IOP Conference Series: Earth and Environmental Science

Study on the Correlation between Aerodynamic Thickness of Airborne Aerosol and PM2.5 in Chongqing Region

To cite this article: Xianghong Wang *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **108** 042001

IOP Conf. Series: Earth and Environmental Science **108** (2018) 042001 doi:10.1088/1755-1315/108/4/042001

Study on the Correlation between Aerodynamic Thickness of Airborne Aerosol and PM2.5 in Chongqing Region

Xianghong Wang[1, 2], Lin Qin[1, 2], Dingyi Wang[1, 2], Baozhen Wang[1, 2]

[1]The Research Center for ecological environment monitoring and disaster control of the Three Gorges Reservoir, Yangtze Normal University, Chongqing 408100, China
[2]Collaborative Innovation Center for Green Development in Wuling Mountain Areas, Yangtze Normal University, Chongqing 408100, China

*Corresponding author e-mail: 26252265@qq.com

Abstract. The correlation between MODIS aerosol optical thickness AOT and PM2.5 concentration in Fuling District of Chongqing was studied. The results showed that AOT and PM2.5 had significant seasonal variation characteristics, and the daily mean correlation Which was significant in the summer and poor correlation in winter. The influencing factors affecting the correlation between MODIS AOT and PM2.5 were studied, and the correlation coefficient between them was also greatly improved. Therefore, it is of great value to use MODIS AOT to monitor the distribution of PM2.5 in atmospheric particulate pollutants.

1. Introduction

Aerosol scale scope includes liquid or solid particles from 10-3um to 10um molecular groups, and the earth radiation budget can be changed, which has major influence on global energy radiation balance [1]. However, since sound space coverage information can not be obtained from aerosol distribution, it is difficult to reflect the macro distribution of pollutant sources and changing trend [2]. Satellite remote sensing data can make up for these deficiencies, it becomes a novel means to monitor global aerosol pollution [3], satellite remote sensing can obtain pollutant distribution in greater scope than that of ground monitoring. In addition, satellite remote sensing can be adopted for distinguishing smaller ground objects [4], remote sensing data can be further inverted for obtaining PM2.5 density distribution in the region, thereby making important supplement for monitoring the distribution in one region on the ground.

Currently, MODIS satellite data is used for study and inversion aiming at PM2.5 monitoring method, and it has made considerable progress and achievements. The most widely used inversion method is shown as follows: an relationship is established between total mass of aerosol gas and ground inhalable particle density [5]. Hoff et al. proposed to use AOTAOD-based method for estimating PM2.5 concentration [6]. In the study of PM10, Chu et al. [7] found that the moderate resolution imaging spectroradiometer (MODIS) AOD product has the potential of being applied in air quality monitoring. When Koelemeijer [8] et al. studied aerosol, the meteorological factors such as boundary layer height, air relative humidity, etc. are considered for obtaining better correlation coefficient between PM and AOD. When Gupta et al. [9] studied aerosol spatial distribution, it was discovered that cloud deck ratio and mixing layer height would affect the correlation between MODIS

AOD and PM. The correlation thereof was weakened with the increase of the mixing layer height. Liu et al. [10] established two general linear regression models in the U.S. St. Louis to estimate the ability of near-surface PM2.5. Li Yajuan utilized MODIS L1B data to estimate the spatial distribution of PM2.5 concentration in Lanzhou urban area in winter through establishing an AOD-PM relationship model [11]. Guo Jianping, etc. utilized PM2.5 observation data in atmospheric composition site. Scatter fitting and time series fitting verification were carried out for AOD product estimation model [12]. Xie Yi utilized MODIS aerosol product which was combined with ground PM2.5 measured air pollution data and meteorological data. An estimation model of PM2.5 satellite remote sensing is established [13].

In the paper, regional air pollution monitoring status was studied, and time sequence diagrams of AOT data and near ground PM2.5 daily measured data of Fuling District of Chongqing in 2015 were measured. Their seasonal variation characteristics were compared, the correlation thereof is discussed, and the application and environmental significance of aerosol data in regional and local air pollution monitoring were verified.

2. Data information and processing methods

2.1. MODIS aerosol data

MODISAOT data product was downloaded from NASA LAADS. Lidu Town Yangtze Normal University in Fuling District of Chongqing (north latitude N29°45 ' and East longitude E107 °15 ') is regarded as the center. 100km2 space scope was selected for research. The optical thickness data at 0.55μm of land aerosol was extracted. The remote sensing precision was affected by weather surface type, environmental status and cloud content [14].

