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SYNOPTIC FEATURES OF THE YUNAN RAINY SEASON
BEFORE THE ONSET OF THE TROPICAL MONSOONS

by

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Chen Yuxiang Zhu Baozhen

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ABSTRACT

This article studies a special type of weather phenomenon associated with the leeward slope of the Qinghai-Tibet Plateau-- the Yunnan early rainy season. It discusses weather systems which directly create continuous precipitation as well as the special characteristics of their seasonal development. Diagnostic analysis of static energies clearly show that there are areas of difference between the Yunnan early rainy season and the arrival of the subsequent Indian monsoon with the beginning of its rainy season. It was discovered that there is a correlation between the period of the beginning of the early rainy season each year and the period of the appearance of the first storms in the Bay of Bengal. Finally, it discusses the relationships between this and seasonal changes in East Asian atmospheric circulation.

I. FORWARD

As far as monsoon phenomena which are prevalent on the continents of Asia and Africa are concerned, among them, the tropical southwest monsoons which are prevalent on the south side of the Qinghai-Tibet Plateau most attract peoples' attention. Yunnan Province is closely connected to the Qinghai-Tibet Plateau. The altitude of the majority of the land area is over 1000 meters above sea level. The topography is complicated. Famous transverse mountain ranges stretch away unbroken to the western part of Yunnan. Special geographical conditions cause the climate here to have a form all its own. Layers close to the surface of the ground see the constant blowing of southwest winds almost

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* Numbers in margins indicate foreign pagination. Commas in numbers indicate decimals.

throughout the whole year. Because of this, according to the classical concept of monsoons, one can say that Yunnan has no monsoon. However, the rain days and the amounts of rainfall in a year are both concentrated in May and October, presenting a clear dry season and wet season. This is a classical climatic characteristic of monsoons. Due to the fact that the monsoons of Yunnan do not have the special feature of an opposite shifting of average wind direction between winter and summer, it is necessary, because of this, to begin studies from seasonal changes in precipitation [1].

On the basis of data from the Yunnan Province weather bureau, normal rainy seasons all begin in the middle ten days of May [1]. This is a month earlier than the onset of the Indian tropical monsoons. This article makes a study of the subsynoptic characteristics of this phenomenon, that is, questions associated with the establishment of Yunnan rainy seasons before the onset of the tropical monsoons.

II. DEFINITION OF THE YUNNAN RAINY SEASON

The topography of Yunnan is complicated. Variations by area in the dates of the beginning of the rainy season are very great. Up to the present time, there is still no method for how to precisely fix the Yunnan rainy season which satisfies people. We recognize that, studying the rainy season in a particular area, it is necessary to carry out a comprehensive examination of precipitation in the region as a whole. On the basis of a division into climatic districts by the Yunnan Province weather bureau [2], in the area where, in terms of climate, the rainy seasons normally begin, we selected seven representative stations (Kunming, Zhaotong, Lincang, Maosi, Lancang, Mengzi, and Tengchong)--generally carrying out statistical studies of rainfall in the majority of areas east and south of the central part of Yunnan Province. For the various stations discussed above and the rain days and amounts of rainfall for April and June each year from 1975 to 1979, the calculation integral is

$$R = \int_{t_1}^{t_2} \int_1^M r(t,i)\,di\,dt \qquad (1)$$

In the equation, R is the total amount of precipitation. i /102
is the identification number of the station. t is the time or duration serial number. t_1 and t_2 are, respectively, the dates for the starting and stopping of statistics on the amounts of rainfall. r(t,i) is the 24 hour amount of precipitation. R structures associated with April and June, including the development of precipitation in Yunnan Province from winter to summer, also includes changes in Yunnan precipitation before and after the onset of the Indian monsoons. On the basis of formula (1), we made the integral curve for rainfall amounts--Fig.1. Taking it as representative, we only drew out the example for the year 1979. It is possible to see that, from the beginning of April to the middle of May, precipitation was very sparse. With the arrival of May 17th, the amounts of rainfall abruptly increase, marking the establishment of the rainy season. This date is approximately one month before the establishment of the Indian monsoons. On these dates, at the seven stations in Yunnan, the daily amounts of rainfall for the various stations, on average, all exceeded 10 mm. Viewed in terms of the requirements of the local farmers and livestock raisers, a precise determination of the beginning of the rainy season is also appropriate.

