THE FEATURES OF MCS DURING THEIR INITIATION OVER TIBETAN PLATEAU IN SUMMER

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ABSTRACT: Using the Polar Satellites IR data in 182 days of the summers of 1998～2000 over Tibetan Plateau, 28,685 Mesoscale Convective Systems (MCSs) and some features during their initiation, such as daily frequency, intensity, shape, daily variation and geographic distribution were automatically tracked and extracted by computer. The results show that the daily mean number of MCSs was 163, among which about 76% was only several hundreds Km^2 in size and small percentage(4%) was over $10^4 Km^2$. The shapes of most of them were band, comma and other irregular types and about 30% of them fell into types of circular and ellipse. The mean minimum temperature at the cloud top of them was around –51°C, the number of MCS in the early afternoon was over twice comparing that in the early morning and the number of MCS with $T_{BB} \leqslant$-54°C was five times; the MCS initiating area were mainly over the southern Plateau of 33°N where two active regions located over Yaluzangbu River basin and the western Sichuan province to Hengduan Mountain, respectively.

1. INTRODUCTION

In the 1990s, heavy rainfall frequently attacked south China, which led to many times of floods. It is found that during the period of flood-leading storm, Mesoscale Convective Systems (MCS) from Plateau often involves in the process [1] [2] [3]. Therefore, its movement and propagation to the east should be a main factor of successive storm in south China. Hence, the research of formation and development of MCS over Plateau is quite important for analyzing its impact on precipitation of south China.

In last two decades, with the rapid development of mesoscale meteorology, it is proved that disaster-inducing weather, such as storm and intensive convection is directly caused by MCSs. Since the spatial and temporal resolutions of conventional observations cannot meet the end of tracking, analyzing and research of MCS hitherto we lack of understanding initiation and of development mechanism, structure, movement and propagation of MCS. Consequently, China, Japan and other countries are now conducting a serious of research in this area. As for Qinghai-Tibet Plateau, due to insufficient conventional observations, the research of MCS over Plateau is even more difficult. Since 1970s, several conventional observatories have been established during the period of some Plateau weather experiments, but it is far less than enough for research of MCS. Although the stationary satellite image with high resolution can show some important features of MCS, it cannot quantitatively reveal the intensity, daily variation and distribution of MCS over Plateau over a long period. Additionally, the satellite image of Plateau is dramatically distorted on image of Japanese GMS. Therefore, the inferred images of Chinese FY-1 and American NOAA-14 during summers from 1998 to 2000 are chosen to analyzing the frequency, intensity, shape, development geographic and distribution of MCSs.

2. METHODS AND DATA

Polar satellite NOAA-14 passes over the Plateau at 2:00pm (local time) every day. At this time, the MCS forms actively. Hence, using the information obtained by this satellite, many features which show the initial characteristic of MCS can be extracted. In the period from June to Aug., 1998 to 2000, the observations of 182 days are chosen randomly. Among them, there are 61 days in June, 55 days in July, 66 days in Aug. Chinese Polar weather satellite FY-1C was launched on May 10, 1999 passes over Plateau at 8:00am (local time) every day when MCS is inactive. The satellite data which is collected by FY-1C and by NOAA-14 from June to August, 2000 is compared to reveal the Plateau thermal and dynamic influence against the initiation and development of MCSs.

Because the data of 182 days is gathered, the analysis of this large amount of information would definitely be persuasive. A serious of computer program is constructed to process the data. According to the data processed, some meaningful results are obtained.

3. ANALYSIS AND RESULTS

3.1 The Initiate Frequency of MCS

MCS is a kind of deep convectional weather system. Based on the active characteristics of MCSs over Plateau (27-40°N, 75-105°E) excluding MCS of r-scale which is smaller than 100 Km^2 , the MCS can be defined as cloud top temperature TBB≤-32°C with area larger than 100Km^2 . According to this definition, the data of 182 days between 1998 and 2000 is processed to detect meso-α- and β-scale MCS as illustration in table 1.

Table 1. MCSs frequency within different sizes over Plateau in the afternoon in summers of 1998~2000.

