AOD to PM2.5 to AQC – An excel sheet exercise

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ARSET

Applied Remote Sensing Education and Training

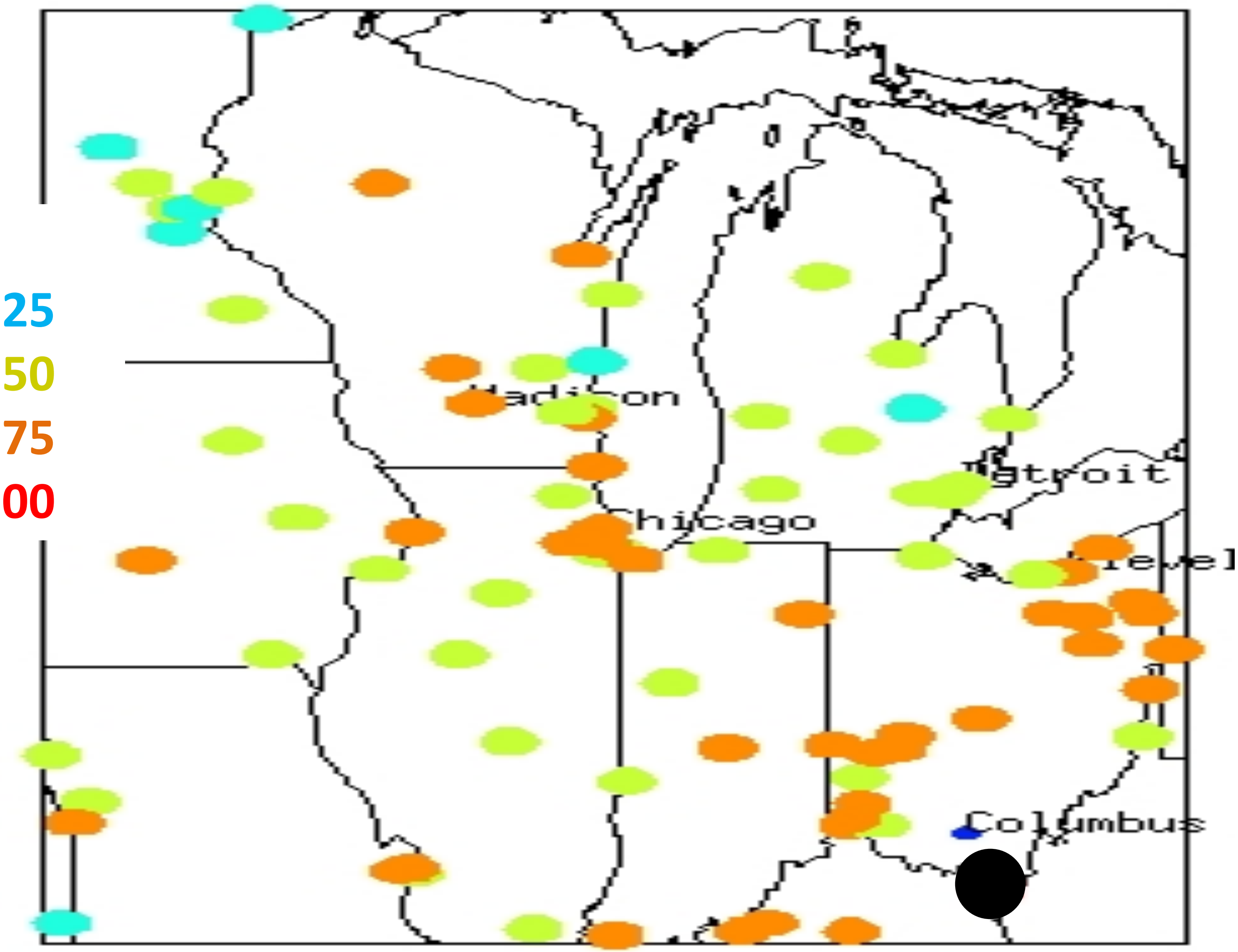
A project of NASA Applied Sciences

Exercise -1 – Converting AOD to PM2.5

Required Data

- PM2.5 mass concentration from ground monitors
- Satellite Derived Aerosol Optical Depth
- Meteorological Fields – only if working with multi-variable method