TABLE 1

(2) 年份	1975	1976	1977	1978	1979
(3) 云南雨季开始	5月(6) 7日(7)	5月2日	5月14日	5月12日	5月17日
(4) 孟买季风爆发	6月18日	6月5日	6月16日	6月9日	6月19日
(5) 该年第一次孟湾风暴建立	5月4日	4月30日	5月10日	5月14日	5月6日

Key: (2) Year (3) Beginning of the Yunnan Rainy Season (4) Onset of the Bombay Monsoons (5) Establishment of the First Storms in the Bay of Bengal in the Year in Question (6) Month (7) Day

We recognize that the beginning of the rainy season marks the conclusion of the dry season which is maintained through the entire winter, that is, the establishment of the Yunnan rainy season.

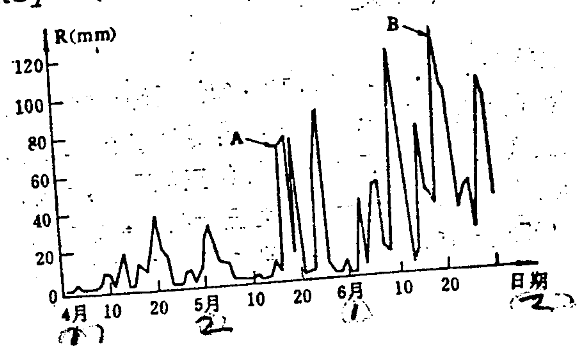
III. SYNOPTIC FEATURES ASSOCIATED WITH THE ESTABLISHMENT OF THE YUNNAN RAINY SEASON

The results of our examination clearly show that weather systems which lead to the beginning of the Yunnan rainy season are frontal precipitation processes. Up to the end of April, the whole winter season, in the eastern part of Yunnan, one normally has quasi-stationary fronts associated with north-south structures lingering in the vicinity of 104° E. The life histories of these fronts are generally 4 to 5 days. The longest are capable of reaching approximately a month. They have great difficulty in reaching central Yunnan and crossing over the Ailao mountains. They are paired by chance with those moving west. However, these are very rarely seen.

Fig.1 Integral Curve for Rainfall Amounts in 1979

Point A Represents the Establishment of the Yunnan Rainy Season. Point B Represents the Establishment of the Tropical Monsoons in Bombay.

Key: (1) Month (2) Date



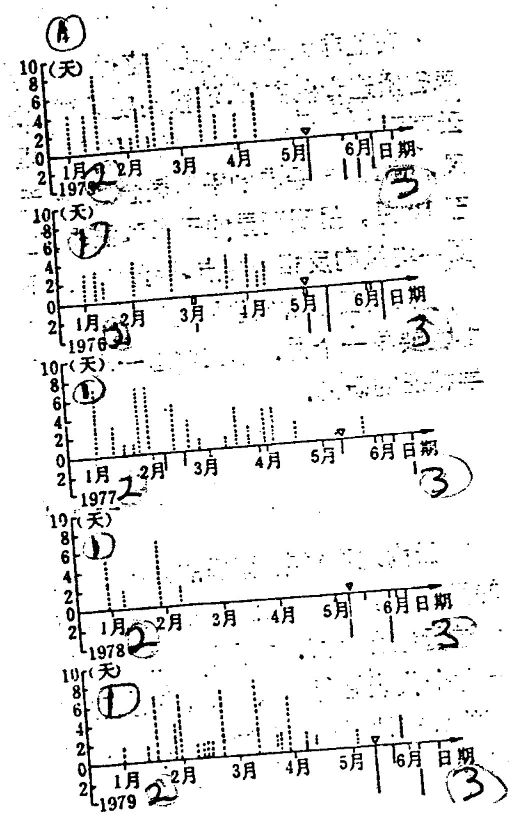


Fig.2 Statistics for Frontal Processes from January-June Dotted Lines Are Stationary Fronts. Solid Lines Are Cold Fronts.

Key: (1) Day (2) Month (3) Date

Beginning in May, moving cold fronts advance from the 103 northeast corner of Yunnan toward the southwest, creating large areas of precipitation. The rainy season begins. From this time on, one sees the appearance of fronts in Yunnan. They are almost all cold fronts, and quasi-stationary fronts become individual phenomena.