Year	June					July					August				
	Days	No. of MCS				Days	No. of MCS				Days	No. of MCS			
		$\geq 10^2$ KM^2	$\geq 10^3$ KM^2	$\geq 10^4$ KM^2	$\geq 10^5$ KM^2		$\geq 10^2$ KM^2	$\geq 10^3$ KM^2	$\geq 10^4$ KM^2	$\geq 10^5$ KM^2		$\geq 10^2$ KM^2	$\geq 10^3$ KM^2	$\geq 10^4$ KM^2	$\geq 10^5$ KM^2
1998	14	1224	335	69	14	12	1541	356	61	14	12	1500	399	86	10
1999	22	2832	646	140	12	17	2442	677	122	19	26	3610	891	140	32
2000	25	2661	718	121	21	26	3005	799	129	37	28	3162	709	115	36
∑	61	6717	1699	330	47	55	6988	1832	312	70	66	8272	1999	341	78
Daily Ave.		110.1	27.9	5.4	0.8		127.1	33.3	5.7	1.3		125.3	30.3	5.2	1.2

From table 1, there are 28,685 MCSs in these 182 days and averagely 163 per day. Among these three months, MCSs occurs the most frequently in July with 167.3 per day, then comes to the Aug and June with 162/day and 144/day, respectively. Salient characteristics of MCS in size can be identified. Most of MCSs, accounting 76%, is smaller than 1,000 Km^2 . MCSs of the area between 1,000 and 10,000 Km^2 is 20% of the total. Overall, the majority of MCSs over Plateau is smaller than 10,000 Km^2 while only a few are larger than 10,000 Km^2 . We can see that the area of MCS over Plateau is smaller than the MCS over the other part of China.

3.2 The Shape and Intensity of MCS During Its Initial Stage

The shape of MCS detected by polar satellite is more accurate than by GMS which is distorted seriously. The shape of MCS during its initial stage is a good indicator to analyzing and conjecturing its cause and intensity. For example, circular and ellipse MCSs are generally closely associated with local ground features and weak atmosphere force process. Its accompanying convection system, such as MCC is intensive. Other shape, such as band comma, is mainly relevant to specific weather system. According to widely accepted definition, MCS is circular when its eccentricity is greater than 0.9 and ellipse when between 0.7 and 0.9. MCS whose eccentricity is less than 0.7 falls in the category of others. For sake of intensity analysis in table 2 MCSs are divided into two categories, TBB≤-32°C and TBB≤-54°C which correspond to convection cloud and intense convection with strong thunderstorm, respectively. The minimum temperature of cloud top is also showed in table 2.

Table 2.the shape and intensity of MCSs in their initial stage in summers of 1998-2000

Shape	No. of MCS with different size and TBB								Mean Min. T_{BB}	Fre. (%)	
	$\geq 10^2 Km^2$		$\geq 10^3 Km^2$		$\geq 10^4 Km^2$		$\geq 10^5 Km^2$			≤-32℃	≤-54℃
	≤-32℃	≤-54℃	≤-32℃	≤-54℃	≤-32℃	≤-54℃	≤-32℃	≤-54℃			
Circular	1497	238	381	112	61	26	18	8	-51.5	6.8	8.5
Ellipse	4065	652	1065	290	194	75	34	19	-51.0	18.5	23.2
Others	16415	)19	4084	898	728	251	143	74	-49.0	74.7	68.3
∑	21977	2809	5530	1300	983	352	195	101		100	100

It is illustrated in Table 2, circular MCS account for 7-8% in above-mentioned two temperature categories and ellipse is as twice as much, amount for 18-23%; while the majority is others about 70%. Therefore, it could be infered that the the initiation and development of most of MCSs is the result of thermal convective cells merged each other under the situation of synoptic system impact in the westerly or monsoon surging into Plateau. The minimum temperature of cloud top for circular and ellipse is -51°C while it is slightly low than other shapes, which is -49°C. Similarly, the intensive convection whose temperature of cloud top is lower than -54°C with thunderstorm accompanied mainly emerges in MCS smaller than 10,000 Km ^{2} , especially smaller than 1,000 Km ^{2}

3.3 Frequency and Daily Variation of MCS

The information of 67 days obtained by FY-1 an NOAA-14 which pass by Plateau in the morning and afternoon,respectively is processed to expose the intensity and frequency of MCS as in table 3.

Table 3 The features of daily variation of MCSs during their initiation over Plateau in summer of 2000

Time	No. of MCS with different intensity								Σ		Ave. Min T_{BB}
	≥10^2Km^2		≥10^3Km^2		≥10^4Km^2		≥10^5Km^2				
	≤-32℃	≤-54℃	≤-32℃	≤-54℃	≤-32℃	≤-54℃	≤-32℃	≤-54℃	≤-32℃	≤-54℃	
08:00/FY-1C	3168	155	658	88	149	36	21	4	3996	283	-48℃
14:00/NOAA-14	6553	926	1671	456	265	95	70	40	8459	1517	-51℃
14:00/08:00	2.0	6.0	2.5	5.2	1.8	2.6	3.3	10	2.1	5.4	

