Longitudinal Displacement of the Subtropical High in the Western Pacific in Summer and its Influence

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(Received 27 December 2002; revised 20 May 2003)

ABSTRACT

Using the relative vorticity averaged over a certain area, a new index for measuring the longitudinal position of the subtropical high (SH) in the western Pacific is proposed to avoid the increasing trend of heights in the previous indices based on geopotential height. The years of extreme westward and eastward extension of SH using the new index are in good agreement with those defined by height index. There exists a distinct difference in large-scale circulation between the eastward and westward extension of SH under the new definition, which includes not only the circulation in the middle latitudes but also the flow in the lower latitudes. It seems that when the SH extends far to the east (west), the summer monsoon in the South China Sea is stronger (weaker) and established earlier (later). In addition, there exists a good relationship between the longitudinal position of SH and the summer rainfall in China. A remarkable negative correlation area appears in the Changjiang River valley, indicating that when the SH extends westward (eastward), the precipitation in that region increases (decreases). A positive correlation region is found in South China, showing the decrease of rainfall when the SH extends westward. On the other hand, the rainfall is heavier when the SH retreats eastward. However, the anomalous longitudinal position of SH is not significantly related to the precipitation in North China. The calculation of correlation coefficients between the index of longitudinal position of SH and surface temperature in China shows that a large area of positive values, higher than 0.6 in the center, covers the whole of North China, even extending eastward to the Korean Peninsula and Japan Islands when using NCEP/NCAR reanalysis data to do the correlation calculation. This means that when the longitudinal position of the SH withdraws eastward in summer, the temperature over North China is higher. On the other hand, when it moves westward, the temperature there is lower. This could explain the phenomenon of the seriously high temperatures over North China during recent summers, because the longitudinal position of SH in recent summers was located far away from the Asian continent. Another region with large negative correlation coefficients is found in South China.

Key words: longitudinal position of subtropical high, large-scale circulation, rainfall, temperature

1. Introduction

It is well known that the activity of the subtropical high in the western Pacific strongly influences the summer climate in China. The longitudinal position of SH affects the temperature and precipitation in China. Recently, the intensity of SH and its relationship to sea surface temperature (SST) have been studied (Sun and Ying, 1999; Ying and Sun, 2000). However, only a few studies focus on the longitudinal displacement of SH. Actually, the anomalous position of SH in the longitudinal direction strongly relates to the date of summer monsoon onset in eastern Asia (Zhu et al., 1987), rainfall in the Changjiang River valley (Chen and Wu, 1998), and temperature in North China (Xie et al., 1999). For example, the subtropical high was located persistently farther to the southwest in the summer of 1998, which was responsible for the later onset and weaker strength of the South China Sea summer monsoon and longer period of mei-yu with very strong rainfall in the Changjiang River Valley (Chen and Zhu, 1999; The National Climate Center of China, 1998). In contrast, the eastward withdrawal of SH was associated with less precipitation in the Changjiang River valley and high temperature in North China in the summer of 1999 (Song, 1999).

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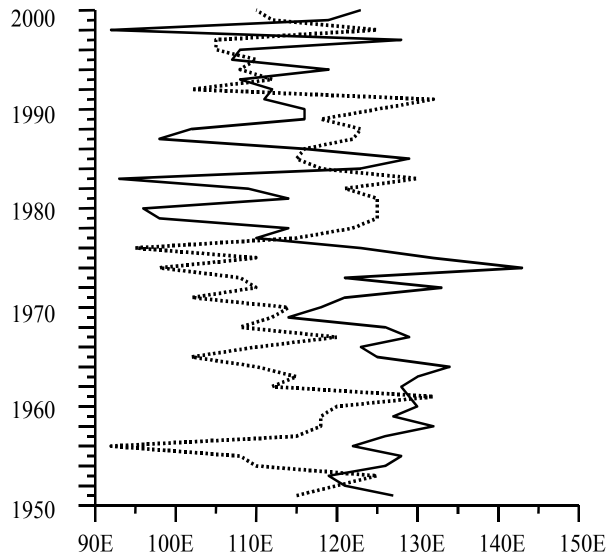

Fig. 1. The longitudinal positions of SH (solid line: the longitude of the west end of SH based on the contour of 5860 gpm) and the Qinghai-Xizang high (dashed line: the longitude of the east end of the Qinghai-Xizang high based on the contour of 16760 gpm).

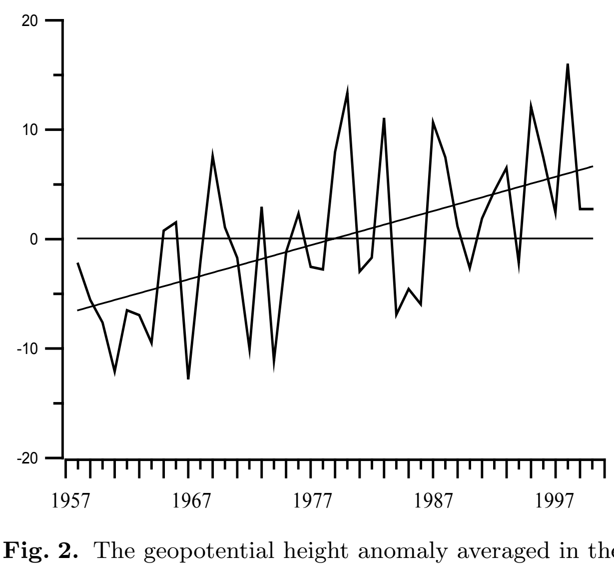

Fig. 2. The geopotential height anomaly averaged in the region of 110°–130°E, 10°–30°N at 850 hPa (oblique line: linear fitting). Units: gpm.

Therefore, the longitudinal position of SH and its influence is an important topic.

First, a comparative study on different previous indices for describing the longitudinal position of SH in the western Pacific is made in this paper. Then a new index is proposed which avoids the shortcomings of previous indices based on geopotential height. The interannual variation of the longitudinal position of SH is studied and its influence on the climate (both on the rainfall and temperature) in China is also investigated.

In this work, the National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis monthly data on a $2.5° \times 2.5°$ grid from 1951 to 2000 are used. The monthly mean rainfall and temperature data at 160 stations of China compiled by the China Meteorological Administration are also used.

2. Study on the index of the longitudinal position of SH

2.1 *The problem of defining the SH longitudinal position by height field*

In an attempt to investigate the rule of the SH longitudinal shift, it is necessary to define an index describing such movement. A usual way to describe the east-west shift of SH is the longitude of the west end of a specific contour (for example, the contour of 5860 gpm). We use this way to get the longitude of the west end of SH for the 1951–2000 JJA-mean (Fig. 1). The solid line of Fig. 1 is the longitudinal position of the west end of SH based on the contour of 5860 gpm at the 500-hPa level. It can be seen from the figure that the position of the west end of SH swings around 125°E before 1976. After 1976, the west end of the SH shifts 15° westward, swaying around 110°E. With reference to the yearly location of the SH (figure not shown), we can see the contour surrounding the SH gradually moves westward.