2.2. PM2.5 concentration

The monitoring site of Yangtze Normal University is located in Fuling New District of Chongqing, which is surrounded by Changshou, Fuling Baitao and other chemical industrial parks. It is close to traffic main road, which is affected by life pollution, industrial pollution and traffic pollution and has typical basin air pollution characteristics. The sampling device used in PM2.5 concentration monitoring belongs to U.S. XHPM 2000E, which is equipped with a PM2.5 cutting head, and the flow rate is 16.7 L/min. The sampling volume was converted according to the real-time temperature and air pressure, and the sampling time and date were set.

2.3. Meteorological data

Chongqing Fuling is located in the intersection of Yangtze River and Wujiang River. Its geographical environment mostly belongs to hilly area. Fuling is located in the hinterland of Wuling Mountainous Area, thereby leading to the special complex basin distribution in Fuling. It is characterized by perennial rain, static and stable weather with less wind, high temperature, etc. The special geographical environment and geographical location cause slower atmosphere circulation speed. Soot, particles and other pollutants discharged by production and life to atmosphere can not spread timely. Meteorological parameters are monitored during monitoring of PM2.5 at the same time, thereby obtaining daily measured temperature, humidity, wind speed, wind direction and other meteorological data, and analyzing the influence with daily means.

3. Results and discussion

3.1. Change characteristics of MODIS AOT and PM2.5

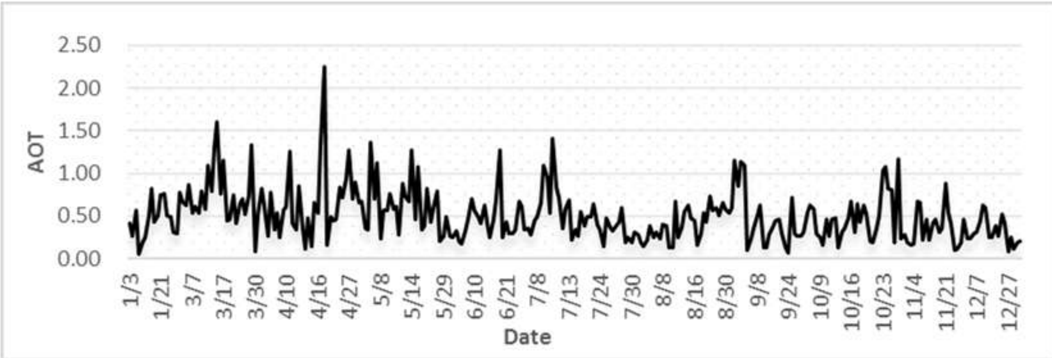
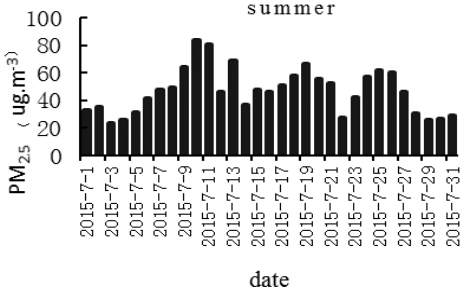


Figure 1. AOT daily variation diagram of Fuling District of Chongqing in 2015

The annual change range of MODISAOTAOT (figure 1) is 0.047 ~ 2.25, wherein 95% is changed between 0 and 1.4. During the summer months (from April to September), The daily change amplitude is larger, and there is a trend of continuous increase before high value for six months in summer (from April to September). The daily change amplitude is relatively smooth for six months in winter (from October to March). The monthly average changes of AOT is also obviously periodic, which is changed between 0.312 and 0.745. The monthly maximum value appears in March. The minimum value appears in December. The AOT for six months in summer is higher than that of six months in winter prominently. MODIS AOT has obvious seasonal variation, the AOT is the highest (about 0.67) in spring and the value is slightly declined in the summer (about 0.45), and the optical thickness is equivalent in autumn and winter (about 0.43 and 45).

The temperature of Chongqing Fuling is high in spring with high humidity and other environment characteristics, thereby promoting hygroscopic growth process of aerosol particles. The AOT value is increased with the influence of artificial pollution sources such as industrial concentrated production emission etc. at the beginning of the year. Therefore, AOT value is high in spring, the air circulation speed is fast in July and August with prominent high temperature, and the aerosol content in summer is slightly lower than that in spring. Optical thickness in winter and autumn is relatively low, which is caused by frequent weather system movement in large scope from north to south in winter and autumn, namely clean air southward movement, which leads to cleaner air, and is conducive to the diffusion of the pollutants from the upper air.



