Application of Aerosol Optical Thickness Product (MOD04) to Air Quality Monitoring in Thailand – a case study of Bangkok Metropolitan

Study II

Period of Data used for Study
Jan 01, 2007 to Jan 31, 2009

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1. **Introduction to MODIS imagery**

The MODerate resolution Imaging Spectrometer (MODIS) instrument is a sensor onboard Terra and Satellites which its mission is for Earth observation in global scale and multi-temporal time series for global environmental study. The application of MODIS data is widely used for land, ocean and atmospheric research and study because of the wide-range of spectral bands from red to thermal bands which is in total of 36 bands. Therefore, Geoinformatics Center at the Asian Institute of Technology in Bangkok, Thailand has established Terra/Aqua MODIS receiving system to receive the data daily which has the coverage from central part of China to Java of Indonesia and from India to Philippines and provide the possibility to have better understanding about the environment in the region.

2. **MODIS Aerosol Product – MOD04**

There are many products that can be derived from MODIS data. Details about the MODIS products can be found at http://modis.gsfc.nasa.gov/. The aerosol product or MOD04 is one of the MODIS products which is generated from MODIS data of Level 1B and contains the aerosol optical depth physical parameter. This aerosol product can be generated from MODIS seven wavelength bands in the visible range which are band 1, 2, 3, 4, 5, 6 and 7. The corresponding wavelengths of these seven bands are given in Table 1.

Table 1. Characteristics of MODIS bands used in the aerosol retrieval

Band #	Bandwidth (μm)	Weighted Central Wavelength (μm)	Resolution (m)
1	0.620 - 0.670	0.646	250
2	0.841 – 0.876	0.855	250
3	0.459 – 0.479	0.466	500
4	0.545 – 0.565	0.553	500
5	1.230 – 1.250	1.243	500
6	1.628 – 1.652	1.632	500
7	2.105 – 2.155	2.119	500

Source: Algorithm for Remote Sensing of Tropospheric Aerosol from MODIS: Collection 5. pp.

The MOD04 product can be downloaded from Level 1 and Atmosphere Archive and Distribution System (LAADS) ftp site (lftp://adsweb.nascom.nasa.gov/) free of charge. The MOD04 product is 5-minutes chunks called 'granule'. The granule has the size from 0.5 – 3.0 MB which is in HDF-EOS format. The spatial resolution of the product is 10x10 km. In Aerosol product, there are several Scientific Data Set (SDS) related to aerosol and other physical parameters. The SDS that used in this study is 'Image_Optical_Depth_Land_And_Ocean' which is the AOT at 0.55 μm for both ocean (best) and land (corrected) with all quality

data. This parameter is unitless. In the AOT image, the digital number (DN) has the range from -100 to 5000. These digital values have to be converted to AOT using linear equation:

$$AOT = a * DN + b \qquad\qquad\qquad\qquad\qquad Eq.\ 1$$

Where a – the scale factor and b is the offset, which equal to 0.001 and 5.0, respectively, but in our case study, we have found that the minimum and maximum AOT value is -0.05 and 3.5, respectively. Therefore, we have setup the scale bar to AOT range from -0.05 to 3.5

Figure 1 shows an example of aerosol optical depth data, that derived from MODIS imagery for Southeast Asia for the date of January 05, 2006 at 03:40 GMT.
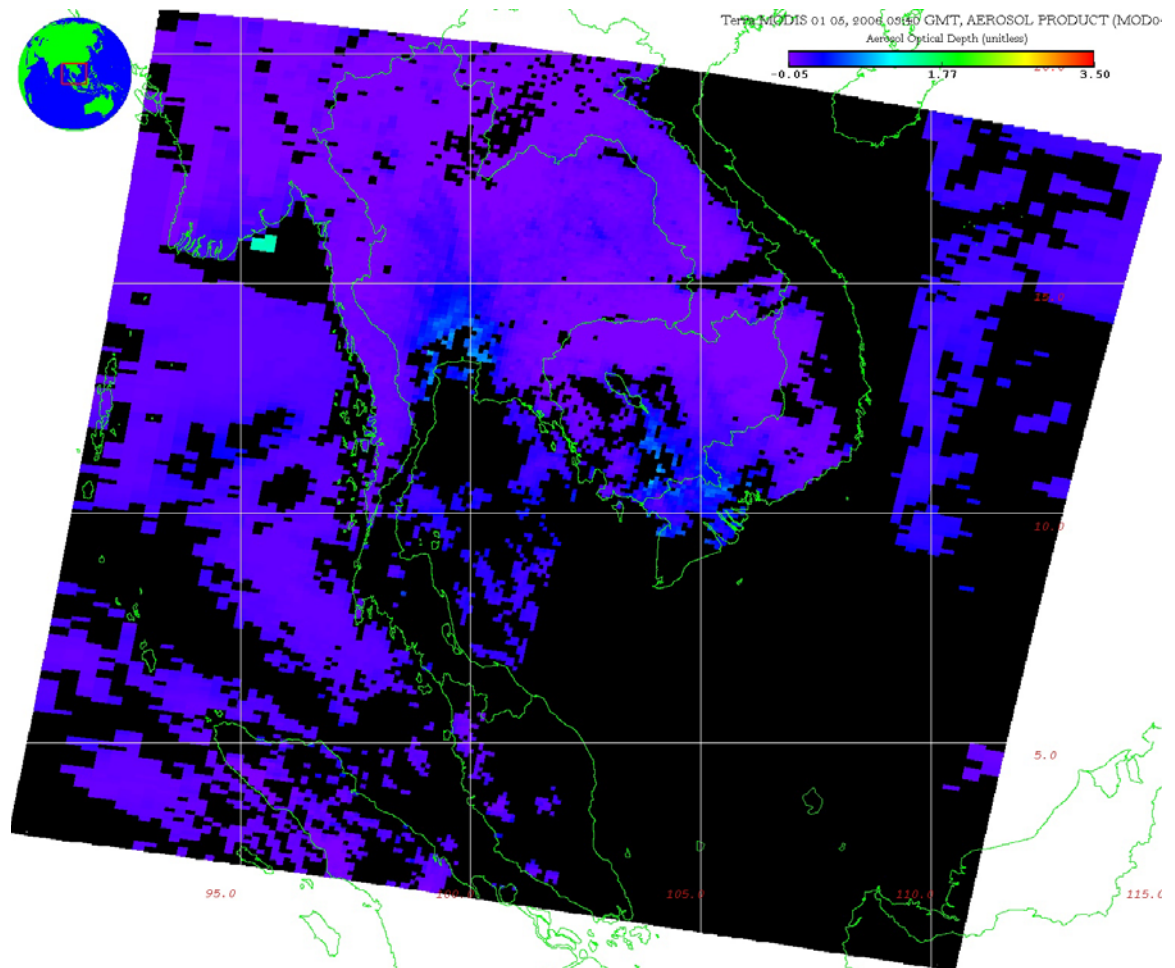

