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PRELIMINARY ANALYSIS OF EFFECTS OF OLR FIELDS ON ANNUAL FREQUENCY OF TROPICAL CYCLONE IN FUJIAN

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ABSTRACT: Outgoing Longwave Radiation (OLR) has been shown to play an important role in climatic diagnosis and long-term prediction and research. With the OLR data 1974 ~ 1997 as observed by satellites, the characteristics are computed. The results are used to depict the location and intensity of the subtropical high in the study of the relationship between the annual frequency of tropical cyclones affecting the Fujian province and ITCZ / subtropical high. It is shown that in years of fewer (more) tropical cyclones, the ITCZ is southward (northward) located with weaker (stronger) intensity, and the subtropical high is southward (northward). As shown in the relationship between the anomalous years of tropical cyclones and characteristics of preceding OLR fields, the OLR anomalies are just oppositely distributed in the Pacific Ocean for years of more (fewer) tropical cyclones. In other words, the years of fewer (more) tropical cyclones are associated with positive anomalies of OLR in the tropical west Pacific but negative (positive) anomalies in the equatorial central and eastern Pacific. It is hoped that our study be setting foundation for short-term climatological prediction of tropical cyclones.

Key words: tropical cyclones; anomalies; OLR fields; characteristic analysis

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1 INTRODUCTION

The tropical cyclone is a synoptic system that forms over the tropical ocean and is marked with intense rotation. Much of related research[1, 2] have indicated that the generation and development are associated with large-scale atmospheric and oceanic backgrounds. Comprehensively studying these circulation factors, Li[3] suggests that the tropical cyclone is closely related with the El Niño phenomenon and the location and intensity of the intertropical convergence zone (ITCZ) and subtropical high. Being the longwave radiation going out from the terrestrial-atmospheric system as observed by satellites, the OLR reflects rich information about the ocean and the atmosphere. The magnitude of OLR much depends on the temperature of cloud tops and the underlying surface. It is the condition of clouds rather than the temperature, which varies little due to small amplitude in time and space in the tropics, that plays a greater role. As OLR well reflects large-scale rise and fall in the tropical atmosphere, it can be employed to have accurate and effective study of the ITCZ and the subtropical high.

The OLR has been shown in a number of studies to be one of the important factors in climatic diagnosis and long-term prediction. To cite some of the work here, Mao et al[4] study the characteristics of the OLR field of low summer temperature in northeast China; Li et al[5] deal with the relationship between the OLR field and drought/floods in the Changjiang River valley; Xie et al[6] make attempts in understanding the links between low-frequency oscillations of OLR and typhoon

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activity in the west Pacific. In our work, the focus is on the characteristics of the OLR field in anomalous years of tropical cyclones posing influence on Fujian province and the behavior patterns and causality for the anomalies. On the basis of the finding, telecorrelation factors are searched with the method of correlative analysis to pave the way for short-term climatic prediction.

2 DATA

(1) Monthly mean OLR: 2.5° × 2.5° mesh covering a period June 1974 through December 1997, in which the data is missing from March to December 1978. The OLR data originate from the American Climate Analysis Center.

(2) Annual frequency of tropical cyclones affecting the Fujian province in 1951 ~ 1997, which refer to the storms making direct landfalls on the province, or landing on neighbouring provinces (Guangdong & Hainan) before the eye reentering the province, or coming ashore south of the Hanzhou Bay in the Zhejiang province and east of the Pearl River Mouth in the Guangdong province with the eye off Fujian but within 3 latitudes or longtitudes of its coast.

