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ANALYSIS ON EFFECT OF SOUTH ASIA HIGH ON MID-SUMMER EXTREME DROUGHT AND FLOOD IN SICHUAN-CHONGQING REGION

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Abstract: NCEP/NCAR data are utilized to analyze an extreme flood year (1998) and an extreme dry year (2006) in the Sichuan-Chongqing region (SCR) and the results are as follows. The positive divergence of South Asia High (SAH) is stronger in the flood year; the position of the ridge line of SAH is southward compared with the annual average; Western Pacific Subtropical High (WPSH) extends westward and its ridge line is southward. In the drought year, the positive divergence of SAH is weaker, its ridge line is northward, and the position of WPSH is also northward. As shown in the dynamics, in drought (flood) years, negative (positive) vorticity advection in the upper atmosphere can cause the atmosphere to ascend (descend), and anomalous circulation of SAH displays divergence (convergence), and anomalous circulation of the lower atmosphere shows convergence (divergence). Thermal structure of the atmosphere shows that there is warm (cold) temperature advection in the lower atmosphere, and the vertical distribution of diabetic heating causes SAH's local circulation to display convergence (divergence) and affects vertical motion of the lower atmosphere circulation eventually. To some extent, the two extreme years in the SCR is closely related to the vertical motion of atmosphere circulation and the variation of such vertical motion is caused by differences of interactions between SAH and lower atmosphere circulations.

Key words: Sichuan-Chongqing region; South Asia High (SAH); characteristics of drought and flood; anomalous circulation

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1 INTRODUCTION

South Asia High (SAH) is an important factor for the change of the atmospheric circulation in the Northern Hemisphere in summer. A large number of studies have demonstrated that SAH has great influence on the change of weather and climate in China[1-16]. In the early 1960s, Tao and Zhu[2] pointed out the close relationship between SAH and the rainfall in China. Later Luo et al.[3] divided SAH into an east type, a west type, and a band type through analyzing a 13-year-long dataset. They also pointed out that it is rainless in the middle and lower reaches of Yangtze River, eastern Sichuan and Guizhou while it is rainy in the western Sichuan and north China with the east type and band type of SAH. On the contrary, in the middle and lower reaches of Yangtze River, eastern Sichuan and Guizhou it is rainy but rainless in western Sichuan is rainless, consistent with the west type of SAH. Sun and Song[4] also observed that the migration time of SAH is correlating with the summer rainfall in China to some extent. According to some studies[6-9], the position and intensity change of the SAH also have great impact on the regional climate anomalies in China and large-scale rainfall in Yangtze River. Extensive research showed the importance of SAH change in the distribution of drought and flood in China. In recent years, studies showed that the distribution of drought and flood in the Sichuan-Chongqing region (SCR) is closely linked to the SAH. The north-south oscillation change of the central location of SAH has a direct impact on the summer rainfall of the Sichuan Basin, a finding determined by independently analyzing the drought and flood differences of Sichuan Basin in 1981 and 1982[11-13]. These authors further noted that in the year of the severe drought (flood) in the eastern Tibetan Plateau region, preceding geopotential height fields

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over the Tibetan Plateau at 100 hPa are low (high), the main body of SAH and the central location are northward (southward) and westward (eastward), respectively, and the eastern plateau is controlled by negative (positive) anomalies. It is revealed from different points of view that the relationship between the drought and flood characteristics of the SCR and the SAH is of great significance to the understanding of the relationship between the droughts and floods and the SAH in the SCR[17-20]. However, works are rare on exploring the physical processes that cause the extreme droughts and floods and their roles in the extreme droughts and floods. The SAH in the upper troposphere shows unclear and indirect impact on the rainfall. In addition, its large spatial scale effect is limited in interpretation of drought and flood events affected by SAH. Therefore, it is necessary to consider the matching degree between the spatial scale of SAH and the geographical scope of SCR in the discussion of the SAH in association with droughts and floods characteristics in SCR. The differences in the influence of the dynamic and thermodynamic features on the atmospheric circulation should be analyzed from the whole and partial SAH modes. Based on this, this work analyzed the extreme summer flood year 1998 (referred to as "the flood year" hereafter) and the extreme drought year 2006 (referred to as "the drought year" hereafter) in the SCR in recent years.

This paper is organized as follows: section 2 introduces the data and methods while section 3 discusses the drought and flood distribution and circulation characteristics in 1998 and 2006. Furthermore, dynamic and thermodynamic characteristics of the extreme drought and flood years are commented in section 4. Finally, summary and discussion are presented in section 5.

2 DATA AND METHODS

The monthly rainfall data of 160 stations in China and NCEP/NCAR reanalysis data (with horizontal grid distance 2.5°×2.5°, including the geopotential height, U and V wind field, temperature field, and vertical velocity) are used, and the midsummer months of July and August are selected for the analysis. In order to reflect the differences in the dynamic and thermodynamic characteristics of SAH in the extreme drought and flood years of SCR, vorticity equations and thermodynamic equations are employed. In the analysis of the anomaly field, the related information spans from 1951 to 2007. According to Zhu et al.[19], the vorticity equation in the p-coordinate system under the background of large-scale circulation is

$$\frac{\partial \xi}{\partial t} = -\vec{V} \bullet \nabla_h \xi - \beta v - f \nabla_h \bullet \vec{V} \quad (1)$$

where $\frac{\partial \xi}{\partial t}$ is the local vorticity change, $-\vec{V} \bullet \nabla_h \xi$ the vorticity advection, $-\beta v$ the geostrophic vorticity advection, and $-f\nabla_h \bullet \vec{V}$ the divergence term. The derivative of pressure p is sought for the vorticity equation and then combined with the continuity equation to determine:

$$f\frac{\partial^2 \omega}{\partial p^2} = \frac{\partial}{\partial t}\left(\frac{\partial \xi}{\partial p}\right) + \frac{\partial}{\partial p}\vec{V} \bullet \nabla_h \xi + \beta \frac{\partial v}{\partial p} \quad (2)$$