In order to further explain this interdecadal variation of SH, we follow the definition of Lu (2001). In Lu (2001), the index of the longitudinal location of SH is defined as the geopotential height anomaly averaged in a subtropical area of 110°–130°E, 10°–30°N at 850 hPa where the variation of geopotential height indicates the east-west shift of SH. Figure 2 portrays the variation of this index. The oblique line in the figure is a linear fitting. The variation of the longitudinal movement of SH from 1958 to 2001 in the figure reveals the increasing trend of height.

This "interdecadal variation" may result from the warming climate causing the isobaric surface at the middle-lower latitudes to lift, or the NCEP/NCAR reanalysis has some systematical bias. Anyway, the height increase might have some influence upon a well and realistic presentation of the SH interannual variation. To investigate the interannual variation of SH, we must find some other measure to define the SH longitudinal position.

2.2 *An index to define the SH longitudinal position by relative vorticity*

In an effort to avoid the above-mentioned disadvantage in describing the SH longitudinal position

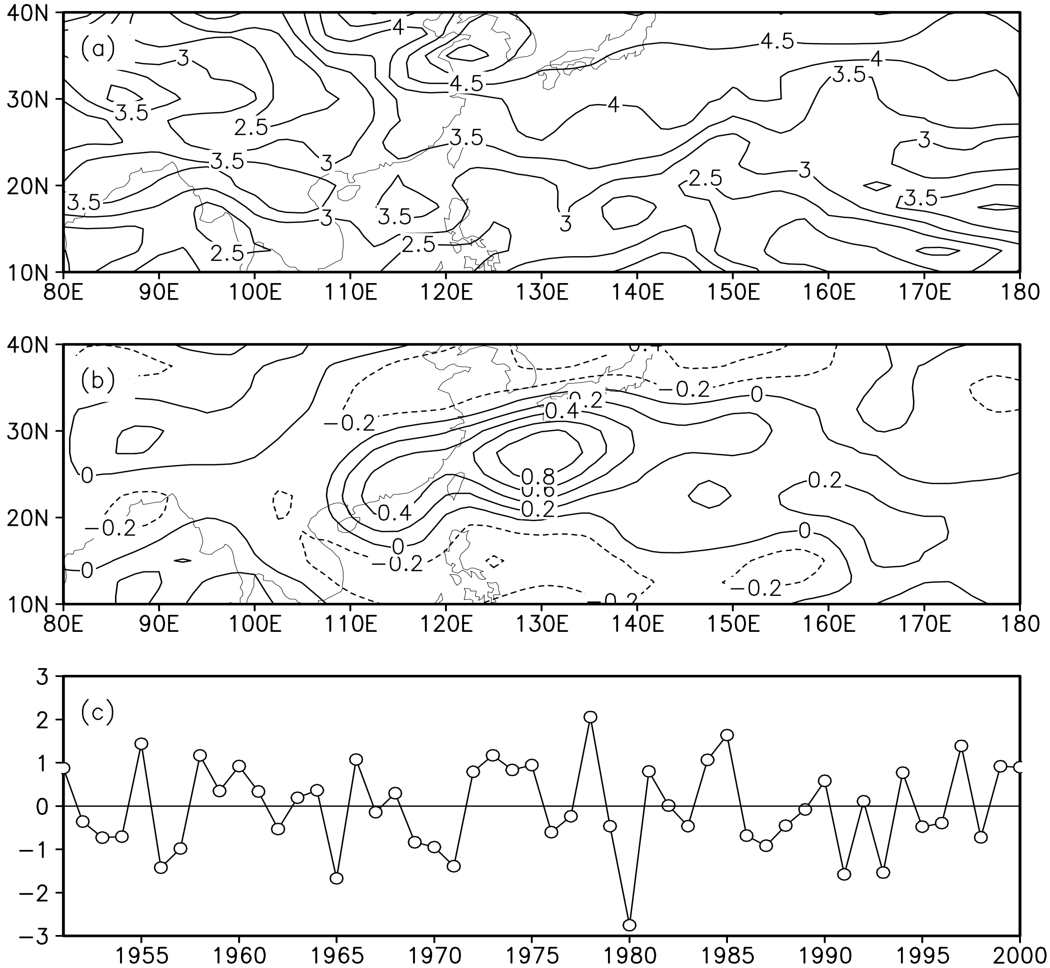

Fig. 3. Standard deviation (a), correlation coefficients (base point: 130°E, 27.5°N) (b), normalized deviation of the SH index (c) of relative vorticity at 500 hPa. Units of standard deviation: 10^{-6} s^{-1}.

by height field, we use the relative vorticity in a specific area to describe the longitudinal position of SH because of the larger curvature curl in the west end of SH. Figure 3a illustrates the distribution of the standard deviation of the JJA-mean relative vorticity at 500 hPa for 1951-2000. Inspection of the figure shows that a larger standard deviation of relative vorticity exists around 27°N, where the SH occupies. It indicates that the SH has a larger interannual variation in this region. For better defining this area, the correlation coefficients between the relative vorticity at the point where it has the largest standard deviation and that at every point at 500 hPa is given (Fig. 3b). It can be found that a significant correlation coefficient coincides with the above-mentioned larger standard deviation. Thus, we use the relative vorticity averaged in the area of 22.5°–30°N, 115°–140°E as an index of the longitudinal position of SH to measure the longitudinal movement of the west end of SH. A larger negative relative vorticity or negative relative vorticity anomaly of that area means that the SH extends westward. A smaller negative relative vorticity or positive relative vorticity anomaly indicates that the SH withdraws eastward. Figure 3c delineates the normalized deviation of the newly defined index from 1951 to 2000. Compared to Fig. 1 and Fig. 2, the new index has no interdecadal variation, and basically fluctuates around zero in Fig. 3c.

