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DIAGNOSES OF THE SEVERE DROUGHT OVER YUNNAN AREA IN THE EARLY SUMMER OF 2005

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Abstract: High temperature and drought occurred in Yunnan province during the late spring and early summer in 2005, which was the most severe event in this region since 1950's. Based on the observational data and relevant diagnoses, this extreme weather event was studied and discussed. The results show that the occurrence of this event could be due to the following observational facts that happened in 2005. (1) The seasonal adjustment of middle-high-leveled atmospheric circulation was delayed. (2) The cold air activity center was deviated north. (3) The onset of summer monsoon over South China Sea was delayed. (4) The tropical convection activity was much weaker than usual. (5) The subtropical high over the western Pacific was located southwestwards and relatively strong.

Key words: Yunnan; high temperature and drought; summer monsoon of South China Sea subtropical high; tropical convection

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1 INTRODUCTION

Drought is the most severe meteorological disaster in Yunnan province. It often occurs not only in Yunnan but also across China. Drought occurs almost every year in Yunnan, although in different time and with different strength level. In particular, the drought appearing in early summer affects Yunnan more, yet many studies focus on the precipitation in Yunnan during early summer [1 - 7]. In 2005, a weather of high temperature and drought occurred in Yunnan province during the late spring and early summer (Apr.1 to Jun.10), and it is the most severe one in this region since the 1950's. Because of continuous high temperature and little rain at that time, the production of industry and agriculture, and also everyday life, were affected gravely, leading to a lot of economic loss. Therefore, it is very necessary to study atmospheric circulation and the various physical signal of the late spring and early summer in 2005. The analysis will help to improve the forecasting of short-term climate in the late spring and early summer in Yunnan.

2 DATA

The datasets used in this study are include (1) Daily Precipitation and temperature recorded by Kunming station between Apr.1 and Jun.15, from 1951 to 2005, (2) Daily precipitation and temperature recorded by 124 stations in Yunnan province between Apr.1 and Jun.15, from 1961 to 2005, (3) NCEP/NCAR reanalysis datasets on a 2.5°×2.5° grid from 1951 to 2005, (4) NOAA OLR datasets from 1979 to 2005, and (5) *Climate System Monitor Notice*[8] and *East Asia Monsoon Monitor Briefing*[9] by National Climate Center in 2005.

3 DROUGHT OBSERVATIONS

3.1 Precipitation

The precipitation which was recorded by the 124 stations around Yunnan and averaged from Apr.1 to

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Jun.10 in 2005, decrease by 20% – 80% as compared to the same period in earlier years. There are 99 stations, corresponding to 79.8% of the area in Yunnan, with the precipitation reduced by more than 20%; and 51 stations, 41.2% of the area, by more than 60%. The rain days recorded by Kunming station from May 1 to Jun. 15, in which the precipitation was greater than 10 mm, are only two (Fig.2c). Fig.1 denotes rainfall anomalies of 124 stations averaged from Apr.1 to Jun.10 (1951 – 2005). It can be seen from Fig.1 that in the 1960's, the late 1980's and the early 1990's there appeared more drought, while from the mid-1970's to the early 1980's, and from the late 1990's to the beginning of the 21st century, there was relatively more rain. The negative rainfall anomalies during the late spring and early summer in 2005 is the maximum in the history with record. In the same time it did not rain for a very long time. They are both rare in the meteorological history of Yunnan. The coverage, intensity and sustaining time of Yunnan drought disaster in 2005 have all broken historical records. The drought in 2005 is the No.1 during the past 55 years in Yunnan province.

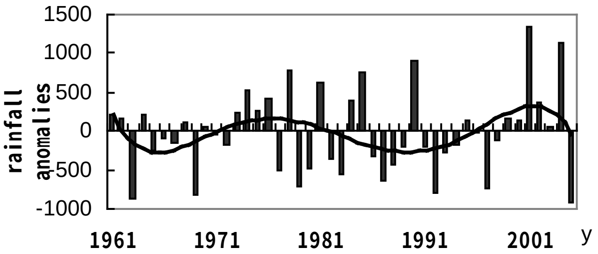

Fig.1 Rainfall anomalies for 124 stations in Yunnan for the period Apr.1 – Jun. 10 from 1961 to 2005. The columns are for rainfall anomalies and curves for the tendency. Unit: 0.1 mm.

