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STUDY ON THE CHARACTERISTICS OF TROPICAL CYCLONES ACTIVITY OVER THE WESTERN NORTH PACIFIC IN 2004 AND THE CAUSATION

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Abstract: In this paper, we summarized the characteristics of tropical cyclones (TC) activity over the western North Pacific in 2004 and analyzed their causation. Compared with the normal, the annual frequency of TC in 2004 was slightly higher, tropical cyclones in 2004 had a longer life span and occurred in a concentrated period, the source of TC were situated eastward; in all tracks of TC, the recurvature tracks took up larger proportion, the landfall regions of TC were located northward, which concentrated from East China to Japan. The primary causes were revealed as follows. Firstly, the intensity and area of the western North Pacific subtropical high was stronger and larger than usual respectively, and its ridge was frequently in the form of cells and stretched northwestward. Secondly, the convergence of intertropical convergence zone (ITCZ) was reinforced and the convergence zone moved more eastward than average. Thirdly, the meridionality of the westerlies was larger than average and the cell-shaped ridge formed a saddle region, which is in favor of TC northward motion and recurature.

Key words: tropical cyclones; characteristics; causation

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1 INTRODUCTION

The TC is one of the main destructive weather systems that influence China. There have been rich achievements on it previously[1-3]. In general, much of the study is on the medium- and short-range variation with the focus on specific patterns of evolution for one or a few TCs owing to the limitation of available data[4-8]. Few of the research address the annual, monthly and seasonal changes of the TC[9-10] and statistical analysis was the most common method[12-14]. There are quite a number of differences in viewpoints on a particular issue in the research results[12-14] and there has not been much extensive discussion of the mechanism and principles for short-term climatological change in the activity of the TC. In this paper, the TCs during the typhoon season of 2004 are studied and their characteristics are summarized for the region of western North Pacific and South China Sea, and then the causation is analyzed and discussed from the viewpoint of weather and climate. Relevant physical mechanisms are probed so that guidelines can be provided to operational forecast and scientific research.

2 BRIEF ACCOUNT TO TCS IN WESTERN NORTH PACIFIC IN 2004

There were a total of 30 tropical cyclogeneses in the western North Pacific in 2004 (tropical depressions are not included in this work, see Fig.1). After continuously being less than the multi-year mean, the total number of TCs surpassed it for the first time since 1995, i.e. it was the year with most TCs in the ten years. Nineteen of them intensified into typhoons, taking up the total by 63.33%, which was higher than the normal rate of 61.7%. The year witnessed less cyclogenesis (only three) than normal in the South China Sea, lower than the average of 4.92.

In 2004, TCs usually had longer life cycles. Twenty of them sustained for five days or more, taking up 66.67% of the total. Six TCs maintained for 10 days or more. It is known from the monthly distribution of cyclogenesis (Tab.1) that TCs form mainly in summer, more than half of the total. Seventeen of the TCs