Actually, many of the years that are chosen for the anomalous longitudinal position of SH on the basis of relative vorticity definition are the same as those chosen according to the height definition. Table 1 shows the years of anomalous longitudinal position of SH from Fig. 1 and Fig. 3c. The years based on relative vorticity definition are selected if the absolute value of the normalized deviation is greater than 0.5. The years

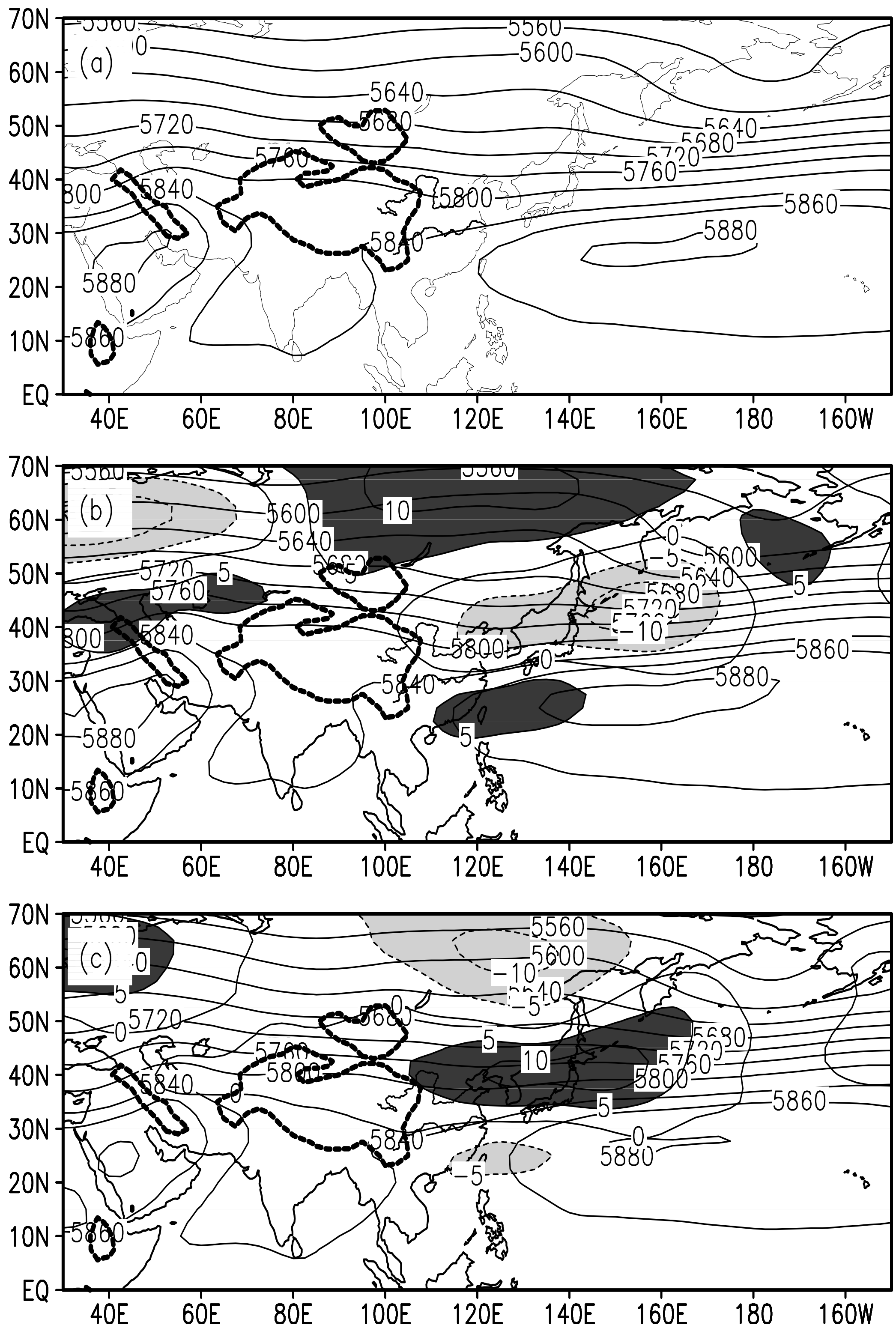

Fig. 4. Average for 1951–2000 (a), composite for the WP (b), composite for the EP (c) of the JJA-mean 500-hPa geopotential height. The anomalies greater than 5 gpm are in dark shading and those less than –5 gpm are in light shading. Units: gpm.

Table 1. Comparison of years for anomalous longitudinal position of SH by different indices

EP		WP	
relative vorticity index	height index	relative vorticity index	height index
1951	1951	1953	1953
1955	1955	1954	
1958	1958	1956	1956
1960	1960	1957	
	1964	1962	
1966		1965	1965
	1967		1966
1972	1972	1969	1969
1973		1970	1970
1974	1974	1971	1971
1975		1976	
1978	1978	1979	1979
1981	1981	1980	1980
1984	1984	1983	1983
1985	1985	1986	
	1989	1987	1987
1990	1990	1991	
1994	1994	1993	1993
1997	1997	1995	1995
1999	1999	1998	1998
2000	2000		

of 1979, 1983, and 1995 are also included, with the index just approximating -0.5. As summarized in Table 1, many of the years by the relative vorticity definition and by the height definition are the same, except for a few years. For example, in 1966, the SH was in an east position (EP) by the relative vorticity definition, but in a west position (WP) by the height definition. From Fig. 1, the longitudinal position of the western end of the SH based on the contour of 5860 gpm was a little westward in 1966. The same phenomenon appeared in 1973 and 1975. In 1964, when the western end of the contour of 5860 gpm extended eastward, the normalized deviation of relative vorticity equaled about 0.4, also expressing that the SH lay relatively to the east of the mean position. In 1967 and 1989, the SH was situated in an EP according to the height definition. The normalized deviation of relative vorticity of the two years are negative although the values approximate zero, indicating the western end of the SH stood in its average position. The years chosen for WP on the basis of the relative vorticity definition include the years for WP by the height definition. Therefore, the relative vorticity definition accurately describes the longitudinal position of the SH.

In consequence, the magnitude of relative vorticity is a successful measure of the longitudinal position of the SH. The phenomenon of the gradual westward shift of SH by an increasing trend of height is avoided because the gradient of wind or height is used in the new index, which is a relative value. Therefore, the relative vorticity definition is suitable for describing the interannual variation of SH, whether or not the gradual westward shift of SH is true.

In the following section, we investigate the large-scale circulation associated with distinct longitudinal positions of the SH defined by the new index, thus further illustrating that it is reasonable and useful.

3. Circulation for the anomalous longitudinal position of SH

In order to perform a composite study, we choose 37 extreme years out of these 51 years: 19 for WP and 18 for EP. The years chosen for the anomalous longitudinal position of SH are listed in Table 1 according to the relative vorticity index.

