST data (1921–1938, 1950–1976) provided by Rasumusson et al. (1982) is also used for comparison. According to these data, the basic characteristics of SST variation with time are consistent. For the typhoon actions, the statistical results (1884–1955) compiled by Gao Youxi et al. (1957) and some typhoon Almanacs (1951–1979) are used together.

Based on the above-mentioned SST data, 24 El Nino years and 16 inverse El Nino years over a span of 80 years (1900–1979) are defined at first. They are given in Table 1. The typhoon frequency is based on the number presented in every month. If a typhoon was present in two months, it was counted into the month in which the typhoon was formed. The landing typhoon is only counted when it lands on continent, while it is not counted landing on islands.

Table 1. El Nino Years and Inverse El Nino Years during 1900–1979

El Nino	1902	1904	1905	1911	1913	1918	1919	1923
Years	1925	1930	1935	1940	1941	1944	1945	1948
	1951	1953	1957	1963	1965	1969	1972	1976
Inverse El Nino	1907	1909	1912	1917	1921	1924	1937	1942
Years	1949	1954	1955	1964	1967	1970	1973	1975

III. ANALYZED RESULTS

In order to expose the influence on typhoons caused by El Nino, composite analyses of the typhoon actions in total El Nino years and in total inverse El Nino years were carried out. Some statistical results are given in Table 2. There the first line is the average number in a span of 80 years (1900–1979), while the other lines are the average number in a span of 30 years (1950–1979). The results show that an average of 24.3 typhoons occurred every year over the western Pacific and South China Sea. The average occurrences of typhoons in El Nino were only 21.4, less by 3 than those in the normal and by 5 than those in the inverse El Nino year. In the inverse El Nino year, more typhoons occurred than in the normal. Just the same, the average number of typhoons entered the South China Sea from the western Pacific, the average number of typhoons generated over the South China Sea and the frequencies of typhoons landing on the continent of China in El Nino year are less than those in the normal. But in the inverse El Nino year all these are more than those in the normal. The statistical tests of them using T-test indicate that the above-mentioned statistics are believable. It shows that the occurrence of typhoons over the western Pacific and South China Sea is closely related with El Nino.

Table 2. Average Number of Typhoons Generated over Western Pacific and South China Sea and Landing on the Continent of China

	Multi-Year Average (Normal)	El Nino Year Average	Inverse El Nino Year Average
Occurrence of Typhoons over Western Pacific and South China Sea	24.3	21.4	26.2
Number of Western Pacific Typhoons Entering in South China Sea	6.9	4.9	8.7
Number of Typhoons Generated over South China Sea	3.4	2.0	4.1
Frequencies of Typhoons Landing on the Continent of China	6.2	5.2	7.3

To understand further the relationship between the El Nino and the typhoon actions over the western Pacific, we have made a composite analysis of the monthly average occurrences of typhoons. The result is given in Fig. 1. It reflects the fundamental situation in different months. The solid line is the average for 80 years, the dashed line for the inverse El Nino years and the dotted line for the El Nino years. It can be seen that the departure from the normal occurrence of typhoon over the western Pacific appears mainly in July–November.

