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Haze variation in valley region its affecting factors

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Abstract The haze has a great harm on the environment and human health. Based on the daily meteorological observation data including visibility, relative humidity, wind speed, temperature, air pollution index and weather record of Baoji region in China, and using least squares method, wavelet and correlation analysis method, the temporal and spatial characteristics of haze were analyzed. While the factors affecting the haze change were discussed. The results showed that the haze mainly occurs in plain areas, and in hilly areas and mountain the haze frequency is relatively small. Overall the annual average haze is decreasing, especially in winter and spring the reduction trend of haze is most obvious, however, in summer haze is increasing. The haze has a 5-year short period and 10-year and 15-year long-term cycles change. Moreover, there was a significant negative correlation between temperature and wind speed with haze, while the relative humidity was significantly positively correlated with haze. These studies provide the basis for atmospheric environmental monitor and management.

1. Introduction

In recent years, due to the rapid economic development and urban expansion resulting in serious air pollution, haze weather often appear, which cause great harm to the environment and the human health. Usually, haze is defined as a weather phenomenon that a large number of tiny dust particles, smoke particles or salt aggregates lead to Turbidity of the air and horizontal visibility of below 10km. So the haze weather aroused the attention of scholars [1-3]. At present, the study of haze is mainly focused on the large-scale temporal and spatial variation characteristics of haze [4-7], and the relationship between aerosol optical properties of atmospheric particles and a haze weather diagnosis process [8-9]. Although many scholars have a lot of research, which have some limitations and need to has a comprehensive understanding of the haze changes and influencing factors.

This study takes Baoji area as an example. Baoji area is located in the central valley of Shaanxi Province with plain, mountainous and hilly terrain features. While in the south, west and north of the Baoji area it is surrounded by mountains, and the plains is in middle. Therefore, the temporal and spatial characteristics of haze are analyzed in Baoji area and the influencing factors are discussed. It can provide reasonable scientific basis for the monitoring, control and management of haze in valley area.

2. Materials and Methods

The daily climate elements including visibility (8:00, 14:00, 20:00), relative humidity, air pollution index, weather phenomena, air pollution index, wind speed and temperature used in this paper were obtained from 11 weather station of Baoji area from 1981 to 2013 in China. When daily average

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visibility is below 10km and daily average relative humidity is below 90%, except for precipitation, sandstorms, sand, dust, smoke, snow, snow storms and other events leading to changes of visibility, those conditions are recorded as a haze day. The haze days of year, season and month were carried out.

In this paper, the least squares and wavelet methods were used to analyze the changing trend and periodic characteristics of haze. The relationships between haze and meteorological factors were analyzed by correlation method, while the affecting mechanism of haze was discussed.

3. Results

3.1. Distribution and trend of haze

From Fig. 1, it can be seen that the annual average largest haze days is located in the middle of the plain, while the haze from north to south is reduced, which is related to the geographical environment of Baoji area. In hills of the north and mountain areas of south the haze is less. The maximum value of haze days is located in Baoji City, and the annual average haze is 79.6 days. The minimum value appears in Taibai, and the annual average haze is 2 days. Statistics show that in spring and summer, there are three largest frequency values of haze in Baoji city, Fengxiang and Meixian, and in the autumn and winter there are two largest centers of hazer in Bbaoji city and Fufeng. Overall, the city has the highest frequency of haze. In January and December haze was the most for more than 6 days, and in June and September haze is least, however, in July the haze is relatively more.

Fig. 2 displays the trend of annual average haze. As can be seen, the annual average haze is decreasing at a rate of 0.3 d / 10 year. Especially after 2000, the haze showed a significant decline. The haze change was the difference in different ages. In the 1980s, the average haze was 3.7 days, 4.1 days in the 1990s, 3.3 days in the 2000s, the trend rates were -0.06 per year, -0.01 per year and -0.2 per year respectively.

The statistics show that in spring, summer, autumn and winter the annual average haze is 3.6 days, 1.9 days, 2.4 days, 6.7 days respectively. From Fig.3, it can be seen that in spring, autumn and winter the haze is reducing with the trend rate of -0.93/10 year, 0.02/10 year 0.95/10 year respectively. However, in the summer, the haze is increasing with a rate of 0.77/10 year. In the four seasons the trends of haze are the similar to the annual change.

From Fig.4, it can be seen that annual average haze is characterized by multi-time scale. Haze has a short period of 5 years and a long period of 10year and 15 years. The 10 year cycle is most obvious and the cycle range is roughly in the 1995-2010, while 15year cycle range is in 1981-2005.