3.1 *500-hPa geopotential height*

Figure 4a is the average 500-hPa geopotential height for 1951–2000 in summer. Figures 4b and 4c respectively show the composites for WP and EP in summer. In the case of the normal, the west end of the 5860-gpm contour of SH is located around 120°E. However, in the case of WP, the west end of the ridge is shifted 5° to the west of its normal longitude and the center of SH is also shifted westward. During the year of EP, the end of the ridge in terms of the 5860-gpm contour moves eastward to the longitude at about 150°E. In the corresponding anomalous composites (shaded area), positive geopotential height anomalies appear in the west part of SH as the SH extends westward, and negative height anomalies as the SH withdraws eastward. This indicates that the definition based on relative vorticity is useful to describe the longitudinal movement of SH.

In the corresponding composites of relative vorticity (not shown), in the case of WP, negative vorticity anomalies are found in the areas of 110°–140°E, south of 35°N. This indicates that the SH in those areas is strengthened, and extends westward. In the composite of EP, positive vorticity anomalies are found in those areas. This means that the SH is weakened in those areas, and withdraws eastward. That accords with the purpose of the newly defined index.

By referring back to Fig. 4, we can investigate the pattern of the westerly belt that has a relationship to SH. Negative (positive) height anomalies are found

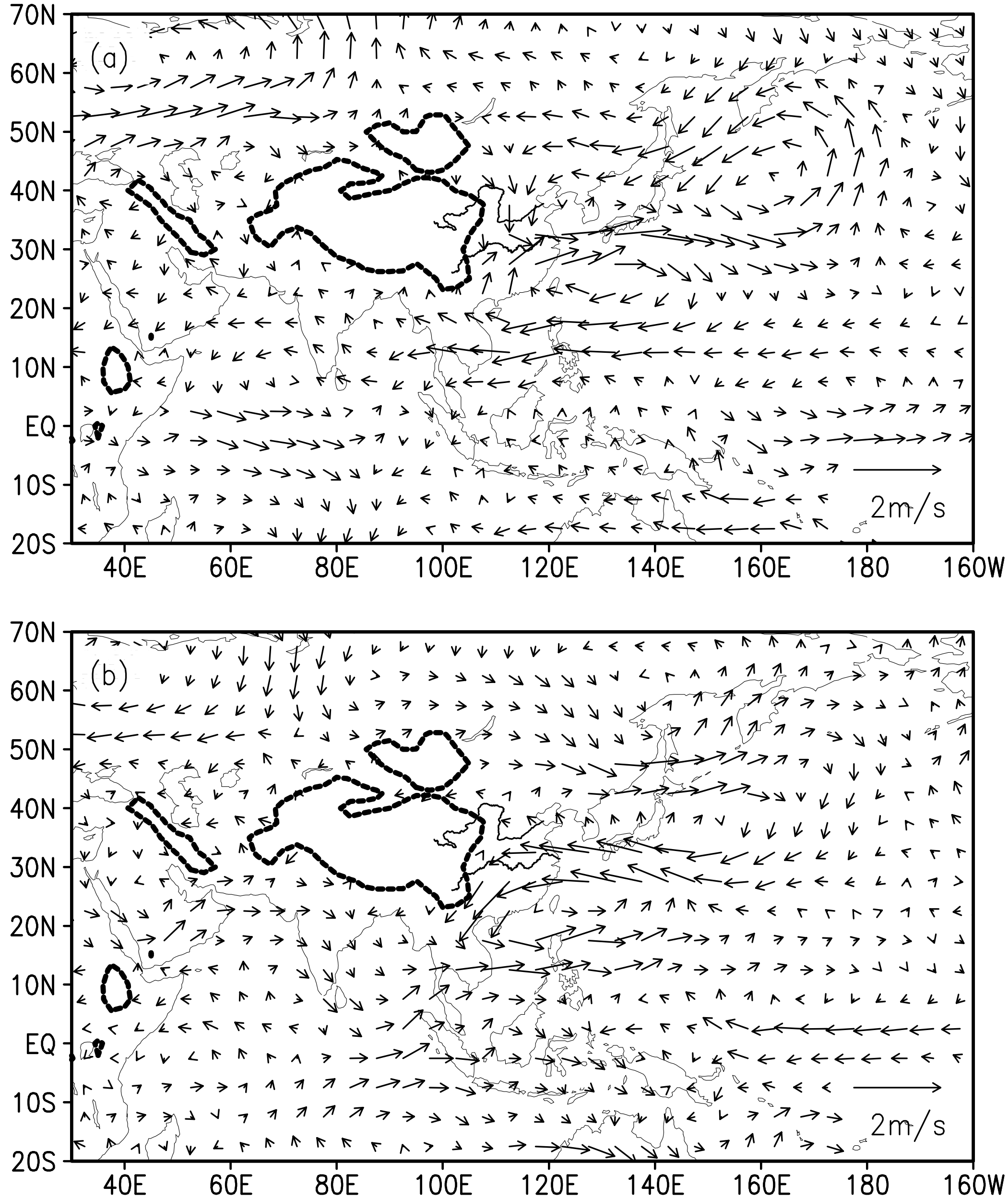

Fig. 5. The composites of the 850-hPa wind vector anomalies for the WP (a) and the EP (b).

to the north of SH as it is located in WP (EP), which means that the westerly trough over that region is intensified (weakened). Negative (positive) height anomalies are also found in the Ural ridge, which means that the ridge is weakened (developed). Thus, anomalous height fields in the westerly belt exhibit remarkable differences between EP and WP, and they are even out of phase. This suggests that the longitudinal shift of SH is related to the change of circulation in the westerly belt.

3.2 *850-hPa wind*

The patterns of the composites of height and their anomalies at 850 hPa are similar to those of 500 hPa. Figure 5 depicts the composites of anomalous wind at 850 hPa. In the case of WP of SH, there is an anomalous anticyclonic circulation over the western Pacific SH place. The southwesterly wind on the northwest side of the anomalous anticyclonic circulation and anomalous northerly wind converge to form a strong convergence zone around 30°N that is just the