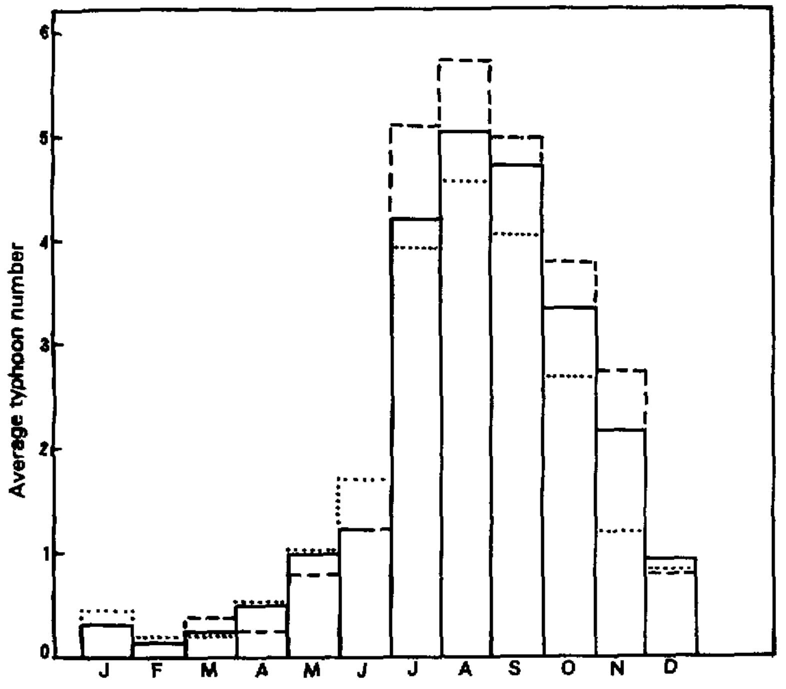

Fig. 1. Monthly average occurrences of typhoons over the western Pacific (period 1900–1979) .

In general, the El Nino begins in March–April, while the anomaly of typhoon begins in July, lagging behind the occurrence of the El Nino. This indicates that the El Nino might exert an effect on the tropical atmosphere circulation at first and the typhoon action over the western Pacific afterwards.

Fig. 2 shows the percentage distribution of the monthly average anomaly of typhoon occurrence over the South China Sea in El Nino year and in the inverse El Nino year. The difference between that in El Nino year and that in the inverse El Nino year is very clear. Moreover, the anomaly of typhoons over the South China Sea mainly occurs in October and November.

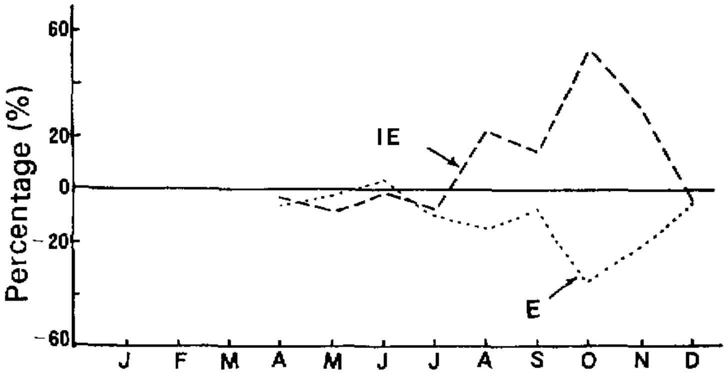

Fig. 2. Percentage distribution of the monthly average anomaly of typhoon occurrence over South China Sea (period 1950–1979).

The above-mentioned analysis shows that the occurrence of typhoons over the western Pacific and South China Sea is in close relation with El Nino and the anomaly of typhoons occurs behind the El Nino event. Therefore, we may conclude that El Nino is an important cause leading to the anomaly of typhoons.

IV. ENVIRONMENT CONDITIONS CAUSING TYPHOON ANOMALY

As we know, El Nino events can cause anomalistic variation of the atmospheric circulation in vast areas, especially in the tropics. These anomalistic variations of the atmospheric circulation are sure to influence the occurrence of typhoons. Therefore, according to the generating conditions of typhoons, different variations of the atmospheric circulation and SST in the western Pacific during summer in El Nino years and inverse El Nino years will be analyzed respectively. Then, some qualitative explanations about the influence of El Nino on the typhoon over the western Pacific can be obtained.

The surface pressure in the western Pacific and East Asia shows that an identical positive anomaly appears in the vast areas to the south of 35°N latitude during the summer in El Nino year (Fig. 3). The average surface pressure differences during the summer between an El Nino year and an inverse El Nino year show that the surface pressure in El Nino year is higher than that in the inverse El Nino year to the south of 30°N latitude and it is lower in the middle-latitude area in El Nino year. The annual variations of the surface pressure anomalies in El Nino year (dotted line) and in the inverse El Nino year (dashed line) at Guangzhou and Haikou are shown in Fig. 4. It is obvious that basically there is a positive anomaly in El Nino year and a negative anomaly in the inverse El Nino year after March in those tropical regions. The above-mentioned distribution and variation of the surface pressure show that there is an anomalous action of the high pressure system in the tropical western Pacific and South China Sea in El Nino year. Then ITCZ in this area may be weaker and its position is on the southern side.

