



# Estimating Ground Level PM2.5 Concentration in the Pearl River Delta Region of China using Landsat 8 and Ground Measurements

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## INTRODUCTION

In 1952, the London Smog Disaster, killed almost 12,000 people as reported by 20th Century History. Since then, the world started the environmental movement, including air quality assessment and management. In February 2015, a Chinese documentary film named Under the Dome drew two hundred million hits in 48 hours after it is released, which immediately rose the public awareness of PM2.5.

Particulate matter (PM) is a complex mixture of airborne particles with different compositions and diameters (Gupta et al., 2006). PM 2.5 is the fine particles with the aerodynamic diameter less than 2.5  $\mu$ m. The sources of it mainly include nature (sea salt, dust, volcanic eruptions etc.) and human activities (fossil fuel burning, industry, transport etc.) (Emili et al., 2010).

PM2.5 negatively affects human health and previous research has proved the correlation between PM2.5 and asthma, cardiovascular problems, respiratory infections, lung cancer, mortality, etc. A recent research (Hamra, 2014) shows that the lung cancer rate will increase 9% with per 10% increase of PM2.5.

Early researches show the high agreement between satellite-derived aerosol optical depth (AOD) and ground-level PM concentration. AOD is a parameter of the extinction of electromagnetic radiation at a given wavelength (Chudnovsky et al., 2014).

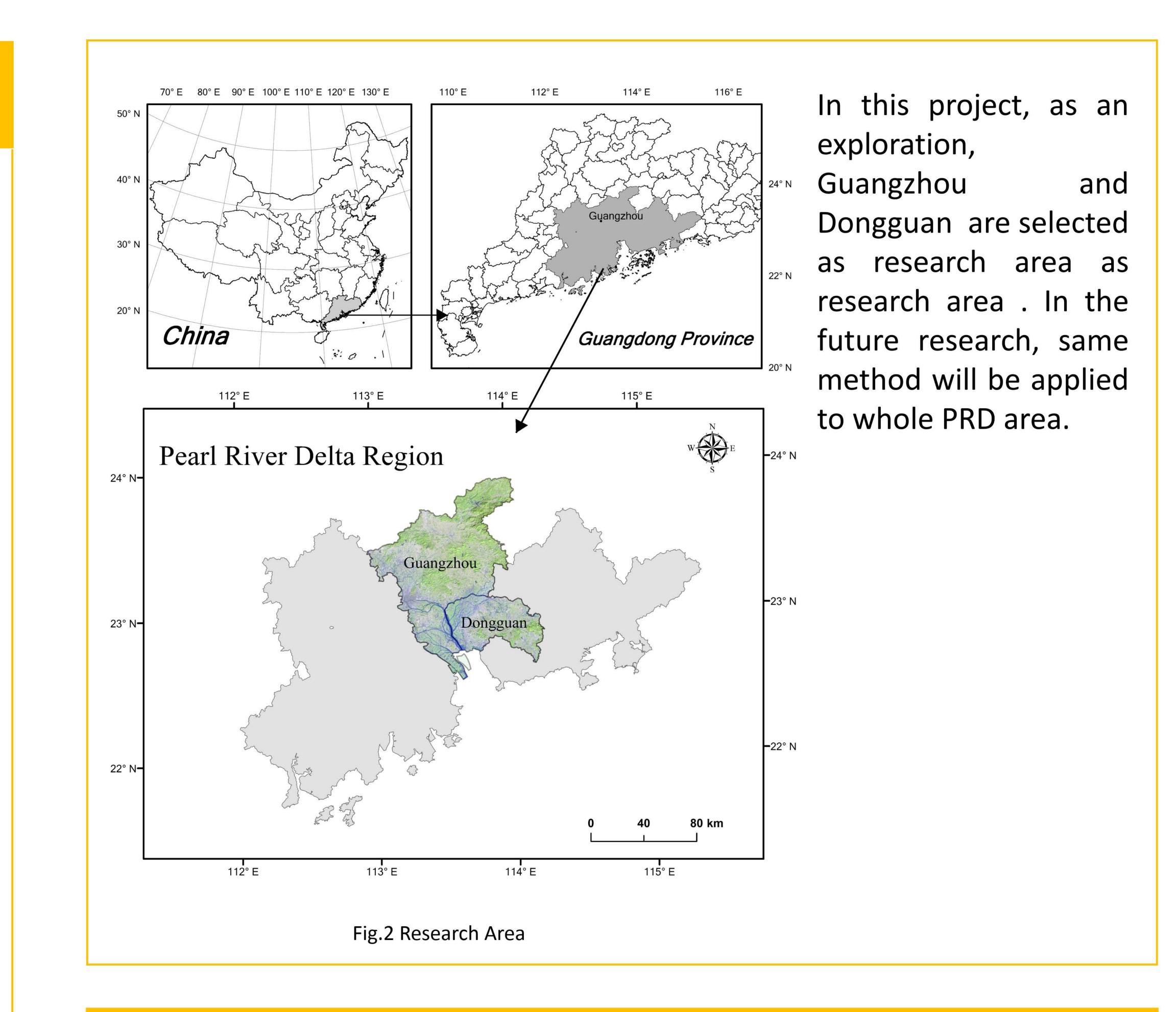
Although ground-based monitoring data is a relatively accurate measurement, it is a representative of the distribution in a limited region around monitoring stations (Tian Jie, 2010). Moreover, the temporal coverage of monitoring information also varies (Benas 2013). On the contrary, satellite image could provide AOD information in a larger coverage with a constant temporal resolution. However, when monitoring PM2.5 concentration, remote sensing instrument does not always work due to cloud and snow cover, which result in the lack of AOD information.

