Research on Features of Sandstorms in the Hinterland of Taklimakan Desert- A Case of Tazhong Area

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1. Abstract

To clarify the occurrence of sandstorms in the Hinterland of Taklimakan desert，the north-west part of China, we analyzed the data of sandstorms collected during 5 years from 1997 to 2001 at Tazhong Weather Stations in the hinterland of Taklimakan desert. The results are as follows: 1) The annual average days with sandstorms in Tazhong is 18 days，compared with the north and south fringe of Taklimakan desert; 2) Sandstorms occur more frequently in daytime, in particular, in afternoon and evening. 3) Sandstorm occurrence from March to September is very frequent, especially from April to July is most frequently, accounting for more than 90%，63% of a year respectively; 4) The sandstorm occurrence varies greatly among years，adds up to 36 times in 1998，otherwise reduces to 7 times in 2001; There is a clear trend to decline in 1990's. 5) During sandstorm occurrence process there is a special stage with abrupt wind speed decline and wind direction turning before sandstorm occurrence; 6) According to the main wind direction of sandstorms, the sandstorms occur in Tazhong can be classified into five types, the type of eastern cold air mass invasion take places frequently.

2. Introduction

Many works about methods, temporal and spatial distribution and tendency of variation of sandstorm in Taklimakan Desert (Qing He, 1996; Xu Xihui, 1997; Chen Yonghang, 1999; Kang Shujuan, 1999; Shalamaiti, 1996; Cui Caixia, 2001) done by many scholars before are mainly concentrated on the fringe, But natural conditions and sandstorm occurrence of different regions in the wide area of Taklimakan Desert vary greatly. After the instruction of Tarim Desert Highway in 1995, Use of Tazhong Weather Station to study on sandstorm occurrence in the hinterland of Taklimkan desert is very significant, especially for the exploration of oil resources in Tarim Basin.

Tazhong is located in the hinterland of Taklimakan Desert with geographical coordinates of N 39°06′，E83°40′. Air temperature is very high; climate is very arid with scarce precipitation (annual mean 11.05mm, mean relative air humidity 29.4%) and intensive evaporation (annual mean 3638. 6mm) ; aeolian landform of sand is dominated by high complex longitudinal sand-ridge with mean strike N 50° E～N 60° E (Wang Xunmin,2001) height 30～70m, covering secondary sand dune chains 5～15m high, inter-ridge 1～3km wide occupied by sand dune chains, crescent sand dune and small-scale ridge; Aeolian activity is frequent with over 500 times of shifting wind (6.0m/s at the 11.4m high above the ground) and annual mean wind speed 2.5m/ s, instantaneous wind speed 20.0 m/ s, the index of blown sand activity over 8000; prevailing wind directions are ENE,NE,NNE and E due to the eastern pouring airflow.

All data were come from Tazhong Weather Station at the north of Tazhongsi Joint Oil Station. Date of sandstorm occurrence and start-stop time in each day of every month were registered based on the weather data of Tazhong Weather Station during the years from 1997 to 2001.Wind speed and wind direction p.d. were obtained from the self-recording (automatically registered) columns of wind speed and wind direction within 24 hours. Persistent time of sandstorm and days of sandstorm in every month, every year were stated. And the threshold wind velocity of sandstorm generation was defined as the mean wind velocity self-recorded in 24h (average of 10min) when sandstorm begins. Data of temperatures and precipitation in the weather data was used to analyze the influencing factor of sandstorm occurrence.

3. Data analysis

3.1 Intensity of sandstorm

3.1.1 Annual days of sandstorm

During the years from 1997 to 2001, 90 days had sandstorms with 18 days a year averaged in Tazhong. The days of sandstorms in Tazhong is more than that of Luntai at the north brim of the desert（1.4d/a，1961～1996）, is less than that of Andehe in the south part of the desert（20.9 d/a，1961～1996）and that of Minfeng at

the south brim of the desert（35.7.00 d/a，1961～1996）.

3.1.2 Duration of sandstorm

Within 5 years from 1997 to 2001 sandstorm occurred 77 times with 277.67h duration totally and 55.53h annually .The length of every sandstorm duration varied from a few minutes to 29 hours which could occur in one weather recording day commonly. And exceptional violent sandstorm could present in two weather-recording days intermittently or continuously.

3.1.3 Wind speed

Sandstorm often accompanied with strong wind . And the wind speed exceeded 8m/s , 10-13 m/s for instance and could reach 18 m/s at the most .

3.2 Temporal changes

3.2.1 Daily changes

Sandstorms in Tazhong occurred periodically with the temperature changes during a daytime and night (table 1). Namely sandstorms occurred mainly in daytime for higher temperature but less in night, and in daytime sandstorms occurred most frequently in afternoon and evening.