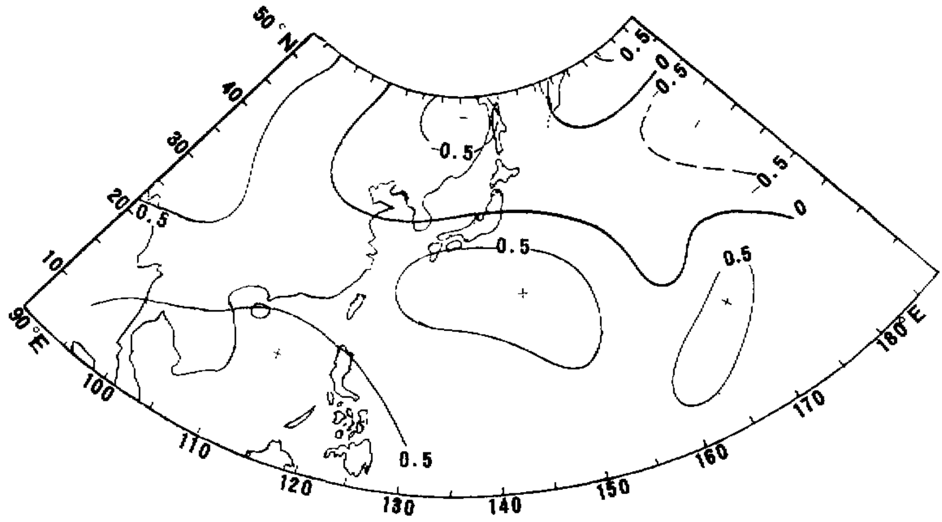

Fig. 3. Surface pressure anomalies (hPa) during July-August in El Nino year (period 1950–1979).

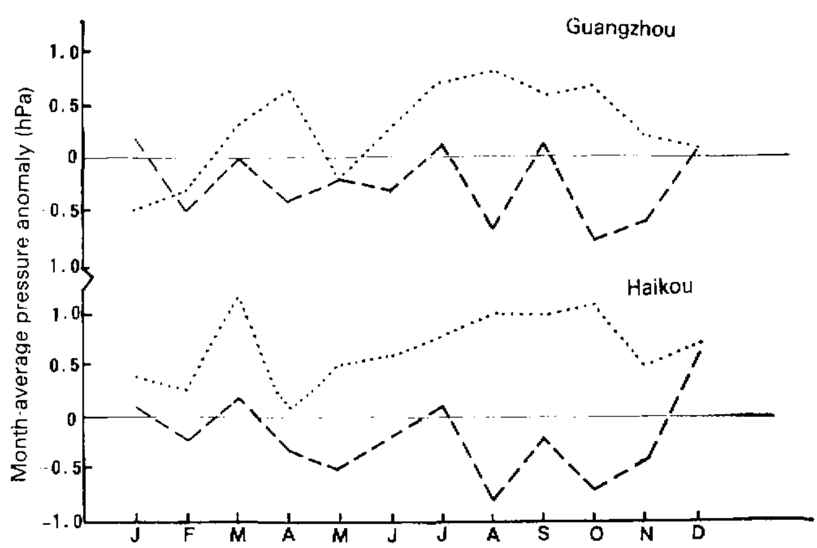

Fig. 4. Annual variation of the surface pressure anomaly at Guangzhou and Haikou in China in El Nino year (dotted line) and in the inverse El Nino year (dashed line) for the period 1950–1979.

El Nino events also influence the height field at 500 hPa. The average height difference at 500 hPa between El Nino year and inverse El Nino year during summer (Fig. 5) has a similar horizontal distribution to the surface pressure difference. There is a lower geopotential height in the middle-latitude region in El Nino year and a higher geopotential height to the south of 30°N latitude. Then, the position of subtropical high over the western Pacific is obviously on the southern side in El Nino summer.

In El Nino year, the above-mentioned abnormities of the geopotential field and the surface pressure field inevitably make the position of ITCZ to be on the southern side. This can be seen from an example analyzed. The average position variations of ITCZ with time at 700 hPa in the 130°-150°E area during summer in 1976 (dotted line) and 1967 (dashed line) are counted and shown in Fig. 6. It is obvious that the latitude position of ITCZ over the western Pacific in El Nino year is lower than that in the inverse El Nino year.

