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INTERDECADAL VARIATION OF THE RELATIONSHIP BETWEEN ENSO AND SUMMER INTERANNUAL CLIMATE VARIABILITY IN CHINA

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Abstract: Interdecadal variation of the relationships between ENSO and the summer interannual climate variability in China is investigated by using techniques of sliding correlation analysis with the tropical Pacific SSTA and the observed surface air temperature and precipitation from stations in China. The results indicate that there are stable and robust relations that the Northern China is relatively dry during the developing phase of ENSO while the Yangtze River valley is relatively wet during the decaying phase of ENSO. On the other hand, interdecadal variations of the relations are also found in other regions. Over the time both prior to the Pacific decadal climate shift (before the late 1970s) and after it (after the late 1970s), during the developing phases of ENSO the summer precipitation anomaly in South China changed from below to above normal, whereas that in Northeast China changed from above to below normal; the summer surface air temperature anomaly in North and Northeast China changed from cooling to warming, whereas that in South China changed to cooling; during the decaying phases of ENSO the North China changed from wetter to dryer while the Huai River valley changed from dryer to normal; North China, Yangtze River valley and South China tend to be warmer. Based on the composite analysis of the NCAR/NCEP reanalyze datasets, significant differences existing in ENSO-related atmospheric circulation anomaly in East Asia during pre- and post-shift periods may be responsible for the interdecadal variation of relationships between ENSO and surface air temperature and precipitation in China.

Key words: ENSO; PDO; summer precipitation and temperature; interannual variability; interdecadal variation

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1 INTRODUCTION

ENSO is the strongest signal of interannual climate variability for the air-sea system in the tropical Pacific Ocean. It exerts significant influence on regional as well as global climate anomalies. The ENSO cycle is closely related with the winter and summer monsoon in East Asia[1 – 3] such that the winter and summer monsoon may be relatively weak (strong) during the warm (cold) phases of ENSO. Located in the monsoon region of East Asia, eastern China receives summer precipitation that is of significant monsoon nature. The ENSO cycle has great influence on the summer precipitation in China[4 – 7], and in a way that has something to do with its phases[8 – 9], though with uncertain relationship. It is attributed to a very complicated interaction between ENSO and East Asian monsoon and unstable interrelation between them [10, 11] on the one hand and the existence of PDO[12] on the other. Acting as the background of interannual variability, as shown in recent studies that there are significant Pacific Decadal Oscillation (PDO) in the air-sea system of the Pacific Ocean, PDO can modulate the way in which the ENSO episode affects the summer interannual climate anomalies in China[13, 14]. Previous

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study usually addressed the overall correlation between ENSO and summer interannual climate anomalies in China, without taking into account whether and how their correlation will change with different interdecadal background. It is therefore necessary to probe into the interdecadal variation of the relationship between ENSO and summer interannual climate anomalies in China.

2 INTERDECADAL VARIATION BETWEEN ENSO AND SUMMER INTERANNUAL CLIMATE ANOMALIES IN CHINA

The data of summer precipitation and air temperature from 160 stations across China for 1951 – 1998 and the Niño3 index for winter (Dec. – Feb.) are used to determine the sliding correlation coefficient between them, with the sliding window taken at 21 years.

2.1 *ENSO episodes in phase of development*

Over the past 50 years, developing ENSO episodes are usually associated, quite stably, with less summer

