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ON THE PREDICTION OF TROPICAL CYCLONE LANDFALL AND INFLUENCE ON SOUTHERN CHINA USING MONTHLY OLR ANOMALIES FOR PRIME SUMMER

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ABSTRACT: With the OLR data, the landfall and activity of tropical cyclones (TC) in southern China over a 20-year period (1975~1994) are studied. The result shows that the variation of the monthly anomalous OLR is somewhat teleconnected with the TC activity in southern China. The former is used to predict short-term climate for the latter over months with frequent or no TC influence. To some extent, the relationship between the TC activity in southern China and the monthly mean OLR anomalies is dependent on the climatological location of the subtropical high in northwestern Pacific region.

Key words: trend of anomalies; tropical cyclones; months with frequent tropical cyclone influence; months with no tropical cyclone influence; key areas of prediction; characteristic quantities of prediction

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1 INTRODUCTION

At present, the application of OLR data in various weather forecasts in China is increasingly wide[1, 2]. With the perfection of the OLR product issued by the Satellite Meteorological Center of the China Meteorological Administration, the data are becoming one of the important supplements to conventional weather data, especially for tropical areas. The current work involves itself with the study of the monthly frequency with which the tropical cyclone makes landfall or affects the southern part of China, using the monthly mean OLR data. It has recognized different responses of monthly mean OLR data to months with frequent or no landfall or influence of the tropical cyclone and located key forecast areas and points of consideration.

2 DATA AND METHODS OF TREATMENT

The conventional tropical cyclone data used in the paper are taken from the *Yearly Book on Typhoons* that covers a length of 20 years from 1975 to 1994. The criteria for a tropical cyclone to meet the condition with which to make landfall on or affect the southern China are that the eye is in the area between 15°N ~ 23°N, 106°E ~ 118° or moves over land within it, with the maximum wind reaching or surpassing 18 m/s near the eye.

Following the statistics of tropical cyclones in the western Pacific and South China Sea over the 20 years, the paper sets the month as one of frequent influence by the tropical cyclone if there are within it ≥2 landfalls or situations in which it is around the region (FTC month) and the

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month as one of no influence by the tropical cyclone if there are not any landfalls or situations in which it is around the region (NTC month). In view of the applicability of the study results, there may be cases in which tropical depressions are deleted in the NTC month. Besides, cases of cross-month influence and irregular track are also removed from consideration for the convenience of research and comparisons. Then, the selected results are classified by the month and listed in Tab.1.

Table 1 Statistic listings of FTC and NTC months in 20 years in southern China

Month	FTC Months	NTC Months
July	1977, 1979, 1980, 1981, 1982	1975, 1987
	1983, 1986, 1989, 1991, 1992	
August	1976, 1981, 1987, 1991, 1993	1977, 1982

The monthly mean OLR data are taken from CAC, the United States. The grid intervals are 2.5×2.5 degrees of longitude/latitude, with the length corresponding to that of conventional data. The characteristic predictands used here are the geometrical mean of monthly OLR anomalies within the key forecasting area (KFA). It is expressed as

$$R = \frac{1}{N} \Sigma_{ij} \, \mathrm{OLR}_{\mathrm{m}}$$

in which N is the number of total gridpoints within KFA, $\mathrm{OLR}_{\mathrm{m}}$ the monthly anomalies of OLR at individual gridpoints, and R the characteristic value representing the overall intensity of monthly mean anomalies of OLR within the KFA, or the intensity of the OLR trend within it.

3 DISTRIBUTION OF MONTHLY OLR ANOMALY FIELD IN THE FTC AND NTC MONTHS AND ANALYTIC STUDY

3.1 *Distribution of situations*

Classified by the FTC or NTC month, the monthly mean OLR data are used in averaging computation by the original and anomalous fields. As shown in the result, the OLR field has basically the opposite response in the FTC and NTC months, more significantly so with respect to the mean field for the group of anomalies.

Figs.1 & 2 are the distribution of monthly mean OLR anomalies respectively for the FTC and NTC months of July and August. The solid lines are the areas where OLR $>$ 0 and the dashed lines those where OLR $<$ 0. It is known from the figures that when July (Fig.1a & b) is a FTC month, a situation of strong negative anomalies prevails over the central Indian Ocean, northwestern Pacific, equatorial southwestern Pacific, central Australian continent and central America while a situation of strong positive anomalies dominates over the regions with a NTC month. In other regions, like the equatorial Oceania, tropical northeastern Pacific, southwestern Pacific, southern North America, positive anomalies are found in the FTC months but negative ones exist in the NTC months.