Fig.2 gives the statistics for the nature of fronts from January to June. The horizontal coordinates are the time or duration sequence. The vertical coordinates are the number of days frontal processes were maintained. The inverse triangles are placed on the dates for the beginning of the rainy season in the various years. On the basis of data for these five years, before the beginning of the rainy season, quasi-stationary fronts occupied an absolutely dominant position. Some years--for example, 1978 and 1979--before the beginning of the rainy seasons, everything was quasi-stationary frontal processes. In the two years 1975 and 1976, in the months from January to April, each had only a single instance of cold front processes. The year 1977 was somewhat special. Before the rainy seasons, there were four instances of cold front processes. However, in conjunction with this, there was no creation of large amounts of precipitation. After the beginning of the rainy season, the situation changes abruptly. Almost everything changes into activity processes associated with cold front systems. This type of transition, in the data for these five years, demonstrates a very good regularity. It seems that this is not a kind of coincidental phenomenon. Rather, it is the demonstration of the occurrence of a transformation in the nature of weather in the Yunnan area. In May, once one has the appearance of cold fronts in Yunnan, by contrast, the air flow structures influencing Yunnan will show the occurrence of even greater changes. Taking it as an example, we give the planar diagrams for the transformation from quasi-stationary fronts associated with the winter (dry) season to cold fronts associated with the summer (wet) season in 1979 (see Fig.3). Fig.3a is the quasi- stationary fronts active in the eastern part of Yunnan from 1-6 April. Through the whole winter season, there is this type of pattern. Fig.3b is a branch of cold front which began on 17 May invading the northeastern part of Yunnan. After that, it continues south and becomes a cold front process associated with the beginning of the rainy season. Fig.3c is one instance of cold front activity from 16-19 June. It represents the path of fronts after the beginning of the Yunnan rainy season. This time is positioned squarely in the onset phase of the Indian monsoons (June 19th). The planar diagrams in Fig.3 sketch the process of transition from quasi-stationary fronts to cold fronts. It also represents the special characteristics of other years.

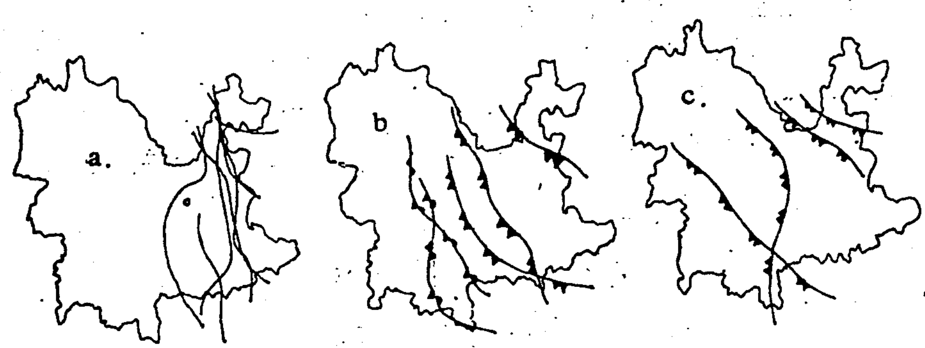


Fig.3 Frontal Activity in Yunnan in 1979

2. Transition Features Associated with Static Energies

Static energy is an expression of the nature of air masses. Due to the fact that southwest winds blow throughout almost the entire year in Yunnan Province (surface winds, that is), we hoped to use the special features of static energy in order to distinguish what differences there were between the southwest winds in winter and summer seasons. For stations such as Kunming and Tengchong, we calculated the static energies Et for the various standard layers. In order to facilitate graphing, we first subtracted 70 calories from the various layers. Following that, we took differential value summations for the layers as a whole:

$$E_t = \sum_{i=1}^{N} (C_p T + gz + Lq_s)_i \qquad i = 1, 2, \cdots, N. \tag{2}$$

We selected the surface, 700, 500, 300, and 200 mb with N = 5. In the equation, the other symbols are regularly used in meteorology. The results for the five years clearly show that, from April to June, static energies generally all show two jumps. One instance is in May. This coincides with the beginning of the rainy season which we determined. The other instance is in June. This corresponds with the Indian monsoons influencing Yunnan. Only 1978 is an exception. In this year, there was only one jump. It was during May. Fig.4 gives the static energy curves for the year 1979. From the Fig., it is possible to clearly see that, before the middle ten days of May, Et changes in the vicinity of 45 calories. After the beginning of the rainy season on May 17th, Et abruptly increases, fluctuating in the vicinity of 54 calories. The explanation for this is that southwesterly winds before the beginning of the rainy season are one type of air mass. Southwesterly winds after the beginning of the rainy season, by contrast, are a different type of air mass. The natures of the two are absolutely different. Moreover, after the onset of the Indian monsoons, Yunnan is influenced by them. This increases flows of moist air even more. There are obvious differences between these three--despite the fact that they all blow from the southwest toward Yunnan.