The major issue which limits the PM2.5 estimation is that AOD presents the totally atmospheric aerosol concentration, while in-situ PM2.5 is only measured near the ground with particular matter with the aerodynamic diameter less than 2.5  $\mu$ m (Benas et al., 2013).

## RESEARCH AREA

Pearl River Delta (PRD), in southern China (Fig.2), includes 9 cities (Guangzhou, Dongguan, Shenzhen, Foshan, Jiangmen, Zhuhai, Zhongshan, Zhaoqing, Huizhou) on mainland, Hong Kong and Macau.

In PRD, with population over 60 million people, rapid industrialization and urbanization since 1978 has had a significant impact on the environment of the whole PRD region. As a result, the annual mean PM2.5 in this region was 42  $\mu$ g/m³ in 2014, 320% higher than the World Health Organization's guideline (10  $\mu$ g/m³).



# DATA

#### Ground-Based PM2.5 Data

The ground-based PM2.5 information (hourly averaged) is provided by the Ministry of Environmental Protection of China. And the recording time is 19<sup>th</sup>

		Table.2 Monitoring Sta	tions		
No.	City	Monitoring Station Name	Longtitude	Laltitude	pm2.5 (ug/m3)
1345A	Guangzhou	Guangya Middle School	113.24	23.14	100
1346A		No.5 Middle School	113.27	23.10	95
1347A		Tianhe Zhiyou	113.32	23.14	87
1348A		Guangdong Business College	113.36	23.09	82
1349A		No.86 Middle School	113.44	23.10	93
1350A		Panyu Middle School	113.36	22.91	85
1351A		Huadu Normal School	113.22	23.39	68
1352A		City Monitoring Station	113.26	23.12	84
1353A		Zhenglong, Jiulong Town	113.57	23.28	87
1354A		Li Lake	113.29	23.15	78
1355A		Maofengshan Forest Park	113.46	23.30	90
1387A	Dongguan	Experimental Middle School	113.79	23.05	103
1388A		Yuanling Nancheng	113.76	23.02	99
1389A		Guangcheng No.2 Water Plant	113.77	23.05	71
1390A		Dongcheng Shijin	113.81	23.05	97
1391A		Nancheng Xiping	113.75	22.9	100

January 2015 18:0019:00 GMT. In the research area, there are 11 monitoring stations in Guangzhou and 5 stations in Dongguan. Detail information of monitoring stations can be found in Table. 2 and the locations of these stations are mapped in Fig.1

#### Satellite Remote Sensing Data

Previous research has adopted MODIS, MISR, etc. into PM2.5 estimation. However, relatively lower spatial resolution (250m\*250m) can hardly provide detail PM2.5 distribution. In this project, Landsat8 OLI data is employed to retrieve AOD information. Landsat 8 was launched on February 11, 2013. In this project, the acquisition date is 19th January 2015 at Path/Row 122/44 and the scene start time was 18:58 GMT. Blue, red and SWIR band is mainly used in the AOD retrieval process and their wavelength can be found in Table.1.

#### Land Use(LU) Information

Land use information is also integrated in this project. The land use information is extracted basing on object-based method by eCongition 8.7 software. The distribution of urban area can is shown on Fig.1

Vegetation is employed to retrieve the AOD

information. The principle of this method is

for the dark objective, the reflectance in red

Monitor	OLI/TIRS	
Satellite	Landsat 8	
Launch Year	2013	
Date Acquired Time	2015. Jan.19. 18:58 GMT	
Spatial Resolution	30m*30m	
Path/Row	122/44	
Spectral Coverage(µm)	0.43-12.5	
Band 2(Blue) Wavelength(um)	0.45-0.51	
Band 4(Red) Wavelength(um)	0.64-0.67	
Bnad 7(SWIR2) Wavelength(um	) 2.11-2.29	

Fig.4 The Interface of Retrieval Program

and blue band are negligible. Thus, the reflectance received by satellite can be considered the contribution of atmosphere. Then through radiation functions, AOD can be derived. And using C#, we program an application (Fig.4). The Satellite-based AOD distribution is

The Satellite-based AOD distribution is shown in Fig.5.