3 OLR CHARACTERISTICS IN YEAS OF ANOMALOUS TROPICAL CYCLONES

During the 47 years from 1951 ~ 1997, a total of 239 tropical cyclones have posed influences on the Fujian province, with the annual mean frequency being 5.1 and the standard deviation 1.9. In view of the large fluctuation of the annual frequency of tropical cyclones affecting the province, they are divided into 5 levels: 7 years are labeled least frequency ($\Delta TC \leqslant -\sigma$), 9 years less frequency ($\sigma \leqslant \Delta TC \langle -0.5\sigma$), 18 years normal frequency ($-0.5\sigma \leqslant \Delta TC \langle \sigma$), 5 years more frequency ($0.5\sigma \leqslant \Delta TC \langle \sigma$), 8 years most frequency ($\Delta TC \leqslant \sigma$). Four of the least frequency years are enriched with the OLR data (1983, 1993, 1996, 1997) but two of the less years are added with it (1990, 1994).

3.1 *Characteristic analysis of OLR for anomalous years of tropical cyclones*

Here in our work the characteristic OLR values are used to depict the intensity and location of the ITCZ and subtropical high. In a domain stretching from 120°E to 150°E for study, the area bounded by the contour 240 W/m^2 is the coverage of ITCZ and the line joining the minimum OLR values stands for axis of the ITCZ and the minimum value itself for the intensity. As the OLR is easily exposed to the influence of SST due to the prevalence of descending airflow in the subtropical-high-controlled area, some problems occur with the presentation of the intensity of the latter. On the other hand, the mean maximum OLR axis goes consistently with the ridge of the subtropical high. The area bounded by the contour 250 W/m^2 is thus set as the coverage of the subtropical high and the maximum OLR axis as the ridge of the subtropical high and the domain of study is between 110°E and 160°E.

The characteristic OLR means are separately computed for the years of most and least frequency of tropical cyclone affecting the province. Fig.1 presents the location and intensity of the axis of ITCZ in the west Pacific during the anomalous years of tropical cyclone. As what is shown in the figure, whether it is in the most or least frequency year, the ITCZ is seen in the Southern Hemisphere from December to May, which in February arrives in 6°S ~ 8°S but it is active in the Northern Hemisphere from June to December which in July ~ September moves to 8°N ~ 14°N. The lower the OLR value, the stronger the ITCZ is supposed to be. For the most and least years of frequency, the OLR is the lowest respectively in January and February in the Southern Hemisphere

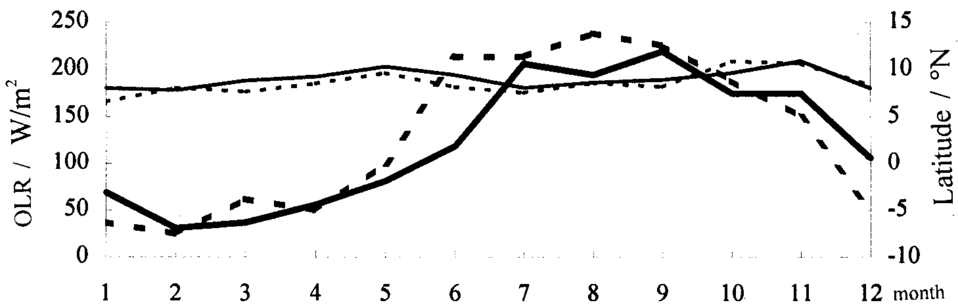

Fig.1 Location and intensity of ITCZ axis in the west Pacific (120°E ~ 150°E) in years of least (solid line) and most (dashed line) frequent influences by tropical cyclones. The thick line stands for the intensity and the thin line for the location.

and the secondary lowest in July in the Northern Hemisphere. The difference between the most and least frequency of the tropical cyclones affecting the province is shown in that the ITCZ has been stronger and located more northward in May ~ September of the former years than the least years.