$f\frac{\partial^2 \omega}{\partial p^2} \propto -\lambda \omega$ is easily obtained from the ω equation, in which λ is a positive constant. It can been seen that the change of λ is determined by the terms changing on the right side of Eq. (2), in which $\frac{\partial}{\partial t}(\frac{\partial \xi}{\partial p})$ is the term of local change of vertical vorticity gradient, reflecting that the sum variation of vorticity equation changes with the height. $\frac{\partial}{\partial p}\vec{V} \bullet \nabla_h \xi$ is the term of relative vorticity advection change varying with height; if there is significant negative vorticity advection ($-\vec{V} \bullet \nabla_h \xi < 0$) in the high altitude, it will result in $\frac{\partial}{\partial p}(\vec{V} \bullet \nabla_h \xi) < 0$, $\omega > 0$ and sinking motion. Conversely, if there is significant positive vorticity advection ($-\vec{V} \bullet \nabla_h \xi > 0$) in the upper level, it will lead to $\frac{\partial}{\partial p}(\vec{V} \bullet \nabla_h \xi) > 0$ and ascend motion ($\omega < 0$).

In the discussion of diabatic heating effect for the atmosphere, a thermodynamic equation is used for the reversed calculation, as follows:

$$\frac{1}{Cp}\dot{Q} = \frac{\partial T}{\partial t} + \vec{V} \bullet \nabla_h T + \left(\frac{\partial T}{\partial p} - \frac{RT}{PCp}\right)\omega \quad (3)$$

3 DROUGHT AND FLOOD DISTRIBUTION AND CIRCULATION FEATURES IN 1998 AND 2006

In order to determine whether 1998 and 2006 are the extreme drought and flood year, the method reported in Zhang et al.[23], namely, the Z index method, is employed to grade the droughts and floods standard with the formula below:

$$Z_i = 6/c_s(c_s/2 \times Y_i + 1)^{1/3} - 6/c_s + c_s/6 \quad (4)$$

where $Y_i = \frac{x_i - \bar{x}}{\sigma}$, x_i is the rainfall of one year, $\bar{x}$ the calendar year average, σ the standard deviation, and c_s the coefficient of skew, i.e., $c_s=\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^3/\sigma^3$. According to Zhang et al.[23], the grade standards of droughts and floods applied to the SCR are obtained. The calculated results are shown in Fig. 1, which demonstrated that the western highlands of Sichuan, Sichuan-Chongqing basin, and Hubei area reach the degree of floods (Fig. 1a). Especially, the Z index is larger than 1.65 in parts of the western highlands and basin of Sichuan, the maximum Z index is 3.5 and 2 respectively, reaching the highest level of extreme floods. The Z index reaches the level of drought in most places of the SCR in 2006 (Fig. 1b), which was already up to the highest level of drought. Obviously, there are significant differences between the distribution of droughts and floods in 1998 and 2006. In addition, analysis showed that the 2006 drought index of SCR is historically largest among recent decades and becomes an extreme drought year according to Zhang et al.[23]. On the contrary, 1998 is the extreme flood year, in which the partial flooding index peaks in the historical record. It is not difficult to find that 1998 and 2006 are the years of extreme weather in recent decades.

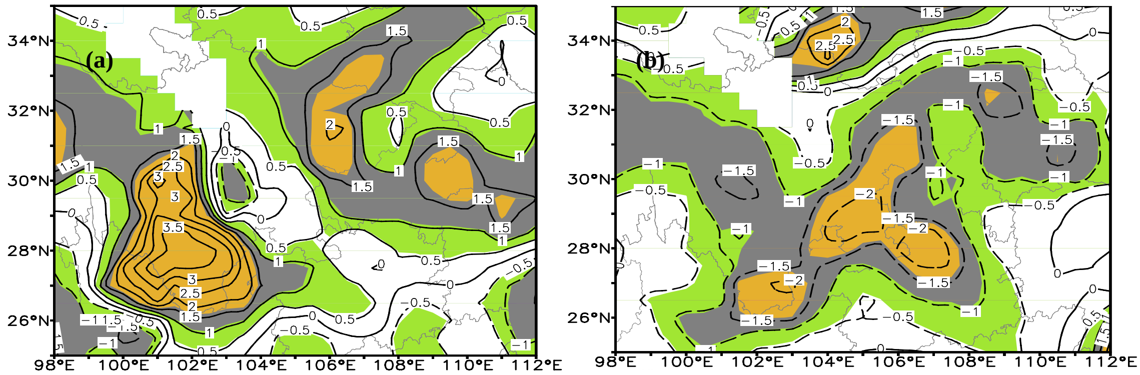


Figure 1. Spatial distribution of the Z Index for midsummer rainfall in (a) 1998 and (b) 2006. $|Z| > 0.55$ in the shades.

Work has been done in the past to study these two extreme years from different angles. What makes us more interested is the role of SAH in the extreme droughts and floods in SCR, because the SAH is a center of summer upper-level atmospheric circulation. In order to analyze the problem, distributions of SAH and its mid- and lower-level flow fields were further analyzed, as shown in Figs. 2 and 3. Fig. 3 shows the comparison between simulated and measured wind speeds at a wind measurement tower located in Paiya Mountains. The simulated wind profile displays logarithmic characteristics at the surface layer and provides wind speeds generally similar to measured data at different elevations for both point of simulation time.