It is distributed likewise in August (Fig.2a & b). In regions of northeast Africa / the Arabian Peninsula, equatorial Oceania / Australian continent, central / southeastern Pacific and tropical central / western Pacific, strong negative (positive) anomalies are found in the FTC (NTC) months. In contrast, in regions of central Indian Ocean, tropical southwestern Africa, South Asia and subtropical northwestern Pacific, equatorial southwestern Pacific, central America and South America continent, strong positive (negative) anomalies are found in the FTC (NTC) months.

It is evident from the characteristics above that the OLR field is in good out-of-phase

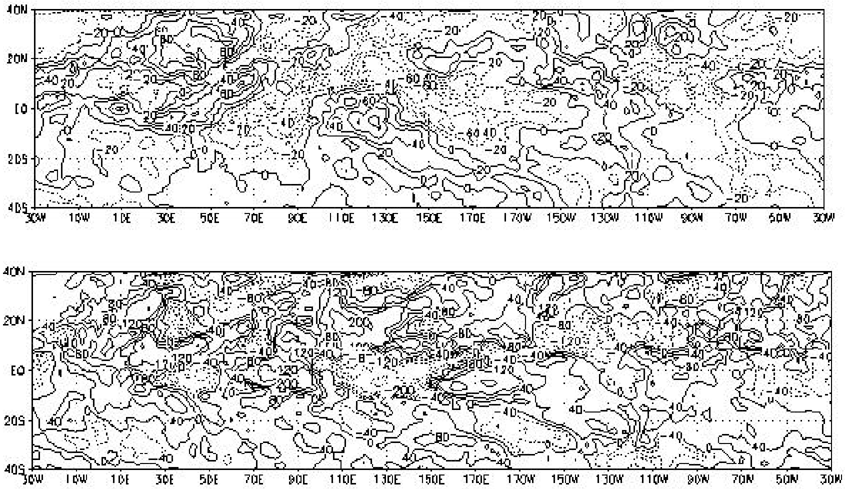

Fig.1 The monthly mean OLR departure distribution in FTC（a）and NTC（b）months of July.

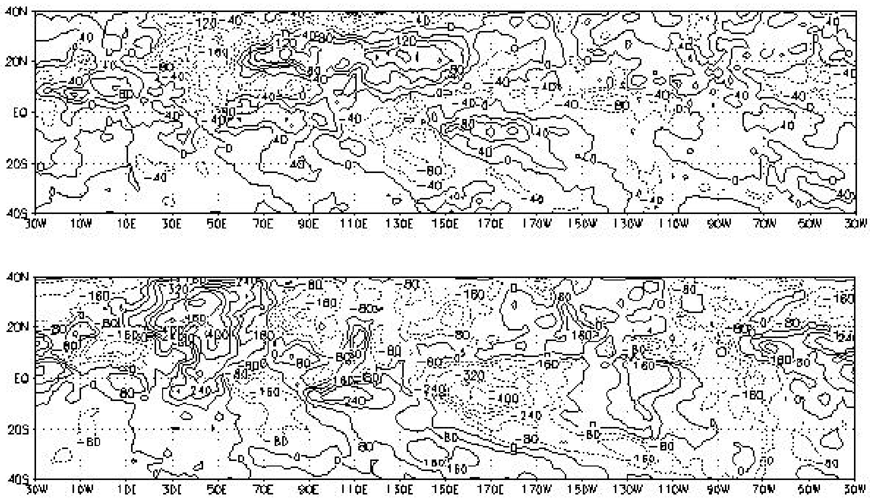

Fig.2 The monthly mean OLR departure distribution in FTC (a) and NTC (b) months of August.

connection between the FTC and NTC months, whether it is July or August.

3.2 *Analytic study*

Making more analysis of the distribution of the monthly mean OLR anomaly field in the above FTC and NTC months, we notice that the anomalies of the OLR field tend to vary much both with the region and month. The trends can be similar in some regions, different in others and even reversed in the rest. In regions over Malaysia, the Philippines and equatorial Oceania, positive (negative) anomalies are found in July of FTC (NTC); in regions of subtropical northwestern Pacific, i.e. 10°N ~ 30°N, 110°E ~ 150°E, negative (positive) anomalies are found in July of FTC (NTC). The trends of monthly mean OLR is just the opposite for the same regions in August.

In view of it, more study is done in the work. It is thought that it is associated with basic flow patterns at upper levels and climatic probability. Twenty years of 500-hPa subtropical high activity (1975 ~ 1994) have been studied to show that it has a more northward coverage in August than in July.

