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PREVIOUS CONVECTION ANOMALY IN AUTUMN AND WINTER ASSOCIATED WITH THE GENERAL CIRCULATION OVER EAST ASIA IN WINTER AND SPRING AND APRIL PRECIPITATION IN SHANDONG

HU Gui-fang (胡桂芳)[1], ZHANG Xuan (张　璇)[2], GU Wei-zong (顾伟宗)[1]

(1. Shandong Climate Center, Ji′nan 250031 China; 2. Shandong Meteorological Observatory, Ji′nan 250031 China)

Abstract: Using OLR and 850 hPa and 200 hPa wind fields data (1979 – 2006), this paper diagnoses the characteristics of convection over the tropical area in preceding autumns and winters in association with April precipitation anomalies in Shandong province. It is found that preceding convection anomalies over the Western Pacific Warm Pool in December have close relationships with the April precipitation in Shandong. Further analysis of the relationship with the general circulation over the East Asia shows that the convection anomaly over the Western Pacific Warm Pool has close relationships with the Main East Asian Trough, the Hadley cell over East Asia and the Walker cell. The characteristics of East Asian atmospheric circulation anomalies accompanied with stronger (weaker) convection are consistent with those of less (more) April precipitation anomalies in Shandong. Therefore, the convection anomaly over the tropics in December may be an important indicator for April precipitation in Shandong.

Key words: convection over the tropics; general circulation over East Asia; April precipitation in Shandong

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1 INTRODUCTION

Outgoing Longwave Radiation (OLR) is a kind of radiation dataset that reflects multiple atmospheric and marine information such as cloud amount, rainfall, convection intensity, latent heat from condensation, divergence wind, large-scale vertical circulation and air-sea interactions. Over the past few years, OLR data has been widely and successfully applied in the prediction of droughts and floods in the Yangtze River basin [1], summer precipitation in North China [2 - 3] and East China [4 - 5] and precipitation during the raining season of South China [6 - 8]. In contrast, little efforts have been spent on using it to forecast precipitation during the springtime, which is key to crop seeding and growth. It is therefore very important to identify from the preceding OLR field quantitative indicators for the prediction of precipitation trends during this season.

As shown in observed facts and results of research [9], tropical western Pacific is a basin with the highest sea surface temperature in the globe, which is marked with such intense air-sea interactions across the sea surface that its thermodynamic state and convection above are playing a vital role in climate anomalies in the summer of East Asia. It is discovered in our routine work that weak convection above the Western Pacific Warm Pool in preceding autumns and winters is usually followed by heavy precipitation in Aprils over Shandong; the same is true vice versa. Are they just coincidences or linked together with certainty? Discussing their relationships from possible linkages between tropical convection and atmospheric circulation in East Asia, this paper aims at providing objective basis with clear physical implications for the predication of precipitation tendency of April in the province of Shandong.

2 TROPICAL CONVECTION CHARACTERISTICS IN PRECEDING AUTUMNS AND WINTERS FOR ANOMALOUS APRIL PRECIPITATION IN SHANDONG

Data used in this work include the monthly mean OLR from NOAA [10], which covers a spatial domain

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Biography: HU Gui-fang, female, native from Shandong province, senior engineer, mainly undertaking the operation of short-term climate prediction and research.

E-mail for correspondence author: hgf@sdan.com.cn

of 30°S – 30°N at a resolution of 2.5° × 2.5°, reanalysis data for 200 hPa and 850 hPa monthly mean wind from NCEP / NCAR (0 – 80°N, 30°E – 180°; 2.5° × 2.5°), monthly mean geopotential field for 500 hPa from the National Climate Center, and precipitation measurements from 17 representative stations in the province (34°N - 38°N, 114°E - 122°E) which are used in the operation of short-term climate prediction. In practice, the latter, which span from 1976 to 2006, are transformed to anomalous percentages.

For the precipitation anomaly of the 17 stations, 40% is the percentage which is set as the threshold to distinguish the years with more rain from those with less rain. By this standard, there are five years with more rain since 1979, i.e. 1980, 1983, 1987, 1998 and 2003; there are eight years with less rain, i.e. 1981, 1986, 1988, 1989, 1992, 1995, 2000 and 2001. Composite analysis is conducted on the OLR field for the preceding autumn and winter of these years and monthly composite anomalies are computed and plotted for the time from the preceding September to the current February. As shown in the result, there are sharp differences in the tropical OLR field for the time between the years with more rain and those with less (Fig.1).

