ATMOSPHERIC BOUNDARY LAYER CIRCULATION ON THE EASTERN EDGE OF THE TIBETAN PLATEAU IN SUMMER

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Abstract: By using radiosonde data in Sichuan Province and Chongqing Municipality of China during May- September from 1982 to 2002, the meteorological significance and evolution regularity of atmospheric boundary layer (ABL) wind on the eastern edge of Tibetan Plateau are analyzed. Results show that the ABL wind at Chengdu near the eastern edge of the Tibetan Plateau varies with regularity. Because of the interaction between the circulation and the topography, the wind field exhibits alternately northeast wind with southwest wind. When northeast(southwest) ABL winds prevail at Chengdu, the ABL in Sichuan Basin maintains a cyclonic(an anti-cyclonic) flow field, and corresponds with heavy rain(rainless, fine weather) in the Sichuan Basin. Under the special background of the northeast-southwest topography between the Plateau and the Basin, the dynamic trigger of the ABL at Chengdu is a very important cause for the occurrence and development of severe, convective weather such as heavy rain in Sichuan Basin. The Chengdu station is the key information point for weather variation in Sichuan Basin near the eastern edge of the Tibetan Plateau.

Keywords: *atmospheric boundary layer, circulation, the eastern edge of Tibetan Plateau are analyzed*

1. INTRODUCTION

The Tibetan Plateau is located in South Asia, covering more than one quarter of China, with an average altitude above 4 km. It influences the atmospheric circulation over China, Asia and even the Northern Hemisphere, and hence affects the formation and evolution of the weather and climate in these areas (Flohn, 1968; Hahn and Manabe, 1975; Yeh and Gao, 1979; Zhang et al., 1988).

The Tibetan Plateau causes confluence and convergence zones, shear lines, and the Southwest vortex, which directly influence the weather and the climate in large areas around the Plateau (Yeh, 1950; Yeh et al., 1957; Yeh and Gao, 1979). And the atmospheric boundary layer (ABL) over the Tibetan Plateau also has important effects on atmospheric variation. Yanai and Li (1994) first analyzed the mechanism of heating and the boundary layer over the Tibetan Plateau. Following their study, many works about the ABL over the Tibetan Plateau have been done (Zhou et al., 2000).

However, the Sichuan Basin lies close to the eastern Tibetan Plateau, and is surrounded by mountains. Because of the influence of steep topography, the western Sichuan basin is a pluvial region in Southwest China (Xu, 1991). Even though thermal and dynamic effects in the ABL have key influences on strong convective weather such as heavy rain in China (Tao et al., 1979; Zhao et al., 1982), the circulation of the ABL in Sichuan Basin and its influence is not well understood. Li (1995) first discovered that the ABL wind moves alternately northeast and southwest at Chengdu, in the Sichuan Basin during May-September from 1982-1986, and is closely related to the weather in the region. But, to better understand the ABL circulation and its weather significance, we used 21 years of observational data and 10 days of intensive in situ observations to characterize the ABL circulation in Sichuan Basin, and determine its influence on weather.

2. DATA AND EXPLANATION

The data are the daily observations from the Monthly Aerological Bulletin of China published by China National Meteorological Center at seven radiosonde stations in Sichuan Province and Chongqing Municipality, China, on the eastern edge of the Tibetan Plateau (Chengdu, Yibin, Dazhou, Xichang, Ganzi, Hongyuan, and Chongqing). These stations are all in operational use in China. Among them, Chengdu is an international data exchange radiosonde station of WMO, and the other six stations are the domestic data exchange radiosonde stations of China. These data are reliable and used in many studies (Liu, 1992).

3. ANALYSIS OF THE ABL WIND FIELD

We examined the horizontal and vertical distribution and variation of the ABL wind field by using daily data from the above seven radiosonde stations in Sichuan Province and Chongqing Municipality, China, on the eastern edge of the Tibetan Plateau. Data were collected daily at 2300 and 1100 UTC between May-September from 1982 to 2002. The wind vector analysis was only conducted for wind data and obtained the u and v components. Thus, we were specifically interested in the regional characteristics and the evolution of the ABL wind field and its relationship to weather in the Sichuan Basin.

3.1 ABL wind field characteristics

The variations of the ABL wind field in Sichuan Basin are the same as Li's (1995). It varies with the regional characteristics. The ABL consists of a northeast（southwest） wind at Chengdu, there is heavy rain （dry weather） in the Sichuan Basin. The ABL wind changes direction anywhere from several hours to one day before heavy rain occurs, which may be useful in predicting weather in the Basin (see also Li, 1995).