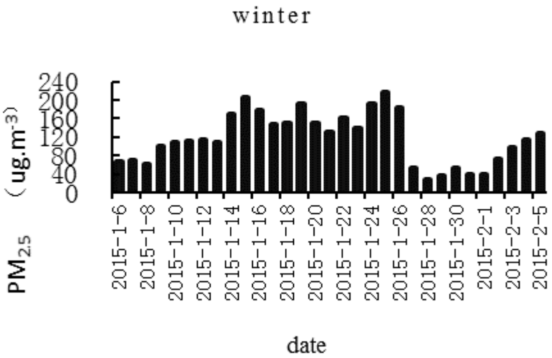


Figure 2. PM2.5 concentration daily average change of Fuling District of Chongqing in 2015

The concentration range of PM2.5 is 27.40~216.61μg•m^{-3} in winter, and the mean value is 116.28μg•m^{-3}; The concentration range of PM2.5 is 23.21~83.33μg•m^{-3} in summer, and the mean value is 46.80μg•m^{-3}. The concentration of PM2.5 in winter is significantly higher than that in summer, which is about 2.5 times of summer. The difference is caused because Fuling is located in the mountainous area of Chongqing, which belongs to east valley of Sichuan Basin with low wind speed and long static wind duration. In addition, fog weather is frequent in winter, which is not conductive for diffusing ground surface contaminants, there is much rain in summer, which is helpful to remove particulate matter. The PM2.5 concentration in winter is larger than that in summer. It is obvious that the pollution of atmospheric fine particulate matter in winter is higher than that of summer.

3.2. Analysis on correlation between MODIS AOT and PM2.5

In Chongqing, the seasonal variation difference of AOT and PM2.5 is great because ground surface PM2.5 concentration is increased due to poor diffusion conditions in winter and increase of various emission sources, thereby vertical distribution of particles is uneven. In addition, cloudy weather is frequent in winter, thereby the AOT effective duration is decreased, and the deviation is larger. Furthermore, rainfall is large in Chongqing during summer, the pollutant diffusion environment is good, and the vertical distribution is relatively uniform, thereby resulting in low value of ground surface PM2.5 value. Since weak southerly wind is popular in spring and summer, high humidity, high temperature and other environmental characteristics are caused, thereby promoting photochemical and aerosol particles moisture absorption growth process as well as obvious increase of AOT.

Figure 3 shows that series 1 corresponds to PM2.5 concentration in summer, series 2 corresponds to AOTAOT. The results show that the correlation between AOT value and PM2.5 daily mean is very good in summer. The correlation thereof is poor in winter. AOT and PM2.5 undergo linear regression to compare the correlation thereof. The linear correlation coefficient R reaches 0.702, which is more than 99% statistical confidence level requirements. It is obvious that the correlation between AOT and PM2.5 is excellent in daily variation analysis and comparison. In winter, the correlation coefficient thereof is lower, and it indicates that the seasonal changes have severe influence on the correlation between AOT and PM2.5.

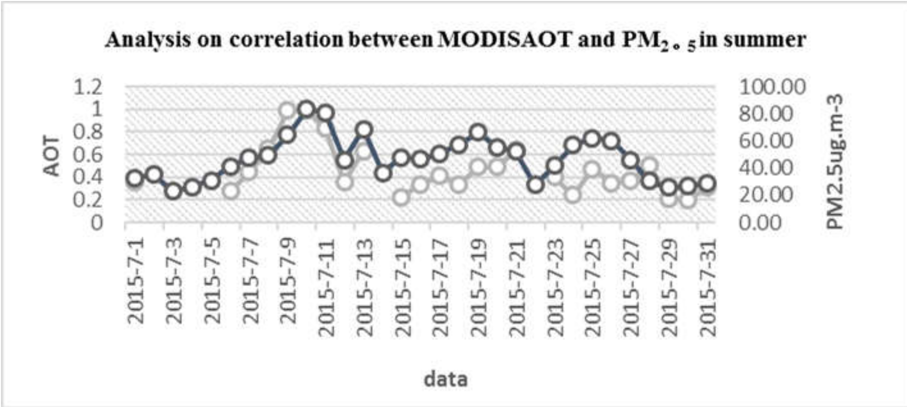


Figure 3. Analysis on correlation between MODISAOT and PM2.5 in summer

3.3. Factors affecting the correction between MODIS AOT and PM2.5

Humidity factor can affect the size of the aerosol particles, temperature can affect the photochemical conversion reaction and the presence of semi-volatile components, which has influence on the distribution of aerosol particle size spectrum in terms of influence of environmental background meteorological factors. Therefore, the seasonal variation will lead to influence on the correlation. Wind speed affects the diffusion and dilution capacity of atmosphere. The diffusion conditions and transmission performance of pollutants in the atmosphere directly affect the observation of PM2.5 and AOT. In Chongqing, the vegetation coverage area is reduced in winter because of weather factors. The ground is covered by ice sometimes, thereby forming bright background. It is greatly different from the requirements of remote sensing inversion algorithm. It is also the source of important error in winter. Seasonal variation factors are further studied, such as humidity, boundary layer height and other environmental conditions, and the correlation thereof is also enhanced.