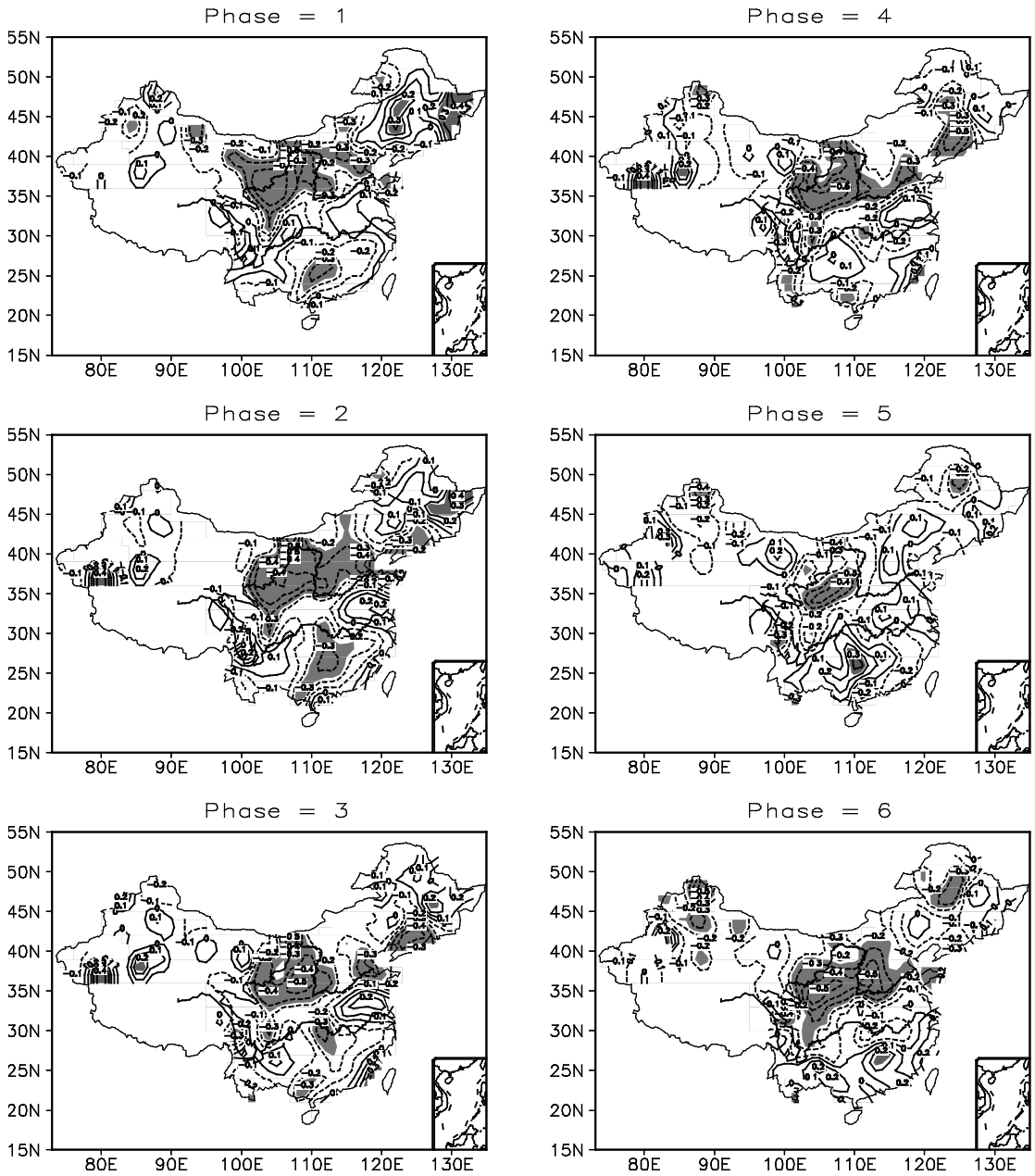

Fig.1 The evolution of coefficients for sliding correlation between summer precipitation anomaly in China and Niño3 index in current winter during the developing phase of ENSO. The shaded area is for the correlation that is more than 95% confidence level. The sliding step is about 5 years in interval between the panels.