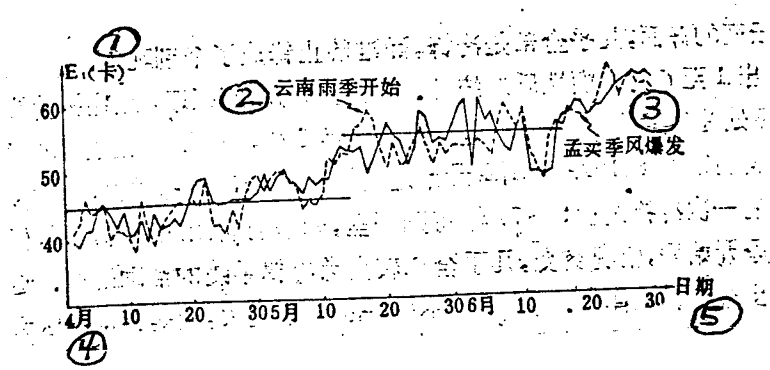


Fig.4 Relative Values for Changes in Yunnan Static Energies in 1979 Solid Lines Are Kunming Station. Broken Lines Are Tengchong Station.

Key: (1) Calories (2) Beginning of the Yunnan Rainy Season (3) Onset of the Bombay Monsoons (4) Month (5) Date

3. The Appearance of the First Storms in the Bay of Bengal

As far as the changes in static energies which were discussed above are concerned, they are one of the synoptic features associated with the Yunnan rainy seasons. They mark the fact that the air flows which influence Yunnan in different periods of time have their own special characteristics. We also paid attention to Indian weather diagrams for each day. Before and after the beginning of the Yunnan rainy season, there was often storm activity on the surface of the sea in the Bay of Bengal. Fig.5 gives the paths of the first storms in the Bay of Bengal during the period of the establishment of the Yunnan rainy season for these several years. Their life histories, at the shortest, were three days. At the longest, they were capable of reaching eight days. As far as the appearance of this type of storm is concerned, it changes the circulation forms in the Bay of Bengal. Southerly winds replace the northerly winds prevalent in winter. These storms are produced in the lower latitudes of the Bay of Bengal on the surface of the sea. Speaking only in terms of these five years, in the interval between 6.5-13° N, there is a deepening in the processes shifting toward the north. After hitting land, they rapidly weaken and disappear. The southerly air flows on the eastern side take the moist air from the surface of the sea and transport it to the eastern side of the plateau, having obvious effects on the establishment of the Yunnan rainy season. Even though the storm path for 1979 was shifted west, due to the fact that the scale of the storm was relatively large, however, air flows shifted south still had definite effects in the transportation of moist air. Of course, at this time, the relative influence on Yunnan was somewhat smaller.

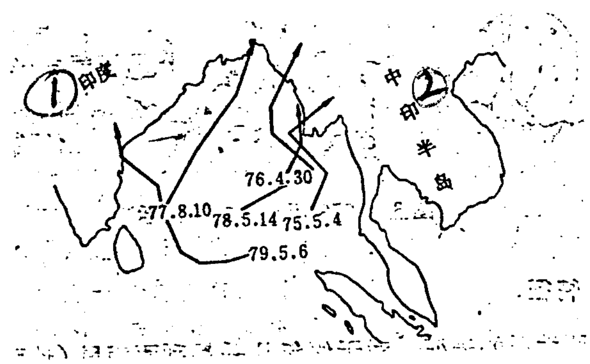


Fig. 5 Paths of the First Storms in the Bay of Bengal Before and After the Beginning of the Yunnan Rainy Seasons from 1975-1979

Key: (1) India (2) Indo-China Peninsula

One phenomenon worthy of attention is that these storms, which have a close correlation with the establishment of the Yunnan rainy seasons, are all the first storms to appear on the sea surface of the Bay of Bengal from winter to summer in the years in question. We know that the sea surface in the Bay of Bengal in winter is normally controlled by anti-cyclonic circulations. Summer seasons, by contrast, shift to cyclonic circulations. As far as the appearance of the storms is concerned, it marks the beginning of this type of circulation transition.