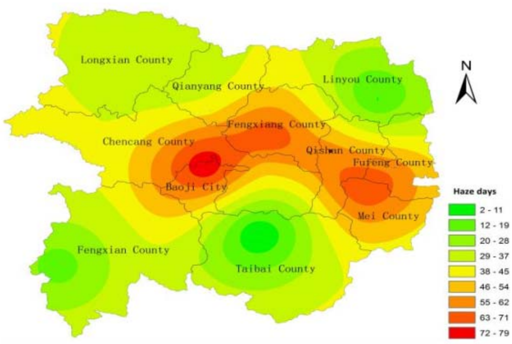

Fig.1 Spatial distribution of annual haze

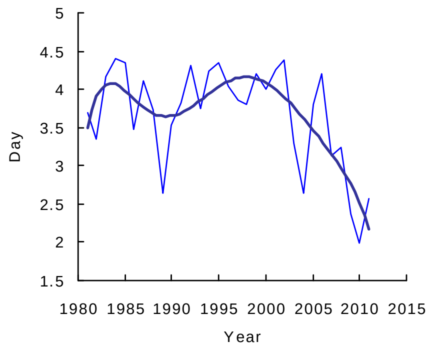

Fig.2 The change of annual mean haze

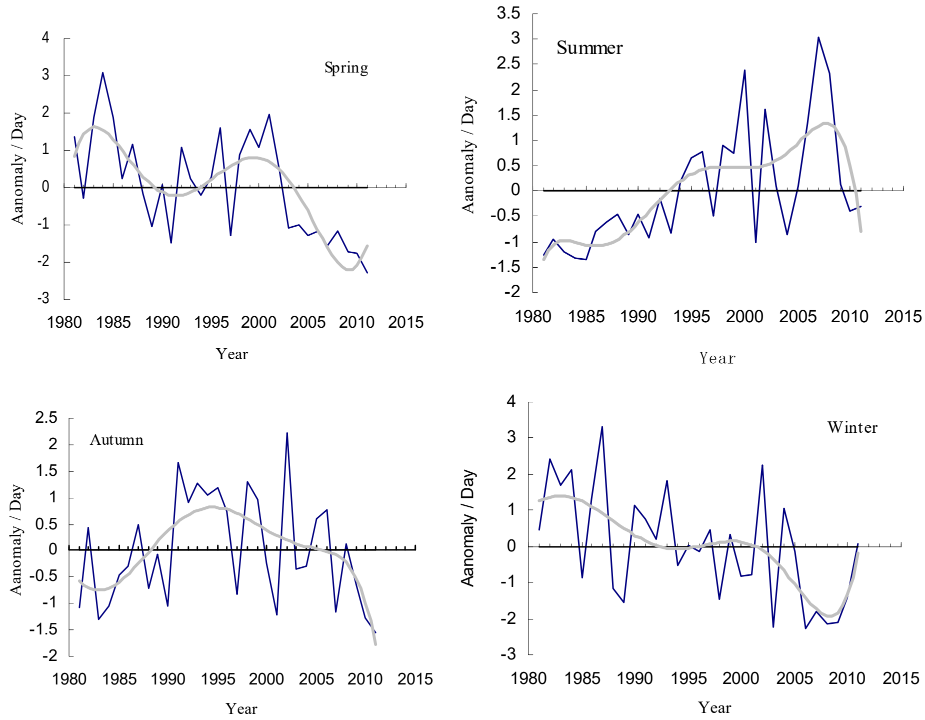

Fig.3 Anomaly change of the haze in four seasons

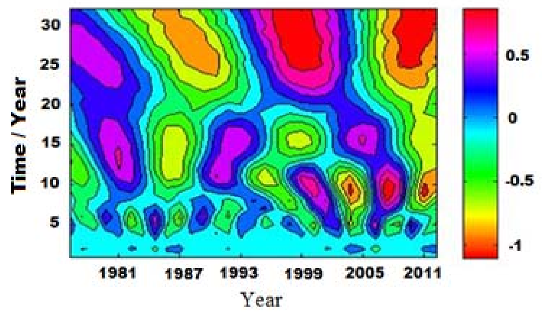

Fig.4 Real part of the wavelet analysis of haze

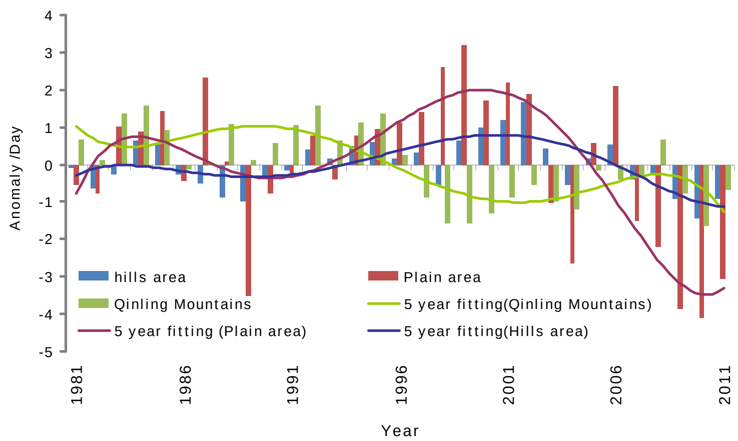

Fig.5 Changes of haze in different areas

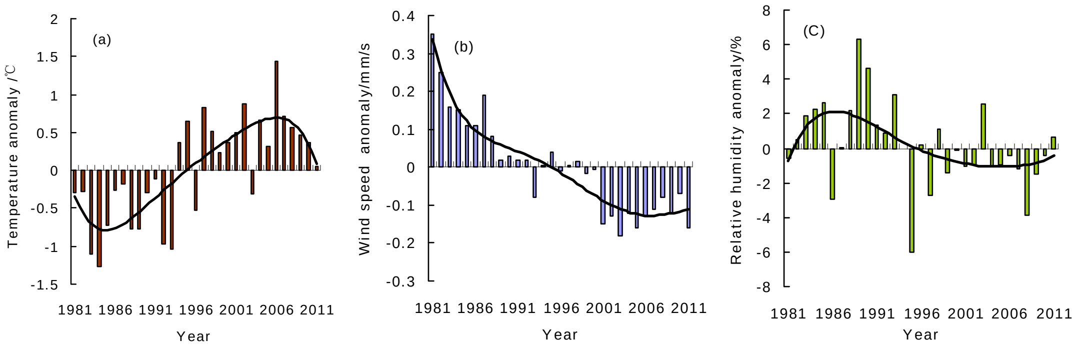

Fig.6 Variations of relative humidity, wind speed and temperature

In order to further understand the difference between the haze in the valley area, Baoji area is divided into 3 units: the northern hills (including Long County, Qianyang County and Linyou County), the central plain (Baoji City, Chencang District, Fufeng, Fengxiang and Qishan) and the southern Qinling Mountains (Meixian, Fengxian and Taibai). The haze trend was analyzed. From fig.5, it can be seen that in the southern Qinling Mountains, the haze has the very obvious reduction trend with a trend of 0.69 days /10 year, especially after 1995, the haze significantly reduced. In the plains of the middle, the haze showed a fluctuating change with a rate of 0.66 days /10 year, and after 2000, haze mainly showed a significant reduction trend. In the northern hilly area, the haze changes are basically similar to plain areas with a rate of -0.02 days /10 year.

3.2. Affecting factor analysis

Haze formation is associated with many factors, such as meteorological elements, energy emissions, air pollutants and aerosols [10-12] .Fig. 6 indicates the change in meteorological elements. As can be seen that the temperature is increasing at a trend rate of 0.52℃/10 year, and relative humidity and wind speed are reducing at a trend rate of -0.13mm/10 