Article ID: 1006-8775(2002) 01-0037-07

# INFLUENCE OF SPRING EQUATORIAL EASTERN PACIFIC SSTA ON THE SEASONAL CHANGE FROM SPRING TO SUMMER OF EASTERN ASIAN CIRCULATION

PENG Jia-yi (彭加毅)[1,2], SUN Zhao-bo (孙照渤)[2], WANG Yuan (王 元)[1]

(1. *Department of Atmospheric Sciences, Nanjing University, Nanjing,* 210093 *China*; 2. *Department of Atmospheric Sciences, Nanjing Institute of Meteorology, Nanjing* 210044, *China*)

**ABSTRACT:** Based on the analysis of NCEP height, wind and OLR data, the influence of spring equatorial eastern Pacific SSTA on the seasonal change from spring to summer of eastern Asian circulation has been investigated. Results show that related to the warm (cold) spring SSTA in the equatorial eastern Pacific, the anomalous anticyclone (cyclone) circulation emerges around the South China Sea and the Philippines, the strong (weak) west Pacific subtropical high locates to the west (east) of its normal position, which induces to the late (early) onset of the South China Sea monsoon. The numerical simulations have also shown that the remarkable influence of spring SSTA in the equatorial eastern Pacific on the spring seasonal change of eastern Asian circulation will last till summer.

**Key words:** SSTA; eastern Asian circulation; seasonal change

**CLC number:** P732.6 **Document code:** A

## 1 INTRODUCTION

The position and strength variations of the West Pacific Subtropical High (WPSH) play an important role in the seasonal change from spring to summer of the eastern Asian circulation. Zhao et al. (1995) discussed the mechanism and forecast of the long-range variations for the WPSH northern/southern position in early summer. Peng (1999) revealed that the strongest 3-5-year oscillation of the summer WPSH inter-annual variability was consistent with the main period of ENSO. Further analysis by Peng et al. (2000) showed that the equatorial eastern Pacific spring SSTA closely connected with the strength and position of summer WPSH on interannual and seasonal scales. Related to the warm (cold) spring SSTA in the equatorial eastern Pacific, the east Asian summer monsoon is weak (strong), the mid-lower reaches of the Yangtze River is hit by floods (droughts), accompanied by droughts (floods) in the South China and the Yellow River valley (Peng et al. 2000). On the basis of the foregoing discussion, this paper focuses on the influence of spring equatorial eastern Pacific SSTA on the seasonal changes from spring to summer of the eastern Asian circulation. As we know, the South China Sea (SCS) monsoon onset is closely related with the westward / eastward movements, and northward / southward shifts as well as the intensity of the WPSH from spring to summer. Nevertheless, the early (late) onset of the South China Sea monsoon has remarkable influence on the eastern Asian summer monsoon

**Received date:** 2000-11-06; **revised date:** 2002-04-25

**Foundation item:** Post-doctorial Degree Foundation of the Nanjing University; The Science Foundation of Jiangsu Province Education Bureau (00KJB170001); NSF of Jiangsu (BK99020); The State Key Basic Program (G1998040907 & G1998040901-3); The National Natural Science Foundation of China under Grant 40075011 & 40175025

**Biography:** PENG Jia-yi (1967 –), male, native from Chongqin City, lecturer, Ph.D, mainly undertaking the study of air-sea interactions.

rainfalls. Consequently, for the problem of summer monsoon rainfall prediction, it is beneficial and indeed meaningful to deal with the influence of spring SSTA on the seasonal change of eastern Asian circulation from spring to summer, in particular, its effect on the eruption of the South China Sea monsoon.

According to the division of warm/cold spring equatorial eastern Pacific SSTA by Peng et al. (2000) and the seasons, there are six warm spring SSTA years (1982, 1983, 1987, 1991, 1992, 1993) and four cold spring SSTA years (1975, 1985, 1989, 1996) in the period of 1975-1996. In this paper, the warm/cold spring SSTA year has been identified in the composite analysis of those years. The data used in this paper include geopotential height, wind and outgoing long-wave radiation (OLR) data from 1975 to 1996, which are provided by the National Centers for Environmental Prediction (NCEP) of the U.S.A. Before we make composite analysis, the T-tests are taken upon the difference of the 500 hPa geopotential height, the 850 hPa wind and outgoing long-wave radiation between warm and cold spring SSTA year (figure not shown).