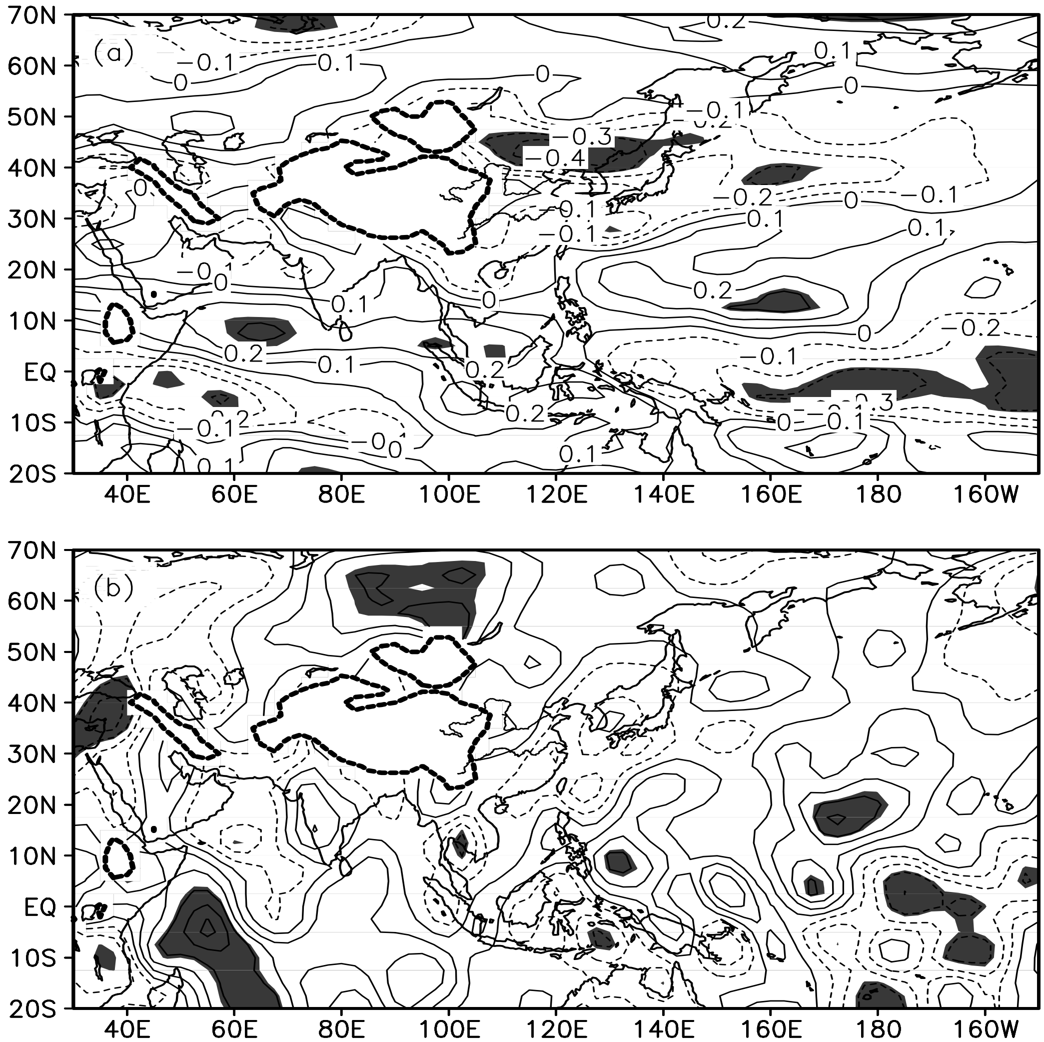

Fig. 6. Correlation coefficients between the SH index and 850-hPa zonal wind (a), and meridional wind (b) of May. The dark shading shows the t-test significance at the 95% level.

area of the Changjiang River valley rain belt. However, South China is dominated by the anomalous anticyclonic circulation, which is not favorable to the rainfall of South China. The case of EP of SH is in sharp contrast to the case of WP. From Fig. 5b, we find the anomalous cyclonic circulation to the south of 30°N. An anomalous divergence air stream controls the middle-lower valley of the Changjiang River. This pattern is distinctly unfavorable to the rainfall of the Changjiang River valley. However, South China is controlled by anomalous cyclonic circulation, which is favorable for heavier rainfall. This issue is further discussed in the next section.

3.3 *The relationship between the longitudinal position of the SH and the South China Sea (SCS) monsoon*

In order to study the relationship between the longitudinal position of the SH and SCS monsoon, the 850-hPa winds in May are investigated. Figure 6a illustrates the correlation coefficients between the relative vorticity index expressing the SH longitudinal position of summer (SH index) and the 850-hPa zonal wind of May. A negative correlation coefficient shows that the westerly wind is enhanced if the SH withdraws eastward; the easterly wind strengthens if the SH stretches westward. It is seen that there are remarkable positive correlation coefficients in the tropical westerlies from the Indian Ocean to SCS. This indicates that the tropical westerlies strengthen if the SH retreats eastward, and weaken if the SH extends westward. In the composite wind anomaly at 850 hPa in May (not shown), there exists a strong anomalous westerly wind over the tropical regions from the Indian Ocean to SCS if the SH is located in EP, but an anomalous easterly wind if the SH is locates in WP.

