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Relationship between the Climate Change and Dust Storm Occurrence in China

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Abstract: Monthly mean air temperature and precipitation data, monthly dust storm frequencies (times of dust storm occurrences) of 107 stations in North China were analyzed to clarify the relationship between the climate change and dust storm occurrence. Arid regions of North China were divided into five and trends of dust storm occurrence and climate changes showed different patterns for these regions, although a decreasing trend of total dust storm occurrence and an increasing trend of temperature for whole North China. Dust storm occurrence decreased clearly and had a good relationship with temperature increasing in spring and precipitation increasing in winter in Northwest China, while that in Northeast China showed an increasing trend in recent years and had no clear relation with temperature and precipitation change.

Keyword: Climate change, Dust storm, Regional division, Temperature increase

1. Introduction

Aeolian dust deduced mainly by dust storm has great impacts on the agriculture and living activities in its origin arid and semiarid area. Furthermore, aeolian dust influences directly or indirectly the atmospheric radiation balance and hence global climatic variations as the largest source of aerosols (Tegen *et al*., 1996). Because of the growing interests in the influences of Asian dust aerosols on the climate system, atmospheric environment and human health, the spatial and temporal characteristics of dust weathers including dust storm, blowing dust and floating dust are extensively studied in recent years (e.g. Chun *et al*., 2001; Sun *et al*., 2001; Qian *et al*., 2002; Yoshio, 2002a, 2002b). It was demonstrated that in most areas of northern China dust storm frequency generally revealed declining trends. In spite of the decreasing trends of dust storm frequency in most arid and semi-arid lands of northern China, Asian dust frequency (or Kosa) observed in Japan does not show any decreasing trends but some decadal variability and recent increase of Asian dust frequency is related to the increase of dust storm frequency in the eastern part of Mongolia and Inner Mongolia shown a regional difference of dust storm frequency (Tian *et al*. 2007). However, it seems that there is no study on regional division of dust occurrence, especially on regional relationship between climate change and dust occurrence. This paper will give some detailed results on the regional characteristics of the relationship between climate change and dust storm occurrence in China.

2. Data and method

Dust storm frequencies data were compiled from two sources. One is prepared by Chinese Meteorological Administration (CMA), which covers the period of 1954-2000 for 107 stations. Another is from the monthly summary of SYNOP Weather Reports, which is derived from the original four time observations every day and covers the period of 1999-2006 prepared by Japanese Meteorological Administration (JMA) for 63 stations. Dust storm is defined when the current weather code is one of 9, 30-35 and 98. Sixty-three stations included in the both datasets were used for the analyses of long-term trend.

Monthly mean of air temperature and precipitation data of 107 stations prepared by Chinese Meteorological Administration (CMA) were used for the analysis of climate change and the relationship between the climate change and dust storm frequencies.

Arid regions of North China (north than N 35˚) are divided to five as follows: (1) northeast region: east than E 115˚ and north than N 45˚; (2) east region: east than E 115˚ and south than N 45˚; (3) central

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region: between E 105˚ and E 115˚; (4) east northwest region: between E 95˚ and E 105˚; (5) west northwest region: west than E 95˚.

3. Results and Discussions

3.1 Dust storm occurrence and climate change in the whole North China

Figure 1 shows the inter-annual variations of dust storm frequencies (total times or days of a year and in spring (March, April and May), mean air temperature in spring and precipitation in winter (December, January and February) of North China (mean of 63 stations) in recent 53 years (1954-2006). The inter-annual variation of dust storm frequency (both total times and that in spring) shows a decrease trend and inter-annual variation of temperature shows an increase trend. However, inter-annual variation of precipitation shows a decrease trend in 1950's and early 1960's and large variations or increase trend after the decreasing period.