Figure 1. AOT derived from MODIS for Southeast Asia

3. Application of MOD04 to Air Quality Monitoring in Thailand – a case study of Bangkok Metropolitan

Air quality is an important issue, in particularly, for the urban environment of mega-cities like Bangkok Metropolitan; therefore, air quality monitoring is necessary to conduct for better management of the urban environment which is related to air pollution that cause negative impact to human health. In order to understand the air quality in the city, Thailand Pollution Control Department has set up 13 air quality measurement stations in Bangkok to have hourly and daily average concentration of the pollutants. However, the measurement result can not cover all the city area, which is difficult to have the information for the whole area. Therefore, the air quality monitoring using remote sensing technique is introduced and applied to the study. This technique is widely used for environmental monitoring, including air quality.

3.1 Methodology

The methodology of the study is described in the flowchart in Figure 2. First, a set of MODIS Aerosol product were downloaded according to the PM_{10} measurement records obtained from PCD, then the data were geometric corrected and stored as binary images, which will be used to calculate the correlation between the MODIS AOT and PM_{10} concentration by district.
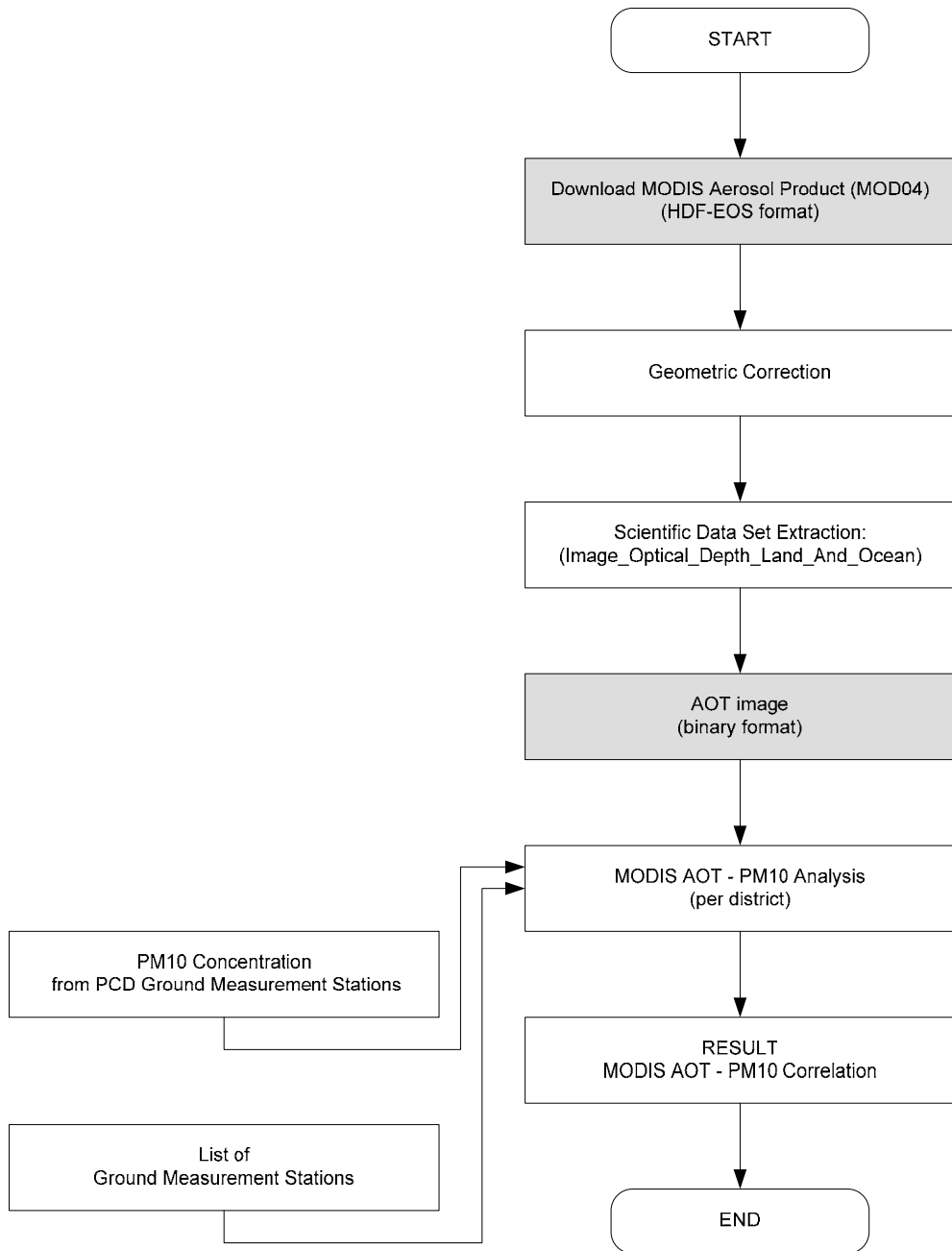
Figure 2. Flowchart of the Methodology

Table 2 shows the list of 12 ground measurement stations in Bangkok for PM_{10} concentration of Bangkok area. The concentration was collected for the period of Jan – Jan 01, 2007 to Jan 31, 2009 and were used to calculate for the correlation with MODIS AOT.