Tab.2 compares the mean position of the western Pacific subtropical high and the monthly mean position in the FTC months. It shows that the 20-year mean is in average about 2 latitudes more northward in August than in July, judging either from the mean position of 500-hPa subtropical high or from that of the northern 5880 contour. It is known from the comparison of subtropical high between the multi-year mean position and monthly mean position that for the FTC month, it is 1 latitude more southward in August but 0.2 latitude more northward in July.

Tab.2 Comparisons of northwest Pacific subtropical high between multi-year mean and monthly mean positions in MTC months

Mean position at 500 hPa	July	August
subtropical high over 20 years (°N)	24.9	27.2
5880 N. contour over 20 years (°N)	30.4	32.1
Subtropical high ridge in the FTC months (°N)	25.1	26.2
5880 N. contour in the FTC months (°N)	30.5	30.8

It is conceived that the southern and southeastern airflows south of the mean subtropical high in August are relatively more northward, which is more favorable for the landfall and activity of the tropical cyclone at a more northern location[3]. If it is to be around areas more southward against such climatic background, the subtropical high has to be more southward than normal. In other words, for the subtropical high to be stronger than normal in the southern part of activity area over northwestern Pacific (10°N ~ 25°N), the OLR field has to, in response, show positive anomalies in August. If the OLR shows negative anomalies in the areas, the subtropical high will be weaker than normal, assoc iating with more northward location of the subtropical high and the southern and southeastern airflows to the south. The circulation situation is very unfavorable for the tropical cyclone to land and stay over the southern China.

In general, when the subtropical high is more northward, the ITCZ is completely out of the equatorial Oceania and the Australian high dominates in August, the OLR field is of positive anomaly and increasing in the subtropical northwestern Pacific and of negative anomaly in the equatorial Oceania and Australian continent, it favors the landfall and movement of the tropical cyclone in southern China. In contrast, when the OLR field is of negative anomaly and decreasing in the subtropical northwestern Pacific and of positive anomaly and increasing in the equatorial Oceania and Australian continent, it does not favor the landfall and movement of the tropical cyclone in southern China. It is different for July. When the OLR field is decreasing in the subtropical northwestern Pacific and increasing in the equatorial Oceania and Australian continent, it favors the landfall and movement of the tropical cyclone in southern China. Otherwise it is unfavorable for them.

4 ON THE FORECASTING OF FTC AND NTC MONTHS USING MONTHLY OLR ANOMALOUS FIELDS

4.1 *Determination of the Key Forecasting Areas (KFA)*

For the monthly OLR anomalies in individual months, the difference in monthly mean field is sought between the FTC and NTC months and the KFA is determined for every month by identifying relevant centers of extreme positive and negative values. See Fig.3a & b. There are 7 KFAs in July, which distribute in central Africa (KFA1), central Indian Ocean (KFA2), subtropical northwestern Pacific (KFA3), equatorial Oceania (KFA4), Australian continent (KFA5), equatorial southwestern Pacific (KFA6) and central America (KFA7). There are 8 KFAs in August, which distribute in northwestern Africa (KFA1), South Asia (KFA2), subtropical northwestern Pacific (KFA3), equatorial Oceania (KFA4), Australian continent (KFA5), equatorial southwestern Pacific (KFA6), southeastern Pacific (KFA7) and South American continent (KFA8).

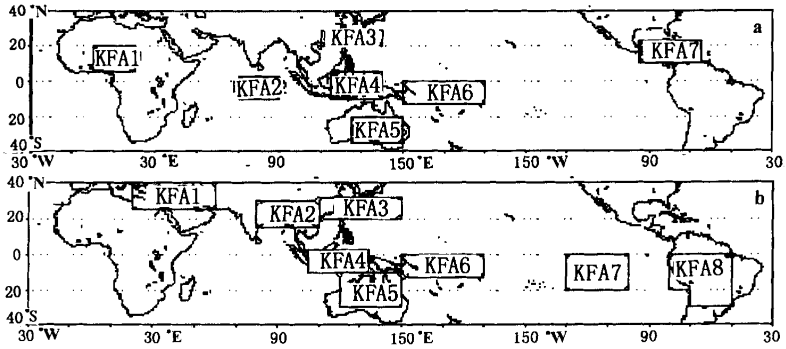

Fig.3 Key forecasting areas for July (a) and August (b).

4.2 *Computation and analysis of characteristic quantities in the KFA*

To assess the role played by the monthly mean OLR anomalies on the forecasting of the landfall and activity of the tropical cyclone in southern China, we computed characteristic quantities over preceding periods by the FTC and NTC month with regard to individual KFA's monthly mean OLR anomalies in July and August. The results are shown in Figs.4 & 5.