According to table 3, overall the number of 9976 MCSs, in the afternoon is 2.3 times as much as in the morning 4279 MCSs. Furthermore, the category of cloud top temperature less than -54°C, the former is 5.4 times as much as the latter. This shows that much more MCSs occur in the early afternoon than in the early morning and intensive MCSs mainly occur in the early afternoon, which show the considerable Plateau thermal influence. MCSs smaller than 10,000 Km ^{2} at any category of temperature show the similar characteristic. The number of MCS larger than 100,000 Km ^{2} is negligible but the ratio of number of MCSs in the afternoon and morning reaches to 10 under the category of -54°C.

3.4 The Geographic Distribution Of MCSs During Its Initial Stage

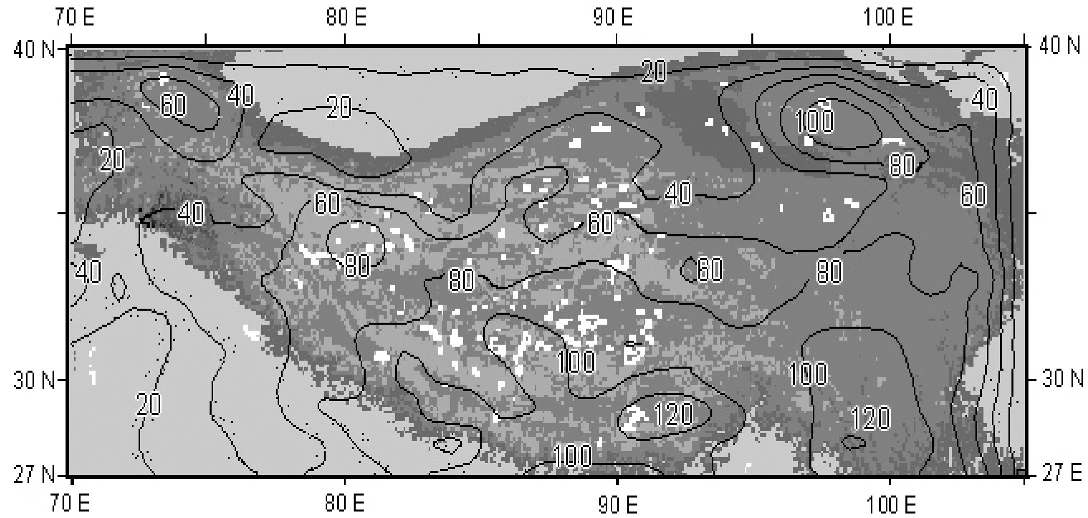

Fig.1 The geograpic distribution chart of MCSs in 182 days in summers of 1998~2000 over Tibetan Plateau.

Fig.1 shows that according to data gathered by NOAA-14 in above mentioned 182 days, the initial geographic location of 28,685 MCSs considerably unevenly distributed over Plateau and mainly concentrated over the southern Plateau of 33° N, The iso-MCS number was orientated quasi-west to east and its strong gradient located around 35 ° N which indicated the close relationship between MCS frequency and Plateau topography of high south and low north parts and also summer monsoon activity in southern Asia.

Two concentrated MCSs regions presented over southern Plateau ,the first one with highest frequency located in up- and middle-streams of Yaluzangbu River basin and the center with 120 MCSs was around middle-stream basin and more than 100 MCSs distributed in other regions. The second highly frequency region with 110~120 MCSs centerd in the western Sichuan province to Hengduan Mountain where some of MCSs moved eastward and caused heavy rainfall over the southwestern and southern China and middle-and down streams of Chang Jiang basin.There was other smaller highly frequency region of MCSs activity in the northeastern Plateau ,which the possible reason was the interaction between synoptic system climbing from the northern slope in the westerly and monsoon streteching northward .

4. CONCLUSION

In this research, data of 182 days gathered by polar satellite is processed. 28,685 MCSs over Plateau is detected. Their main characteristics, such as frequency, intensity, shape, daily variation, geographic distribution are also obtained. This amount of typical information is quite important for us to understand the initiation and development of Plateau MCS. Furthermore, it is an indispensable clue for studying the formation region, intensity and possible routine of moving and propagating of MCS.

The characteristics of Plateau MCS, for instance large number, small area, low top of cloud are significantly different from that of MCS of the other area of China. This inflects the thermal and dynamical impact of Plateau. It can be safely drawn that the precipitation accompanied is shower, which does not induce heavy rainfall and convection weather is large in number but not intensive over Plateau.

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