## 2 THE 500-hPa GEOPOTENTIAL HEIGHT COMPARISON BETWEEN THE WARM AND COLD SPRING SSTA YEAR

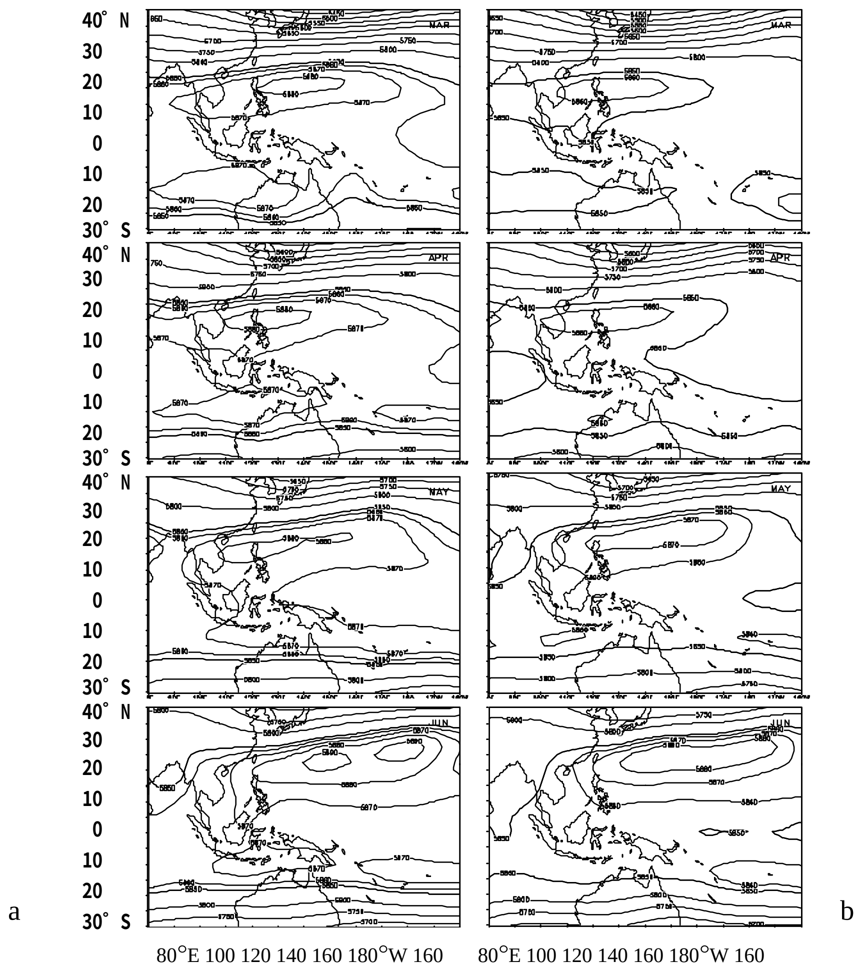


Fig.1 The 500-hPa height from March to June for warm (a) and cold (b) spring SSTA in the equatorial eastern Pacific.

The 500 hPa height from March to June for warm and cold spring SSTA in the equatorial eastern Pacific are illustrated in Fig.1. From the seasonal change of WPSH in the warm year, one can see that the WPSH center in March situates in the Philippines and waters to the east, and migrates westward in April with the 5880 gpm characteristic contour line located in the east coast of the Indo-China peninsula, when the WPSH cell dominates over the South China Sea, the Philippines and the western Pacific. As compared with that of April, the WPSH band in May lies in the same areas, with its center shifted northward and strengthened to some degree. In June, the WPSH cell withdraws from the South China Sea, and intensifies and moves northward remarkably. On the contrary, for the cold spring SST year the WPSH is very weak in March and April, with its center (5860 gpm contour) situated around the SCS, the Philippines and its eastward waters. The WPSH of May lies to the east of the Philippines, with its intensity increased. In June the WPSH displays a certain pattern in the manner of shifting northward and eastward, and strengthening to some extent.