The subtropical high in the Pacific is closely related with the ITCZ to the south. Fig.2 shows the ridge line of the subtropical high in the west Pacific (110°E ~ 160°E) in the anomalous years of tropical cyclones. Tab.1 is the intensity and location of the ITCZ and subtropical high in May ~ September in these years. By comparing the difference between the most and least years of tropical cyclones affecting the province, we find that the ridge has been northward from January to Sep-

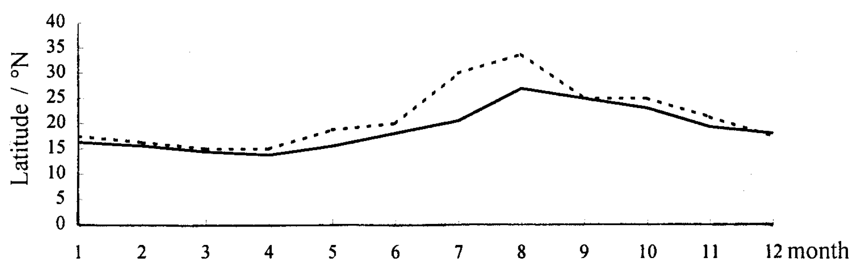

Fig.2 Location of the ridge line of subtropical high in the west Pacific in the anomalous years of tropical cyclone influences where the solid line stands for the least frequency and the dashed line for the most frequency.

Tab.1 Location of intensity of ITCZ and subtropical high from May to September in years of anomalous tropical cyclone influences

Month		May	Jun.	Jul.	Aug.	Sept.
Intensity of ITCZ (W/m^2)	Least frequent	202.9	194.2	180.7	186.2	189.1
	Most frequent	196.0	181.4	175.5	185.5	181.9
Location of ITCZ (°N)	Least frequent	–1.9	1.9	10.6	9.4	11.9
	Most frequent	0.0	11.30	11.3	13.8	12.5
Location of subtropical high (°N)	Least frequent	15.6	18.1	20.6	26.9	25.0
	Most frequent	18.8	20.0	30.0	33.8	25.0

tember in the years of most frequent influences, reaching 33.8°N in August, while the northernmost position can be 26.9°N in years of least frequent influences.

It is now understood that for the years of most tropical cyclone influences, the ITCZ has been more northward and stronger in the first rainy season (May ~ June) and summer (July ~ September); the subtropical high is more northward located than in the years of least tropical cyclone influences.

3.2 *Analysis of composite OLR anomalies for anomalous years of tropical cyclones*

3.2.1 OLR FIELD CHARACTERISTICS IN PRECEDING PERIODS

Fig.3 is the composite OLR anomaly field in the preceding winter (December ~ February) in the anomalous years of tropical cyclones. Across the meridional circle, an extensive zone of negative anomaly appears south of 5°N around the central and eastern Pacific (170°E ~ 120°W) for the years of least frequent influences. It appears north of 5°N in the years of the most frequent influences, just contrary to the case above. Zonally examining, we find that the anomaly field displays a "–, +, –" distribution across 110°E ~ 110°W near the equator for the least frequent years and the pattern is just the opposite for the most frequent years. It is now apparent that sharp differences exist in the OLR anomaly field of the preceding winters between the least and most frequent years of tropical cyclone influences.