Because the aerosol type is defined as

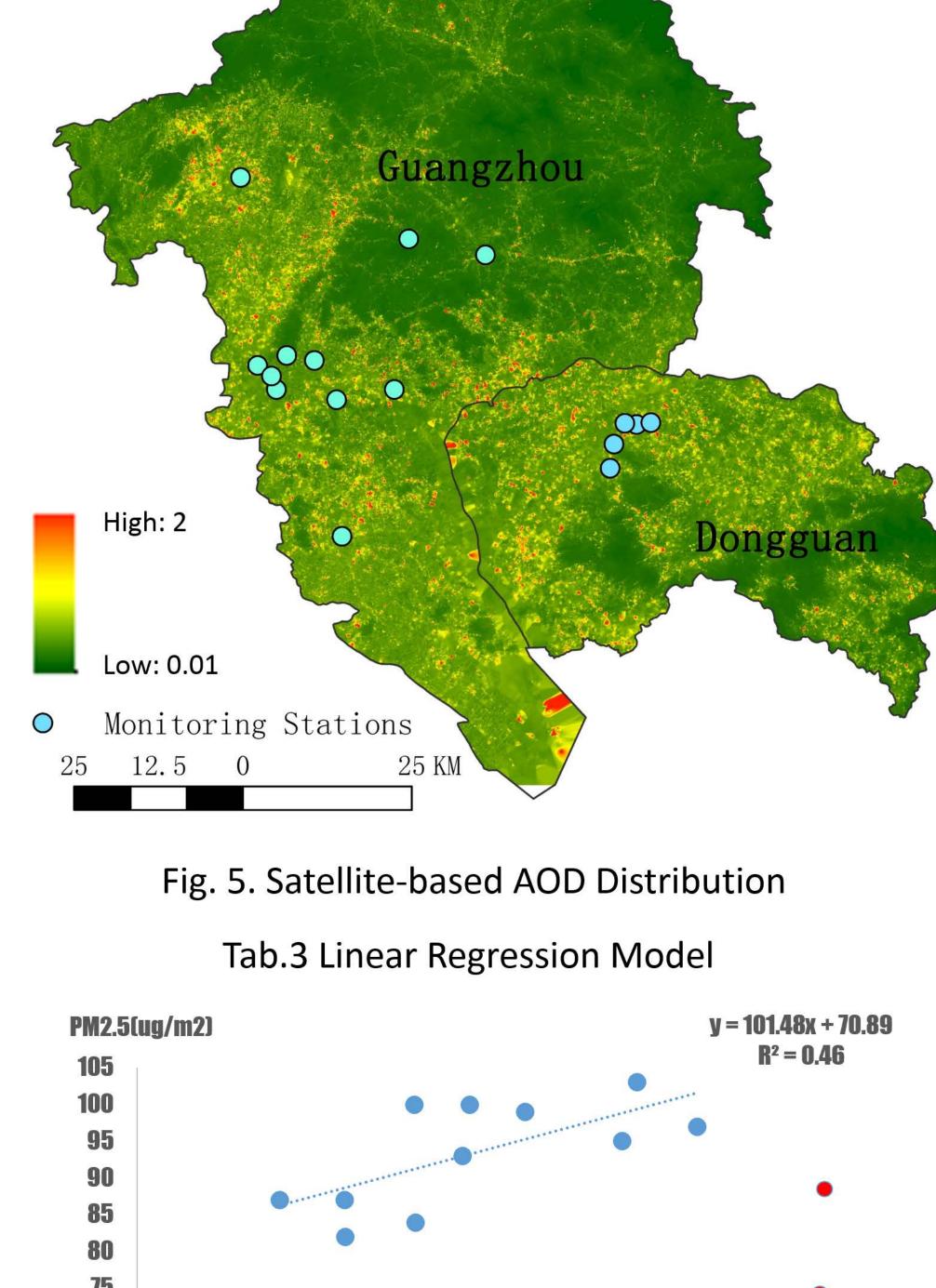
Urban Aerosol in 6S model (a model in retrieval process), our model may not work well in non-urban area. 2 monitoring stations (Maofengshan Forest Park and Li Lake) are located in non-urban area, which will not be used in PM2.5 estimation.