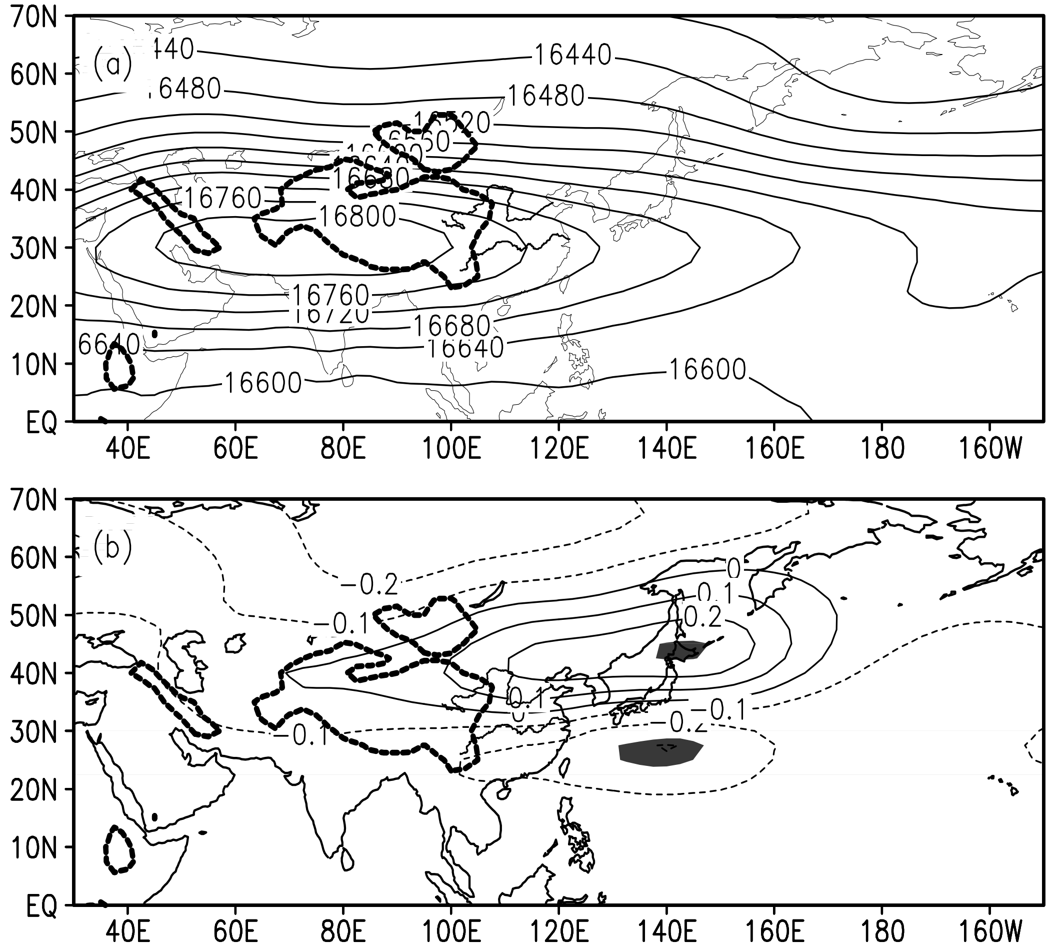

Fig. 7. (a) Average JJA 100-hPa geopotential height for 1951–2000 (units: gpm), (b) correlation coefficients between the SH index and JJA-mean 100-hPa geopotential height. The dark shading shows the t-test significance at the 95% level.

This means that the equatorial westerly wind from the Indian Ocean increases and benefits the onset of the SCS monsoon if the SH is located in EP. Figure 6b depicts the correlation coefficient between the SH index and the 850-hPa meridional wind of May. There exist significant positive coefficients in some regions around 40°–60°E, 80°E, and 140°E. The three regions are exactly the locations of climatological cross-equatorial flows. The positive coefficients in the three regions suggest that these cross-equatorial flows strengthen if the SH withdraws eastward, or weaken if the SH stretches westward. The appearance and enhancement of the cross-equatorial flows are also the important signs of an earlier onset of the SCS monsoon (Shi et al., 2001).

The results indicate that if the summer SH is located in EP, the SCS monsoon is established earlier and stronger. On the other hand, if the summer SH is located in WP, the SCS monsoon is established later and weaker. These are consistent with previous research work on the activity of the SH and SCS monsoon (Liang and Wu, 2002). This also suggests that the new index of the longitudinal displacement of the SH based on relative vorticity is reasonable and reliable.

3.4 *The longitudinal movement of the Qinghai-Xizang High*

Previous research and experience have shown that the longitudinal displacement of SH is related to the Qinghai-Xizang high at upper levels (Tao and Zhu, 1964). Figure 7b presents the correlation coefficients between the SH index and the 100-hPa JJA-mean geopotential height. To the south of 32°N, there are negative correlation coefficients. This means that the 100-hPa geopotential height over these regions increases as the SH shifts westward. From the 1951–2000 mean height (Fig. 7a), we can see that the Qinghai-Xizang high moves southeastward. When the SH shifts eastward, the Qinghai-Xizang high moves northwestward. This means that the Qinghai-Xizang high moves oppositely to the SH. In general, the Qinghai-Xizang high and the SH go in opposite directions as shown by the locations of the western end of the SH (solid line) and the eastern end of the Qinghai-Xizang high (dashed line) in Fig. 1. The movement of the subtropical high at high levels and low levels is important, helping us to realize the 3-dimensional structure of the subtropical high and the interaction between the two large-scale systems.

4. Relationship between the longitudinal and latitudinal positions of the SH

The meridional and zonal displacements of the SH have been a major concern in the forecasting of summer precipitation in China. In general, it is found from experience that the SH appears to shift northward as the SH shifts eastward, or the SH shifts southward as well as westward. The relationship between the longitudinal and latitudinal positions is worth examining further.

A quantitative and objective definition is needed to investigate the latitudinal position of the SH. The latitude of the ridge line in the west of the SH has been widely used to define the latitudinal position of the SH. However, the ridge line of SH is subjectively given with some uncertainty. In this study, we use two ways to describe the latitudinal position of SH. One is the latitude of the northern boundary of the 5880-gpm contour at some longitude. Another is the latitude of the contour of the zero zonal wind (Wu et al., 2002). Therefore, four indexes (A, B, C, D) are set to define the latitudinal position of the SH.

A: latitude of zero zonal wind at 120°E at 500 hPa; B: same as index A, but at 150°E; C: latitude of the northern boundary of the 5860-gpm contour at 130°E; D: same as index C, but at 150°E; E: the SH index of the longitudinal position of SH.

The correlation coefficients (R) between them are as follows:

R_{AB}=-0.1286; R_{AE}=-0.1444; R_{BE}=0.0944;
R_{CD}=0.2580; R_{CE}=-0.3163; R_{DE}=0.2365.

The correlation coefficient between A and B equals –0.1286. It is negative and insignificant. It indicates that when the latitudinal position of the zero zonal wind at 120°E moves southward, the latitudinal position of the zero zonal wind at 150°E is likely to move northward. That means if the west part of the SH shifts northward, the east part shifts southward. The correlation coefficients between the latitudinal position of the zero zonal wind and E are small and insignificant, which is consistent with the result about the longitudinal and latitudinal displacements of the SH (Lu, 2002).

The correlation coefficient between C and D (R_{CD}) equals 0.2580, and is below the 95% significance level. But it indicates that based on the northern boundary of the 5860-gpm contour, the SH shifts in the same direction at 130°E and 150°E. The correlation coefficients between the longitude position E and the latitudinal positions C and D are –0.3163 and 0.2365 respectively. The former exceeds the significance level of 95%. It indicates that the west part of the SH shifts eastward as it shifts southward or the 5860-gpm contour expands southward. The reverse is also true. However, the correlation coefficient between the east part of SH and the longitude position E (R_{DE}) is insignificant.

The above results suggest that there exists some relation between the longitudinal and latitudinal positions of the SH in the west part of SH. However, it suggests that the relationship between the longitudinal and latitudinal positions of the SH depends on the latitudinal position definition of the SH. The movement in the east part of the SH differs from the west part.