LADCO Region – Correlation between PM2.5 and AOD



R

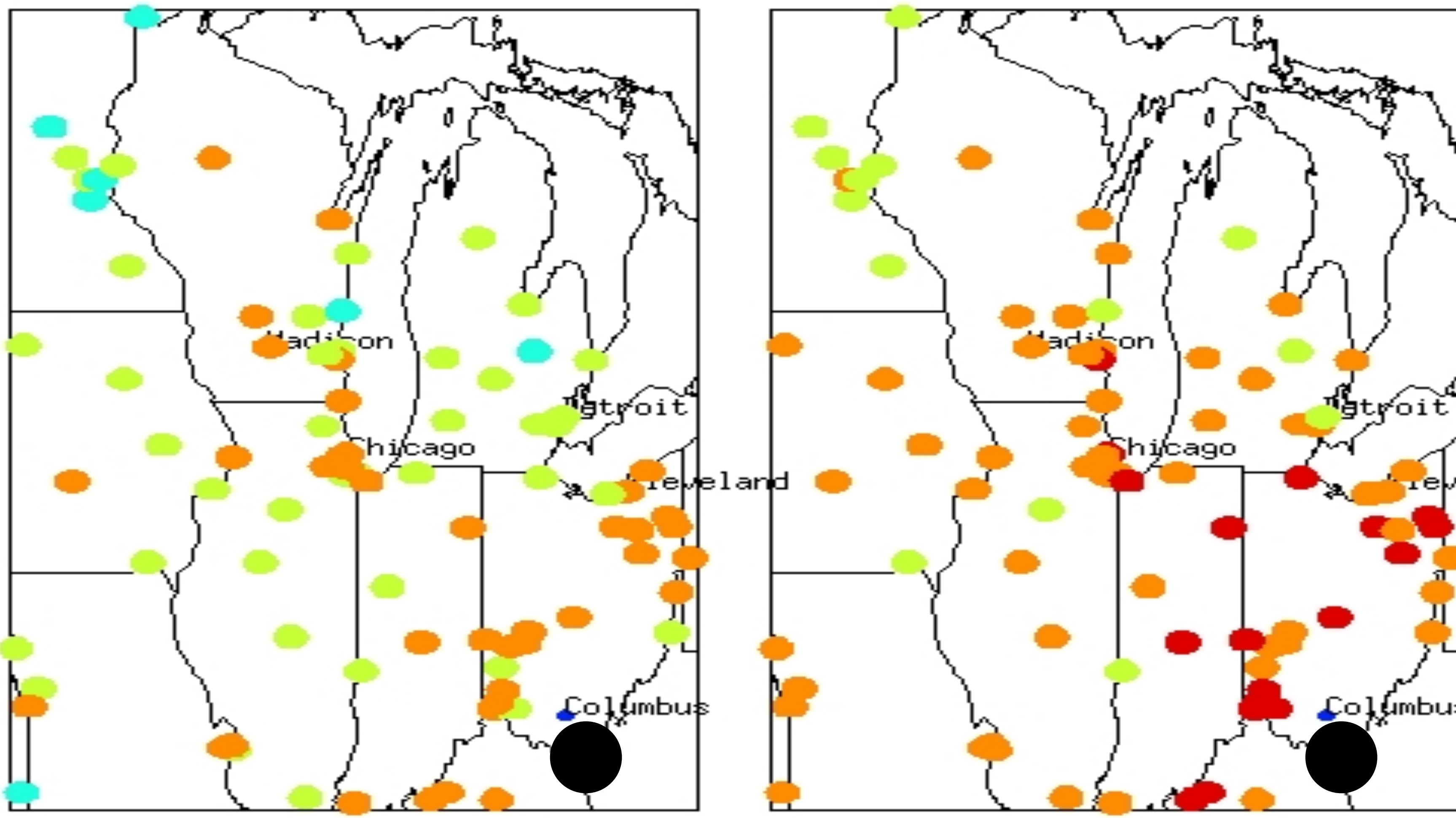
0.00-0.25

0.25-0.50

0.50-0.75

0.75-1.00

Two Variable Method   Multi Variable Method



R

0.00-0.25 0.25-0.50

0.50-0.75 0.75-1.00

Exercise -1 – Converting AOD to PM2.5 to AQC …

STEP # 1 - Getting Satellite and Surface Data

• Obtained MODIS AOD data file from NASA data server for your region/date/time of interest

(http://ladsweb.nascom.nasa.gov/) – from earlier exercise

• To get PM2.5 data for your region
  - http://www.epa.gov/airdata/ad_maps.html -- FOR US Data
  - http://aqicn.org/ - Global air quality monitoring system
  - Your own data source/measurements

Exercise -1 – Converting AOD to PM2.5 to AQC …

STEP # 2 – Collocating Satellite and Surface Data

•Run IDL/Matlab/HDFLook/Python etc. code to obtained AOD at location of the PM2.5 ground monitor.