Table 2. Ground measurement stations in Bangkok with their geographical coordinates

No.	Station name	Easting	Northing	latitude	longitude
1	Thai Meteorological Dept	671260	1509577	13.6523	100.5998
2	National Housing Authority	678600	1523822	13.7783	100.6521
3	Huai Khwang	669233	1521606	13.7588	100.5653
4	Nontri Vithaya	667906	1514015	13.6903	100.5526
5	Singharatpitayakom	657401	1512713	13.6791	100.4554
6	Public Relation Dept	666523	1524294	13.7833	100.5404
7	Bodindacha School	674551	1522837	13.7697	100.6146
8	MOSTE	665311	1522144	13.7639	100.5291
9	Land Transport Dept	677941	1523985	13.7798	100.6460
10	Chula hospital	666137	1518376	13.7298	100.5365
11	Thonburi Substation	660212	1519544	13.7407	100.4818
12	Traffic Police Residence	672843	1525252	13.7916	100.5989
13	Dindaeng	668147	1521566	13.7585	100.5553

3.2. Results

The result of the correlation between the PM_{10} concentration values with the AOT MODIS for each station in Bangkok is shown in the Appendix.

Table 3 Correlation values between MODIS AOT and PCD PM_{10} ranging from highest to lowest correlation values.

No.	Station name	Correlation
1	Thai Meteorological Dept	0.550
2	National Housing Authority	0.299
3	Singharatpitayakom	0.289
4	Public Relation Dept	0.276
5	Thonburi Substation	0.266
6	Chula hospital	0.252
7	Bodindacha School	0.235
8	Huai Khwang	0.215
9	Traffic Police Residence	0.191
10	MOSTE	0.181
11	Dindaeng	0.158
12	Nontri Vithaya	0.146
13	Land Transport Dept	0.065

From the obtained results, as shown in Table 3, we can see that, in the observed period, the correlation value varies from 0.550 to 0.065. The highest value was obtained from the station at Thai Meteorological Department (0.550), following by the National Housing

Authority (0.299), Singharatpitayakom (0.289) and the Public Relation Dept (0.276) , which can be seen in Figures 3, while the lowest one is from the station near Land Transportation Department (0.065).
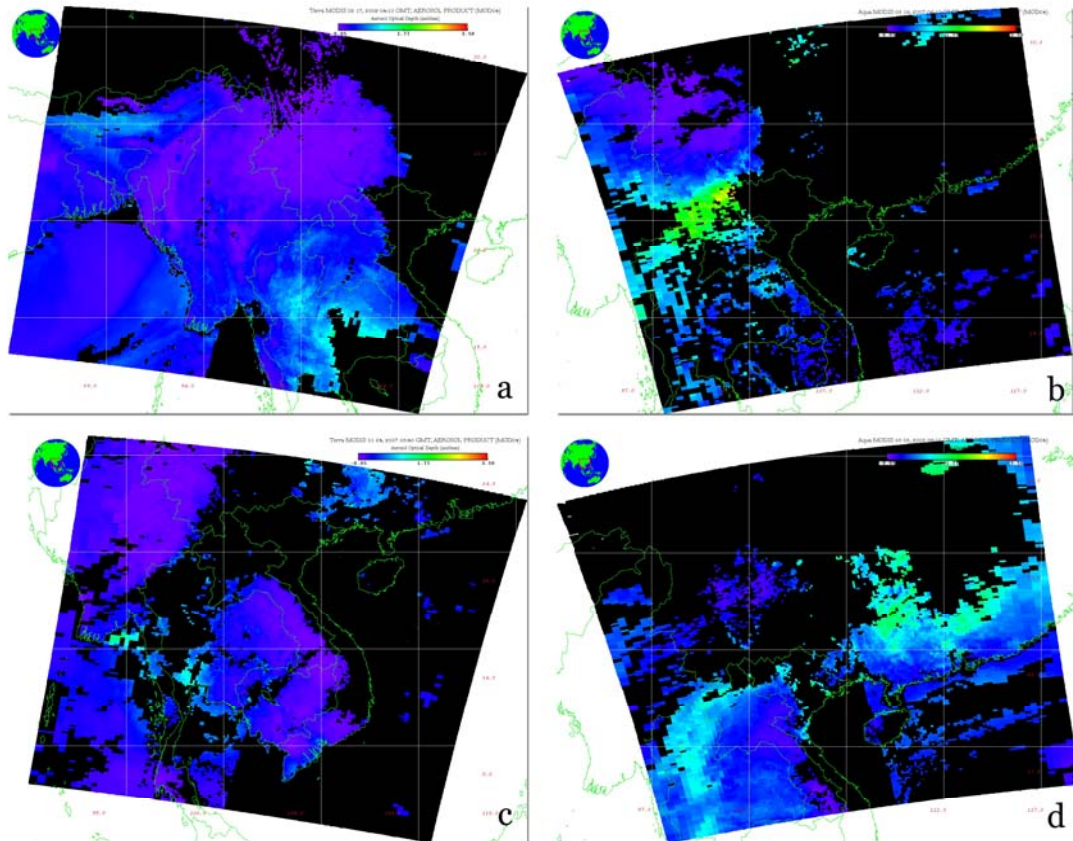

Figure 3. This figure shows the AOT values detected by MODIS sensor which has high correlation with the first 4 stations in Bangkok that varies from 0.550 to 0.276. The station   at a) Meteorological Department, b) National Housing Authority, c) Singharatpitayakom and d) Public Relation Department. The images were selected for by the date and time when the AOT values reach highest values at the 4 stations.

As the input PM_{10} values from PCD is the daily value which were measured hourly and there is some missing data for some stations, and also the AOT obtained from MODIS product is according to the pass that covers Bangkok area, which are not matching each other. Another reason is, according to the statistical analysis at each station, there are unusual observations which are the observations with large standard residual and those with value which give large influence. It is suggested that these observations need to be checked in order to improve the correlation of the data.

4. Conclusion

From the study, it is obviously that the aerosol optical depth (AOT) derived from MODIS data can be used to apply for air quality monitoring in Bangkok Metropolitan, since MODIS is multi-temporal remote sensing data which can be use for global scale study. It can be correlated to the air pollutant values obtained from ground-based measurement and to develop the near-real time air quality monitoring system. It can be also apply to monitor other pollutant gazes as well.