By comparing in detail the difference of seasonal change between the warm and cold spring SST year, particularly in May, we know that the WPSH slightly intensifies in the warm spring SST year, and locates westward of its normal position as well as actually covering the SCS and west Pacific areas, and in consequence constraining the development of the convection in and around the SCS. On the contrary, for the cold spring SST year, the WPSH weakens in some degree, and situates to the east of its mean position and dominates over the Philippines and its eastward sea areas, which is beneficial to the onset of convection over the SCS.

## 3 THE 850-hPa WIND DIFFERENCES BETWEEN THE WARM AND COLD SPRING SSTA YEAR

The 850-hPa wind anomaly from March to June for warm and cold spring SSTA year is shown in Fig.2. And it is in evident that, for the warm spring SSTA year, an anomalous anticyclone emerges to the northwest of the New Guinea in March, and moves northward to the southeast part of the Philippines in April. The anomalous anticyclone strengthens noticeably in May, with its center located at the SCS and the sea areas north to the Philippines. In June, the anomalous anticyclone is divided into two centers, with its intensity decreased. However, for the cold spring SSTA year, there exists a west-east orientation of remarkable anomalous cyclone over the west Pacific to the east of the Philippines, with its intensity increased in April and decreased in May, and in June an anomalous cyclone locates to the north of the South China Sea and the sea areas northeast to the Philippines.

The foregoing discussion clearly illustrates that there exists anomalous anticyclone (cyclone) in the SCS area and the Philippines from March to May in the warm (cold) spring SSTA year.

## 4 THE INFLUENCE OF SPRING SSTA ON THE ONSET OF SCS MONSOON

From the above analysis, we know that in the warm spring SSTA year, the WPSH in May slightly strengthens and lies to the west of its normal position, preventing the eruption of the convection in the South China Sea and its adjacent areas. On the other hand, for the cold spring SST year, the WPSH weakens to some extent, and situates to the east of its mean location, which is of benefit to the onset of the convection over the SCS. To further justify this significance, the OLR pentad data is used to draw the longitude-time cross section along 15°N for the warm and cold spring SSTA year (see Fig.3).

We use values lower than $250 W/m^2$ as the OLR index to distinguish the area of convection activities . From Fig.3a we can observe that the convection emerges firstly over the