It can be seen from Fig. 2 that there are some differences between the configuration of the SAH and West Pacific subtropical high (referred as to "WPSH" hereafter). For example, the geopotential height of SAH center in 1998 is as much as 1688 dagpm (Fig. 2a) and located west of 90°E, the ridge line is located near 30°N, which is a little more southward than the average. The SAH in middle and high latitudes of southern Asia is basically a positive anomaly area and located north of 50°N. The WPSH showed a westward extending trend (Fig. 2c) and the westernmost ridge point is located in the vicinity of 110°E and a positive anomaly area is mainly located in the middle and high latitudes. Another example showed that the geopotential height of SAH center in 2006 is as much as 1684 dagpm (Fig. 2b) and the easternmost point of the ridge is above Chongqing. Both Sichuan and Chongqing are located in the area of a high-pressure center. The ridge lies near 34°N, which is more northward than the average position. The positive anomaly is located around the vicinity of 30°–50°N. The 588 dagpm line of WPSH (Fig. 2d) is located on the eastern coast of China with the bulk showing a trend of shifting northward, and positive anomaly prevailing over the SCR and mid-latitudes is not conducive to the development of rainfall. The difference between the upper-level and low-level flow fields is shown in Fig. 3.

Figure 3 shows that, above 100 hPa, there is a cyclonic anomaly circulation (a flood year) between 30°N and 40°N with the center in the Inner Mongolia Autonomous Region and North China area (Fig. 3a). An anticyclonic anomaly circulation exists in the south of the Qinghai-Tibetan Plateau at 30°N, indicating that a stronger SAH is located in the vicinity of South Asia. Besides, affected by a northwest flow at the periphery of two anomalous circulations, the SCR is located in a negative vorticity area. Contrary to the flood year (Fig. 3a), an anti-cyclonic anomaly circulation forms in 35°–45°N and the cyclonic anomaly circulation is south of 35°N in the drought year (Fig. 3b), indicating that the SAH divergence is weaker than the perennial value and SCR is mainly affected by easterly winds. At 500 hPa, the flow field and the vorticity distribution are similar to that at 100 hPa. In the flood year (Fig. 3c), the SCR is affected by cyclonic anomaly circulation. South of 25°N is anticyclonic anomaly circulation, which is related to the southward location of the WPSH. In the drought year (Fig. 3d), the SCR is with the anticyclonic circulation. At 700 hPa in the flood year (Fig. 3e), from North China to the Yangtze River region is a positive vorticity area, while the SCR is in an area of air flow intersection, conducive to rainfall owing to the influence from both a southwesterly flow at the periphery of the low-latitude western Pacific subtropical high and a northerly flow at the periphery of a northern anomalous cyclone moving to the south. In the drought year (Fig. 3f), the Mongolia area is controlled by a high-pressure anomaly circulation, while the SCR is subjected to the peripheral northeast airstream and accompanied with negative vorticity. The negative vorticity area corresponds to the area of serious drought and the southwesterly airflow is more southward.

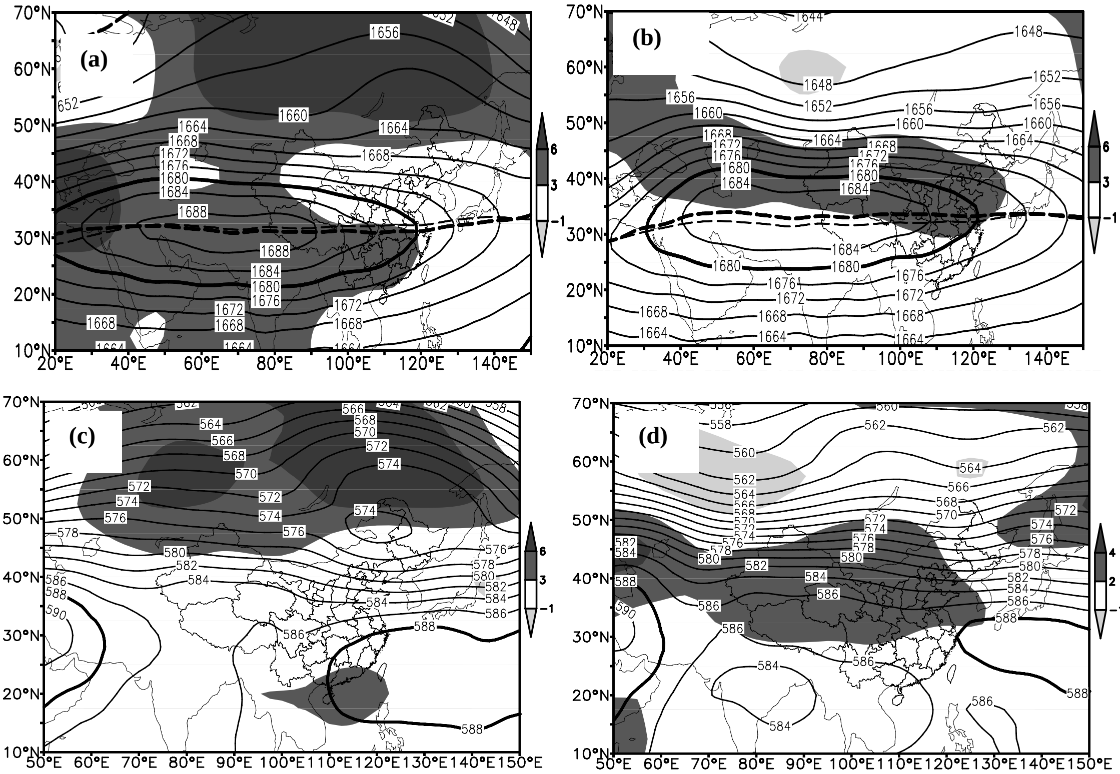
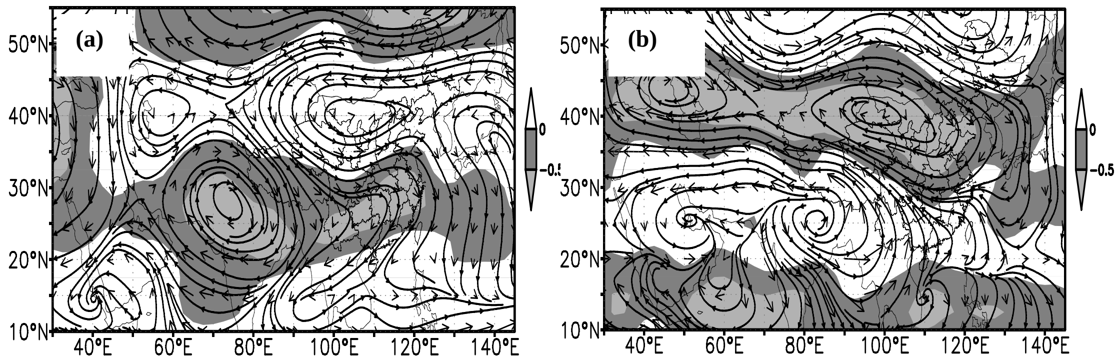