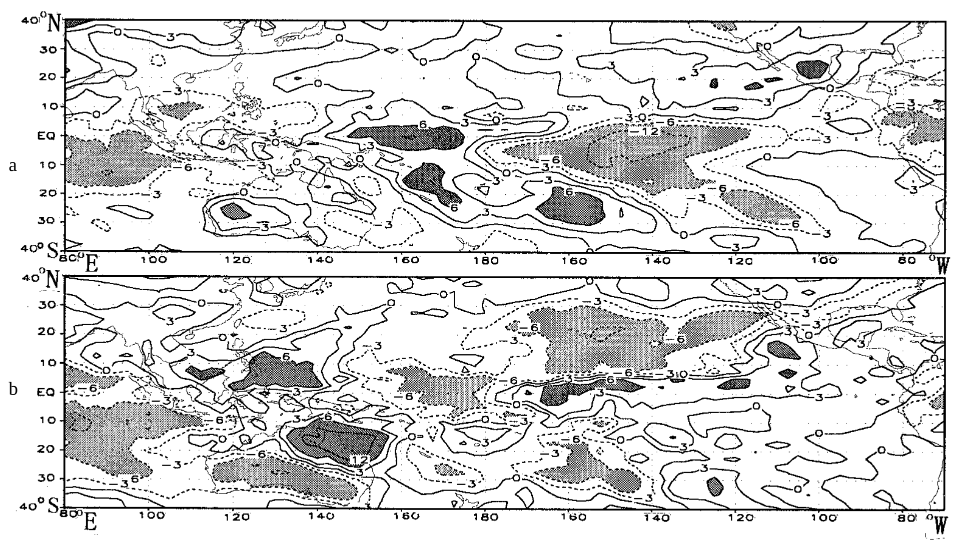

Fig.3 Composite OLR anomaly fields in the preceding winter (December ~ February) of the least frequency years (a) and the most frequency years (b) of tropical cyclones.

For the years of least frequent influences, the negative anomaly keeps intensifying and expanding to 160°E ~ 80°W in the preceding March ~ June, being $-12\ W/m^2$ in May ~ June (Fig.4). In the area of the west Pacific where there are usually tropical cyclones, a positive anomaly zone appears. On the other hand, a strong negative anomaly zone is dominant over the west Pacific in the years of most frequent influences, which is expanding eastward all the time so that the negative anomaly zone keeps control of the central and eastern equatorial Pacific region north of 5°N.

It is now obvious that for the anomalous years of tropical cyclone influences the largest dif-

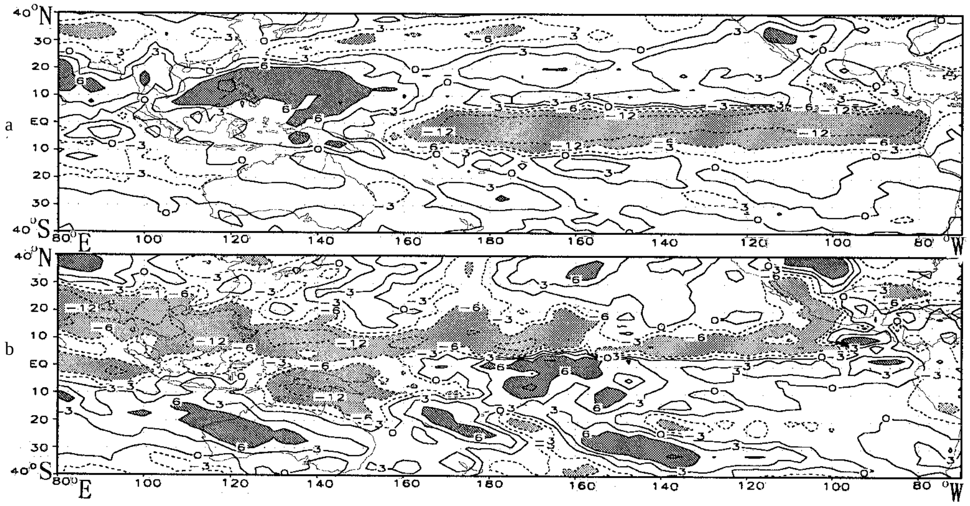

Fig.4 Same as Fig.3 but from May to June.

ference in the preceding OLR anomaly field is found in the generation area of the tropical cyclone in the west Pacific and equatorial central and eastern Pacific. Negative anomalies are present due to warmed SST and anomalous ascending motion of seawater in the central and eastern Pacific, which is a reflection in the OLR anomaly field of the appearance of El Nino phenomena in 3 out of 4 years of least frequent influence of tropical cyclones. The well-defined zones of positive anomalies in the west Pacific suggest that the genesis of tropical cyclones are inhibited because of the anomalous descending motion and checked convection.