5. References

Algorithm for Remote Sensing of Tropospheric Aerosol from MODIS: Collection 5 Product ID: MOD04/MYD04, Lorraine A. Remer, Didier Tanre and Yoram J. Kaufman.

Appendix

Mon May 11 10:43:29 ICT 2009 – vivarad@ait.ac.th

Bangkok Metropolitan (Observation Period: Jan 01, 2007 to Jan 31, 2009)
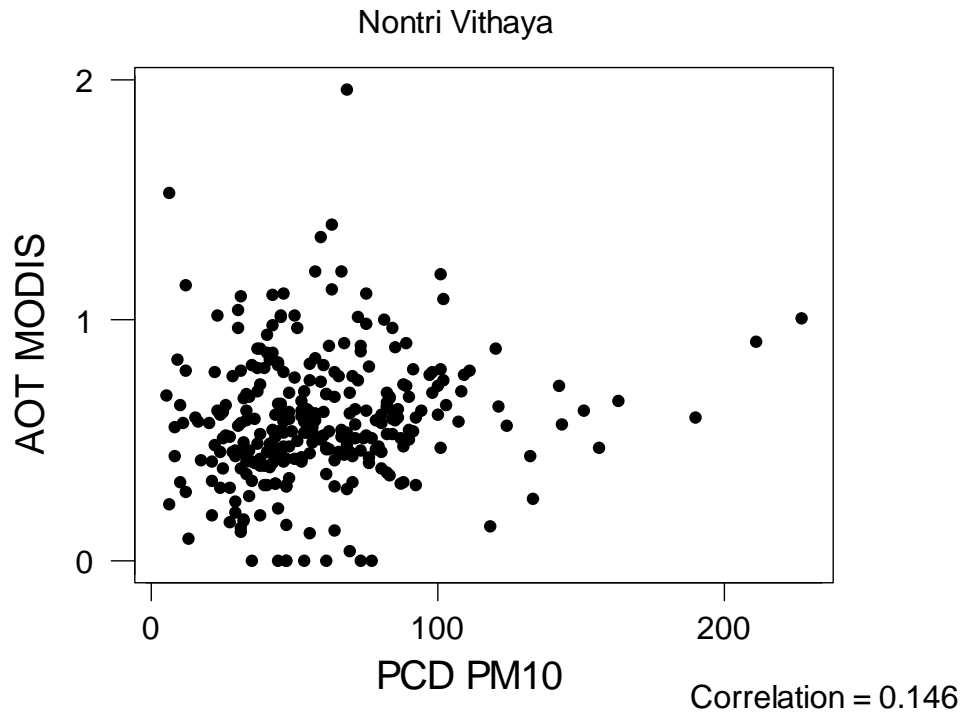
1. Station name: Meteorological Department
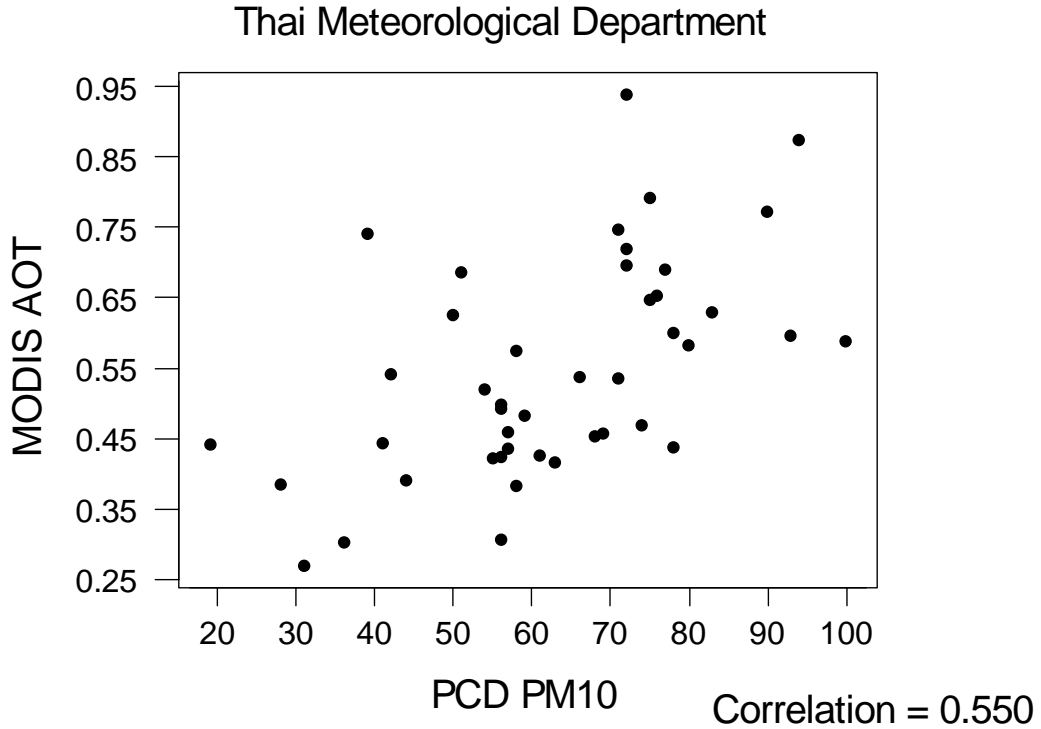
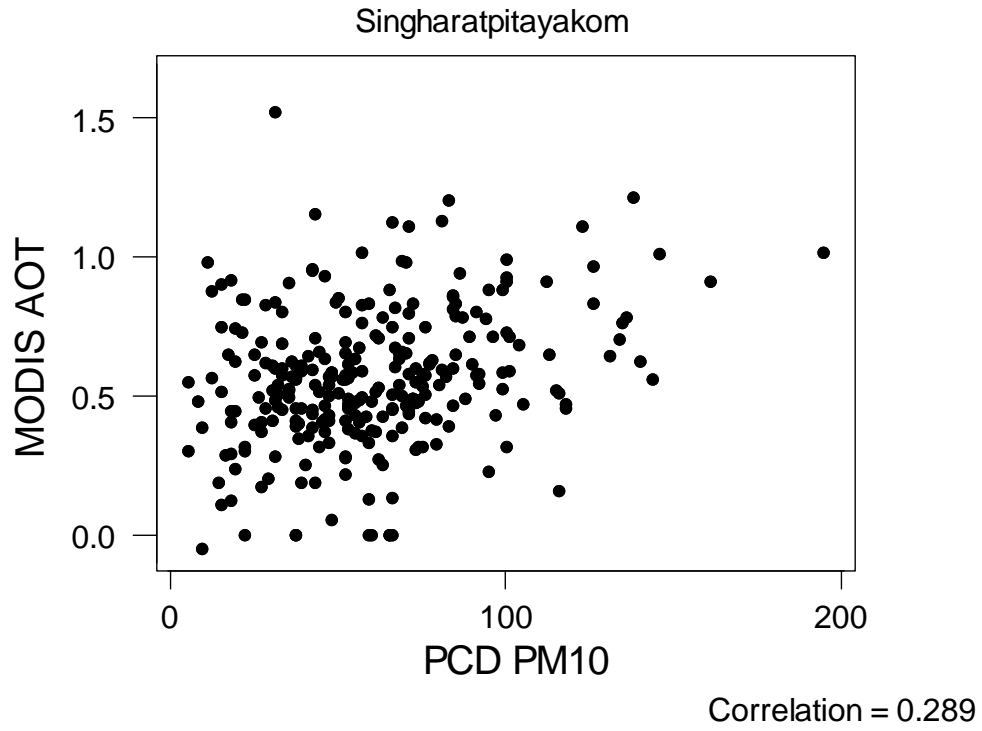## 2. Station name: National Housing Authority