Again, as shown in the computed results, for the time from the preceding September to the current February in the years with more April rain, positive anomalies are covering an extensive region from the tropical western Pacific to the eastern Indian Ocean while significantly negative anomalies are dominant over the tropical eastern and central Pacific. The case is generally the opposite in the years with less rain only that the anomalous values are smaller than those in the years with more rain. These characteristics are clearly shown in the field of composite OLR differences in Fig.2a, which are determined by subtracting the years with less rain from those with more. Relevant computed results (Fig.1b & Fig.2b) are consistent with the result of the composite analysis and the regional correlation coefficient, which corresponds to the center of high positive anomalies in Fig.1a, is as high as 0.5, surpassing the *t*-test of 0.01 significance. More detailed distribution of their correlation is demonstrated in Fig.2b, which depicts the spatial distribution of the correlation coefficient. As shown in the characteristics presented above, when convection is usually active over the tropical western Pacific in the preceding autumn or winter, December in particular, over the tropical western Pacific while being inhibited near the Date Line, precipitation will be less in the current April in Shandong; precipitation will be more if the opposite is true.

In order to identify quantitative prediction

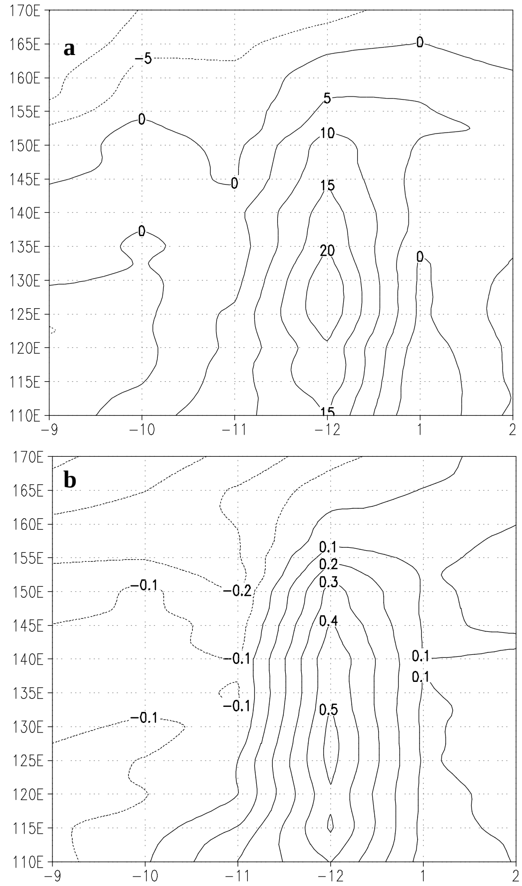

Fig.1 Time-longitude cross section of OLR anomalies in the Aprils of more rain years (a) and correlation coefficients for April precipitation versus OLR field (b). -9 indicates the preceding September, 1 the current January, etc.

indicators, an index for the intensity of convection has been defined in this work using the OLR field data of December [11] and their quantitative relationships have been examined on the basis of the index.

The curves of interannual variations of historical ΔI_Q (the departure of the intensity index for the convection over the tropical western Pacific) versus April precipitation (Fig.3) suggest clear anti-correlations between them. Convection is said to be anomalously strong if $\Delta I_Q \geq 30$ and anomalously weak if $\Delta I_Q \leq -30$. According to this definition, there are nine years of strong convection from 1979 to 2005, i.e. 1985, 1988, 1995, 1996, 1998, 1999, 2000, 2003 and 2005 and eight years of weak convection in the same period, i.e. 1979, 1982, 1986, 1989, 1992, 1997, 2002 and 2004. As shown in a statistical analysis (Table 1), the anomalies of convection in the preceding December over the tropical western Pacific can be used as good indicators for the prediction of precipitation trends in the current April over Shandong province.