Figure 2. Distributions of geopotential height field and anomaly field for mid-summer in 1998 (a, c) and 2006 (b, d). (a, b): 100 hPa; (c, d): 500 hPa. Shades: height anomaly value, unit: dagpm; Note: The coarse (fine) dashed lines in (a, b) are the ridges (multi-year average) of SAH in flood and drought years.



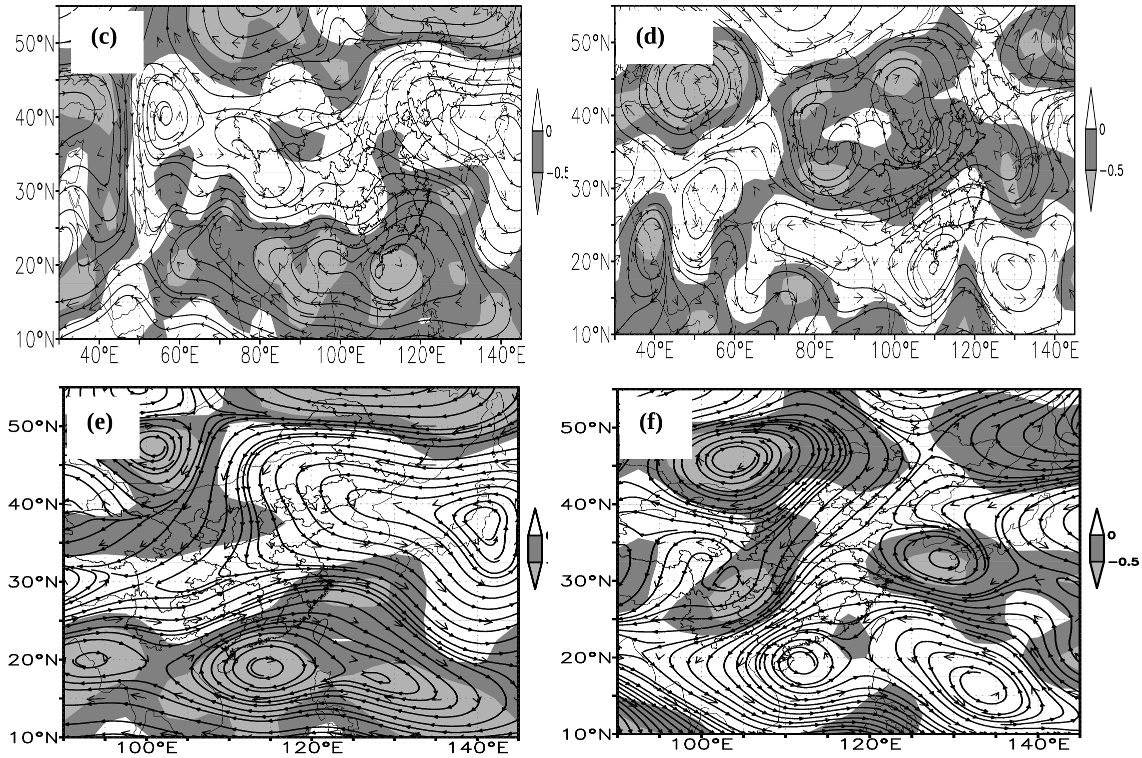
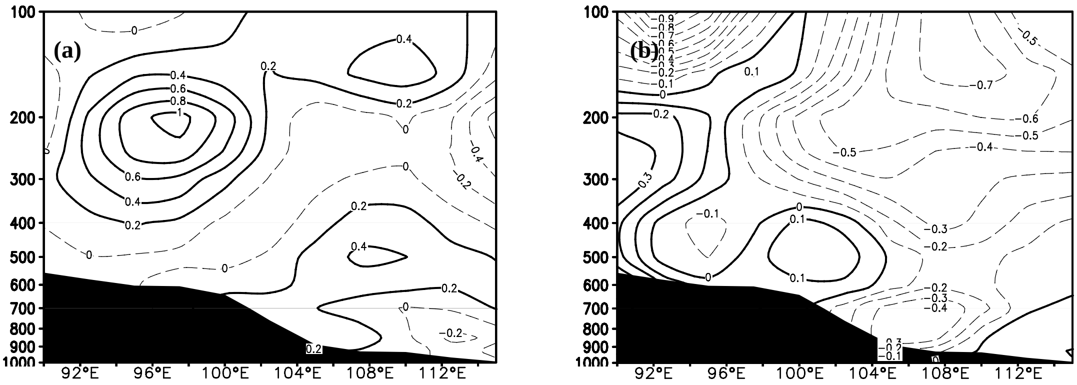