5. The longitudinal position of the SH and the precipitation in China

The longitudinal position of the SH influences the onset of the East Asian monsoon, the precipitation, and temperature in East China. Figure 8a shows the correlation coefficient between the SH index and the JJA precipitation at 160 stations of China. The correlation map clearly shows that there are two significant correlation coefficient regions. One is in the Changjiang River valley with negative correlation coefficients. The greatest coefficients are below –0.4, which are far above the 95% statistical significance level. This indicates that the precipitation of the Changjiang River valley increases when the SH extends westward. On the other hand, the precipitation decreases when the SH withdraws eastward. It is also seen in Table 1 that the severe floods of the Changjiang River valley in 1954, 1962, 1969, 1980, 1991, and 1998 all occurred in WP of the SH. The disastrous droughts of the Changjiang River valley in 1966, 1978, and 1985 all occurred in EP of the SH. Another significant coefficient region is South China. It is seen that the correlation coefficients between the precipitation of South China and the SH index are positive with the center above 0.3. This suggests that the precipitation of South China

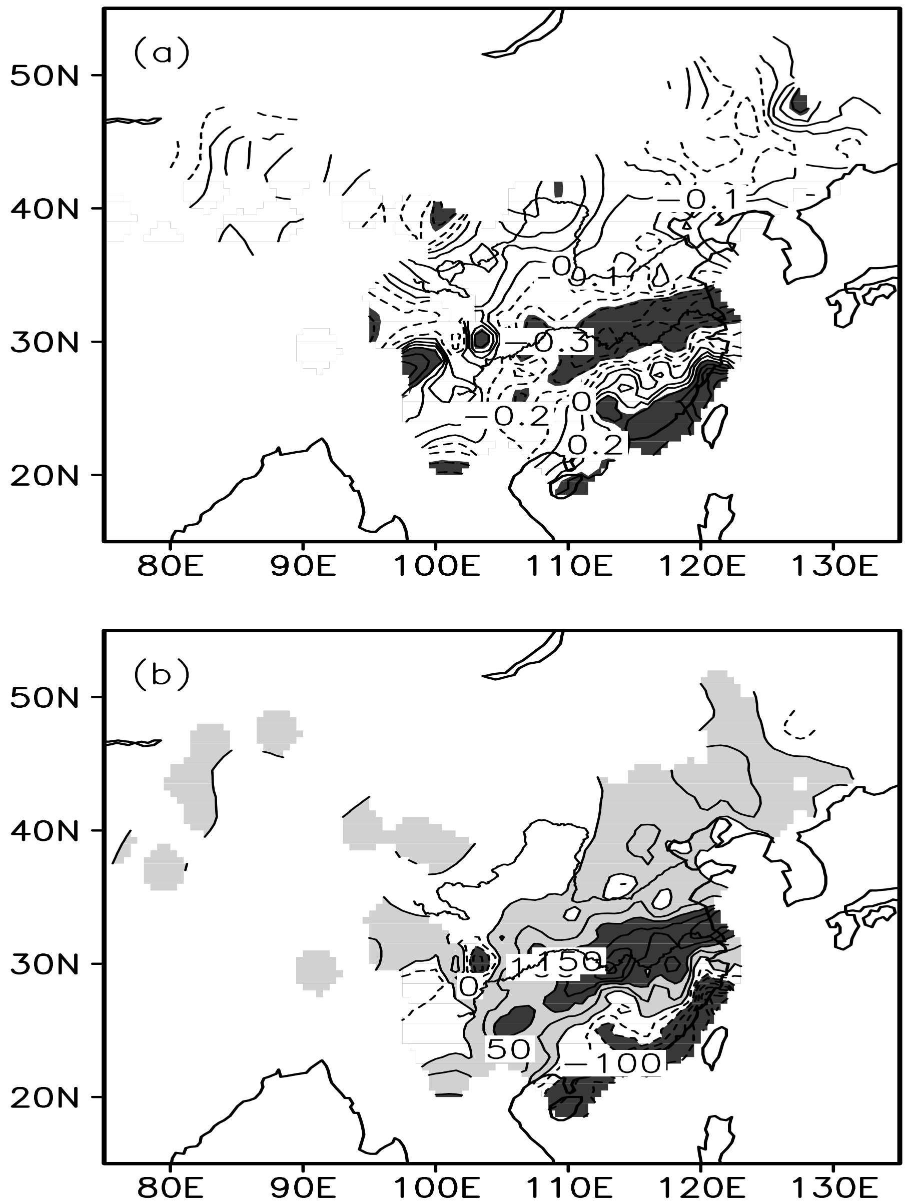

Fig. 8. (a) The correlation coefficients between the SH index and JJA precipitation (dark shading: the t-test significance at the 95% level), and (b) composite difference (the WP minus EP) of JJA precipitation at 160 stations of China (units: mm/JJA; light shading: positive difference; dark shading: absolute difference greater than 100)

decreases when the SH expands westward, while the precipitation increases when the SH withdraws eastward. This corresponds to the results of section 3.3 where the relationship between the South China Sea monsoon and the SH is discussed.

Figure 8b shows the composite difference of the JJA-mean precipitation at 160 stations of China between the WP and EP of the SH. It shows that the differences in the Changjiang River valley are above 100 mm/JJA. The differences in South China are also above 100 mm/JJA. This indicates that the longitudinal position of the SH considerably influences the precipitation of the Changjiang River valley and South China. The Changjiang River valley has more precipitaion in the WP of the SH than in the EP. The precipitation of South China for the WP cases of the SH is less than that for the EP cases of the SH.

It can also be found from Fig. 8 that both the correlation coefficients and the differences are very small in North China, and do not form a centralized region.