National Housing Authority

Correlation = 0.299
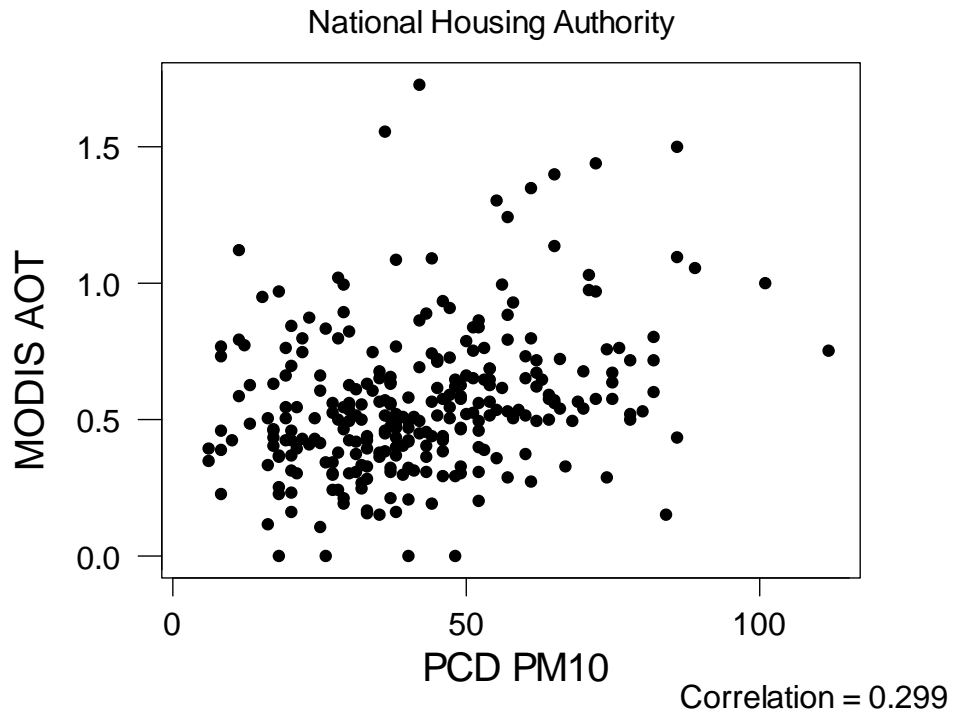
3. Station name: HuaiKhwang

HuaiKhwang

Correlation = 0.215
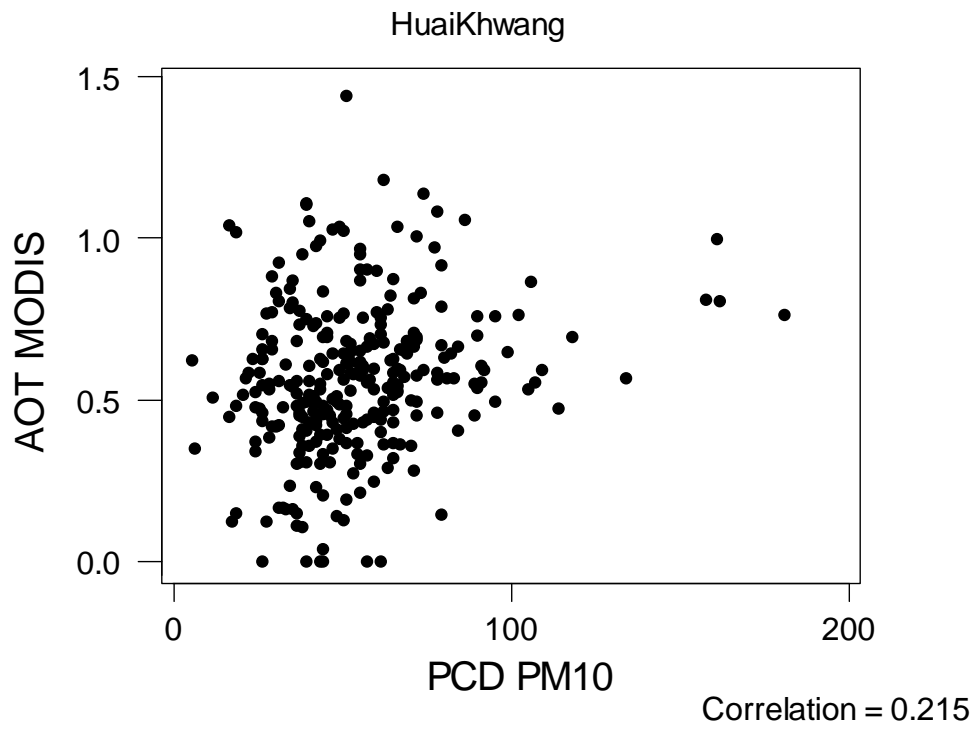
4. Station name: Nontri Vithaya