Figure 3. Anomaly fields and distributions of vorticity at different heights in abnormal years and multi-year average of 1998 at 100 hPa (a), 500 hPa (c), and 700 hPa (e), and those of 2006 at 100 hPa (b), 500 hPa (d), and 700 hPa (f). Shades: negative vorticity, units: $10^{-5}s^{-1}$; wind speed unit: m/s.

4 DYNAMIC AND THERMODYNAMIC CHARACTERISTICS OF EXTREME DROUGHT AND FLOOD YEARS

Obviously, the flow field of the two extreme years is different. Strong divergent circulation areas of SAH are mainly concentrated in the south of 30°N. At lower layers of SCR there is positive vorticity anomaly and the southwest wind is strong in the flood year. Weak divergent circulation areas of SAH are mainly concentrated south of 35°N, while the SCR shows negative vorticity anomaly and northeasterly wind in the drought year. In the allocation of physical quantities, the lower layer of the flood years is of positive vorticity whereas the upper layer is of negative vorticity. The situation for drought years is the opposite from flood years. Wu et al.[10] demonstrated that the subtropical high variability is related to the change of negative vorticity in the dynamic action. In order to analyze the possible reasons for this circulation difference, the vorticity equation is employed for the analysis. First, each term of the vorticity equation is calculated for the selected drought and flood years, and then for a multi-year mean field, and finally average anomalies are obtained, and the results are shown in Fig. 4.



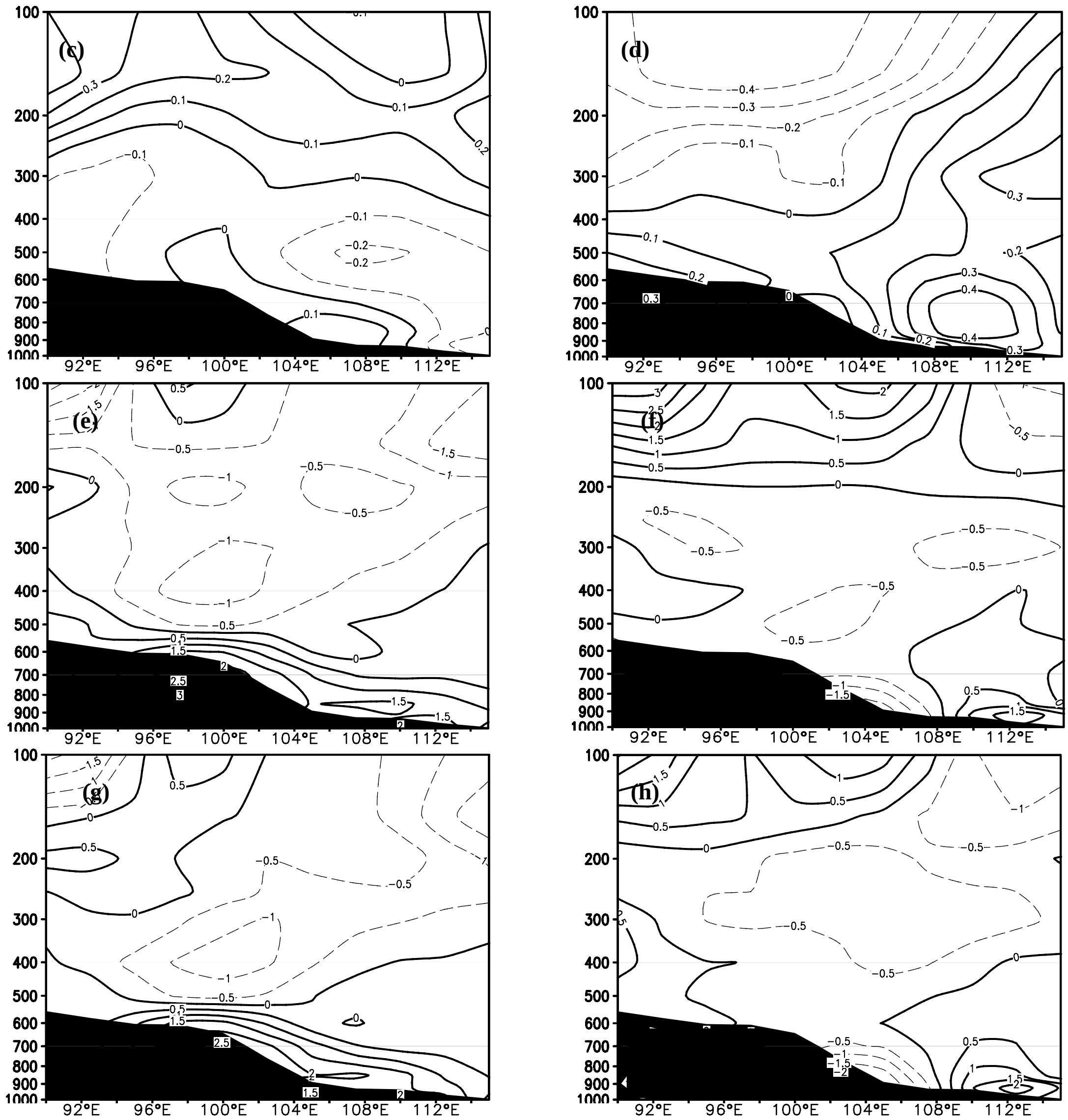


Figure 4. Variations of differences of each term of the vorticity equation along the 30°N section in 1998 (a, c, e, g) and 2006 (b, d, f, h) wherein (a, b) are for $-\vec{V}\bullet\nabla_h\xi$, (c, d) for $-\beta v$, (e, f) for $-f\nabla_h\bullet\vec{V}$, and (g, h) for $\frac{\partial\xi}{\partial t}$. Unit: $\times10^{-10}s^{-2}$; shades stand for the terrain. The ordinate is for the pressure (units: hPa).