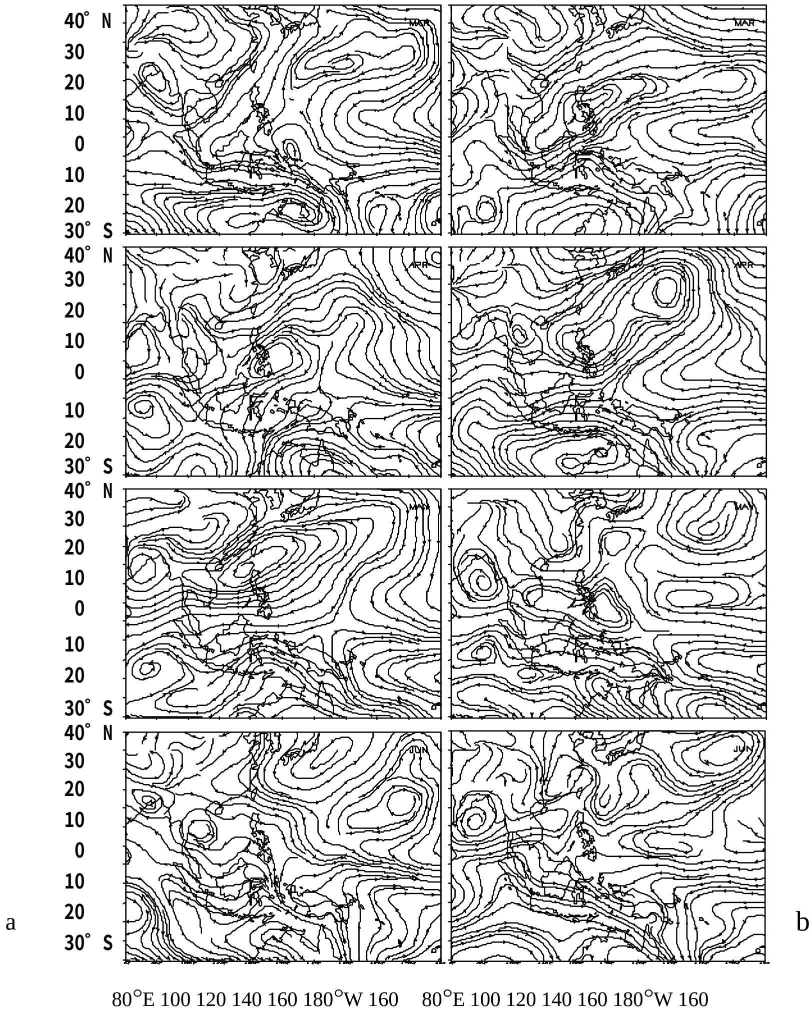


Fig.2 Same as Fig.1 but for the 850 hPa wind anomaly.

Indo-China peninsula, and up to the $30^{th}$ pentad there exists the convection around the SCS of interesting area. Let's then examine the seasonal change of the cold spring SSTA year (Fig.3b). It is known that the convection appears over the SCS in the $27^{th}$ pentad and stronger convection takes place at $28^{th}$ pentad ($OLR < 220W/m^2$). As a result, in the warm (cold) spring SSTA year, the convection occurrs over the SCS at the $30^{th}$ ($27^{th}$) pentad, which makes the benchmark for the later (earlier) onset of the SCS monsoon.

## 5 SENSITIVITY EXPERIMENTS WITH L9R15 MODEL

To further verify the influence of spring equatorial eastern Pacific SSTA on the seasonal change from spring to summer in the eastern Asian circulation, a nine-layer general circulation model which is rhomboidally truncated at zonal wave number 15 (L9R15) is employed in this paper (Wu et al. 1996). To study the influence of spring SSTA on the eastern Asian circulation, three experiments are designed as follows:

①The first experiment (denoted as TEST1) is the control test, in which it uses the ten-year mean SST from 1979 to 1993 (Wu et al. 1992). TEST1 is taken to provide the initial field for the other two experiments.

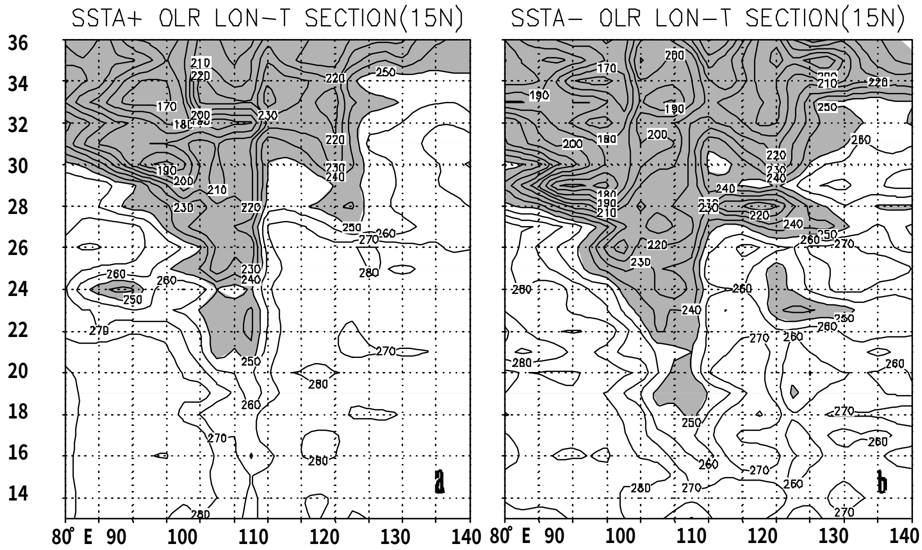


Fig.3 The longitude-time section of OLR along 15° N for warm (a) and cold (b) spring SST in the equatorial eastern Pacific. The abscissa is for the longitude and the ordinate for the pentad.

②In the second experiment (TEST2E), we add positive SSTA (see Fig.4)in the equatorial eastern Pacific (176.25°W ~ 86.25°W, 11.25°S ~ 6.75°N) to the mean SST from March to May.

③Negative SSTA in the same area is added to the mean SST from March to May for the third test (TEST2L). The second and third experiments are integrated from 1 January to 31 December.