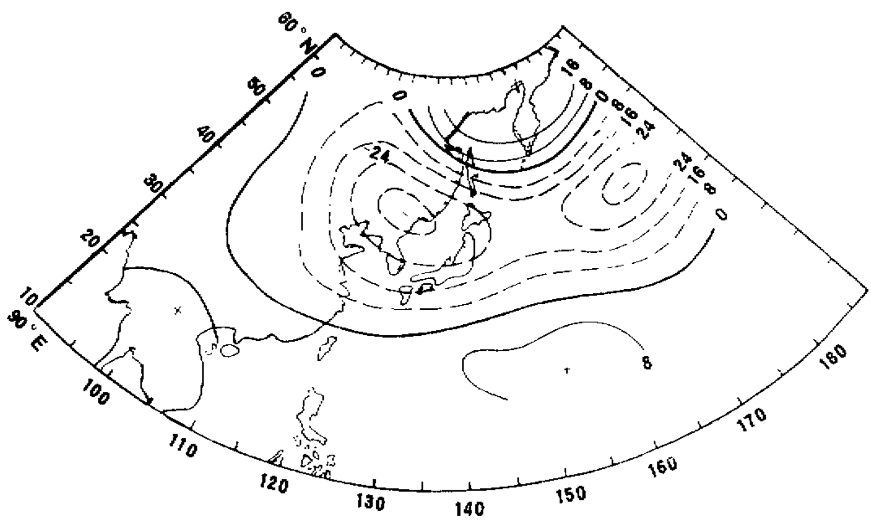

Fig. 5. Average height difference at 500 hPa during July-September between El Nino year and the inverse El Nino year for the period 1950–1979.

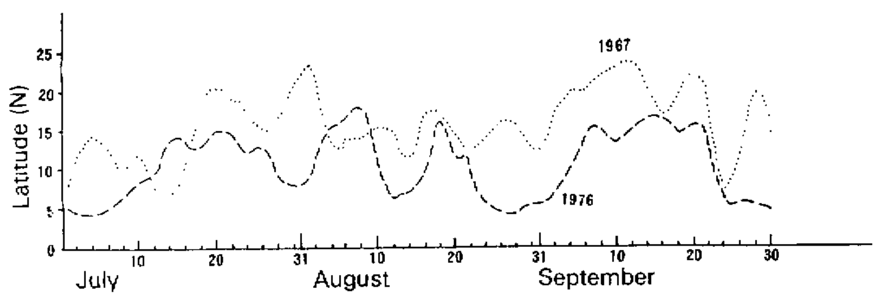

Fig. 6. The average position variations of ITCZ with time at 700 hPa in 130°-150° E area during summer.

The above-mentioned abnormities of the geopotential field and the surface pressure field in El Nino year also cause larger vertical wind shearing in the source region of typhoons. Since the latitude position of ITCZ is lower and the vertical wind shearing is larger in the source region of typhoons during El Nino summer, it is unfavourable to generating typhoons in El Nino year. Therefore, the occurrence of typhoons in El Nino year is less than normal.

The variation of Walker circulation caused by El Nino is well known. In El Nino year there is an anomalous rising motion in the atmosphere over the equatorial eastern Pacific and an anomalous falling motion region is formed near 150°–160°E (Julian et al. 1978). Because of this abnormity of Walker circulation in El Nino year, the anomalous falling motion will be formed in the source region of typhoons. The convective actions will suffer restraint and the occurrence of typhoons will certainly be less. Reversely, the rising motion in the source region of typhoons is enhanced in the inverse El Nino year and is favourable to generating typhoons.

The El Nino event can directly influence the tropical atmospheric circulation over the western Pacific. Simultaneously, the influence of an El Nino event still has a propagating phenomenon westward. In El Nino year, the variation of positive anomalies of height at 500 hPa over the western Pacific is shown in Fig. 7. The expansion of positive anomalies of height at 500 hPa westward is very obvious in El Nino year. This might explain why the anomaly of typhoons appears behind the occurrence of the El Nino.