Figure 4 shows that there exist significant differences in the changes of each physical term in the vorticity equation. For the flood years (Fig. 4a, 4c, and 4e), the upper layer between 300 and 100 hPa has positive vorticity advection, with one center located in the layer of 200 hPa near 95°E, reaching the value of $1\times10^{-10}s^{-2}$, another center locates in the layer of 150 hPa near 110°E, reaching the value of $0.4\times10^{-10}s^{-2}$. In the mid- and lower-layer, SCR is of positive vorticity advection, which reaches $0.4\times10^{-10}s^{-2}$ at 500 hPa near 108°E. These results indicated that the mid- and upper-layer vorticity advection of SCR increases with height, which is beneficial to the development of the vertical upward movement. In addition, the center distribution of the positive vorticity advection is highly consistent with the height of SAH. It can be seen from the distribution of geostrophic vorticity advection ($-\beta v$) (Fig. 4c) that it is positive above 300 hPa, with the center being more than $0.4\times10^{-10}s^{-2}$ at 200–100 hPa; it is negative between 600 and 300 hPa but positive in the lower layer of 700 hPa. These results indicate that the mid- and lower-layer has larger vertical wind shear, which promotes the vertical upward movement. At the same time, these results can be illustrated by $\beta\frac{\partial v}{\partial p}\propto-\lambda\omega$ in Eq. (2). Further, it can be obtained from the divergence term (Fig. 4e) that when $-f\nabla_h\bullet\vec{V}<0$, it is divergence and when $-f\nabla_h\bullet\vec{V}>0$, it is convergence. It is clear that the term is negative in layers above 500 hPa, and the center is located near 100 hPa with value more than $-1.5\times10^{-10}s^{-2}$, indicating that the divergence of the

SAH is strong. It is positive in layers below 500 hPa, and the center is located between 105°–114°E with the value at $1.5\times10^{-10}s^{-2}$, which is beneficial to the convergence of the low-layer flow field and the formation of upper-layer divergence and low-layer convergence.

For the drought year (Fig. 4b, 4d, 4f), Fig. 4b shows that the whole atmosphere is of negative vorticity advection near 102°–110°E, the center is $-0.7\times10^{-10}s^{-2}$ and located the layer of 200–100 hPa. The negative vorticity advection is beneficial to the vertical sinking motion. The geostrophic vorticity advection is negative over the plateau (Fig. 4d), with the center being $-0.4\times10^{-10}s^{-2}$ while it is positive at 108°–112°E below 400 hPa, indicating the presence of a large low-layer northerly wind component. On the other hand, the mid- and lower-layer vertical wind shear is not obvious, which is not beneficial to the ascending motion. Divergence distribution (Fig. 4f) also shows that above 200 hPa it is positive and has opposite impact on the development of SAH circulation. For layers below 200 hPa till the surface, it is negative in the whole SCR and the center is located at 104°–106°E with a value of $-1.5\times10^{-10}s^{-2}$, which indicates strong divergence in the mid- and lower-atmosphere. Besides, the divergent circulation is relatively weak at the upper layer of SAH compared with normal years, which is beneficial for the development of descending air motion.

Overall, the combined effect of the various physical quantities on the vorticity changes are as follows: the low layer experiences positive vorticity changes while the mid- and upper-layer goes through negative ones in the SCR in the flood year (Fig. 4g); the vorticity changes are just the opposite in the drought year (Figure 4h). There exist significant differences in the distribution of the high and low layer. This physical configuration has an important role in the formation of the two extreme drought and flood years. This is the explanation only in terms of dynamic characteristic.

For the SAH, thermal effect is also very important. In the following section, temperature advection and diabatic heating will be discussed further. Similarly, the distribution of element field values of the abnormal years and that of the multi-year average are calculated, and then the anomaly difference is obtained. The results are shown in Fig. 5.

