STUDY OF ANOMALOUS SST FIELD IN TROPICAL PACIFIC IN PRECEDING YEARS OF TWO PATTERNS OF ENSO EVENTS[1]

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ABSTRACT

Analyzing the anomalous field of SST over the tropical Pacific for two kinds of ENSO events after 1956, we find that in the preceding year before the eastern pattern of *El Nino* event there is the *La Nina* event and large negative anomalies of SST in the tropical central and eastern Pacific; the preceding year before the eastern pattern of *La Nina* event witnesses the prevalence of the *El Nino* event and large positive anomalies of SST in the same waters; the preceding year before the central patterns of the *El Nino* (*La Nina*) events are generally marked by significant positive (negative) SST anomalies in central/western (eastern) tropical Pacific. The fields are just the opposite for two patterns of ENSO events. For waters in the warm pool in the western tropical Pacific, the central (eastern) pattern of *El Nino* event is with a warm (cool) preceding year of the pool. The warmer conditions in the western Pacific warm pool are a necessity for the occurrence of the central pattern of *El Nino* event.

Key words: preceding year of ENSO event, tropical Pacific, anomalous field of SST

I. INTRODUCTION

Ever since the 1980's, characteristics of the ENSO event have occurred that are just reversed to what have been shown previously regarding the anomalous distribution and evolution of SST. The *El Nino* events in 1982-1983, 1986-1987 and 1991-95 are just some of them, which all start the warming from the equatorial central Pacific that is propagating eastward, an evolutionary mode that differs from the one with onset from the coast of South America off the equatorial eastern Pacific before traveling to the west. The observational facts challenge the classical theory of ENSO by highlighting the increasing role being played by the western tropical Pacific in evolution of the ENSO event. With analyses of short-term climate fluctuations over the Pacific in 1979-1982, White and Meyers (1985) document substantial changes in oceanic thermodynamic structure of the western Pacific in the preceding one or two years before the mature of the *El Nino* event. More recently, Huang (1996) points out that one of the necessary conditions for the ENSO event to take place is that the warm pool in the western pacific is anomalously warm in the preceding year. Why are there different spatial and temporal patterns of warming for an *El Nino* event? What is the difference between the two patterns of ENSO events in the preceding years with regard to the anomalous SST filed in the tropical Pacific? In addition to the effort aforementioned, Lin and Yu (1993) show in their research that the ENSO event can have totally reversed effects on the precipitation in the floods periods in China depending on the category they belong to. It is hereby both of great significance for studying the mechanism for the formation of ENSO events and of high applicability for predicting precipitation in floods seasons in

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China post the occurrence of an ENSO event.

The SST data used in the work are statistic values for 5.0 lat. × 5.0 long. grids (January 1854 – June 1990) arranged on the basis of COADS products by the Climate Institute, Chinese Academy of Meteorological Sciences, China Meteorological Administration, and Southern Oscillation Index (SOI) (January 1882 – August 1990) published in the Climate Monitoring Bulletin of the National Climate Center of China. The parts of SST and SOI data in the period after 1990 are from the National Climate Center, with the American "Climate Diagnostics Bulletin" as a supplementary source. The SST anomalies are the mean relative to the period from 1949 to 1989. The domain of study is bounded by 30°S – 30°N and 100°E – 80°W for tropical Pacific and the SOI undertake 5-month smoothing filter.

II. CHARACTERISTICS OF SST ANOMALIES IN PRECEDING YEARS OF ENSO IN 40 YEARS

The ENSO cycle is composed of warm and cold phases, the former being the period for the *El Nino* event and the latter for the *La Nina* event. They are separately discussed here. The ENSO event is addressed for periods after 1956 only, because observations are not complete until after 1956 for the open sea, especially the western tropical Pacific. With reference to the principle of categorizing ENSO on basis of the warming location used by Lin et al. (1993) and Fu (1985) and category analyses (Zang and Wang, 1991), the work observes such dividing rules so that a situation in which SST warming (cooling) first appears on the South American coast off the eastern tropical Pacific is defined as the eastern pattern; a situation in which the warming (cooling) first takes place over the tropical central and eastern Pacific is designated as the central pattern. It is based on them that SST fields of the tropical Pacific are studied for the periods after 1956. According to the result, there has been 8 *El Nino* and 8 *La Nina* events in the period from 1956 to 1990, in which the eastern pattern is seen in 1957-1958, 1965, 1972-1973, and 1976 and the central pattern in 1963, 1969, 1982-1983, and 1986-1987, for the former event; the eastern pattern occurs in 1964, 1970-1971, 1973, and 1988-1989, and the central pattern in 1961-1962, 1967, 1975, and 1978, for the latter event. The result, as it turns out, is consistent with that by Lin et al.(1993) with the exception of 1962-1963, which is categorized into the eastern pattern of *La Nina* event. By our definition, there have been 3 central patterns of the *El Nino* event in 1991-1995, occurring from May 1991 to August 1995, from April 1993 to January 1994 and from October 1994 to March 1995, respectively. They are also considered an especially long event of *El Nino* by some researchers. First, basic characteristics of temporal and spatial distribution of tropical Pacific SST are studied for both patterns of ENSO events in 1956-1990. Then, the focus of work is shifted to the *El Nino* event taking place in 1991-1995.