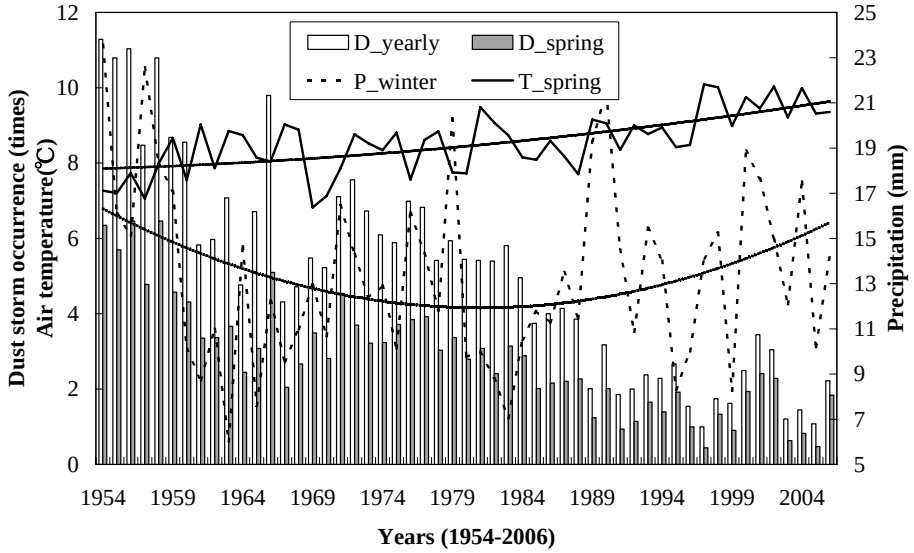

Fig. 1. Inter-annual variations of dust storm frequencies (total times of a year and in spring (March, April and May), mean air temperature in spring and precipitation in winter (December, January and February) of North China (mean of 63 stations) in recent 53 years (1954-2006).

Therefore, as shown in **Figure 2**, dust storm occurrence decreased in proportion to increasing in temperature of spring (March, April and May) during recent 53 years for whole North China. However, Dust storm occurrence in spring was in proportional to precipitation (snowfall) amount statistically before 1984 but not clear relationship after 1984. The correlation coefficients were 0.63 for both relationships.

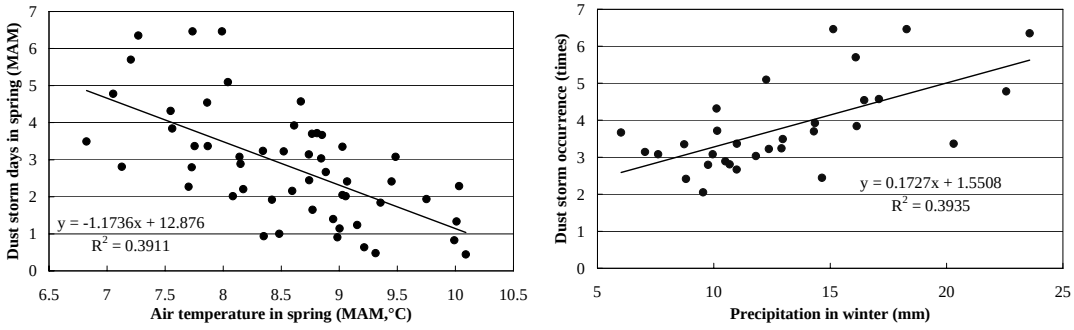

Fig. 2. Relationship between dust storm occurrence and air temperature in spring during 1954-2006 (left) and precipitation in winter during 1954-1984 (right) for whole North China.

3.2 Regional characteristics of the relationship between climate change and dust storm occurrence

Dust storm frequencies were different for the five regions. The west 3 regions (west northwest, east northwest and central) have higher frequencies than the east two regions. Inter-annual variations of dust storm occurrence in the five regions showed decreasing trends with different patterns for each region. There was a period about twenty years in which dust storm occurrence decreased very clearly (decreased about 60%) in each region. However, this period seems appeared earlier in east part regions than west part regions such as periods 1972-1992, 1974-1994, 1976-1996, 1978-1998 and 1980-2000 for northeast, east, central, east northwest and west northwest regions, respectively. Dust storm occurrences decreased about 2, 3, 6, 12 and 9 days during this period for the five regions, respectively.

Relationships between monthly dust storm occurrence and monthly air temperature and precipitation during these periods were analyzed (some are shown in **Figs 3** to **5**). In the northwest 3 regions, dust storm days decreased form about 20 days in 1950's to about 5 days in 2000's. Dust storm occurrence decreased in proportion to increase of the air temperature in spring and increase of the precipitation (snowfall) in winter as shown in Figures 3 and 5. Du *et al*. (2002) pointed out that most dust storms in spring in Northwest China were probably generated by cold frontal systems with dry squall lines. These suggest that the recent global warming is more evident in the Northwest China, where the frequency of cold air invasions from the higher latitudes is decreasing (Du, 1996). However, There are few changes for the dust storm days in the Northeastern China (regions east and northeast) and had an increase trend there in recent twenty years as shown in Figure 4. Relationship between dust storm occurrence and temperature and precipitation was not so clear even during the decreasing period as shown in **Figure 6**. Dust storm in northeast China as well as in East Asia is related with cyclones activity as revealed by Yoshino (2002a, 2002b). Therefore, change of dust storm occurrence in Northeast China may be caused by the developed stronger cyclones in East Asia as a result of global warming (Yoshino, 2002a, 2002b) as well as human activities with severe land degradation there.

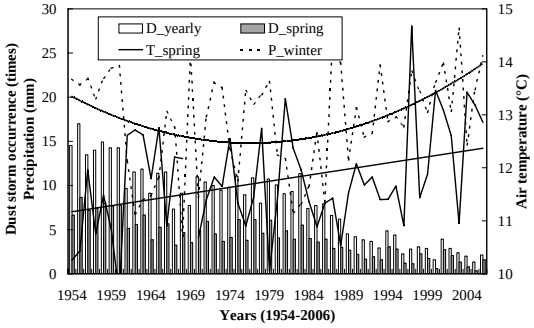

Fig. 3. Same as Fig. 1 except for west part of northwest region.