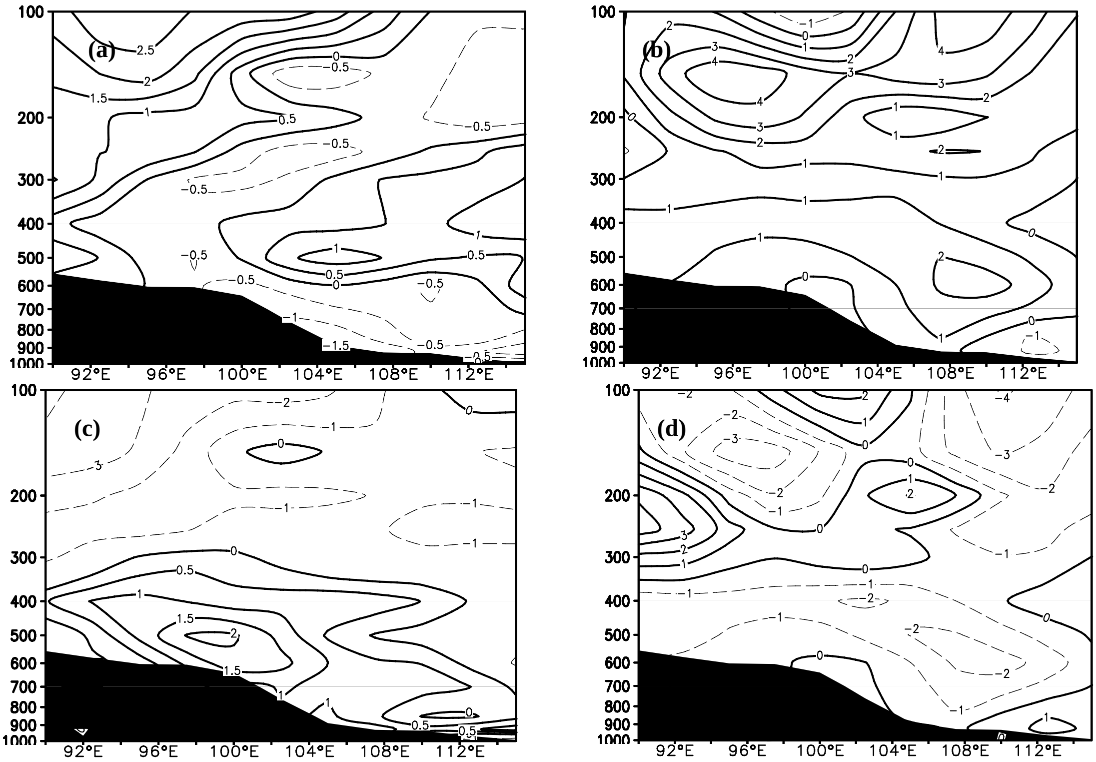


Figure 5. Variations of differences of temperature advection and non-adiabatic heating effect along the 30°N section in 1998 (a, c) and 2006 (b, d), wherein (a, b) are for $-\vec{V}\bullet\nabla_h T$ and (c, d) are for $\frac{1}{Cp}\dot{Q}$, with the unit of $\times 10^{-5}$ °C/s; shades stand for the terrain. The ordinate is for the pressure (units: hPa).

As can be seen in Fig. 5, in the flood year, warm advection is mainly west 104°E while cold advection is east of 104°E above 200 hPa, and warm advection is above 400–600 hPa while cold advection is from 600 hPa to the surface. The vertical distribution of temperature advection is beneficial to the mid-layer atmosphere (103°–108°E) to produce heat for the ascend motion. The cold advection from the low layer to the ground can provide cold air conditions to trigger the precipitation. For the diabatic heating terms (Fig. 5c), it is positive in the Tibetan Plateau and the area to the east below 400hPa, which is a heat source with the center reaching 2×10^{-5} °C/s. A cold source is above 400 hPa and the values reaches -3×10^{-5} °C/s at 100 hPa. According to Ding[22] and Zhang and Liu[23], the following equation can be obtained:

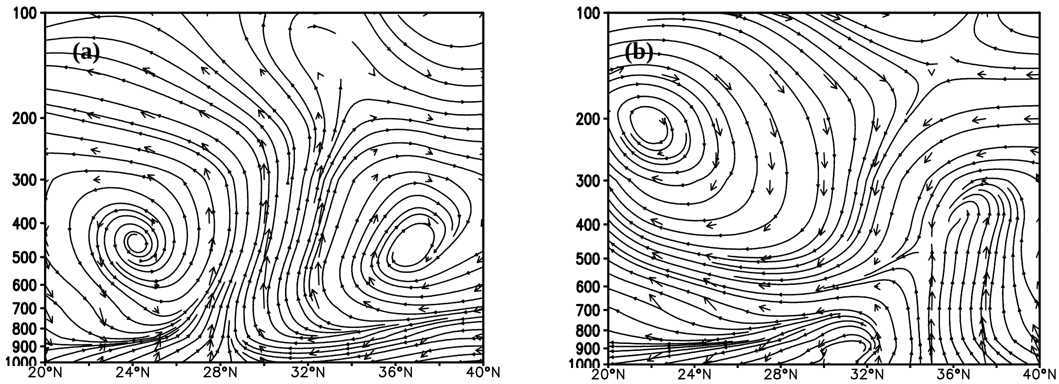
$$\frac{\partial \zeta_{go}}{\partial t} = -\vec{V}\cdot\nabla\zeta_{gu} - \frac{R}{f}\ln\frac{P_0}{P}\nabla^2[-\overline{\vec{V}\cdot\nabla T} + \overline{(\gamma_d-\gamma)\omega} + \frac{1}{c_p}\overline{\frac{dQ}{dt}}] \quad (5)$$

It can be shown that the diabatic term $-\frac{R}{f}\ln\frac{P_0}{P}\nabla^2(\overline{\frac{1}{c_p}\frac{dQ}{dt}})$, in the heat source region $\frac{dQ}{dt}>0$, there have $\nabla^2(\overline{\frac{1}{c_p}\frac{dQ}{dt}})<0$, which is beneficial to the development of cyclones. Oppositely, the cold source areas are benefit to the development of anti-cyclones.

It can be concluded that the vertical distribution of the diabatic heating is beneficial to the formation of anti-cyclonic anomaly circulation for the upper layer and the formation of cyclonic anomaly circulation for the low layer in the SCR.

For the drought year (Fig. 5b) the sky of the Tibetan Plateau is deep warm advection with the center located between 200–100 hPa with value of 4×10^{-5} °C/s. The warm advection is beneficial to the thermal expansion of the upper atmosphere to produce heat sinking. The non-adiabatic term (Fig. 5d) also shows that one part of Tibetan Plateau (90°–110°E) is the cold source area of the 400-hPa layer, while the other part (100°–108°E) is the heat source of the 100-200 hPa layer. The non-adiabatic distribution in the lower layer is of great benefit to the formation of anti-cyclonic anomaly circulation. In the middle and high layer, a cyclonic anomaly circulation forms at 100°–108°E.