1. *SST anomalies in preceding years of two patterns of El Nino event*

1) VARIATIONS OF SST IN EQUATORIAL PACIFIC

Fig.1 gives the time-longitude profiles of SST anomalies in the equatorial Pacific (5°N – 5°S) in 1956-1990. It is seen that the whole of equatorial Pacific was anomalously cold in the year before and in the early times of the current *El Nino* events of 1957-58, 1965, 1972-73 and 1976; the events were all of the eastern pattern, warming first appearing on the South American coast in the eastern Pacific and transporting westward afterwards. For the year before and the early times of the outbreak of the *El Nino* event in 1963, 1969, 1982-1983 and 1986-1987, weak, negative anomalies

prevailed over the eastern tropical Pacific while a warm condition persisted in the warm pool of the western Pacific. They were all of the central pattern, marked by warming in the central Pacific prior to propagation to the east.

2) HORIZONTAL DISTRIBUTION OF SST ANOMALIES IN TROPICAL PACIFIC

In order to show clearly the horizontal distribution of SST anomalies in the tropical Pacific in the preceding year of *El Nino* event, four incidents of the two patterns of the event in terms of the preceding year and current year in 1956-1990 are studied to probe into the distribution and evolution and composite charts of SST anomalies are constructed for both patterns. In the four preceding years of the central pattern of *El Nino* event (1963, 1969, 1982-1983 and 1986-1987), it was generally warmer in the western and central tropical Pacific and the warm sectors left the warm pool in the western Pacific for the northeast; the negative SST anomalies in the eastern tropical Pacific were decreasing with season and becoming normal by winter. In the current year of the *El Nino* event, the positive SST anomalies in spring were expanding eastward to the eastern and central tropical Pacific, accompanied by rapid intensification of positive SST anomalies in summer and fall, resulting in a prime stage for the *El Nino* event in winter in association with decreases in SST in the tropical western SST until the appearance of negative anomalies. For the two strong *El Nino* events in 1969 and 1982-1983, the positive SST went above +0.5℃ in the warm pool in the western Pacific in the winter of 1968 and 1981 (Figure omitted). In the preceding years of four *El Nino* events of the eastern pattern (1957-1958, 1965, 1972-1973 and 1976), the negative SST anomalies prevailed in the tropical Pacific (especially in the central and eastern part) in association with colder oceanic conditions; in the spring of the current *El Nino* events, positive SST anomalies began to appear along the coast of South America off the eastern tropical Pacific, followed by rapid westward extension and outbreak of the *El Nino* event, being the strongest in winter. Throughout the process, negative SST anomalies were dominant in the western tropical Pacific. For each of eastern pattern of *El Nino* events, the negative SST anomalies were higher than -1.0℃ (Figure omitted). Being the composite SST anomaly fields of two patterns of *El Nino* events in the preceding years for the Pacific Ocean, Fig.2 (a, b) is generally representation of relevant seasonal characteristics. The seasons of spring, summer, fall and winter are respectively represented by MAM, JJA, SON, and DJF in the figure. It is then obvious that the SST anomalies are entirely different between the two patterns of *El Nino* events: they were positive in large magnitude in the central and western tropical Pacific and negative in small magnitude in