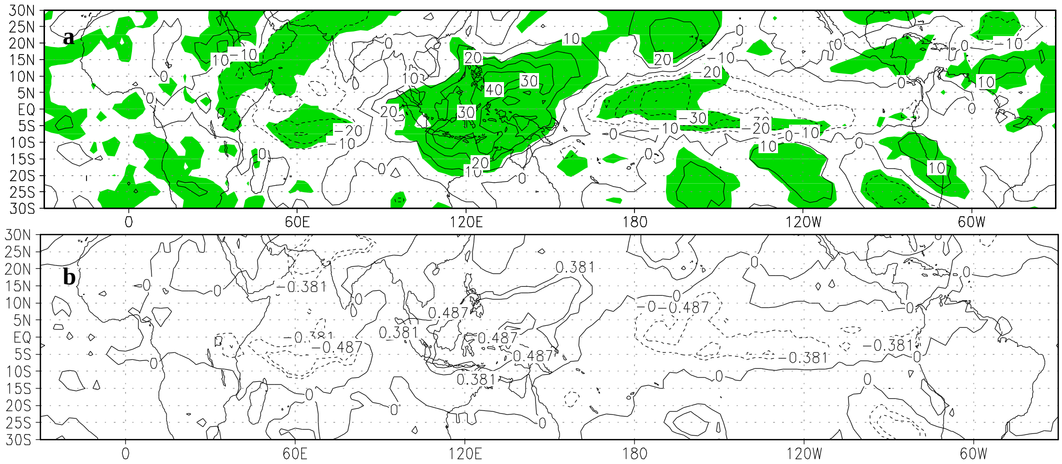

Fig.2 The April field of composite OLR differences as determined by determined by subtracting the years with less rain from those with more (a, the contour interval is 10W/m^2) and the correlation coefficients between the April precipitation and the OLR field of the preceding December (b).

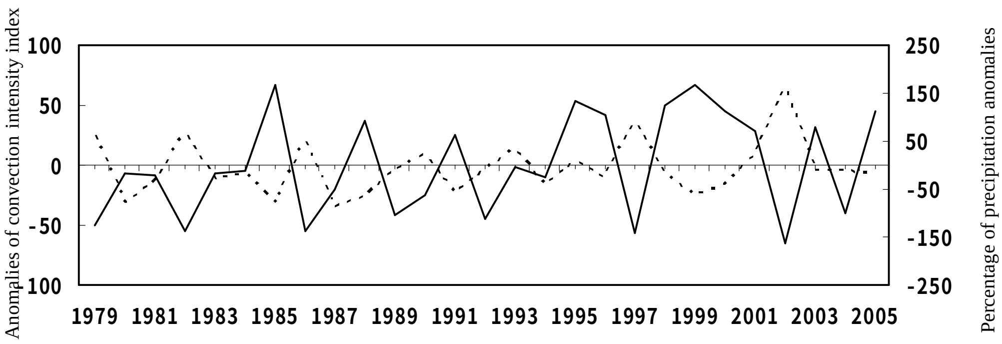

Fig.3 The curve of interannual variations of historical ΔI_Q (the solid line) versus that of Percentage of precipitation anomalies in April of the subsequent year over Shandong province (the dashed line).

Table 1 Relationships between the anomalies of ΔI_Q and the precipitation in subsequent Aprils over Shandong

year	1985	1988	1995	1996	1998	1999
$\Delta I_Q \geqslant 30$	66.6	36.6	53.6	41.6	49.6	66.6
$R_{Apr.}$/%	-79.0	-66.1	8.8	-25.1	-21.7	-63.1
Year	2000	2003	2005	Mean	prob.	
$\Delta I_Q \geqslant 30$	45.6	31.6	45.6			
$R_{Apr.}$/%	-43.1	-10.8	-22.4	-35.8	-8/9	
Year	1979	1982	1986	1989	1992	1997
$\Delta I_Q \leqslant -30$	-50.4	-55.4	-55.4	-41.4	-44.4	-57.4
$R_{Apr.}$/%	63.7	66.1	48.5	-7.5	-8.5	91.2
year	2002	2004	mean	Prob.		
$\Delta I_Q \leqslant -30$	-64.4	-37.4				
$R_{Apr.}$/%	163.7	-11.2	50.8	+5/8		

In order to examine the relationships between convection anomalies in the western Pacific and general circulation in boreal winter and spring over East Asia, composite analysis is applied to the 500 hPa geopotential fields of the preceding December and the current April in the Northern Hemisphere for the eight years of weak convection and nine years of strong convection as defined above. Significance tests have been done on the differences in the composite field (figure omitted).

See the Chinese edition of the journal for more details.

3 CONCLUSIONS

(1) When the convection over the Warm Pool in the tropical western Pacific is anomalously active in the preceding December but is restrained near the Date Line, there tends to be less precipitation in the current April; there will be more precipitation when conditions opposite to the above appear.

(2) When the convection over the Warm Pool in the tropical western Pacific is anomalously intense in the preceding December, the Main East Asian Trough,

local Hadley cell and Walker cell will strengthen and so will the northerly wind in the eastern part of China; the northerly will be weaker than normal otherwise.

(3) When the Main East Asian Trough is stronger than normal, the northerly will strengthen in the east part of China, making it difficult for the warm and humid airflow to reach Shandong from the south to cause less-than-normal precipitation in April over the province.

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