4. Conclusion

In the paper, the obtained AOT and PM2.5 concentration observed on the basis of ground instrument are utilized for comparatively analyzing characteristics of daily change thereof. It indicates that the seasonal influence is obvious. Because they are different description modes on atmospheric particulates, which is vulnerable to various environmental conditions, meteorological factors as well as precision and accuracy of satellite data inversion process. The influence factors are further analyzed and studied. The correlation coefficient thereof has much room to improve. Application of MODIS AOT in monitoring atmospheric particulate pollutants distribution and transmission has higher regional application value.

Acknowledgments

This work was financially supported by Chongqing Municipal Commission of social and livelihood projects (Grant No. cstc2015shmszx20010) and Scientific and Technological Research Program of Chongqing Municipal Education Commission (Grant No. KJ1401205).

References

[1] Huai Hongyan, Li Zhengqiang, Chen Liangfu, et al. Research on atmospheric aerosol property change in the North of Beijing based on foundation polarization observation. Journal of Remote Sensing. 2008, 12 (3): 490—498.
[2] Li C C, Mao J T, Alexis Kai-Hon Lau, etal. The application of remote sensing aerosol products from MODIS data in the research on air pollution of Beijing. Science in China (SeriesD:Earth Sciences). 2005, 35 (Suppl. Ⅰ):177-186 (in Chinese).
[3] Kaufman Y J, Tanre D, Gordon H R, etal. Passive remote sensing of tropospheric aeroso land at mospheric correction for the aerosol effect. JGeophys Res, 1997, 102(D14):16815-16830.

[4] Hu Zimei. Research on aerosol pollution in Shanghai based on satellite remote sensing and ground monitoring data. East China Normal University, 2014.
[5] Li Qian, Li Lingjun, Zhang Dawei, et al. Discussion on remote sensing monitoring business methods of Beijing atmospheric PM (2.5). Environmental Science Research, 2016, (10):1417-1425.
[6] Hoff R M, Brook J R, Creen M, et al. Remote sensing of particulate pollution from space: have we reached the promised Land. Journal of the Air ＆ Waste Management Association, 2009, 59(10): 1130-1138.
[7] Chu D A, Kaufman Y J, Zibordi G, et al. Global monitoring of air pollution over land from the Earth Observing System-Terra Moderate Resolution Imaging Spectroradiometer (MODIS). Journal of Geophysical Research, 2003, 108(D21): 4661, doi:10. 1029 /2002JD003179.
[8] Koelemeijer R B A, Homan C D, Matthijsen J. Comparison of spatial and temporal variations of aerosol optical thickness and particulate matter over Europe. Atmospheric Environment, 2006, 40 (27): 5304-5315.
[9] Gupta P, Christopher S A, Wang J, et al. Satellite remote sensing of particulate matter and air quality assessment over global cities. Atmospheric Environment, 2006, 40 (30):5880-5892.
[10] Liu Y, Franklin M, Kahn R, et al. Using aerosol optical thickness to predict ground-level PM2. 5 concentrations in the St. Louis area: a comparison between MISR and MODIS. Remote Sensing of Environment, 2007, 107 (1-2): 33-44.
[11] Li Yajuan. Analysis on quantitative estimation of PM (2.5) concentration in winter in Lanzhou based on MODIS. Northwest Normal University, 2013.
[12] Guo Jianping, Wu Yerong, Zhang Xiaoye, etal. Estimation of PM (2.5) by MODISAOT product in Eastern China under BP network framework. Environmental Science, 2013, (03):817-825.
[13] Xie Yi. Research on remote sensing estimation model of atmospheric fine particulate matter (PM (2.5)). Nanjing Normal University, 2013.
[14] Levy R C, Remer L A, Dubovik O. Global aerosol optical properties and applicationto Moderate Resolution Imaging Spectroradiometer aerosol retrieval over land. J Geophys Res, 2007b, 112, D13210, doi:10.1029/2006JD007815.