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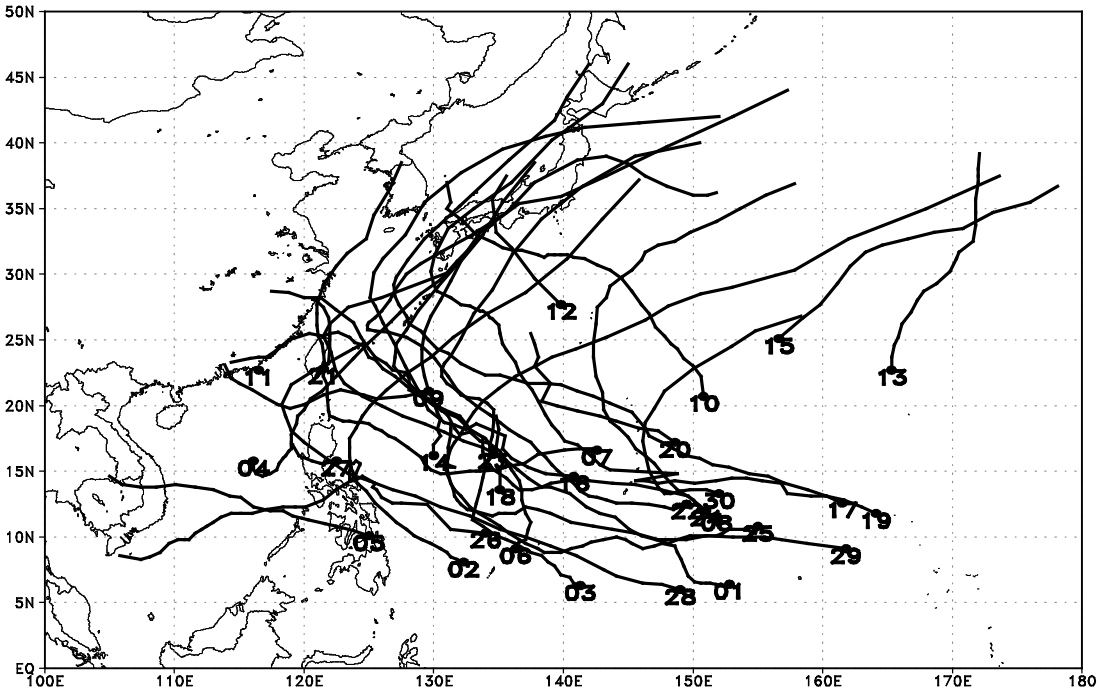

Fig.1 Track of tropical cyclones in 2004. The numerals inside are the codes given by the Central Weather Observatory (CWO) of China.

generated between 120°E and 150°E, being 56.67% of the sum. Eleven of the TCs formed east of 150°E, being 36.67% of the total. The frequency is higher than the multi-year average, indicating more eastward sources of cyclogenesis.

In 2004, the TCs with extreme value between 40 – 50 m/s for the maximum wind speed accounted for 50% of the yearly total, more than the mean by 28%. For the remaining sections of the intensity, they were less than it.

In 2004, eight TCs above the level of tropical storm made landfall on the coast of China, which was more than the mean (6.15), concentrating in a region from the east of the Pearl River estuary in Guangdong to the Hangzhou Bay in Zhejiang.

Of the 30 TCs, 16 of them had recurvatures of track (Tab.2), being 53.33% of the total, which was more than normal.

Following the definition set in this work (omitted), the subtropical high indexes in the summer and autumn for 2004 and climatology have been calculated and presented in Tab.3, using the monthly mean data of NCEP for 1948 – 2004 (with the spatial resolution at 2.5 °×2.5 °). The table shows that the subtropical high had a relatively large area of dominance and maintained at high intensity throughout the summer and autumn of 2004. Analyzing the indexes for its ridge line and westernmost longitude to which it ever reached reveals that the two seasons were dominated by an extensive and intense subtropical high at the level of 500 hPa, which was marked by northward location of the ridge line and substantial westward extension. The subtropical high was also mostly in the shape of lumps and stronger-than-normal southerly airflow to its west, steering the TC on northward movement. It also explains why there were anomalously more recurvatures of TCs in the year.

Tab.1 The monthly distribution of tropical cyclogeneses number in 2004 in contrast with the multi-year mean

Month	1	2	3	4	5	6	7	8	9	10	11	12	Sum
2004	0	0	0	1	2	5	3	8	3	3	3	2	30
Multi-year m.	0.48	0.2	0.42	0.76	1.04	1.94	4.14	5.88	5.04	4.02	2.42	1.3	27.64