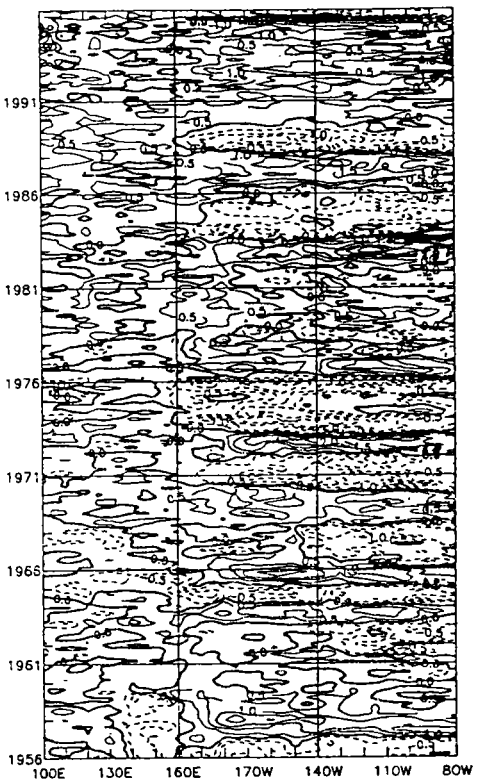

Fig.1. Time-longitude cross-section of SST in equatorial Pacific, with contour intervals of 0.5℃.

eastern tropical Pacific in the preceding years of the central pattern; the whole tropical Pacific was anomalously colder in such periods of the eastern pattern, which happened to be the years with the *La Nina* event.

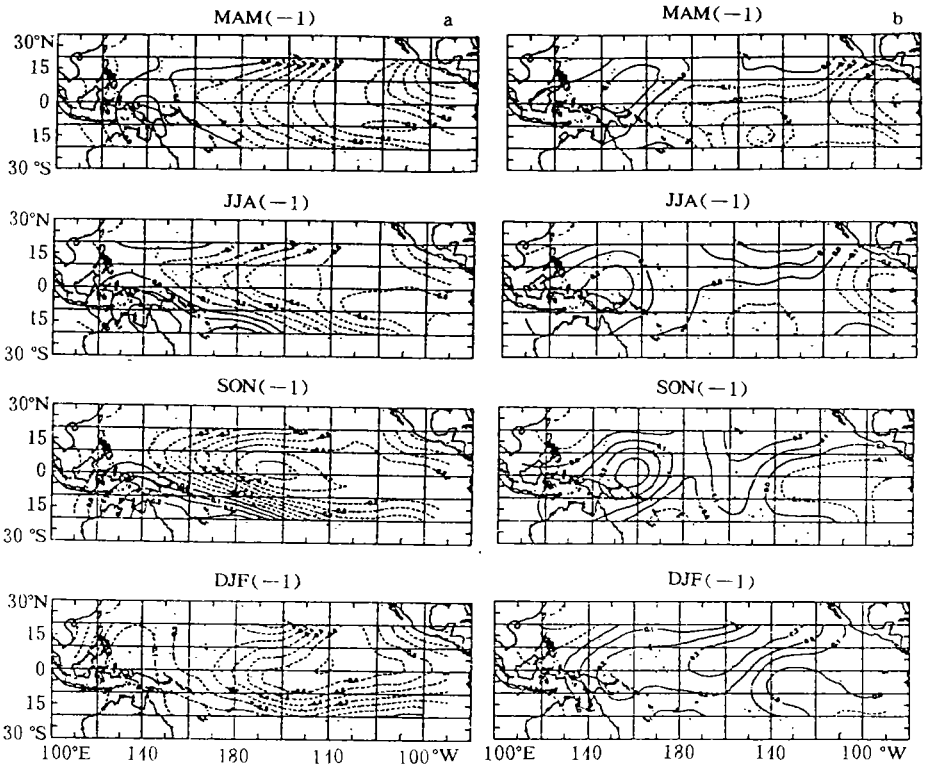

Fig.2. Composite SST anomalies for all seasons in the preceding years of the *El Nino* event for the eastern pattern (a) and central pattern (b).