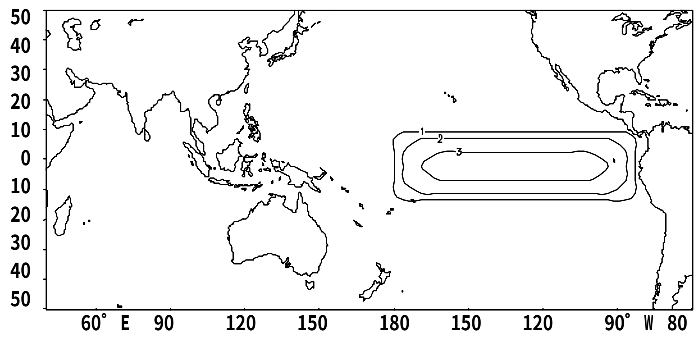


Fig.4 The positive SSTA in the equatorial eastern Pacific for TEST2E or the opposite value for TEST2L (the value ×-1).

From the geopotential height at 500 hPa of TEST2E from March to June (figure omitted), we know that the WPSH cell in March lies to the east of the Philippines, and intensifies in April and shifts westward with the 5880 gpm contour line covering the area in and around the South China Sea and the Philippines. The WPSH in May intensifies itself noticeably, and dominates over the South China Sea and the west Pacific, which tends to prevent the eruption of the convection activities in the South China Sea and its adjacent areas. In the month followed, the WPSH shifts northward remarkably. As displayed in the geopotential height at 500 hPa of TEST2L from March to June (figure omitted), the intensity of the WPSH in March, April and May is smaller than that of TEST2E. There exist two WPSH cells over the SCS and the western Pacific in April and May respectively. The bigger WPSH cell in May locates to the north of the Philippines, which is useful for the eruption of convection over the SCS. In June the WPSH intensifies and shifts northward significantly.

The comparison of the foregoing two figures illustrates that for the positive (negative) spring SSTA in the equatorial eastern Pacific, the WPSH position in May lies to the south (north) of its mean, the west (east) of its normal, and slightly intensifies (weakens), which is unfavorable (favorable) to the convection over the SCS and the Philippines. The seasonal change of the WPSH in the region is in harmony with that displayed in Fig.1, illustrating the true influence of the spring SSTA on the seasonal change from spring to summer in the eastern Asian circulation.

