# Retrieving of Inhalable Particulate Matter Based on SPOT Image

Ming Tang, Wenji Zhao*, Huili Gong, Zhaoning Gong a Wenhui Zhao, Yao Xiao, Wei Yang

College of Resources Environment and Tourism, Beijing Key Lab of Resource Environment and GIS, Capital Normal University, Beijing 100048, China — xyza_113@163.com; zhwenji1215@163.com*; zhwenhui99@gmail.com

**Abstract[1]: This study built a model with DVI, which is computed by near-infrared and red bands of SPOT-5 image, and observed concentration of $PM_{10}$ (inhalable particulate matter) to retrieve concentration of $PM_{10}$ in SPOT-5 image of Beijing urban acquired in 2007. Spatial distribution trends of $PM_{10}$ are basically identical between retrieved result and observed data. In 2007, inhalable particulate pollution in northern area of Beijing urban is more serious than that in southern area, concentration of $PM_{10}$ is lower around greenbelt and water body, and it is higher around roads. The retrieval results help us to know the distribution of $PM_{10}$ pollution, and it is helpful for controlling the air pollution.**

**Key words:** SPOT image; DVI; $PM_{10}$; Retrieval; Spatial distribution;

## 0. INTRODUCTIONS

With urban economy's rapidly developing, environment issues were increasingly serious, and began to threaten human's health. In China even a lot of Asian countries, inhalable particulate matter (IPM) has already become the major pollutant. Therefore, it has received increasing attention in recent years.

Gu Y etc (2008) have analyzed the relationship between dust weather and TSP, $PM_{10}$ pollution in Hohhot. It shows that the concentrations of TSP and $PM_{10}$ increase in varying degrees during the sandstorm and a few days before and after it. The concentrations are the highest in the day sandstorm happens. During the sandstorm, there is linear relationship between TSP and $PM_{10}$. Jin W M etc (2009) have researched the relationship between $PM_{10}$ and meteorological factors in Nantong urban in four seasons. It shows that meteorological factors are important influencing factors of $PM_{10}$. Zhang H X etc (2009) have used the data from monitoring station to analyze temporal and spatial distribution of $PM_{10}$ in Handan. The study shows that the average concentration of $PM_{10}$ in heating period is significantly higher than the concentration in non-heating period. In one day, the concentration of $PM_{10}$ in the morning is the highest, is lower in the night, and is the lowest in the afternoon. Guo J B etc (2009) have analyzed the air pollution index in different areas of Beijing and different periods. It shows that the major pollutant in Beijing is $PM_{10}$. In one year, atmospheric environment is better from June to August, and is worse in winter. The studies above have analyzed the relationship between $PM_{10}$ and sandstorm, seasons, meteorological factors, and heating period. Most of traditional $PM_{10}$ studies use the data from air monitoring stations, air monitoring stations are usually not so many, and they cannot reflect the distribution of $PM_{10}$ in the whole area. However, remote sensing methods can make up this deficiency.

Yu Z M etc (2004) have used AVHRR data to calculate difference vegetation index (DVI), and built the regression equation of DVI and particle pollution index to do quantitative retrieving. SHI T G etc (2008) have retrieved AOD of Jinan by DDV method, in 2005. According to the relationship between AOD and $PM_{10}$, they retrieved the distribution of $PM_{10}$.

The studies above have provided the methods of $PM_{10}$ retrieval, whereas the monitoring stations are still not so many. In this paper, we selected 73 sampling sites in study area to make up this deficiency, and made the sampling sites cover with the whole area. We measured different diameters of $PM_{10}$, and used $PM_{10}$ of 1μm, 3μm, and 5μm diameters to do retrieving research. The distributing trends of retrieval results and measured data are basically consistent.

## 1. DATA AND METHOD

### 1.1 Study area and data

The study area is Beijing urban. We selected 73 sampling sites within Fifth Ring road on different underlying surface to measure $PM_{10}$ in non-heating period. The $PM_{10}$ data was measured by handheld laser particle counter, and the coordinates of sampling sites were measured by GPS.

[1] zhwenji1215@163.com

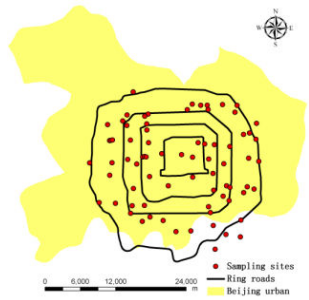



Fig.1 Distribution of sampling sites

SPOT-5 image of Beijing in June 15th, 2007 was used in this study. The sampling period was in June. Because the study area is wide, it is difficult to monitor all the sampling sites during the day when the satellite is passing though. We selected the days which are close to June 15th, and have the same weather as sampling period. It is a sunny day in June 15th, there is no abnormal weather, so the measured data can reflect the distribution of $PM_{10}$ when the satellite is passing though.