3.2 Temperature

The temperature anomalies from the 124 stations in Yunnan, which is averaged from Apr.1 to Jun.10, 2005 increase by 0.5 – 2.0°C as compared to the same period in the history (figures not shown). There are 73 stations, corresponding to 58.9% of the area in Yunnan, with temperature anomalies increased by 1°C, among them 5 stations show temperature anomalies increased by 2°C, such as Kunming. Meanwhile, 24 stations, corresponding to 19.4% of the area, show temperatures that breaking historical record in the same period. In May, the days with temperatures exceeding 40°C in Yuanyang county and Yuanjiang county are 14 and 13, respectively. Especially, on May 17th, the temperature of 43.2°C in Yuanyang had broken the temperature record of Yunnan province. And 14 stations showed monthly averaged temperatures breaking the record of local history in May.

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

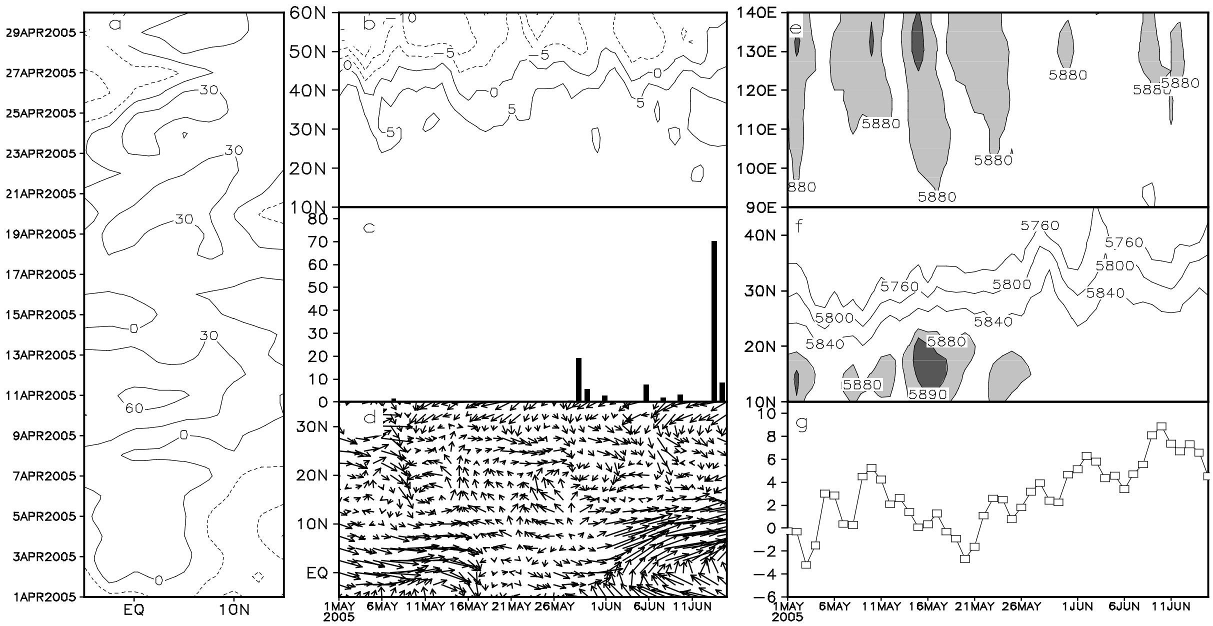

Fig.2 Different factors affecting the precipitation of Yunnan in early summer 2005. a. time-latitude cross sections of the OLR field anomalies averaged over 85 – 100°E from Apr.1 to 30; b. time-latitude cross sections of 700-hPa temperature averaged over 90 – 110°E from May 1 to Jun.15; c. Daily precipitation of Kunming from May 1 to Jun.15; d. time-latitude cross sections of the 850-hPa wind field averaged over 50 – 60°E from May1 to Jun. 15; e. time-latitude cross sections of the 500-hPa height field at 10°N from May1 to Jun. 15. f. time-latitude cross sections of the 500-hPa height field at 110°E from May1 to Jun. 15; g. Evolution of the 850-hPa zonal wind in the area of South China Sea from May1 to Jun. 15.