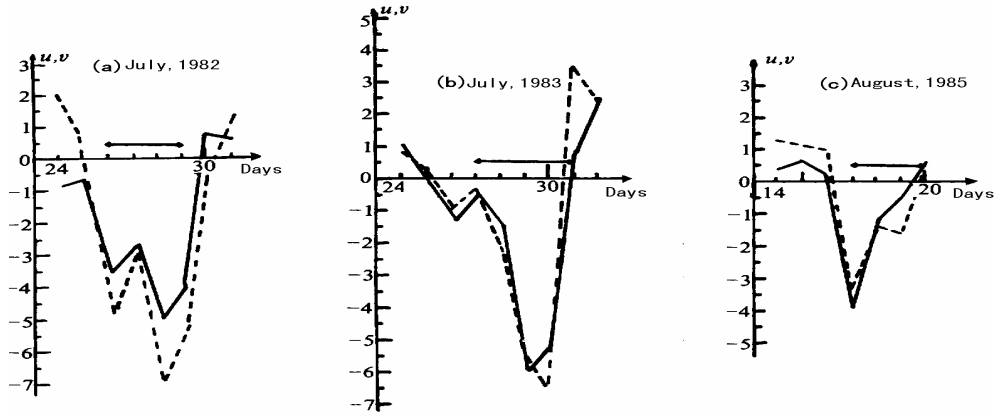

Figure 1: Variation of ABL mean wind speed at Chengdu at 2300 UTC in relation to three instances of heavy rain in Sichuan Basin (unit: m/s). Solid and dashed lines are U and V components, respectively. Line segments denote heavy rain processes.

Figure 1 shows ABL wind speed during three instances of regional heavy rain storms in Sichuan Basin. The average u and v components were 0, 300, 600, and 900 m at Chengdu at 2300 UTC (1100 UTC is similar to 2300 UTC). On 25 July 1982, 25 July 1983, and 16 August 1985, the u and v components become negative, the wind direction began to turn to northeast, and wind speed increased significantly.Anywhere from several hours to more than 40 hours later, heavy rain occurred.

During 26-29 July 1982, 27-31 July 1983, and 17-20 August 1985, the ABL u and v components at Chengdu were still less than 0, and the wind continued in a northeast direction, which corresponds with severe heavy rain processes in the Sichuan Basin. On 30 July 1982, 31 July 1983, and 20 August 1985, the u and v components became positive and the wind direction changed to the southwest. Afterwards, the heavy

rain in Sichuan Basin ended.

A composite analysis (Figure is omitted) shows that during the 92 days of summer in 1998, the composite wind field below 5000 m of the 33 rain days (27-28 June; 9-14 and 19-20 July; 1-4, 9-15, and 18-27 August) had an opposite vertical structure. During rainy (rainless) days in the Sichuan Basin, the wind field exhibits a vertical shear between a northeast (southwest) wind and a southwest (northeast) wind below 5000 m, and the northeast (southwest) wind prevails in the ABL at Chengdu.

3.2 ABL flow field characteristics

The regular change between the northeast and southwest winds in the ABL of Chengdu, and its weather significance, indicate that the two prevailing wind directions in the ABL at Chengdu represent the spatial-temporal changes of regional circulation in the Sichuan Basin.

In the summer of 1998, the ABL wind field in the Sichuan Basin exhibited clear regularity, corresponding to the ABL wind field changes at Chengdu. During rainy(rainless) periods, with an ABL northeast(southwest) wind at Chengdu, the ABL flow field in Sichuan Basin was a cyclonic(anti-cyclonic) circulation that curved along the Plateau-Basin topography. The formation, maintenance, and disappearance of the cyclonic flow field corresponded with the occurrence, development, and end of heavy rain in the Sichuan Basin. Figure 2 shows the composite structures of the ABL mean flow field in Sichuan Basin for the 33 rainy days and 20 rainless days during the summer 1998. This confirms the essential differences of the ABL horizontal flow field between the rain days and rainless days in the Sichuan Basin.