3.2.2 OLR FIELD CHARACTERISTICS IN CONCURRENT PERIODS

Fig.5 is the OLR anomaly field of summer (July ~ September), which shows that the largest difference between the most and least years of tropical cyclone influences is found in 3 areas: (1) is

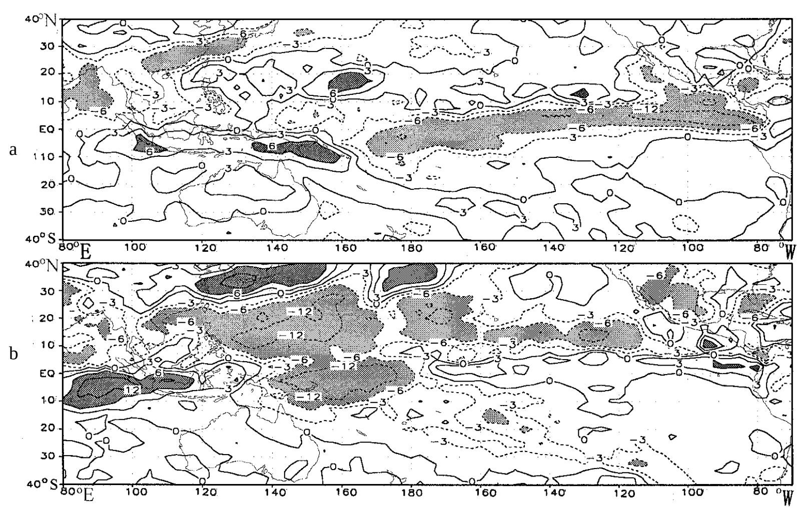

Fig.5 Same as Fig.3 but from July to September.

the equatorial central and eastern Pacific, in which there is a large stretch of negative anomaly in the least frequent years but positive anomaly in the most frequent years. The reason: the seawater gets warmer and the convection gets stronger in the region, reducing the value of OLR, reflecting the El Nino phenomena associated with the least frequent years. (2) is the area in the west Pacific where tropical cyclones are usually generated, in which positive anomalies are found in the years of least frequent influences but large stretches of negative anomalies in the years of most frequent influences with the value as large as $-12\ \mathrm{W/m^2}$, suggesting intensified convection in the area, a favorable condition for the genesis of tropical cyclones. (3) is the area adjacent to the Sea of Japan, which is dominated by positive anomaly in the years of most frequent influences, an indication of more northward location of the subtropical high, but by negative anomaly in the years of least frequent influences.

4 ANALYSIS OF CORRELATION BETWEEN TROPICAL CYCLONES AND OLR

Being 24-year in length, the sample for this work has a criteria of correlation coefficient of *RC* = 0.38 when the level of confidence α is 0.05. The key region is encircled by stretches where the correlation coefficients are higher than the level of confidence and join together.

By the definition, the key regions of correlation between preceding OLR fields and annual frequency of the tropical cyclones affecting the Fujian province are found (1) in the South China Sea (90°E ~ 170°E, 20°N) in March of the preceding year, which is highly negative anomaly, (2) in the Atlantic (30°N ~ 40°N, 60°W ~ 80°W) in June of the preceding year, and (3) in the Pacific (10°S ~ 20°S, 160°E ~ 180°) in July of the preceding year, both of the latter regions being highly positive anomaly and the maximum coefficient of correlation exceeding 0.7. The definition also points to a large span of positive correlation over the equatorial central and eastern Pacific and negative correlation around the Philippines in May of the current year, which is accompanied with negative correlation in the Indochina Peninsula and large positive correlation in waters east of the Caribbean Sea (Fig.6).

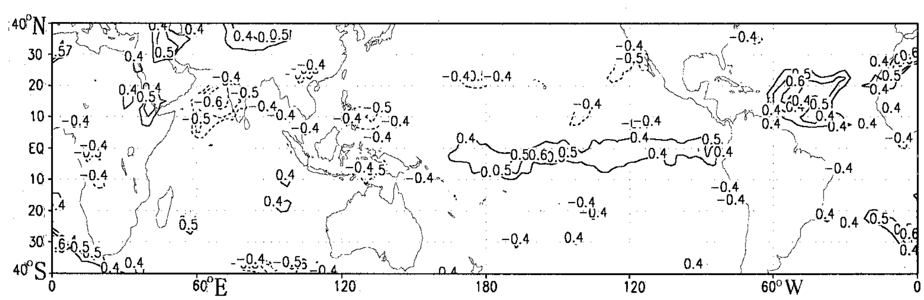

Fig.6 Distribution of regions with monthly mean OLR fields of May in correlation with annual frequency of tropical cyclones affecting the Fujian province (|R| ≥0.4)