Table 1 Occurrence times and probabilities in daily different periods from 1997 to 2001

Periods	8:00-14:00	14:00-20:00	8:00-20:00	20:00-24:00	00:00-8:00	20:00-8:00
Times	18	57	*75*	16	16	*32*
Frequency (%)	16.82	53.27	*70.09*	14.95	14.95	*29.91*

3.2.2 Seasonal changes

Sandstorms mainly presented in the months from 3 to 9 accounting for over 90% in a year, and concentrated in the months from 4 to 7 accounting for over 65% in a year. No sandstorms occurred in January, February and December during the 5 years. So sandstorms occurred mostly in spring and summer, infrequently in autumn and hardly occurred in winter. During the 5 years, sandstorms occurred more in summers than in springs.

The seasonal variation of the persistent hours of sandstorms is incompletely the same as the monthly variation of the days with sandstorms. From table 1 and table 2, the month whose persistent hours of sandstorms is the most is not as same as the month which has the most days occurred sandstorms, and the persistent hours of sandstorms are different greatly in months those have the same days of sandstorms occurrence. Yet their seasonal variation and annual variation are same.

Table 2 Monthly variation of the days of sandstorms

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Full year
1997	/	/	2	/	2	7	4	2	1	/	2	/	20
1998	/	/	7	8	5	2	8	4	2	/	/	/	36
1999	/	/	2	2	2	2	3	1	/	/	/	/	12
2000	/	/	/	1	1	5	4	4	/	/	/	/	15
2001	/	/	/	2	2	1	2	/	/	/	/	/	7
Mean	0	0	2.2	2.6	2.4	3.4	4.2	2.2	0.6	0	0.4	0	18
1989*	/	/	2	8	12	23	12	11	6	1	0	0	60
1990*	0	3	2	7	14	7	10	6	5	2	/	/	56

*, / Denote the data of Tazhongyi quoted from reference 1 and no data respectively

Table 3 Seasonal variation of the persistent hours of sandstorms

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Full year
1997	0	0	0.27	0	6.97	26.45	8.03	8.25	1.13	0	0.67	0	51.77
1998	0	0	55.83	28.33	29.17	9.25	10.57	10.85	2.78	0	0	0	146.8
1999	0	0	3.717	11.5	1.617	2.83	9.08	0.68	0	0	0	0	29.43
2000	0	0	0	4.33	9.367	6.667	7.92	1.72	0	0	0	0	30
2001	0	0	0	12.27	4.8	0.333	2.28	0	0	0	0	0	19.68
Mean	0	0	11.96	11.29	10.38	9.107	7.577	4.3	0.783	0	0.133	0	55.53

3.2.3 Inter-annual changes

The occurrence of sandstorms in Tazhong changed greatly in different years（Table 2，Table 3）. From 1997 to 2001, days of sandstorm were the most in 1998 with 36d and the least in 2001 with 7d. The inter-annual variability coefficient reached 1 at the most. The year of 1998 had the most hours of 146.8h with similar

sandstorms persistent hours and days of sandstorms, and the year of 2001 had the least hours of 19.68h. The inter-annual variability coefficient achieved 1.64 at the most. And the sandstorm distribution in every month was different among years.

3.3 Course feature

3.3.1 Wind speed

It's recognized that threshold wind velocity at the beginning of sandstorms in Taklimakan Desert is 8.0m/s (the mean speed at 10m height above ground in 10min). Yet according to the data of the 77 times sandstorms in the 5 years , sandstorm could occur at speed of 6～7m/s in summer; and but in winter there was not sandstorm even when the wind speed was greater than 8.0m/s in the 5 years. The author considered that the seasonal change of threshold wind velocity of sandstorm is related to the seasonal frequency of the weather courses in Tarim basin.

Sandstorm occurrence course is composed of four phases: fore-formation phase, formation phase, persistent phase, and subsidence phase. Wind speed changed regularly during sandstorm occurrence course. In fig. 1 the two curves of 13th and 28th in June express the wind speed change of sandstorm course and the other one of 10th June expresses wind speed of ordinary dust weather. Just before sandstorm forming the wind speed declined suddenly and even the wind fell to static state. After forming phase, the wind speed increased suddenly and got to the threshold wind velocity of sandstorm generation. The persistent time of sandstorm was different and the wind speed was always above threshold wind velocity accompanying with tiny fluctuation during persistent stage. In the subsidence phase, the wind speed reduced slowly until under threshold wind velocity.