3) THE SST ANOMALIES IN TROPICAL PACIFIC DURING *EL NINO* IN 1991-1995

As shown in Fig.1, a warm condition existed in the central and western equatorial Pacific in 1991-1995 when there were two occurrences of negative SST anomalies in equatorial eastern Pacific in periods of September 1992 through March 1993 and February through September 1994. It is known from seasonal mean SST anomalies for tropical Pacific (Figure omitted) that the warm conditions prevailed over the western tropical Pacific from fall 1990 to spring 1995 with the positive anomaly of SST at +1.0℃. In the summer of 1991, a +1.5℃ SST anomaly appeared in the tropical central Pacific and caused the outbreak of the first *El Nino* event during the period; in the summer and fall of 1992, a negative SST anomaly appeared at 180° – 120°W in the equatorial eastern Pacific with the maximum exceeding -1.0℃ when the aforementioned event ended. In the meantime, the tropical central and eastern (southern part) Pacific was dominated by a positive SST anomaly of +1.0℃. It is, according to Huang (1996), a central pattern of *El Nino* event. In the winter of 1992, the negative SST anomaly weakened in the equatorial Pacific but

warming was rapid in the spring through summer 1993 over the tropical central and eastern Pacific with a +1.5℃ SST anomaly, leading to the second outbreak of the *El Nino* event. In the period from winter 1993 to summer 1994, the negative anomaly reappeared in the equatorial eastern Pacific, growing to -1.0℃ at the extreme and ending the latest event. It is noted, however, that the +1.0℃ SST anomaly was maintained in the aforementioned waters. In the fall of 1994, the negative anomaly of SST disappeared in the equatorial eastern Pacific in association with the appearance of an extensive region of positive SST anomaly in tropical central and eastern (southern part) Pacific, resulting in the third outbreak of the *El Nino* event in the period. In the spring of 1995, the negative anomaly of SST reappeared in the equatorial Pacific and persisted till the development of another weak *La Nina* event at a later time, putting an end to the latest *El Nino* event. For the three *El Nino* events analyzed above, the tropical western Pacific was all anomalously warmer and a weak negative SST anomaly prevailed in the tropical eastern Pacific in the preceding years of the *El Nino* event. The processes are categorized as the central pattern according to the basic features presented earlier in our work. Due to the short breaks between each of them (about 8 months) and maintenance of extensive regions of +1.0℃ anomalies during these breaks over waters in the tropical western and eastern (southern part) Pacific, the period from May 1991 to March 1995 is also considered one that experiences an specially prolonged *El Nino* event of the central pattern.

2. *SST anomalies in preceding years of two patterns of La Nina event*

Similar analysis was done to the two patterns of the *La Nina* event. As indicated in the SST anomalies of the tropical Pacific in the preceding and current years of the eastern pattern of 4 *La Nina* events (1964, 1970-1971, 1973, and 1988-1989), an anomalously warmer state covered the whole tropical Pacific for the former period, with SST in the positive side of the anomaly; by the time of the current spring of the event, however, negative SST anomalies first started on the South American coast off the eastern tropical Pacific, followed by continued extension to the west, reaching the climax in winter. On the other hand, in the preceding and current years of the central pattern of 4 *La Nina* events (1961-1962, 1967, 1975, 1978), cold conditions dominated in the tropical eastern Pacific for the former period, though SST became negatively anomalous and with greater extent with the shift of season, becoming the most pronounced in fall and winter. As the SST anomaly was of normal or a little warmer in the tropical western Pacific, the negative anomaly advanced westward from the tropical eastern Pacific and enhanced most vigorously in the fall till its maximum in the current winter of the *La Nina* event. The composite SST anomalies of all seasons in the preceding years of the event for both the 4 eastern and 4 central patterns [Fig.3 (a, b)] are conclusive of the features of the two *La Nina* events. It is seen in the figure that there is basically opposite distribution of SST anomalies in the tropical Pacific in the preceding years: The whole of tropical Pacific was anomalously warmer in the eastern pattern, corresponding to the *El Nino* years and it was generally colder in the central pattern.

It is then seen that we have just the opposite evolution of SST anomalies for the eastern patterns of *El Nino* and *La Nina* events. A noteworthy point is that all *La Nina* events post the outbreak of the *El Nino* events are of the eastern pattern and vice versa. For instance, the preceding years of the four eastern patterns of *El Nino* events in 1957-1958, 1965, 1972 and 1976 are corresponding to the four *La Nina* events in 1956, 1964, 1971 and 1975, and the preceding years of the four eastern patterns of *La Nina* events in 1964, 1970-1971, 1973 and 1988-1989 are corresponding to the four *El Nino* events in 1963, 1969, 1972 and 1987. The ENSO events can be either the eastern or central pattern in the preceding years. The SST anomalies in tropical Pacific are more closer to each other between the central patterns of *El Nino* and *La Nina* events when