There are two characteristics in common on the correlation map for the 3 summer months (July ~ September) which witness the most concentrated influence of tropical cyclones for the Fujian province. Take July for example. The positive correlation in the equatorial central and eastern Pacific is accompanied with positive correlation near the Sea of Japan (Fig.7).

5 CONCLUDING REMARKS

a. Differences found in the location and intensity of ITCZ and subtropical high are the primary

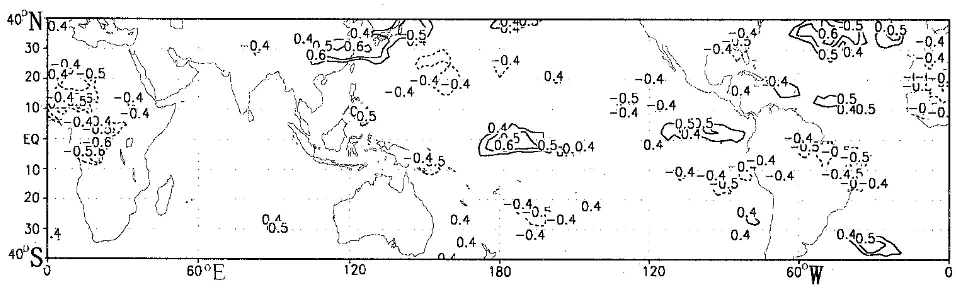

Fig.7 Same as Fig.6 but of July.

reasons for the anomalous annual frequency of tropical cyclones affecting the Fujian province. With southward (northward) and weaker (stronger) ITCZ and southward (northward) subtropical high, there will be fewer (more) tropical cyclones in the distribution of annual frequency that affect the province.

b. Opposite allocations exist for the OLR anomaly fields of the Pacific Ocean corresponding to preceding and current periods of anomalous years of tropical cyclone, i.e. for the least (most) frequent years of tropical cyclone influences, the OLR is positively anomalous in the tropical west Pacific but negatively (positively) anomalous in the equatorial central and eastern Pacific.

c. The annual frequency of tropical cyclones affecting the province is well correlated with the OLR in the tropical Pacific. The correlation is particularly good in May when the large stretch of positive correlation in the equatorial central and eastern Pacific is accompanied by negative correlation near the Philippines.

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REFERENCES:

[1] WEI Yao-xian. SSTA in the equatorial eastern Pacific and typhoon activities in the west Pacific [A]. Collection of papers at the typhoon seminar 1985 [C]. Beijing: Meteorological Press, 1987, 320-333.

[2] YU Zhi-hao, JIANG Quan-rong. El Niño, Anti- El Niño and Southern Oscillation [M]. Nanjing: University of Nanjing Press, 1994. 281-306.

[3] LI Chong-ying. Low-frequency Oscillation in the Atmosphere [M]. Beijing: Meteorological Press, 1993. 213-216.

[4] MAO Xian-min, XIA Mei-yan, LIU Gui-fang et al. The OLR field characteristics of serious cold summer in northeast China [J]. *Meteorological Monthly*, 1988, **14** (12): 4-8.

[5] LI Yue-hong, LIU Yu. The relationship between drought/flood over the Changjiang River basins and outgoing longwave radiation [J]. *Meteorological Monthly*, 1990, **16** (8): 15-19.

[6] XIE An, YE Qian. Relationship between OLR low-frequency oscillation and the formation of typhoon over the western Pacific [J]. *Meteorological Monthly*, 1987, **13** (10): 8-15.