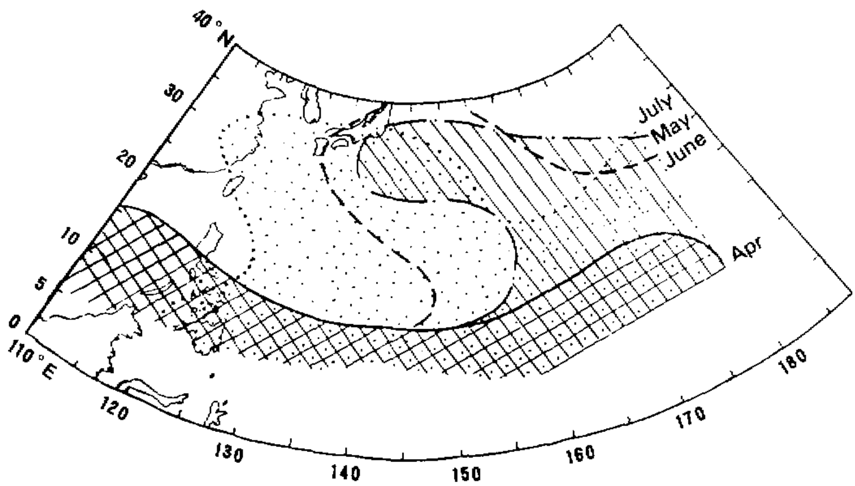

Fig. 7. The variation of positive anomalies of height at 500 hPa over the western Pacific in El Nino year (period 1950–1979).

SST in typhoon source region also plays an important role in the generation of typhoons. In general, it is difficult to generate a typhoon if the SST is lower than 28°C. The distributions of average SST anomaly during June–September in 1976 (El Nino year) and in 1967 (the inverse El Nino year) show that the SST in the typhoon source region is anomalously lower than normal in El Nino year. Therefore, the occurrence of typhoons in El Nino year is less than normal. But in the inverse El Nino year, the SST in the typhoon source region is on the high side so that the occurrence of typhoons is not normal.

CISK is looked upon as a main mechanism for the generation and development of typhoons. And the stability parameter has an important influence on the unstable growth of depression in the CISK theory. In order to compare the atmospheric state in the typhoon source region in El Nino year and in the inverse El Nino year, as an example, the computation of stability parameter between 850–500 hPa in the region nearby Guam Island in July 1976 and 1967 has been completed. The computed static stability σ was respectively 2.28×10^{-2} $m^2 \cdot hPa^{-2} \cdot s^{-2}$ in 1976 and 1.94×10^{-2} $m^2\, hPa^{-2} \cdot s^{-2}$ in 1967. It is obvious that the atmospheric stability in the typhoon source region in El Nino year is greater than that in the inverse El Nino year. This could also explain why the occurrence of typhoons is greater in 1967 and less in 1976.

V. CONCLUSION

The average occurrence of typhoons over the western Pacific and South China Sea area is closely correlative with El Nino. There are fewer typhoons in El Nino years than in normal years but more typhoons in the inverse El Nino years.

The anomaly of typhoons over the western Pacific and South China Sea in El Nino year or in the inverse El Nino year occurs mainly during July–November. It lags behind the anomaly of SST in equatorial eastern Pacific. This lag of typhoon anomaly may be correlative with the propagating of the circulation anomaly caused by an El Nino event progressively westward.

The appearance of an El Nino event will cause anomalous variations of atmospheric circulation and state in the tropics, such as: the latitude position of ITCZ is on the southern side; the vertical wind shearing and static stability in the typhoon source region become greater; the convective action decreases in the source region of the forming typhoon. It also causes abnormity (decrease) of SST in the equatorial western Pacific. The above-mentioned anomalous variations are unfavorable for the generation and development of typhoons. So there are fewer typhoons in El Nino year. Contrarily, the environment conditions are favorable for generation and development of typhoons in the inverse El Nino year. There are therefore more typhoons in the inverse El Nino year.

By investigating the different features of every El Nino event and the relevant actions of typhoons further, we should get some concrete targets on the long-range forecast of typhoon action.

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