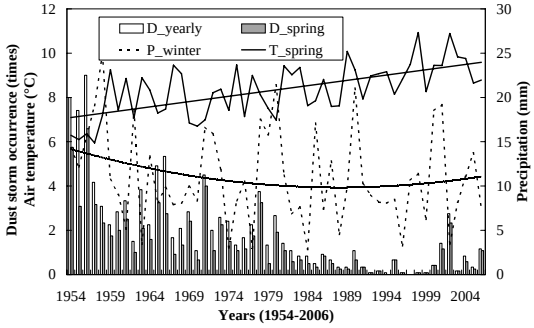

Fig. 4. Same as Fig.1 except for east region.

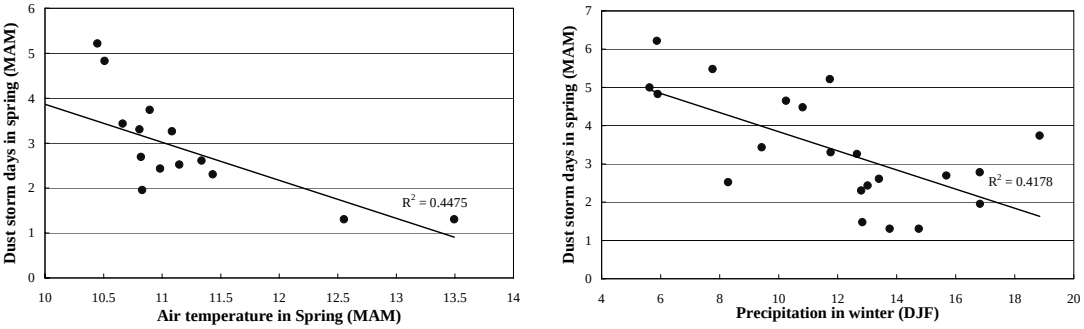

Fig. 5. Relationship between dust storm occurrence in spring and air temperature in spring (left), precipitation in winter (right) for west part of northwest region during 1980-2000.

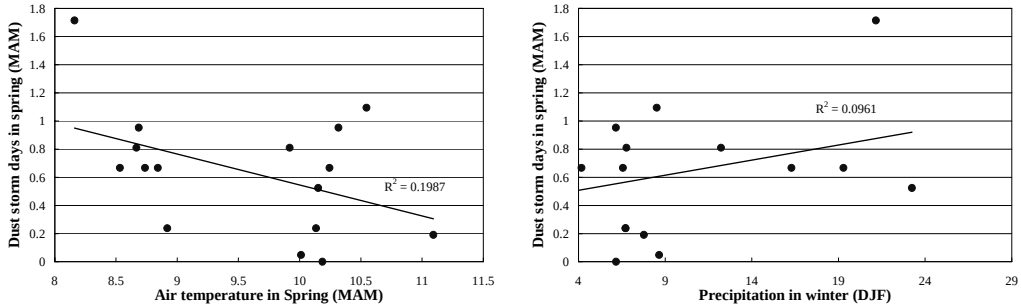

Fig. 6. Same as Fig. 5 except for east region during 1974-1994.

4. Conclusions

Analyses of the relationship between the regional climate change and dust storm occurrences by using monthly mean data in North China led to following results:

1) Dust storm frequency in whole North China has decreased greatly as air temperature increasing during past 53 years (1954-2006). There is a good relationship between dust storm occurrence and temperature. Decreasing rate of dust storm occurrence is in proportional to increasing of air temperature. Dust storm occurrence in spring was proportional to precipitation (snow) amount statistically before 1984 but not clear relationship after 1984.
2) Trends of dust storm occurrence and climate changes showed different patterns for different regions. There was a period about twenty years in which dust storm occurrence decreased very clearly. However this period seems appeared earlier in east regions than west regions. That is 1972-1992, 1974-1994, 1976-1996, 1978-1998 and 1980-2000 for northeast, east, central, east northwest and west northwest regions, respectively. Dust storm had a good relationship with temperature increasing in spring and precipitation increasing in winter in Northwest China (both west and east), while that in east part of North China (northeast region and east region) showed an increasing trend in recent years and had no clear relation with temperature and precipitation change.
3) Relationship between temperature increasing and dust storm occurrence decreasing in spring in northwest regions suggesting that it is the global warming effect by decreasing the cold air invasions. Increase in dust storm days in the Northeastern China in recent years may be caused by the developed stronger cyclones in East Asia as a result of global warming as well as human activities with severe land degradation.

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