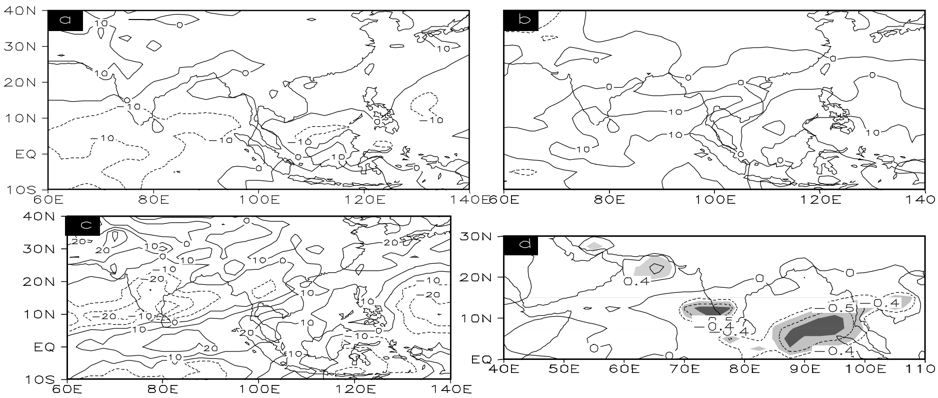

Fig.3 OLR mean anomalies of Apr. combined with more rain years in early summer of Yunnan(a), OLR mean anomalies of Apr. combined with less rain years in early summer of Yunnan(b), long term mean of April OLR anomalies(c), correlation between April OLR anomalies and rainfall combined with May and June of Yunnan province (d).

4 CAUSE OF THE DROUGHT

4.1 Characteristics of Atmospheric circulation

The monthly mean height field of 100 hPa (figure not shown) in May, 2005 shows that the center of the South Asia high was located southwards and relatively weak, and the westerly jet axis laid to the south of 40°N. This means that the South Asia high did not set up over Qinghai-Tibet Plateau and that the seasonal adjustment of mid- and high- level atmospheric circulation was delayed. In the monthly mean height field of 500 hPa (figure not shown) in May 2005, the polar region was controlled by positive height anomalies, and the atmospheric circulation of middle latitudes was flat and the cold air activity was weak. The changes of the subtropical high from June 2004 to May 2005 were analyzed, which showed that the indices of the area and the strength of the subtropical high were both continuously strong. In the latitude-time cross-sections of 700-hPa averaged over the area 90 – 110°E from May 1 to June 15 in 2005 (Fig.2b), the 0°C line laid to the north of 40°N almost from May 1 to June 15, so the activity of low-latitude cold air was also weak. Therefore, the direct cause of the drought of Yunnan province in 2005 is the subtropical high, which controlled Yunnan province (Fig.2f) and cut off the moisture transportation from the south to it.

4.2 Summer monsoon of South China Sea

Whether the establishment of the summer monsoon of South China Sea is early or late is closely correlated to the floods and droughts in China [10 - 13]. From the South China Sea (10 – 20°N，110 – 120°E）monitor by National Climate Center[9] and time series of zonal wind averaged over the area from 10 – 20°N to 110 – 120°E at 850 hPa (Fig.2g) and time series of θ se from May 1 to June 15 in 2005, it can be seen that summer monsoon of the South China Sea did not set up steadily till the 6th pentad of May. From the height field of 200 hPa in May 2005, it can be seen that from the first pentad to the second pentad the center of the South Asia high was over the Pacific and the westerly wind controlled the South China Sea; then in the fourth pentad weak easterly wind appeared over the South China Sea and the situation had been maintained to the 5th pentad; and lastly in the 6th pentad the center of the South Asia high moved over the Indochina Peninsula near 20°N and the easterly wind shifted to north-easterly wind over the south China Sea, which showed that seasonal shift completed and summer monsoon of the South China Sea set up completely. The time of seasonal shift was later by about 10 days than that of the same historical period.

From the time series between the onset pentad of summer monsoon of the South China Sea and beginning pentad of rainy season in Yunnan from 1953 to 2005 (figure not shown), it can be seen that the onset time of summer monsoon of the South China Sea is earlier by 1-2 pentads than beginning time of rainy season in Yunnan. The fact is useful to forecast the beginning time of rainy season in Yunnan. On the decadal variation, there is a good correspondence between the onset of summer monsoon of the South China Sea and beginning of rainy season in Yunnan, especially in early 1970’s and in late 1990’s. The correlation coefficient between onset of summer monsoon of the South China Sea and beginning of rainy season in Yunnan from 1953 to 2005 is as high as 77%. The result shows that moisture transportation is from the South China Sea to Yunnan province in early summer in most years.