It can be seen that the configuration of dynamic and thermodynamic difference is conducive to the occurrence of the two extreme drought and flood years. The abnormal SAH circulation will cause the difference in the horizontal distribution of dynamics and thermodynamics and the vertical structure, and lead to the change in vertical movement through vorticity advection and divergence convergence, as well as diabatic heating. That is to say, in the flood year, the anomaly circulation of SAH is divergent while the mid- and lower-layer is convergent, which is conducive to causing vertical ascending motion; in the drought year, the anomaly circulation of SAH is convergent while the low layer is divergent, which contributes to the sinking movement. This well explains the relationship between the two extreme years with the upper-layer SAH. The vertical circulation cross-section along 102.5°–107.5°E, 27.5°–32 .5°N is investigated, as shown in Fig. 6. In the flood year (Fig. 6a), near 26°–32°E is of updraft, and two vertical anomaly circulations exist in the south of 28°N and north of 32°N respectively. The two vertical circulations result in upward motion in the mid- and lower-layer, divergence in the upper-layer flow, and upward motion in the latitudinal direction (Fig. 6c). In the drought year (Fig. 6b), sinking motion exists near 28°–32°N and vertical circulation occurs near 200 hPa, which is conducive to upper-layer convergence and low-layer divergence and gives rise to the sinking motion; sinking motion is in the latitudinal direction (Fig. 6d). It is obvious that the vertical anomaly circulation of the SCR is significantly different in 1998 from that of 2006. The generation of this vertical circulation difference is caused by the configuration of SAH and low-layer systems.



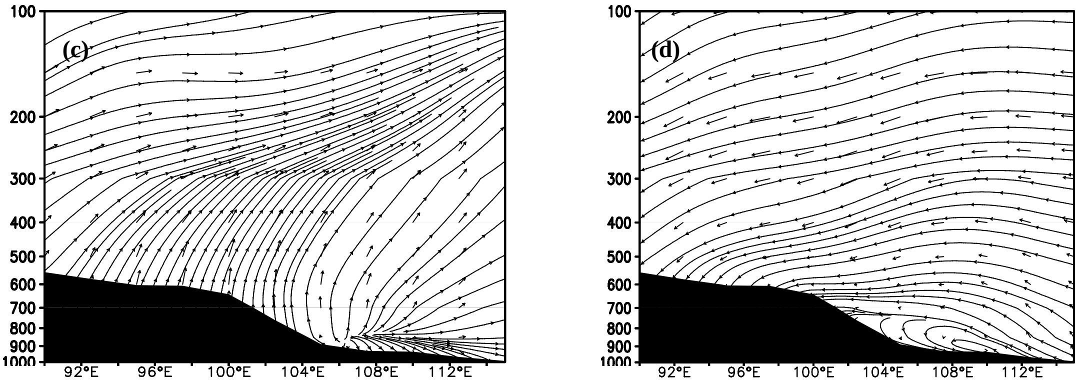


Figure 6. Vertical anomaly circulation section along 102.5°-107.5°E, 27.5°-32 .5°N. 1998: (a), (b); 2006: (c), (d). Shadow: terrain. The ordinate is for the pressure (units: hPa).

5 CONCLUSIONS

This paper takes for example two extreme years, 1998 (flood year) and 2006 (drought year), in the SCR to discuss the role of the SAH in the two extreme years. Preliminary conclusions are drawn as follows:

(1) The SAH ridge line is southward in the flood year while being northward in the drought year. From the view of anomaly flow field, the area of SAH divergence is mainly concentrated in the south of 30°N in the flood year, that is to say, the main body of SAH is southward. The SAH divergence is weak in the south of 35°N in the drought year, mid-latitude regions have significantly divergent circulation. Corresponding to these changes in the characteristics of the low-layer, the subtropical high is southward and the southwest wind is strong in the flood year in the SCR, while the subtropical high is northward and the northeast airflow prevails in the SCR in the drought year.

(2) Differences in dynamic characteristics demonstrate that the difference in relatively negative (positive) vorticity advection of high-layer atmosphere will cause the atmosphere to produce descending (ascending) motion in drought (flood) years. The SAH anomaly circulation shows the performance of convergence (divergence), corresponding to divergence (convergence) characteristics of the lower flow field.

(3) As shown in the differences of thermal characteristics, the low layer of the SCR is characteristic of warm (cold) advection in the drought (flood) year. The mid- and low-altitudes have the negative (positive) adiabatic effect while high-altitudes have the positive (negative) one. Such vertical structure of adiabatic effects is conducive to the formation of anti-cyclonic (cyclonic) circulation in low layer and the formation of cyclonic (anti cyclonic) circulation in the upper-layer.

(4) Both the dynamic and thermal effects are realized by the variation of vertical movement to change the high and low layer system. For the flood years, the dynamic and thermal effects are conducive to the ascending motion. For the drought year, they are conducive to the descending motion. In a sense, the vertical velocity change is a "link" contacting the interaction between SAH and low-layer circulation. The formation of the two drought and flood years in SCR should be realized by the divergence (convergence) which results from the disturbance between SAH and lower atmospheric. However, it is worth noting that the above analysis only focuses on the two extreme years of 1998 and 2006. Whether the vertical motion change caused by the configuration SAH and low-layer system is one of the physical reasons for the formation of droughts and floods in SCR should be further investigated with more examples.

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