Nontri Vithaya

Correlation = 0.146

5. Station name: Singharatpitayakom

Singharatpitayakom

Correlation = 0.289

6. Station name: Public Relation Department

Public Relation Department

Correlation = 0.276
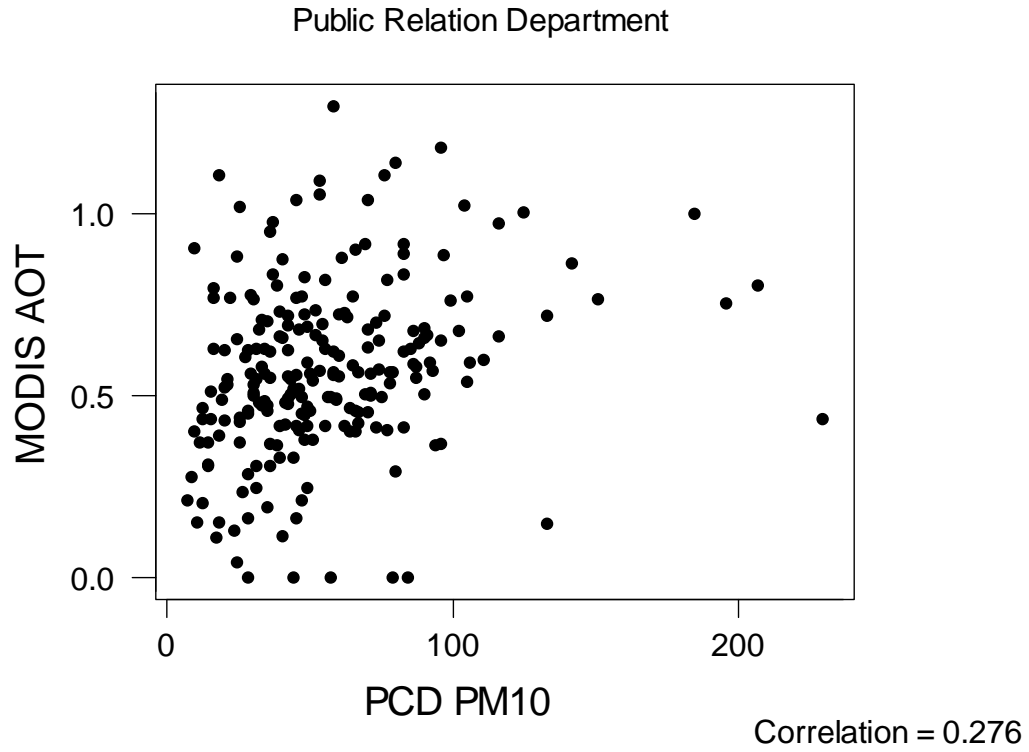
7. Station name: Bodindecha School

Bodindacha School

Correlation = 0.235
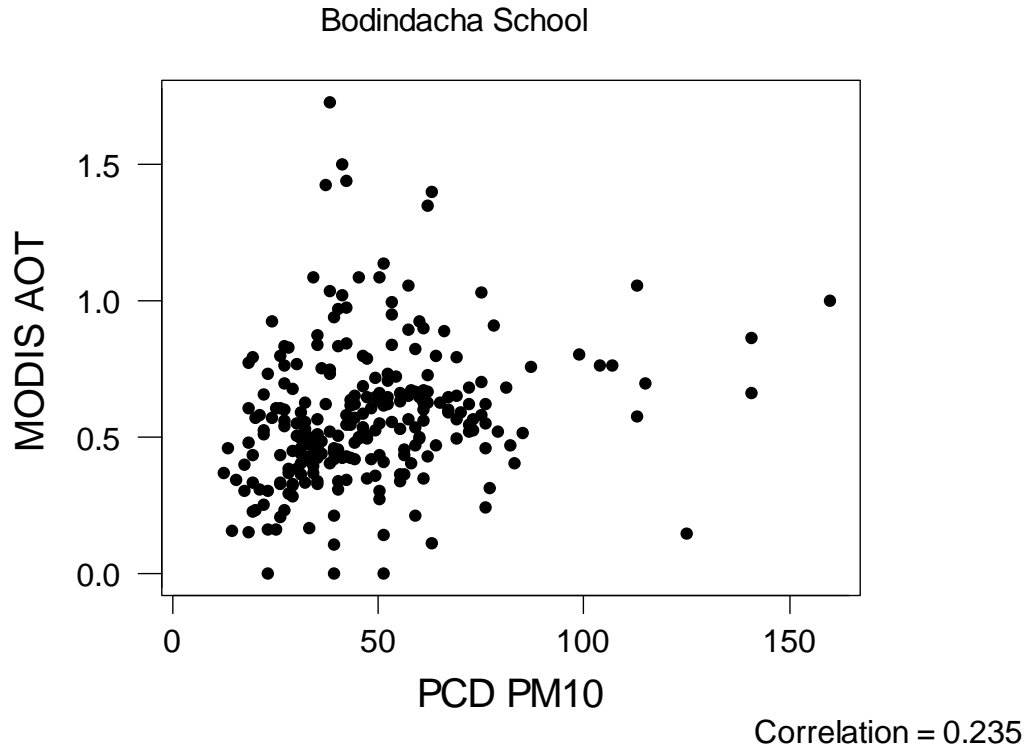
8. Station name: MOSTE