4.3 Convection and moisture transportation

From April to May in 2005, convection activity near the equator in south of the Bay of Bengal was much different from that of the same historical period. Strength of convection activity was very weak (Fig.2a) and lasting time of convection activity was short and convection activity can not spread northwards and neither did convection activity of the Bay of Bengal. From the correlation coefficient between monthly OLR anomalies in April and monthly precipitation of Yunnan averaged from May to June in 1979 – 2005(Fig.3d), it can be seen that there was a good negative correlation between OLR anomalies in the south of the Bay of Bengal and precipitation of Yunnan in early summer and correlation coefficient was up to -0.55 (significance at 99% level, Fig.3d). The result showed that rainfall of Yunnan in early summer is closely related to the strength of convection activity in the south of the Bay of Bengal. From the OLR mean field in April combined with OLR in April of some years (Fig.3a), in which it was more rainy than ever in Yunnan province from May to June, it can be seen that negative OLR anomalies controlled the south of the Bay of Bengal. The result showed that convection activity was strong in the south of the Bay of Bengal and moisture was easy to transport northward. On the contrary, if it was less rainy in some years than ever in Yunnan province from May to June, positive OLR anomalies controlled the south of the Bay of Bengal (Fig.3b), convection activity was weak and moisture was not easy to transport northward. The mean OLR field in April 2005 (Fig.3c) was the same as that in Fig.3b. The result shows that convection activity in the south of the Bay of Bengal was also weak in April 2005. The Somali south-westerly jet set up in the first pentad of June in 2005 (Fig.2d), but because the subtropical high over the west Pacific and subtropical high over the north Africa were strong, the moisture of south-westerly jet did not transport to Yunnan province through the north of the Bay of Bengal till the 3rd pentad of June and the moisture originating from the Bay of Bengal met with cold air originated from middle-high latitude to produce heavy rain in Yunnan, as a result the drought problem of Yunnan province in early summer was completely solved.

5 CONCLUSIONS

The main causes of severe drought of Yunnan province in early summer can be summed up as fellows:

(1) Polar vortex was weak at the 500-hPa and 200-hPa height fields. The seasonal adjustment of middle- and high- level atmospheric circulation was delayed and the cold air activity center was deviated north. The subtropical high over the western Pacific was located southwestwards and relatively strong. It cut off the channel between the cold air originating from the north and the wet moisture originating from the south, leading to the drought of Yunnan province in early summer.

(2) The correlation coefficient between the onset of summer monsoon of the South China Sea and the beginning of rainy season in Yunnan province from 1953 to 2005 is high, (77%). The onset of summer monsoon of the South China Sea was late in 2005, hence the beginning of Yunnan rainy season was also late.

(3) Positive OLR field controlled the south of the Bay of Bengal in April 2005. This means that the convection activity was weak in the region and that the wet moisture was unable to be transported northward.

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

REFERENCES:

[1] LIU Yu, MA Zhen-fen, TAO Yun. Circulation characteristic analysis on earlier onset time of Yunnan's rainy season in 2002 [J]. Plateau Meteorology, 2003, 22(suppl.): 102-109.
[2] QIN Jian, JU Jian-hua, XIE Min-en. Weather and climate over low latitudes [M]. Beijing: China Meteorological Press, 1997: 51-60.
[3] QIN Jian, XIE Min-en, LIU Yu. General meteorological disasters in Yunnan province [M]. Beijing: China Meteorological Press, 2000: 16-64.
[4] LIU Yu, XIE Mini-en. Diagnosis analysis of early summer severe drought in Yunnan in 1997 [J]. Meteorological Monthly, 1998, 24(8):50-56.
[5] LIU Yu. The climatic feature analysis of Yunnan rainy season early or late onset [J]. Meteorology, 2000, 26(7): 45-49.
[6] XIE Ming-en, LIU Yu. Strong ELNO event in 1997 [J]. Journal of Tropical Meteorology, 1998, 14(2): 186-192.
[7] YAN Hua-sheng, Li Yan, YAN Hong-ming. Influence of SST variations of the tropical ocean on rainfall during the season when dryness turns to wetness in early summer in Yunnan [J]. Journal of Tropical Meteorology. 2002, 18(2): 165-172.
[8] National Climate Center. Bulletin of Climate System Monitoring, May 2005.
[9] National Climate Center. East Asia Monsoon Monitor Briefing. (6), Jun.2, 2005.
[10] WANG Li-juan, HE Jin-hai, GUAN Zhao-yong. Characteristics of convection activities over Sumatra area and its relationship with SCS summer monsoon onset [J]. Journal of Nanjing Institute of Meteorology, 27(4): 451-460.
[11] JU Jian-hua, Zhao Er-xu. Impacts of the low frequency oscillation in east Asia summer monsoon on the drought and flooding in the middle and lower valley of the Yangtze river [J]. Journal of Tropical Meteorology. 2005, 21(2): 163-172.
[12] ZHAO Zhen-guo. Summer drought and flooding of China and environmental field [M]. Beijing: China Meteorological Press, 1999: 28-50.
[13] TAN Gui-rong, SUN Zhao-bo. Relationship of subtropical high and summertime floods/droughts over North China [J]. Journal of Tropical Meteorology, 2004, 20(2): 206-212.