High: 2

Low: 0.01

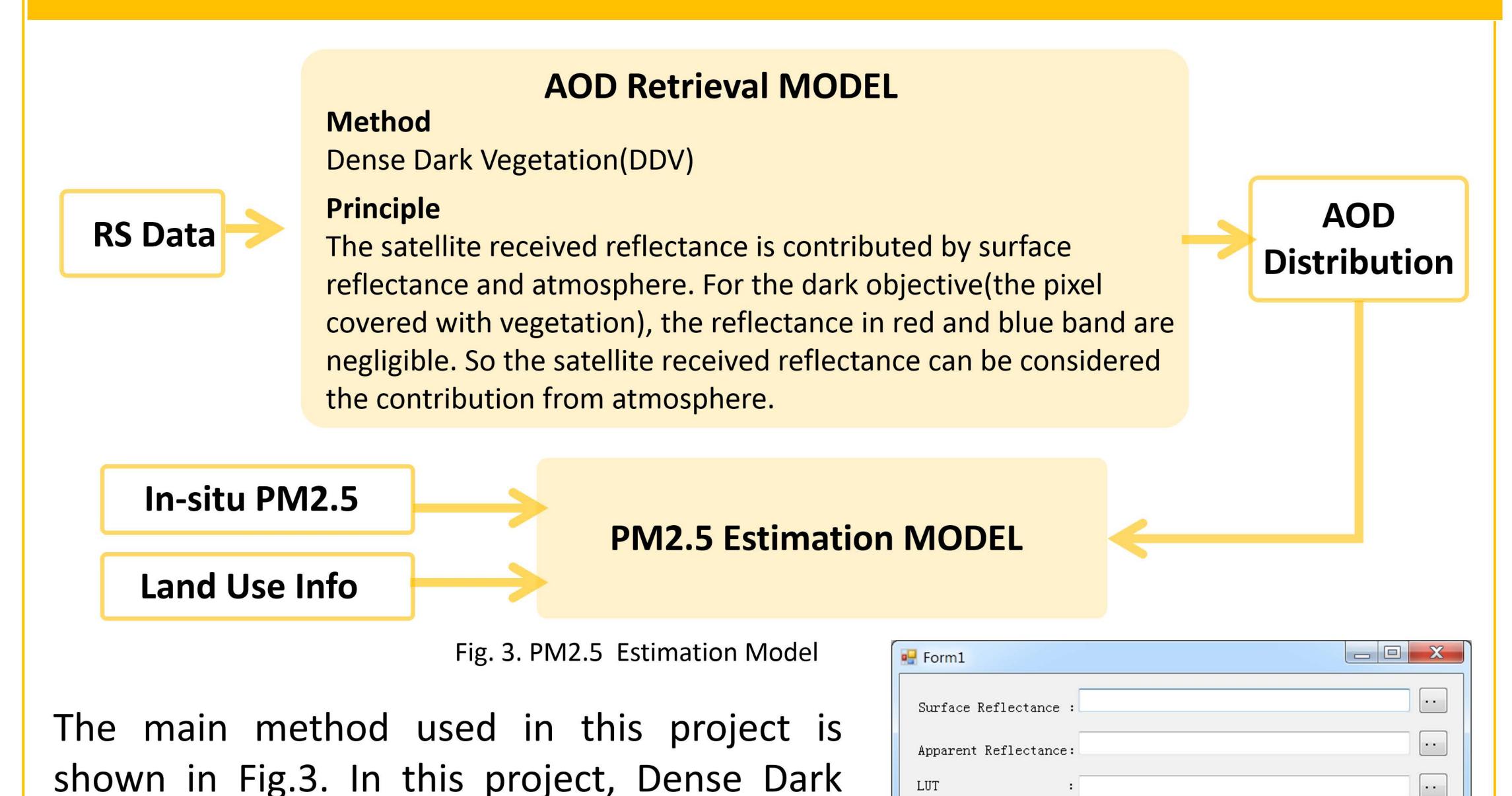
Monitoring Stations 25 I 12.5 0 25 F 12.5 0 2

A simple linear relation is utilized to estimate PM2.5 but is hardly to generate a satisfied regression coefficient (R<sup>2</sup>=0.08) because other factors (meteorological factors, etc.) which may affect the PM2.5 estimation, should be taken account. If the three outliers (red points in Tab.3) can be explained by other factors, the R<sup>2</sup> will



increase to 0.48, which is one of our future directions.





# FUTURE DEVELOPMENT

- 1. **The integration with more meteorological factors**: mass extinction, hygroscopic growth factor, aerosol type and properties, etc.
- Vertical correction: this step will be needed because AOD presents the whole column loading of atmospheric aerosols while PM2.5 is measured near earth surface.
   The verification of retrieval model: in this project, remote sensing based AOD is not verified with the ground-measured AOD because of the lack of measurements.

## ACKNOWLEDGE & REFERENCE

based meteorological measurements. Remote Sensing of Environ

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