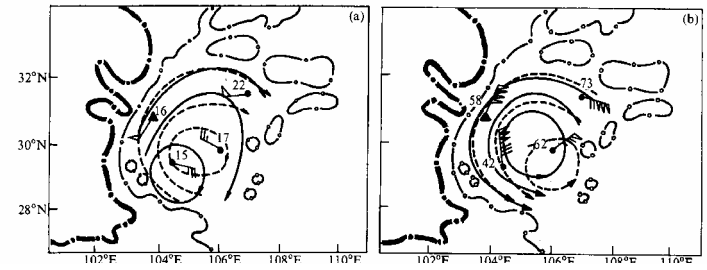

Figure 2: The distributions of ABL mean flow field for 20 rainless days (a) and for 33 rain days (b) in Sichuan Basin in the summer of 1998. Solid and dashed lines are at 2300 and 1100 UTC, respectively. The numbers beside stations are the composite wind speed at 2300 UTC, wind vectors are the composite wind speed at 1100 UTC. The thick and the thin dot-and-dashed lines are the 3000 and 1000 m isohypses, respectively. Triangle denotes the Chengdu station.

4. REASONS FOR ABL WIND VARIATION AT CHENGDU

The Sichuan Basin is located on the eastern edge of the Tibetan Plateau. It is surrounded by mountains. The mean elevation in Sichuan Basin is about 200-750 m (Xu, 1991). However, Chengdu is located on the Chuanxi Plain of the western Sichuan Basin, close to the Chuanxi mountainous region on the eastern Tibetan Plateau. The common boundary between the Basin-Plain and the Plateau-Mountain topographies runs from northeast to southwest, which can be seen along the 1000 and 3000 m topographic isohypses. Chengdu Station is just to the right of the boundary. The u and v components of ABL winds of Chengdu vary in phase, and the ABL prevailing winds are northeast and southwest, which is the result of the unique geographical environment and which indicates an interaction between the large-scale topography and general circulation.

Because of the detaining effect of the Plateau, high-latitude cold air flows around the Plateau into the Sichuan basin, moving along the eastern edge of the Plateau and entering the Sichuan Basin from the north in the low or middle levels of the troposphere. Therefore, the northeast ABL wind at Chengdu is a reflection of the cold advection invading the Sichuan Basin. But when the ABL at Chengdu consists of a southwest wind,

the Sichuan Basin is controlled by a warm air mass (no cold air outbreak) and the weather is dry in the Sichuan Basin. We believe that the alternating northeast and southwest winds in the ABL of Chengdu are the result of interaction between the topography and the circulation.

5. SIGNIFICANCE OF THE ABL WIND VARIATION AT CHENGDU

Under the unique topographical environment of the Sichuan Basin and the Tibetan Plateau, the ABL wind field at Chengdu changes regularly. When the ABL at Chengdu consists of a northeast wind, the ABL in the Sichuan Basin will be controlled by a cyclonic flow field, and will maintain convergence, positive vorticity, and ascending motion, which will cause severe convective weather such as heavy rain. When the Chengdu ABL is southwest, the ABL in the Sichuan Basin is controlled by an anti-cyclonic flow field and is in an unfavorable dynamic configuration. This causes dry weather in the Sichuan Basin.

Due to the unique northeast-southwest trending topography of the Plateau-Basin, high-latitude cold air invades the Sichuan Basin from the Chuanxi Plain through the ABL. The ABL dynamic trigger is an important mechanism for the occurrence of heavy rain in the Sichuan Basin.

6. SUMMARY AND CONCLUSIONS

(1) Due to the unique topography of the Tibetan Plateau and the Sichuan Basin, the ABL wind field at Chengdu exhibits regional characteristics. Influenced by the northeast-southwest trending topography on the eastern edge of Tibetan Plateau, the ABL exhibits alternate northeast and southwest winds. The regular variation between the two winds is the result of the interaction between the topography and the circulation.

(2) Chengdu station is a key measuring and prediction point for severe convective weather, such as heavy rain, in the Sichuan Basin. When the ABL at Chengdu consists of a northeast（southwest） wind, there will be a cyclonic（an anti-cyclonic）flow field in the ABL of the Sichuan Basin corresponding with heavy rain（dry weather）. The formation, maintenance, and disappearance of the ABL northeast wind at Chengdu predict the occurrence, development, and end of severe convective weather in the Sichuan Basin.

(3) Due to the northeast-southwest trending topography of the Tibetan Plateau and the Sichuan Basin, high-latitude cold air invades the Sichuan Basin along the Chuanxi Plain near the eastern edge of the Plateau, through the ABL. The ABL dynamic trigger is related to the occurrence and development of severe convective weather, such as heavy rain, in the Sichuan Basin.

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