Fig.4 schematically gives the comparison of preceding changes in individual characteristic KFA's monthly mean OLR anomalies in the FTC and NTC months of July. The computation covers a time from January to July. The ordinate depicts characteristic OLR anomalies in unit of W/m and the abscissa marks the time (month) axis. Seven blocks are divided based on the KFA, each given a black and white column in pair, standing for January ~ July in turn. The black (white) column represents the characteristic anomalies in the FTC (NTC) months. It is known from the figure that the anomalous response in the FTC and NTO months varies with the KFA, with most of the phase in opposite allocation. For the KFA4, the trend stays above zero from January to July, which are of FTC; it shows strong negative anomaly over the same months when they are of NTC. The remaining KFAs show similar but reversed distribution —the FTC months correspond to a continuous trend below zero from January to July but the NTC months associate with continuous display of strong anomalies over the months.

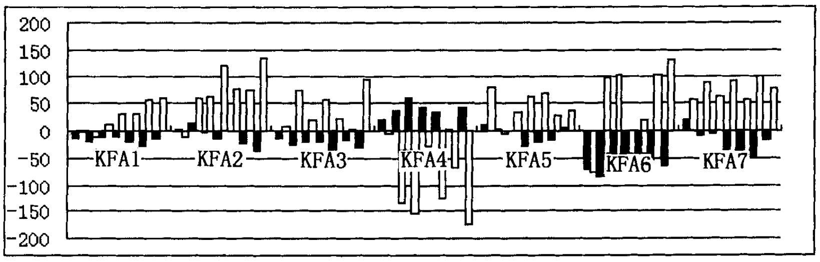

Fig.4 Responses of mean anomalies of monthly OLR in individual KFAS during July of FTC and NTC.

Fig.5 schematically gives the comparison of preceding changes in individual characteristic KFA's monthly mean OLR anomalies in the FTC and NTC months of August. The computation covers a time from January to July. Similar to the case of July, there is obvious out-of-phase performance in individual KFAs in terms of the monthly OLR anomalies in the FTC and NTC months. Continuous, complete out-of-phase performance is shown from January to August in the KFA1, KFA6, KFA7 and KFA8. Correspondingly, negative (positive) OLR anomaly is continuously shown from January to August in the KFA1 and KFA7 (KFA6 and KFA8) in the FTC months. The situation with the NTC months is just the opposite. Strong positive anomalies of OLR (with the mean above +80) prevail for 8 months in the KFA1 and KFA7 while strong negative ones (with the mean below –80) in the KFA6 and KFA8. The out-of-phase trends do not stabilize until March in the KFA3, KFA4 and KFA5.

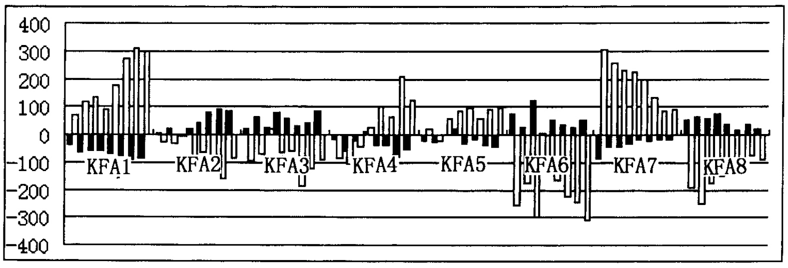

Fig.5 Responses of mean anomalies of monthly OLR in individual KFAs during August of FTC and NTC.

It is understood from the study above that the monthly mean OLR anomaly has an out-of-phase response to the FTC and NTC months by substantial leading margin. It is apparently encouraging predictability for the forecast of tropical cyclone activity in southern China.

5 CONCLUDING REMARKS

a. The variation of monthly mean anomalies of OLR is teleconnected to some degrees with the activity of the tropical cyclone in the southern region of China. The relationship displays itself as out-of-phase response of monthly OLR mean anomalies over some key areas for months with frequent or no tropical cyclone effects.

b. The use of monthly mean OLR anomalous field can help in the short-term climatic predictions for southern China with the FTC or NTO months. In the forecasting, conclusions can be made by following up the characteristic quantities for computation and analysis inside the KFAs and with reference to the points of discussion presented here in this paper.

c. To some extent, the links between the activity of tropical cyclones in southern China and the monthly mean OLR anomalies depend on the mean climatic location of the subtropical high over the western Pacific. If it is more northward than normal, the monthly OLR anomalies will be stronger than normal in the subtropical northwestern Pacific (10°N ~ 25°N) in the FTC month but it will be weaker in the NTC month; if it is more southward, however, the latter will be weaker in the FTC months but stronger in the NTC months.

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