year and -0.1%/10 year. In particular, after 1996, the temperature increased obviously, the relative humidity and wind speed decreased significantly. In addition, the temperature was negatively correlated with haze, while the relative humidity and wind speed were significantly positively correlated with haze, with a correlation coefficient of 0.3806 passed a significant reliability test of 0.01. It indicates that meteorological elements have a significant impact on haze changes.

With the socio-economic development, production and residential life emissions of large air pollutants, resulting in increasing PM2.5 and PM10 concentrations and reduced atmospheric visibility, which will increase the intensity of haze. In the Baoji area, the number of polluted particles has decreased and the vegetation coverage has been increased [13], so the number of haze has decreased. Therefore, reducing the climate change influencing on haze, increasing vegetation coverage and using clean energy, it will reduce the occurrence of haze.

4. Conclusion

In summary, the above analysis shows that the incidence of haze in the plain area is the largest, followed by hilly areas, and the incidence of haze in the Qinling Mountains is the smallest. The number of haze in the city is more than in other areas. The number of haze in winter is the most, followed by in spring, and the least in summer. In the winter and spring, the haze have reduction trend, while in the summer haze slight increases and in the Qinling Mountains, haze reduced significantly. The haze change is closely related to temperature, relative humidity and wind speed, therefore, the human impact on the climate should be reduced, to slow down haze formation conditions.

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