**1.2 Image preprocessing**

Two scenes of SPOT-5 image were used in the study. First, we did image mosaic to the two images, and then did geometric correction. The error was controlled in one pixel. Beijing urban image was cut form the SPOT-5 image. (Fig.2)

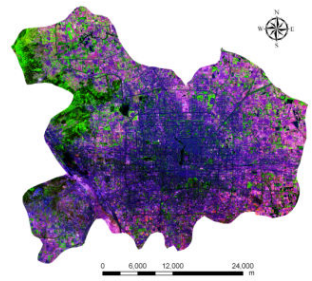


Fig.2 SPOT–5 image

**1.3 DVI calculation**

There is linear correlation between DVI and $PM_{10}$ (2009), therefore, we computed DVI to do correlation analysis. DVI is computed by near-infrared and red bands,

$$DVI = DN_{NIR} - DN_R \quad (1)$$

In this equation, DVI is Deference Vegetation Index, $DN_{NIR}$ is the DN value of near-infrared band, and $DN_R$ is the DN value of red band.

**1.4 PM10 retrieval**

According to the coordinates of sampling sites, the sampling sites were marked on the image. To reduce the error of locating, DVI of 3×3 pixels around every sampling site was taken the average to be regarded as the DVI of the sampling site.

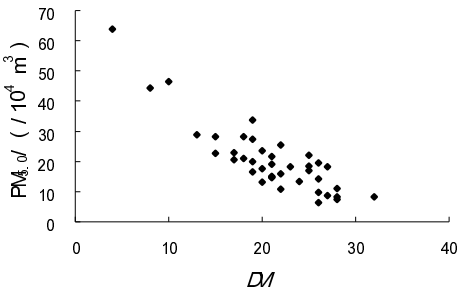
Analysis functions in SPSS software were used to analyze the correlation between DVI and concentration of $PM_{10}$. The sampling sites with obvious errors were rejected to enhance the correlation. In each equation, 30 sampling sites were used to analyze the correlativity, and another 5 sampling sites were randomly selected to do precision verification. The correlation equations between $PM_{10}$ and DVI are as follows.

$$y = -19\ 365.1\ x + 605\ 180.8 \quad (2)$$

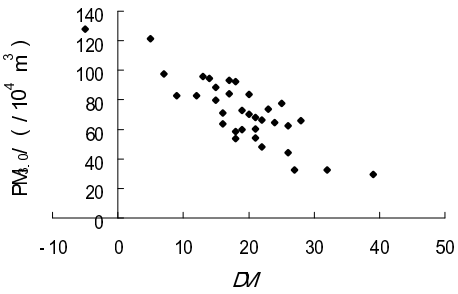
$$y = -24\ 691.2\ x + 1\ 175\ 452 \quad (3)$$

$$y = -299\ 113\ x + 13\ 000\ 000 \quad (4)$$

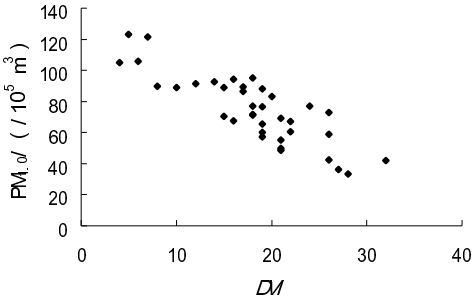
The three equations are correlation equations between DVI and $PM_{10}$ of 5.0μm, 3.0μm and 1.0μm diameters. Correlation coefficients "R" of the three equations are 0.883, 0.748 and 0.775. In the equations, y is concentration of $PM_{10}$, the unit is $/m^3$, and x is DVI. The Scatter diagrams are as follows.




(a) 5.0 μm diameter




(b) 3.0 μm diameter



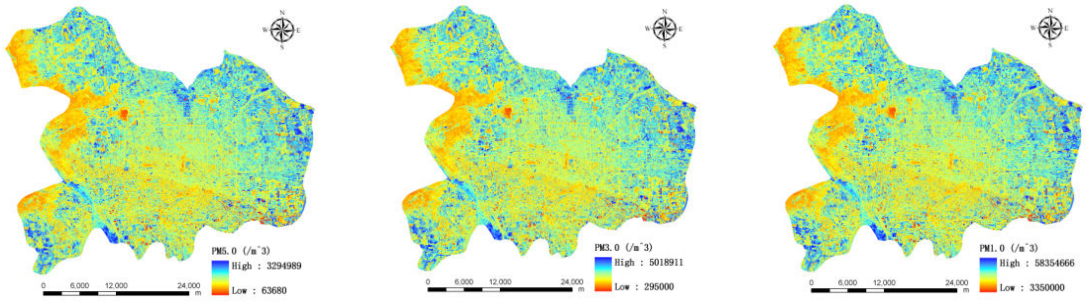

(c) 1.0 μm diameter

Fig.3 Scatter diagrams of correlation between concentrations of $PM_{10}$ with 3 kinds of different diameter and *DVI*

From figure 3, we can see that there is obvious correlation between DVI and $PM_{10}$.

## 2. RESULTS

According to correlation equations, concentration of $PM_{10}$ was retrieved.