Correlation = 0.181
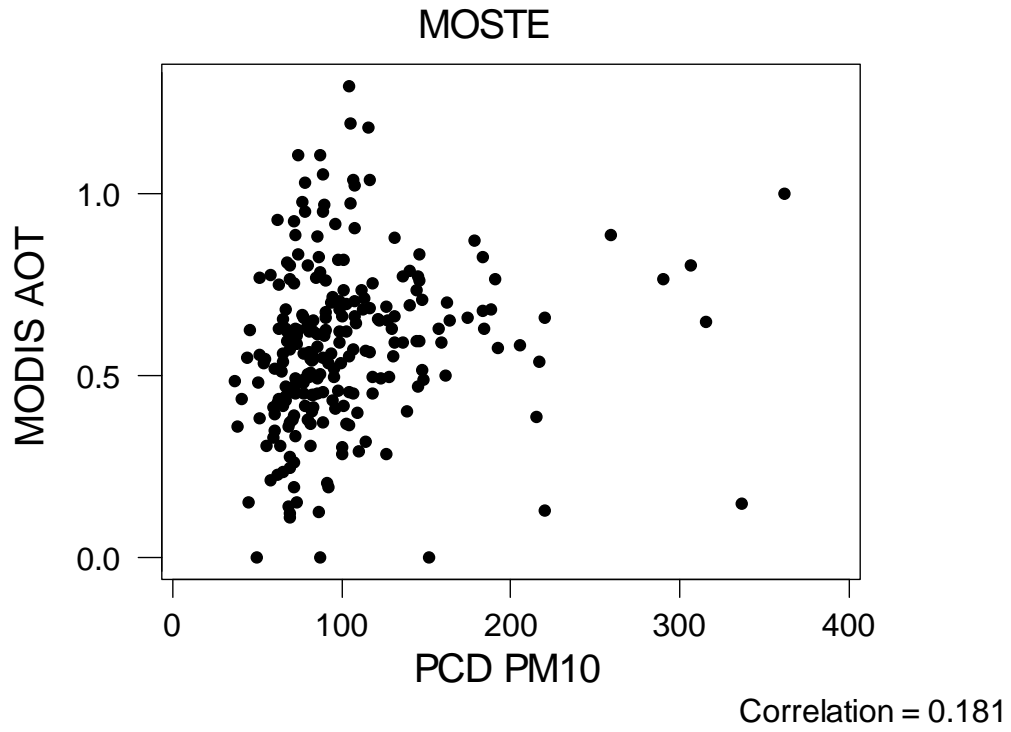
9. Station name: Land Transportation Department

Land Transportation Department

Correlation = 0.065
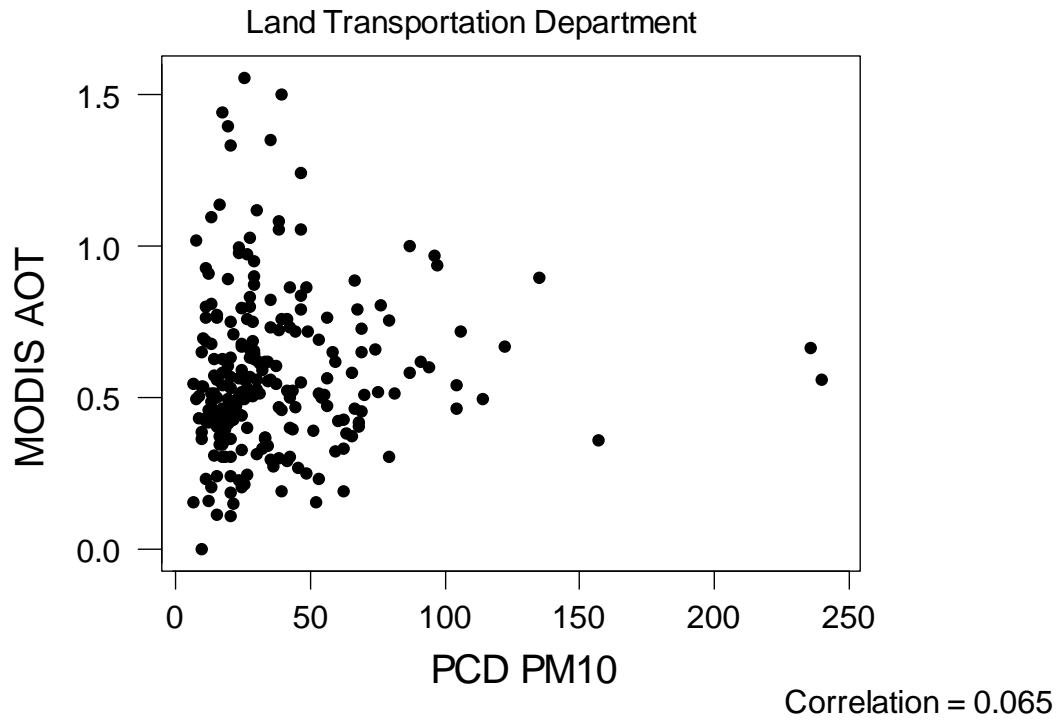
10. Station name: Chula Hospital

Correlation = 0.252
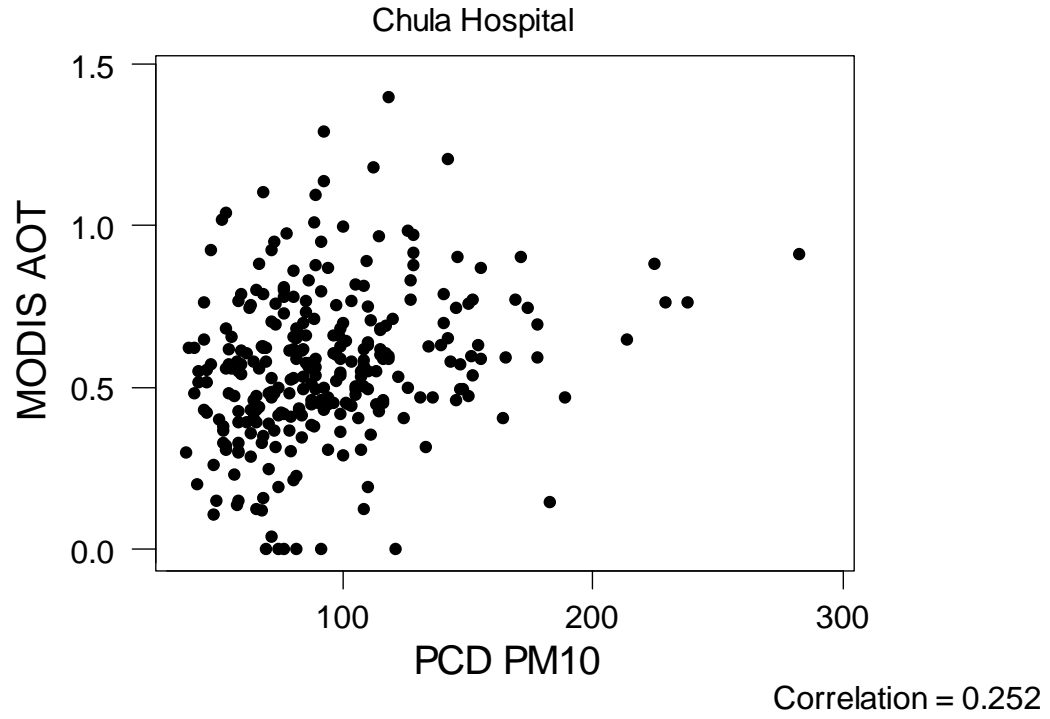
11. Station name: Thonburi Substation