Referring to Table 1 and Fig.5, it is possible to know that the occurrence of storms in the Bay of Bengal, in the majority of cases, is 2 to 4 days before the beginning of the rainy seasons. However, there was also one special year when the rainy season started first. The first storm did not occur until a few days after that. To sum it all up, the storms in the Bay of Bengal and the Yunnan rainy seasons are both components of complex, large scale weather processes which occur in the same periods of time. As far as the appearance of the storms in the Bay of Bengal is concerned, this shows that obvious changes have occurred in the weather of tropical areas. The transition in Kunming from quasi-stationary fronts to moving cold fronts, by contrast, clearly shows that abrupt changes have occurred in subtropical lower layer weather. This explained by the fact that there is a relationship between the establishment of the Yunnan rainy seasons and large scale circulations.

IV. RELATIONSHIPS BETWEEN THE BEGINNING OF RAINY SEASONS AND PLANET SCALE CIRCULATIONS

From the facts disclosed above, we can see that the establishment of the Yunnan rainy seasons is a weather process possessing special characteristics and occurring in the middle ten days of May. These special characteristics or features are related to changes in large scale atmospheric circulations.

We know that, beginning in March each year, the Qinghai-Tibet Plateau and the East Asian mainland begin to warm up. In April, the scope of the warming increases greatly. As far as this type of heating is concerned, it is gradually transmitted from lower layers to higher layers. The thermodynamic effects associated with plateaus and continents cause the average locations of the great East Asian troughs to move inland from the sea coast. Atmospheric warming is capable of causing a weakening in the strength of west winds. Passing over the terrain, its compelling effects also cause the troughs flowing down the plateaus to shift even farther to the west. This special characteristic of large scale flow fields causes the cold air which invades China in the spring to show patterns of activity in April and May which are somewhat different. In April, cold centers are generally all brisk in North China and Central China. In the majority of cases, they choose routes through the various provinces of eastern China and enter the sea in Fujian. A very small number are capable of reaching Yunnan, Guizhou, and Sichuan (see the distribution of black dots in Fig.6). The method by which Yunnan is influenced is one where reflux air flows associated with surface cold high pressure on the southwest side meets the southern branch of westerly winds on the south side of the plateaus, forming quasi-stationary fronts. Under the screening effects of the Yunnan-Guizhou Plateau, these linger in the interval between Kunming and Guiyang. In May, due to the retreat of the great East Asian troughs, the high altitude east-west pulling forces weaken. The positions of cold air centers shift obviously to the west and south compared to April. They normally advance to the south into the two provinces of Guizhou and Sichuan (see the distribution of x symbols in Fig.6). At this time, Yunnan fronts can move west so that cold front processes influence Yunnan. Because of this, the rainy seasons begin.

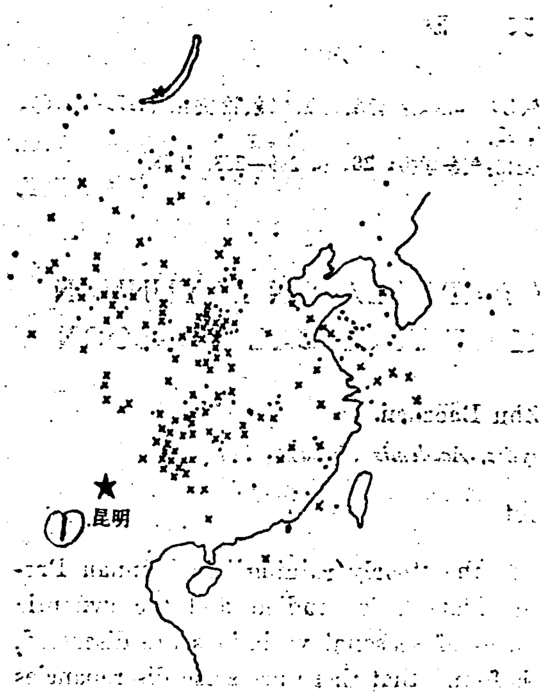


Fig.6 Ground Cold Air Center Activity Locations. • is April. x is May.