(a) 5.0 μm diameter (b) 3.0 μm diameter (c) 1.0 μm diameter

Fig.4 Retrieving results of $PM_{10}$ with 3 kinds of different diameter

Distributions of $PM_{10}$ of 5.0μm, 3.0μm and 1.0μm in Beijing urban are showed in figure 5. The retrieving results are compared with figure 2, and it shows that concentration of $PM_{10}$ around roads is higher than that around vegetation and water. Concentration of $PM_{10}$ in the west of Beijing is lower than that in the east, because there is lots of vegetation in the west of Beijing. Concentration of $PM_{10}$ in the north of Beijing urban is higher than that in the southern part, because Olympic venues were being constructed in 2007, building construction dust had great influence on the air quality in the north, and however, it had little influence on the air quality in the southern part. The spatial distribution pattern of $PM_{10}$ showed in retrieving results is basically identical with measured data.

## 3. PRECISION VERIFICATION

To verify the precision of the results, measured data of 5 sampling sites were randomly selected to be compared with retrieval data, and the retrieval error was calculated.

Tab.1 Precision examination of $PM_{10}$ with 5.0 μm diameter retrieving

| No. | $PM_{10}$ retrieved /($/m^3$) | $PM_{10}$ measured /($/m^3$) | Error /(%) |
|---|---|---|---|
| 1 | 82 323.1 | 182 100 | 54.79 |
| 2 | 353 434.5 | 287 800 | 22.81 |
| 3 | 198 513.7 | 191 200 | 3.81 |
| 4 | 159 783.5 | 182 200 | 12.30 |
| 5 | 198 513.7 | 216 800 | 8.43 |

Tab.2 Precision examination of $PM_{10}$ with 3.0 μm diameter retrieving

| No. | $PM_{10}$ Retrieved /($/m^3$) | $PM_{10}$ Measured /($/m^3$) | Error /(%) |
|---|---|---|---|
| 1 | 508 789.6 | 323 500 | 57.28 |
| 2 | 632 245.6 | 662 700 | 4.50 |
| 3 | 706 319.2 | 727 200 | 2.87 |
| 4 | 558 172.0 | 777 500 | 28.21 |
| 5 | 755 701.6 | 839 200 | 9.95 |

Tab.3 Precision examination of $PM_{10}$ with 1.0 μm diameter retrieving

| No. | $PM_{10}$ Retrieved | $PM_{10}$ Measured | Error |
|---|---|---|---|

| | /(/m$^3$) | /(/m$^3$) | /(%) |
|---|---|---|---|
| 1 | 9 410 644 | 9 147 000 | 2.88 |
| 2 | 5 223 062 | 4 226 000 | 23.59 |
| 3 | 6 419 514 | 6 714 000 | 4.39 |
| 4 | 5 821 288 | 7 705 000 | 24.45 |
| 5 | 8 513 305 | 8 878 000 | 4.11 |

The three tables show that the total error is normal, but there are several sampling sites which have abnormal error. The reason may be that the meteorological condition was abnormal when the data was measuring, such as the data of wind speed, temperature or humidity was too high or too low. On the other hand, the reason may be that there were many cars passed by during the measuring time, the car exhaust effected the concentration of $PM_{10}$. However, the several groups of abnormal $PM_{10}$ data have not significant effect on the total precision.

## 4. CONCLUSIONS

(1)DVI which computed by SPOT-5 image and measured data of $PM_{10}$ can be combined to do quantitative retrieval of $PM_{10}$. Distribution pattern reflected in the retrieval results is basically identical with measured data. The precision verification results show that there are several abnormal sampling sites, and the total error is normal.

(2)The weather and time during the measuring period between different sampling sites have more or less difference. It makes that some measured data is quite different from the retrieval data. Moreover, the range of study area is wide, and it is difficult to monitor all the sampling sites in one day during the satellite passing though, so it makes some errors. We will try to decrease this error in the future study.

## REFERENCES


Jin W M, "The main meteorological factor influences the law discussion to the density of the inhalable particles", Environmental Monitoring in China, vol 25, p.p. 71-75, August 2009.

Gu Y, Li H L, Dong Z and Dai T, "Study on relation between dust weather and TSP and $PM_{10}$ pollution of Huhhot in 2008 spring", Environmental Monitoring in China, vol 25, p.p. 95-98, October 2009.

Guo J B and Chen Y, "Patterns of seasonal change in air pollution and suggestions on pollution control in Beijing", Ecology and Environmental Sciences, vol 18, p.p. 952-956, March 2009.

Shi T G, Duan Y S, Sun L and Li D Q, "Study of $PM_{10}$ retrieve with MODIS over Jinan", Journal of Shandong Jianzhu University, vol 23, p.p. 213-220, June 2008.

Yu Z M, Zhou H M and Zheng Y F, "Study on distribution of urban particle pollution by remote sensing and GIS", Journal of Natural Disasters, vol 13, p.p. 58-64, June 2004.

Zhang H X, Dong Z Q, Yang L Z, Wang L Y and Li M, "Pollution status of inhalation particles and relative meteorological conditions in Handan", Meteorological and Environmental Sciences, vol 32, p.p. 134-147, September 2009.


## ACKNOWLEDGEMENTS


Acknowledgements for the key program of Beijing Natural Science Foundation (ID: KZ200910028006) funding.