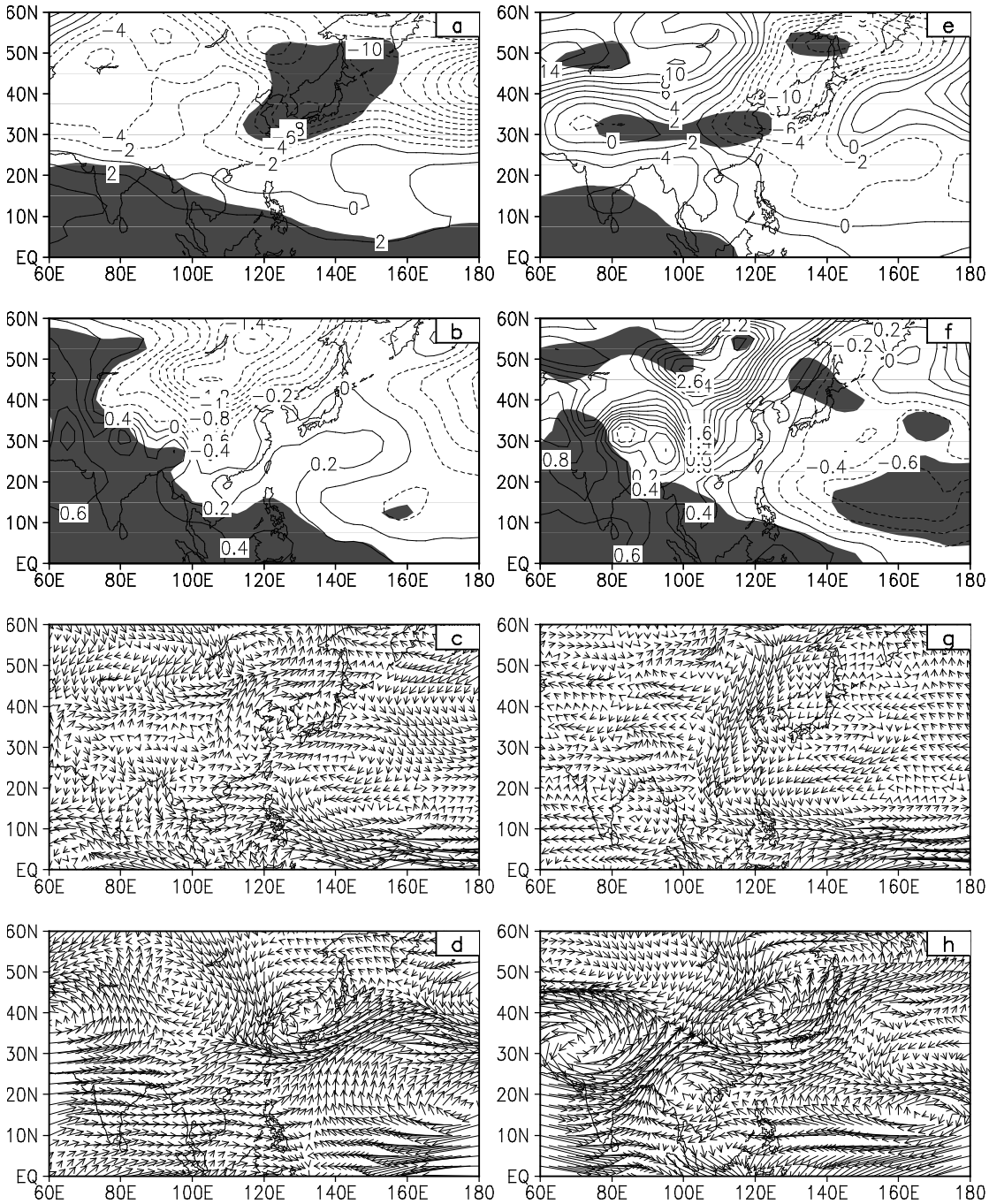

Fig.2 Composite anomalies of summer 500-hPa geopotential height (a, e), 850-hPa flow field (c, g) and 200-hPa flow field (d, h) in East Asia in the developing phase of El Niño in 1951 - 1977 (a - d) and 1978 - 1998 (e - h) El Niño. The shaded areas indicate statistics with the *t*-test passing the 95% confidence level. The unit is geopotential meter for (a) and (e), hPa for (b) and (f) and m/s for (c), (d), (g) and (h).

precipitation in North China. It is noted, however, across the middle and late stages of the 1970s, summer precipitation increased in the area south of the Yangtze River and South China but decreased in North China, while precipitation did not increase much or even decreased in Yangtze – Huanghe River basins, showing significant interdecadal variation (Fig.1). Low summer temperature was not significant in Northeast China and temperature was anomalously high in North China while being anomalously cold in the area south of the Yangtze River. For the whole country, air temperature is higher in the north than in the south (Fig.2).

2.2 *ENSO episodes in phase of decaying*

Decaying ENSO episodes are associated, in a

stable way, with more summer precipitation in the valley of Yangtze River and area south of it. It is noted, however, across the middle and late stages of the 1970s, as there was a significant interdecadal variation in North China and Yangtze and Huaihe River basins, summer precipitation decreased in North China but did not decrease much in the area of the Yangtze and Huaihe Rivers (Figure omitted). The anomalous low summer temperature changed to anomalously high temperature in North China while temperature in the Yangtze River valley and South China shifted from anomalously cold to anomalously warm (Figure omitted).