Key: (1) Kumning

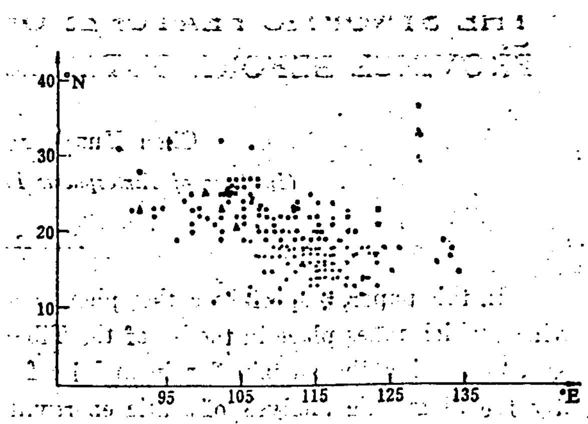


Fig.7 100 mb High Pressure Center Locations Black Dots Represent Locations Before the Beginning of Rainy Season. Circle Symbols Represent Locations in the First Five Days After the Beginning of Rainy Season. Black Triangles Represent Locations on the Day the Rainy Season Began. The Star Symbol Represents Kunming City.

As far as the increase in warmth produced by the thermodynamic effects of the Qinghai-Tibet Plateau is concerned, it causes the convection layer or troposphere to warm up. Because of this, it is advantageous for the northward shifting of South Asian high pressure (200-100 mb) over the Phillipine Sea in April. In May, the centers shift to the Indo-China Peninsula. High altitude anti-cyclonic divergence will increase low altitude convergence. This is advantageous for increases in the amounts of precipitation. Fig.7 is a point distribution diagram of the locations of 100 mb high pressure centers before and after the beginning of the Yunnan rainy season. Before the rainy season, 100 mb South Asian high pressure was located on average at 15° N. After the establishment of the rainy season, high pressure was positioned on average at 25° N.

V. CONCLUSION

As far as the analysis in this article is concerned, it is possible to know that the average date for the establishment of the Yunnan rainy season is in the middle ten days of May. During the period of the establishment of the rainy season, synoptic features are a shift of the great East Asian troughs inland from the sea coast, Kunming quasi-stationary fronts turning into moving cold fronts, a movement northward of South Asian high pressure in the upper layers of the troposphere with an average position around 25° N, and the beginning of the appearance of storms in the Bay of Bengal. These are circulation characteristics before the onset of the southwest tropical monsoons. In general, the onset of the tropical southwest monsoons is indicative of the establishment of the tropical monsoons in Bombay, India. This is generally in the middle or latter ten days of June. In this time period, atmospheric circulations in the northern hemisphere give rise to seasonal adjustments.

The southern branch of the jet stream leaps north. South Asian high pressure is established in the air above the plateaus with an average location around 30° N. Plum rain or "meiyu" phenomena begin in the Yangtze River valley [3]. The atmospheric circulation characteristics of this are obviously different from those of the period of time of the establishment of the Yunnan rainy season discussed above. This article fixed the establishment of the Yunnan rainy season in the middle ten days of May. This coincides with the results of research done by the Yunnan Province weather bureau [2]. This is approximately 30 days earlier than the date for the onset of the tropical monsoons in Bombay. In terms of atmospheric circulation features, this is also obviously different from the characteristics of seasonal changes in atmospheric circulations in June.

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REFERENCES

[1] Gao Youxi, et al; "Certain Questions Associated with East Asian Monsoons", Science Press, 1962

[2] Science Research Laboratory of the Yunnan Province Weather Bureau; "Climatic Analysis and Division into Districts of Yunnan Plateau Monsoon Circulations and Rainy Seasons", Qinghai-Tibet Plateau Collection of Meteorological Treatises (1975-1976), pp 101-108, Qinghai-Tibet Plateau Meteorological Scientific Research, Assistance, and Leadership Team, 1977, 12

[3] Ye Duzheng, Tao Shiyan, Li Maicun; " Seasonal Changes in Atmospheric Circulations in June and October", Meteorological Journal, 28, pp 249-263, 1958

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