3 ANALYSIS OF THE CAUSATION

Tab.2 Summary of recurvature TCs in 2004

CWO codes (Intl. codes)	Names	Point of appearance	Life cycle (h)	Max. wind speed /m·s^{-1}	Point of recurvature
0401（0401）	Sudal	6.4 °N,152.8 °E	352	50	15.4 °N,131.0 °E
0402（0402）	Nida	8.1 °N,132.3 °E	186	50	16.1 °N,123.5 °E
0403（0403）	Omais	6.3 °N,141.4 °E	132	25	11.4 °N,133.0 °E
0406（0406）	Dianmu	9.2 °N,136.3 °E	186	60	23.2 °N,129.1 °E
0407（0407）	Mindulle	16.6 °N,142.6 °E	276	45	27.0 °N,121.1 °E
0408（0408）	Tingting	11.7 °N,151.8 °E	198	40	24.9 °N,142.3 °E
0412（0411）	Malou	27.8 °N,139.9 °E	30	20	35.7 °N,134.5 °E
0416（0415）	Megi	14.7 °N,140.9 °E	156	33	28.3 °N,125.2 °E
0417（0416）	Chaba	12.7 °N,161.5 °E	294	60	30.2 °N,129.8 °E
0419（0418）	Songda	11.9 °N,164.2 °E	264	50	29.3 °N,126.9 °E
0422（0421）	Meari	12.5 °N,149.5 °E	306	45	27.2 °N,124.9 °E
0423（0422）	Ma-on	16.4 °N,134.6 °E	150	50	22.6 °N,130.6 °E
0424（0423）	Tokage	12.0 °N,121.0 °E	234	50	23.0 °N,126.9 °E
0425（0424）	Nock-ten	10.9 °N,155.0 °E	234	45	25.4 °N,121.6 °E
0429（0428）	Nanmadol	6.1 °N,149.0E °	132	45	20.1 °N,118.3 °E
0430（0429）	Noru	13.4 °N,152.0 °E	96	25	17.4 °N,146.2 °E

It is found from the analysis of stream field and divergence field at 850 hPa (figure omitted) that the mean latitude of the ITCZ in 2004 was close to that of normal years but with larger north-south span in WWN-EES alignment. Such non-zonal distribution is unfavorable for the westward movement of the TC. The location of the convergence center of the ITCZ was generally normal but the convergence intensity was stronger than normal in most of the months. Convection was more active and the divergence field was so allocated between upper and lower levels that equatorial convection was easier to trigger the generation and to intensify the development of TCs. It is also why there were much more tropical cyclogeneses in June and August in 2004.

It is known from the analysis of the 500-hPa circulation in mid- and higher- latitudes that the meridional wavelength is larger than usual in the Eurasian region in the summer but generally normal or slightly larger in the autumn. In the monthly mean

Tab.3 Comparisons of the indexes for characteristics of the subtropical high (The numerals inside the parentheses are multi-year mean)

month	Ridge line index / °N	index of area / gridpoint number	Index of intensity / geopotential meter	Index of westward extension intensity / geopotential meter	Index of west-extending longitude / °E
Jun.	23.7（22.3）	138（185）	963.2（2 166.0）	6.2（201.6）	113.8（124.1）
Jul.	26.1（27.3）	219（173）	2 733.3（1 945.1）	344.2（165.3）	125.5（124.9）
Aug.	30.6（30）	162（167）	2 635.7（1 499.2）	43.8（12.5）	126（128.3）
Sept.	26.6（26.0）	268（164）	3 380.2（1 783.0）	744.6（97.9）	115.6（117.5）
Oct.	22.7（22.8）	146（140）	2 169.1（1 504.3）	406.9（168）	110.2（115.9）
Nov.	21.0（19.9）	197（116）	3 189.7（1 053.2）	577.2（131.5）	117.4（117.6）

geopotential height for July (figure omitted), a westerly trough was located between 100°E and 120°E, the southernmost of which extending near 30°N. The southwesterly in the front of the trough could directly influence the TC so that it was likely to head north and make recurvature. It is also why there were more TCs turning directions in 2004.

4 CONCLUSIONS AND DISCUSSIONS

Summing up, the TCs in the western North Pacific in 2004 were characterized by more cyclogenesis, longer life cycle, more eastward source of formation, more recurvature, more landfalls, concentrated and more northward landfall region.

The above results are useful and necessary for the research, prediction and model-construction of short-term climatology of TCs. It should be noted that relevant governing factors are complicated and dependent on one another. Qualitative study has been done in this work to study the TCs in the typhoon season of 2004 with the focus on the circulation of the westerlies, subtropical high and ITCZ. Similar work, with more details and depth, are to be done in the future to address issues like the relationships between the converging intensity of ITCZ and the frequency of cyclogenesis and the links between the location of the subtropical high and that of the high-frequency area of TCs activity.

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