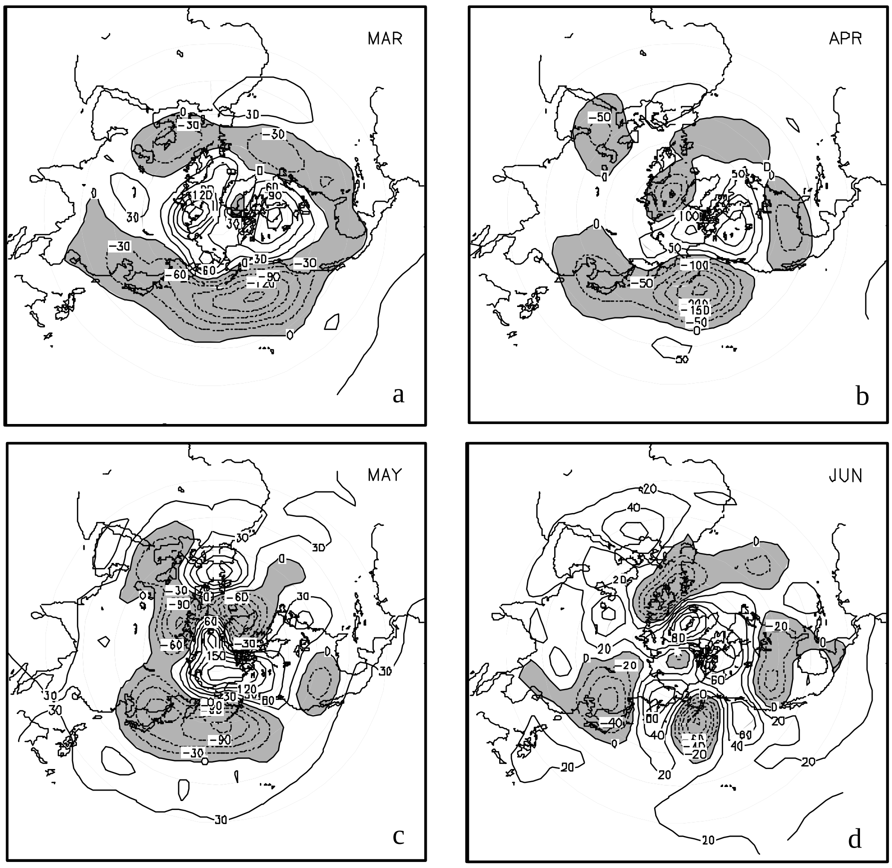


Fig.5 March ~ June (a ~ d) 500 hPa height difference (warm - cold) spring SST in the equatorial eastern Pacific.

The 500-hPa geopotential height difference (TEST2E minus TEST2L) from March to June is shown in Fig.5. As is shown in this figure, the negative value area in March, April and May are located in the East China, Korea, Japan and its eastward sea areas while its two sides are in positive areas. The height difference in June displays that the negative areas in fact include those such as the East China, Korea, Japan and its surroundings, the positive areas are from the SCS to west Pacific and the Okhotsk Sea. Consequently, the influence of the spring SSTA on the eastern Asian circulation will maintain till early summer.

## 6 CONCLUSIONS

The influence of spring equatorial eastern Pacific SSTA on the seasonal change from spring to summer of the eastern Asian circulation is discussed in this paper through diagnosis and numerical simulation. The highlights are as follows:

a. Associated to the positive (negative) spring SSTA in the equatorial eastern Pacific, the WPSH position in May lies to the west (east) of its normal position, and slightly intensifies (weakens), which is unfavorable (favorable) to the convection over the SCS and its surrounding areas.

b. There exists anomalous anticyclone (cyclone) in and around the SCS and the Philippines from March to May in the positive (negative) spring SSTA year.

c. In the warm (cold) spring SSTA year, the convection occurs in the SCS in the range of 110°E and 120°E at the $30^{th}$ ($27^{th}$) pentad, which determines the late (early) onset of the SCS monsoon.

The numerical simulations also reveal that the influence of the spring SSTA on the eastern Asian circulation maintains from spring to summer.

The forgoing analysis shows that the spring SSTA in the equatorial eastern Pacific remarkably affects the eastern Asian circulation from spring to summer. Associated with the warm (cold) spring SSTA year, anomalous anticyclone (cyclone) emerges over the South China Sea and the Philippines, meanwhile the WPSH position lies to the west (east) of its normal position, and is slightly intensifies (weakens), resulting in late (early) onset of the South China Sea monsoon. It remains a topic for further studies and we think that it is necessary to work on the effect mechanism of the SSTA in the equatorial eastern Pacific on the onset of the SCS monsoon, specially the role of the Walker cell.

## REFERENCES:

[1] ZHAO Zhen-guo, CHEN Guo-zhen. The mechanism and prediction of the north/south position of the west Pacific subtropical high in early summer [J]. *Journal of Tropical Meteorology*, 1995, **11**: 223-230.

[2] PENG Jia-yi. The influence on west Pacific subtropical high of ENSO and its interaction with eastern Asian monsoon [D]. Nanjing: Department of Atmospheric Science of Nanjing Institute of Meteorology, 1999, 18-21.

[3] PENG Jia-yi, SUN Zhao-bo. The influence of equatorial eastern Pacific SSTA on west Pacific subtropical high [J]. *Journal of Nanjing Institute of Meteorology*, 2000, **23**: 191-195.

[4] PENG Jia-yi, SUN Zhao-bo, NI Dong-hong. The relation of eastern Asian summer monsoon with the equatorial eastern Pacific spring SSTA [J]. *Journal of Nanjing Institute of Meteorology*, 2000, **23**: 385-390.

[5] WU Guo-xiong, LIU Hui, ZHAO Yu-cheng, LI Wei-ping. A nine-layer atmosphere general cir-culation model and its performance [J]. *Advances in Atmospheric Sciences*, 1996, **13** (1): 1-18.

[6] WU Guo-xiong, LAU Ngar-Cheung. A GCM simulation of the relationship between tropical storm formation and ENSO [J]. *Monthly Weather Review*, 1992, **120**: 958-977.