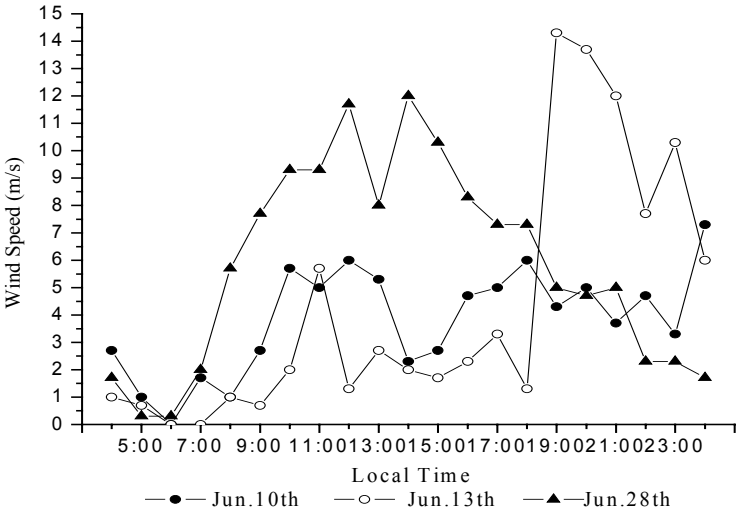

Figure 1 Daily variation of wind speed in different periods of sandstorms

3.3.2 Wind direction

During formation phase the wind direction changed abruptly with the sudden decline of wind speed (table 4). The dominant wind direction of the sandstorm on 13th June was semi-north wind. In the time 11:00～17:00 the direction changed from NE to SE, then to E, N, NE and NNW, and was gradually consistent with the dominant direction. The dominant wind direction of the sandstorm on 28th June was NE, semi-east wind. In the time 6:00～7:00 the direction changed from ENE, E to SE, then to NNE, NE, and was gradually consistent with the dominant direction. In the formation phase, persistent phase, subsidence phase of the sandstorms, the wind directions kept invariability.

Table 4 Daily variation of wind directions in different periods of sandstorms

Time	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00
6.13 Jun.13th	SE	NNE	C	C	NE	NE	ENE	***SE***	***ESE***	E	N	N	N	NE	NW	NNW	N	NNE
6.18 Jul.28th	E	***ENE***	***E***	***SE***	NNE	NNE	NE	NE	NE	NE	ENE	NE	ENE	NE	ENE	E	E	E

3.4 Types of sandstorm

Xihui Xu selected 59 cases from the satellite imagery data of Tarim Basin in the years from 1978 to 1987 and classified into 5 types based on the weather situation of sandstorms. Every type corresponds to a group of wind direction. According to the dominant wind directions of the sandstorms, we classified the 77 times sandstorms in the years from 1997 to 2001.The 5 types all appeared during this 5 years (table.5). The dominant types of sandstorms in this paper are consistent with the conclusions of Xihui Xu's study on Tarim Basin except the other types, which may be responsible to the study area, statistical period of time and the length of statistical period of time.

Table 5 All types of sandstorms in Tazhong and their occurrence frequency from 1997 to 2001

Types of sandstorms	Wind direction during sandstorm	Times	Frequency (%)	Xu's result (%)
Cold air intrusion and falling over mountain	Northwest	23	*29.87*	13.6
Cold air filling eastwardly	Northeast, east	42	**54.55**	**45.8**
Western cold air intrusion	West, southeast	6	7.79	*18.6*
Combination of air crossing mountain and filling eastwardly	Northwest, semi-east	1	1.30	*18.6*
Air-deflating pump effect	Northwest, southeast and southwest in upper atmosphere	5	6.49	3.4

4. Conclusions

1) The intensity of sandstorms in the hinterland of Taklimakan Desert was greater than the north brim of the desert and less than the south brim of the desert. The annual days of sandstorms were 18 days averagely and the annual duration was 55.35h averagely. 2) Sandstorms in Tazhong had evident daily periods. Sandstorms occurred mainly in daytime but less in night, and in daytime sandstorms occurred especially in afternoon or dusk.3) The seasonal changes in one year of Tazhong sandstorms had evident periods and the times of occurrence were fixed. Sandstorms occurred mostly in spring and summer, infrequently in autumn and hardly occurred in winter and namely focused on months from April to July.4) the occurrence of sandstorms in Tazhong changed greatly in different years. The sum of the annual days of sandstorms and its seasonal distribution changed every year, and there were most sandstorms in 1998. 5) The critical wind speed of sandstorm occurrence in the hinterland of Taklimakan Desert was 8.0m/s , yet sandstorms could occur at the speed of 6~7m /s in summer .7) Sandstorm occurrence course is composed of four phases: forestalling formation phase, formation phase, persistent phase, and subsidence phase. Just before sandstorm forming the wind speed declines suddenly and the wind direction is converted.8) The weather formats resulting in sandstorms in Tazhong is as same as the other area in Tarim Basin so the sandstorms could be classified into 5 types: cold air intrusion of crossing mountain and sinking type, cold air filling eastwardly type, western cold air intrusion type, combination of crossing mountain and filling eastwardly type, and deflating pump effect type. The most frequency of occurrence type was cold air filling eastwardly type, then cold air intrusion of crossing mountain and sinking type、the next was cold air intrusion from west type and combination of crossing mountain and filling eastwardly type was the lest one to occurrence .The proportions are a little different from the conclusions of the investigation to Tarim Basin and are related to the statistical ages and to the specific studied area.

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