Thonburi Substation

Correlation = 0.266
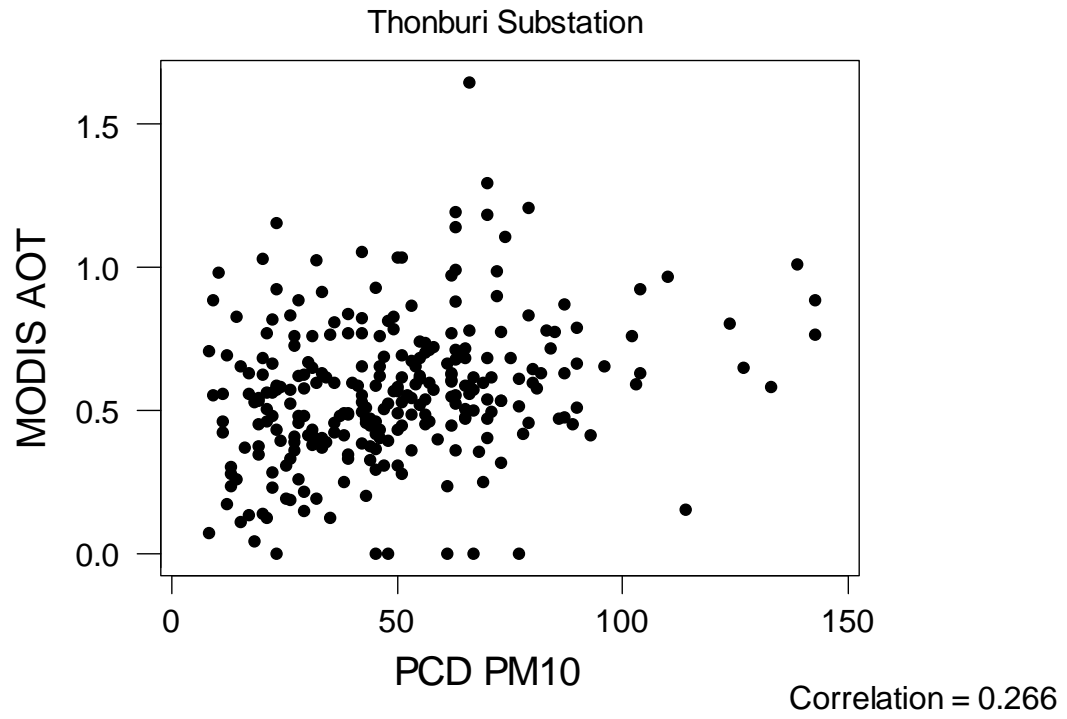
12. Station Name: Traffic Police Residence

Traffic Police Residence

Correlation = 0.191
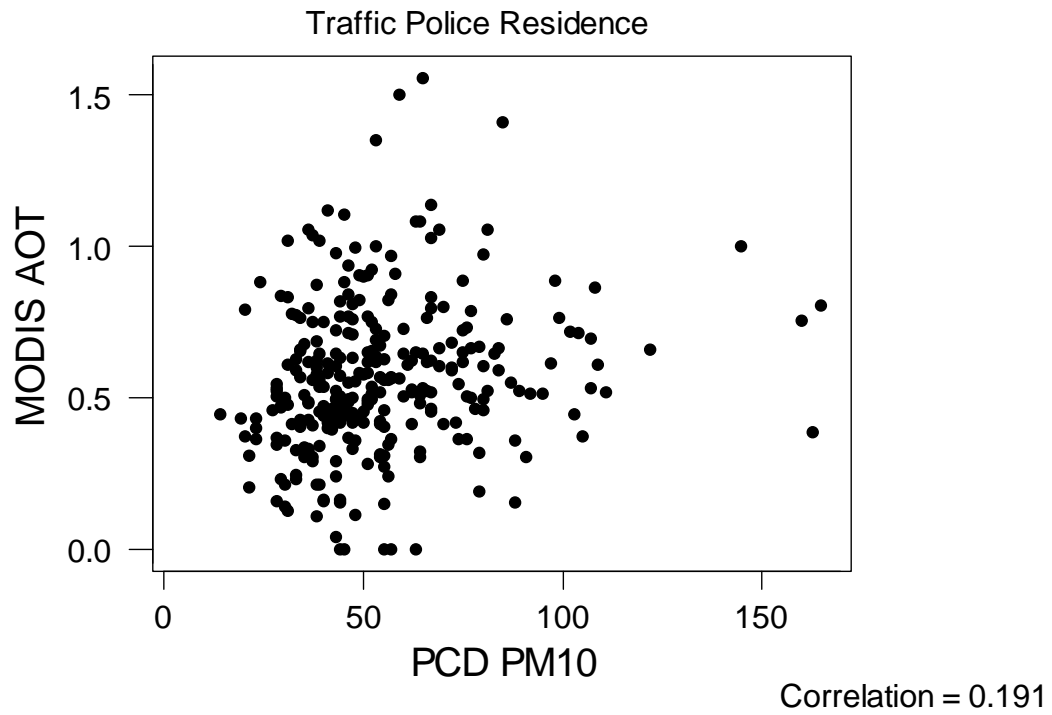
13. Station Name: Din Daeng

Din Daeng

Correlation = 0.158