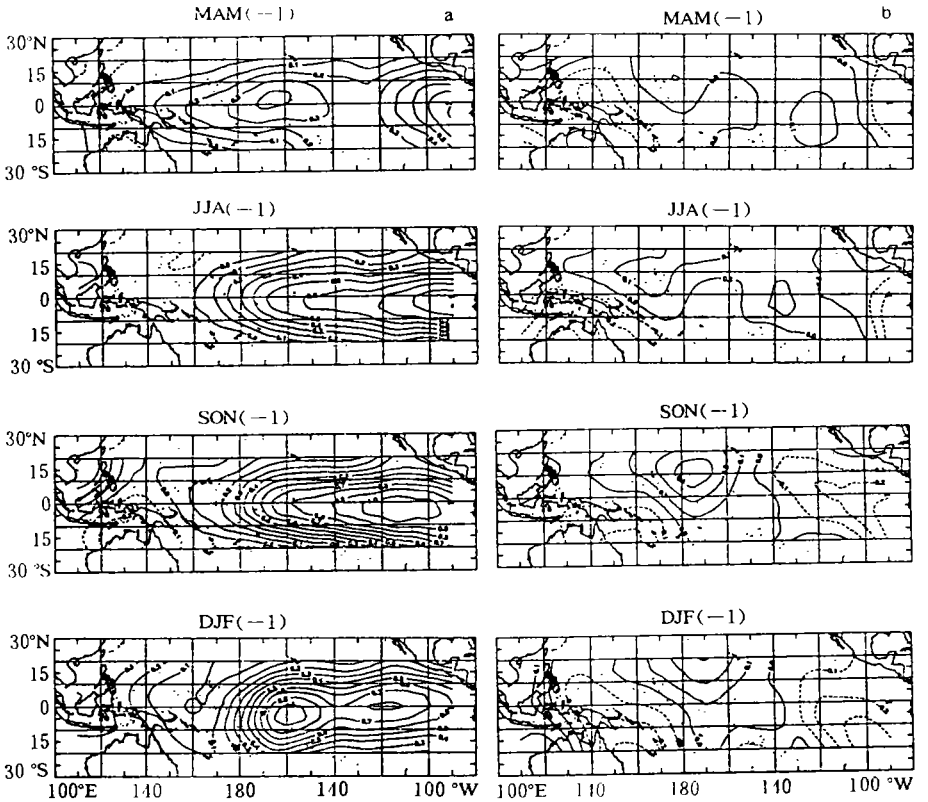

Fig.3. Composite SST anomalies for all seasons in the preceding years of the *La Nina* event for the eastern pattern (a) and central pattern (b).

the tropical western (eastern) Pacific is dominated by positive (negative) anomalies. The only difference is that the positive anomaly is significant in the tropical central and western Pacific for the central pattern of *El Nino* events while the negative anomaly is significant in the tropical eastern Pacific for the central pattern of *La Nina* events, in the preceding years. In this sense, they are reversed in phase.

III. CONCLUDING REMARKS

a. The SST anomalies in the tropical Pacific are generally the opposite for the two patterns of ENSO events in the preceding years: the SST is more of strong positive (negative) anomaly in the western (whole of) tropical Pacific in the central (eastern) pattern of *El Nino* events; the SST is extensively (entirely) strong negative (positive) anomaly in the eastern (whole of) tropical Pacific in the central (eastern) pattern of *La Nina* events.

b. The *La Nina* event takes place in the preceding years of the eastern pattern of the *El Nino* event while the *El Nino* event takes place in the preceding years of the eastern pattern of the *La Nina* event. That the warm pool in the western Pacific is relatively warm is a necessary, preceding oceanic condition for the outbreak of the central pattern of *El Nino* events; that the tropical eastern Pacific is relatively cold is favorable for the occurrence of the central pattern of *La Nina*

events.

The conclusions drawn above are preliminary and premature in that, the outbreak of ENSO events is a consequence of interaction between the ocean and the atmosphere — the preceding oceanic conditions provide the necessary conditions and whether ENSO will begin accordingly depends on the variations of the atmospheric circulation fields and their interactions with the ocean. For this purpose, we will, in the work to come, study in more details the varied patterns of preceding fields of the general circulation for ENSO, investigate into the subtropical highs in the Northern and Southern Hemispheres that cause anomalous distribution of the southeast and northeast trades and the roles being played by such climate regimes as the East Asian and Australian Monsoon which result in the burst or anomalous persistence of the westerly in the tropical western Pacific, and discuss the physics and prediction indexes for the cycle of ENSO.

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