3 GENERAL CIRCULATION IN DIFFERENT INTERDECADAL BACKGROUND WITH ENSO AFFECTING SUMMER CLIMATE ANOMALIES IN CHINA

Eleven El Niño events (see the Chinese edition of the journal for details) for the time after 1951 were selected to run a composite analysis of the anomalous characteristics of the general circulation of summer in East Asia during the developing and decaying phases of El Niño for the two decadal periods of 1951 – 1977 and 1978 – 1998, respectively.

3.1 *ENSO episodes in phase of development*

Before 1977, weak westerly anomalies prevailed in the middle latitudes of East Asian continent for the developing phase of El Niño, indicating a weak summer monsoon. In the meantime, the subtropical high was weak and located more eastward, resulting in weak southwesterly warm and humid airflow that influenced China and in turn causing less precipitation in most of north and South China but more precipitation in Northeast China due to the effect of an anomalous southerly flow. After 1977, however, the southerly airflow formerly prevailing in Northeast China changed to anomalous northerly flow, which may be one of the important reasons for precipitation in Northeast China to decrease anomalously. Subject to the same northerly flow, precipitation kept at a low level and temperature remained high in North China (Figure omitted).

3.2 *ENSO episodes in phase of decaying*

In the summer when El Niño decayed over the past 50 years, the ocean east of the Philippines was in the control of an anomalous anti-cyclone and the western Pacific subtropical high located more westward and southward, possibly leading to persistently more precipitation in the summer of the Yangtze River valley and area south of it during the decaying phase of El Niño. In the period 1951 – 1977, the decaying of El Niño corresponded to negative anomalies of sea level pressure over the continent of East Asia and summer monsoon strengthened. The region of North China was predominant with anomalously southerly wind coming from the Yellow Sea and Bohai Sea so that abundant content of water vapor brought more precipitation there. Subject to a southwesterly flow from the subtropical high, the valley of the Yangtze River received more precipitation. In the period 1978 – 1998, however, the decaying of El Niño corresponded to positive anomalies of sea level pressure over the continent of East Asia and summer monsoon weakened. The region of North China was then in the control of an anomalously northerly flow, which was unfavorable for precipitation to occur and thus caused less rain. Meanwhile, with the interdecadal strengthening and more westward and southward location of the subtropical high, the southwesterly warm and humid flow that affected South China also strengthened and converged with a northerly flow from North China over the valley of the Yangtze River and the area between the Yangtze and Huaihe Rivers, resulting in more precipitation in the valley of the former area and increased the level of precipitation to normal or even a little bit more in the latter area. In the meantime, precipitation was less and air temperature remained high over most of South China due to the dominance of the subtropical high (Figure omitted).

For analyses of other aspects, refer to the Chinese edition of the journal.

4 CONCLUSIONS AND DISCUSSIONS

The current work casts light into the fact of interdecadal variation of the relationship between ENSO and interannual climate anomaly in summer in China, with main conclusions as follows.

(1) For the relationship between ENSO and interannual climate anomaly in China, it is both stable and variable on a significant interdecadal scale.

(2) With different interdecadal background, significant changes have been caused in the patterns of anomalous middle and high latitudes atmospheric circulation in East Asia triggered by ENSO, leading to, consequently, interdecadal variation in the effect of ENSO episodes with different phases on the interannual climate anomalies in China.

The interaction between ENSO and East Asia summer monsoon and its interdecadal variation is a complicated issue that remains to be further understood. It is noteworthy that the most significant interdecadal variation in the correlation between ENSO and summer interannual climate anomaly in China usually took place around the middle and late periods of the 1970s, which was just the period when PDO shifted from the

cold phase to warm phase[12 - 14]. It is, therefore, an important scientific issue that is worth more effort to study as to how PDO, as a strong signal for climate variability on the decadal and interdecadal scales, modulates the interaction between ENSO and East Asia summer monsoon and consequently results in the interdecadal variation of the relationship between ENSO and summer interannual climate anomaly in China.

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