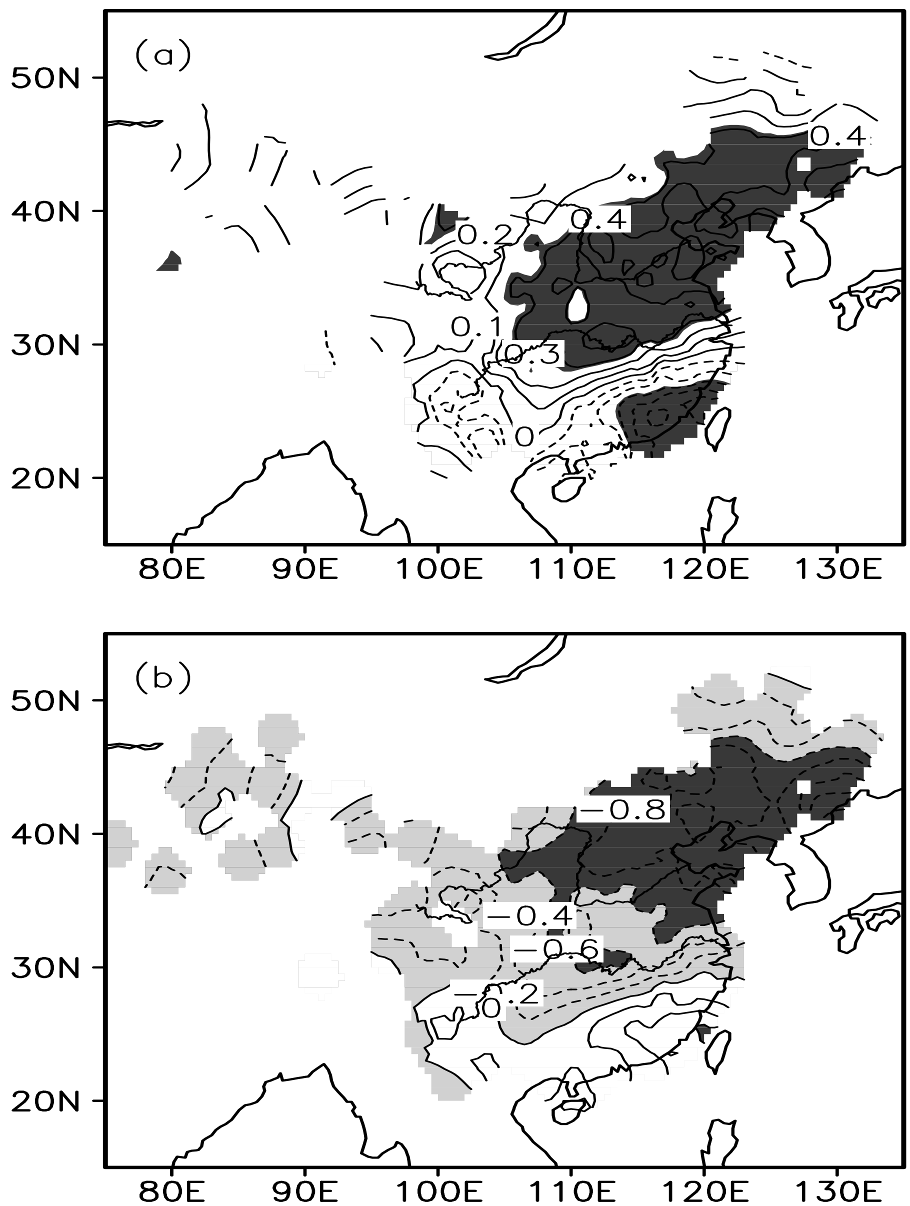

Fig. 9. As in Fig. 8 except for surface air temperature (units: °C; light shading: positive difference; dark shading: absolute difference greater than 0.6).

So the influence of the anomalous longitudinal position of the SH on the precipitation of North China is not clear. The relation of the longitudinal position of SH with precipitation in the east of China should not be discussed as a whole, but separately instead.

6. The longitudinal displacements of the SH and the temperature in China

Summer temperature has enormous social impact on human life. The relationship between the SH longitudinal index and temperature is revealed in this section. The correlation map between the SH index and the JJA-mean surface air temperature at 160 stations of China is shown in Fig. 9a. There exist positive correlation coefficients in the regions between the middle-lower reaches of the Changjiang River and south of Northeast China. The most significant regions with coefficients above 0.5 are found in North China. It is clearly found that the air temperatures in North China and the south of Northeast China increase when the SH withdraws eastward, while they decrease when the SH extends westward. The negative correlation coefficients are observed in South China with the significant coefficients below –0.4. This suggests that the air temperatures in South China decrease when the SH moves eastward, which is related to a frequent activity of the South China Sea monsoon, and vice versa. Figure 9b shows the composite difference of the JJA-mean surface air temperature at 160 stations of China between the WP and EP of the SH. The distribution of the difference is similar to Fig. 9a. The region with negative anomalies is consistent with the positive coefficients, and the positive anomalies correspond to the negative coefficients of Fig. 9a. This distribution of the temperature difference suggests that the SH eastward (westward) withdrawal corresponds to higher (lower) temperatures in North China and lower (higher) temperatures in South China.

A severe, hot summer climate has occurred frequently in recent years in North China, and affected human life and economy. This has been attached importance by meteorologists (Xie Z., et al, 1999; Sun et al., 1999). The severe high temperatures expand from North China to Korea and Japan. The relationship between the surface temperatures of the NCEP/NCAR reanalysis data and the SH index reveals that high positive correlation coefficients stretch to Korea and Japan (figure not shown). The above results suggest that the longitudinal position of SH provides the very important circulation background field for the high temperature of those regions. The seriously high temperatures over North China in the summertime in recent years, such as 1994, 1999, 2000, and 2002, all occurred when the longitudinal position of SH was clearly located to the east of its normal position. As the SH withdraws eastward, an adjustment of long waves in the westerlies occurs and a continental high develops strongly and dominates East Asia and the coastal area. A detailed discussion on this issue will be given in a future paper.

7. Conclusions

(1) A comparative study of different indices for describing the longitudinal position of SH in the western Pacific is made first in this paper. It indicates that the index related to geopotential height is not suitable for investigating its interannual variations due to the increasing trend of height, which is responsible for the westward motion of the isopotentials in the last 50 years. According to the large value of curvature vorticity of SH at its western flank, we try to use the value of vorticity averaged in a certain area as an index to measure the longitudinal position of SH. In this approach, the rising trend of height no longer appears, since the vorticity is a scalar calculated from the differentials of height or wind. The years of extremely westward and eastward extension of SH using the new index are in good agreement with those defined by the height index.

(2) There exists a distinct difference in large-scale circulation between the eastward withdrawal and the westward extension of SH under the new definition, which involves not only the circulation in the middle latitudes but also the flow in the lower latitudes. It seems that when the SH extends far to the east(west), the summer monsoon in the South China Sea is stronger (weaker) and established earlier (later).

(3) There exists a good relationship between the longitudinal position of SH and the rainfall in China in summer. A remarkable negative correlation area with a value of the correlation coefficient less than –0.4 at its center appears in the Changjiang River valley, indicating that when the SH extends westward (eastward), the precipitation in that region increases (decreases). Another region of marked correlation (but positive) can also be found in South China, implying a decrease (increase) of rainfall when the SH extends westward (eastward). However, the influence of the anomalous longitudinal position of SH on the precipitation in North China is not clear. The correlation coefficient over the region is not large enough to reach an adequate significance level.

(4) The calculation of the correlation coefficient between the index of longitudinal position of SH and surface temperature in China shows that a large area of positive correlation coefficients with a large value higher than 0.6 in the center covers the whole of North China, even extending eastward to the Korean Peninsula and Japan Islands when we use the NCEP/NCAR data to do the correlation calculation. This means that when the longitudinal position of the SH withdraws eastward in summertime, the temperature over North China increases. On the other hand, when it moves westward, the temperature over the region drops. This could explain the phenomenon of seriously high temperatures over North China in recent summers, because the longitudinal position of SH in those summers wes located far away from the Asian continent. Another region of large, negative correlation coefficients is found in South China. The relationship between the index of SH and the temperature is just opposite to that in North China.

Acknowledgments. This work was supported by the Innovation Key Program of the Chinese Academy of Sciences ZKCX2-SW-210, the National Natural Science Foundation of China under Grant No.40135020, and 40233033.

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