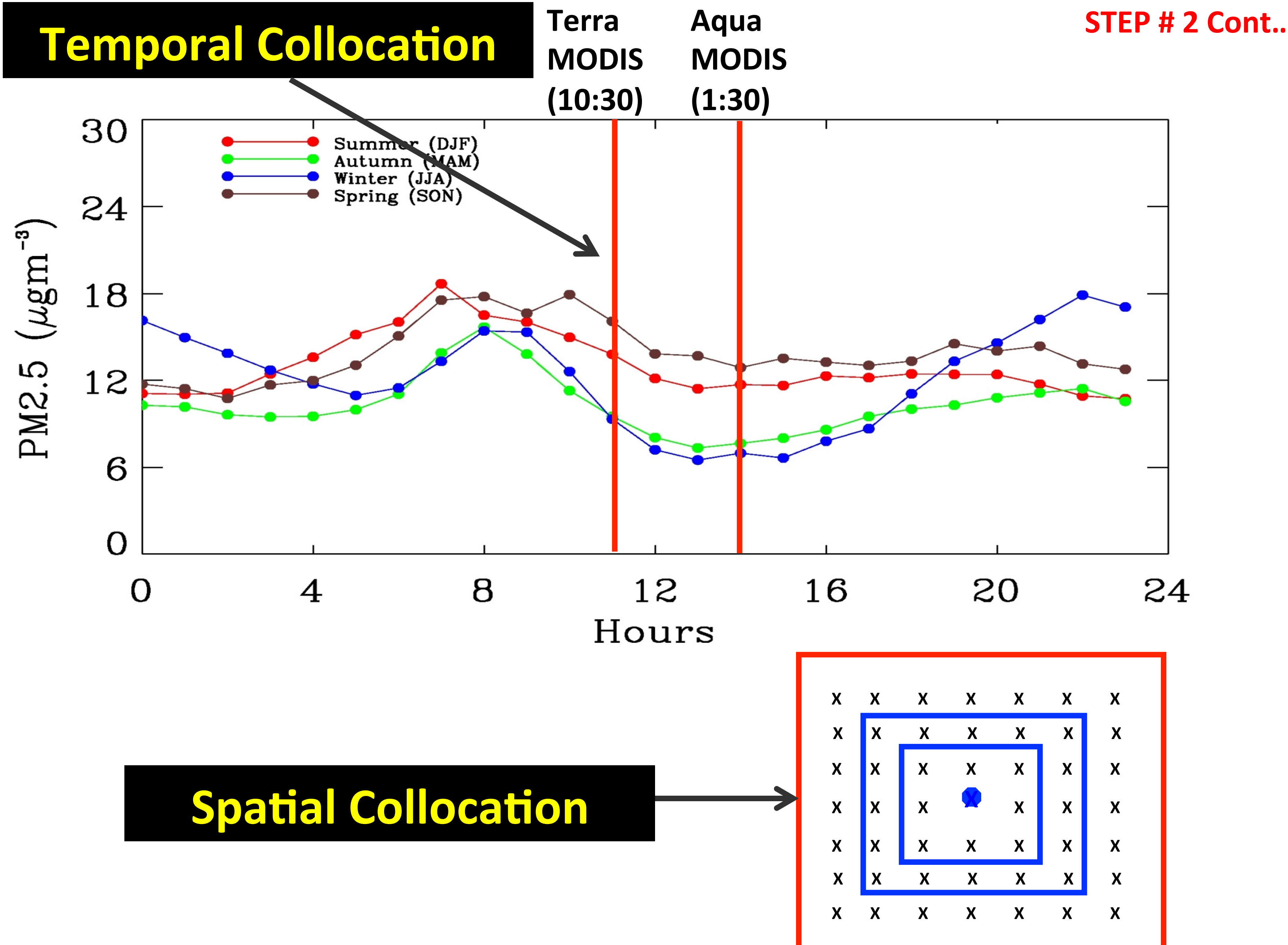
Python Scripts:

http://arset.gsfc.nasa.gov/airquality/python-scripts-modis-aerosol-data-sets

IDL Code:

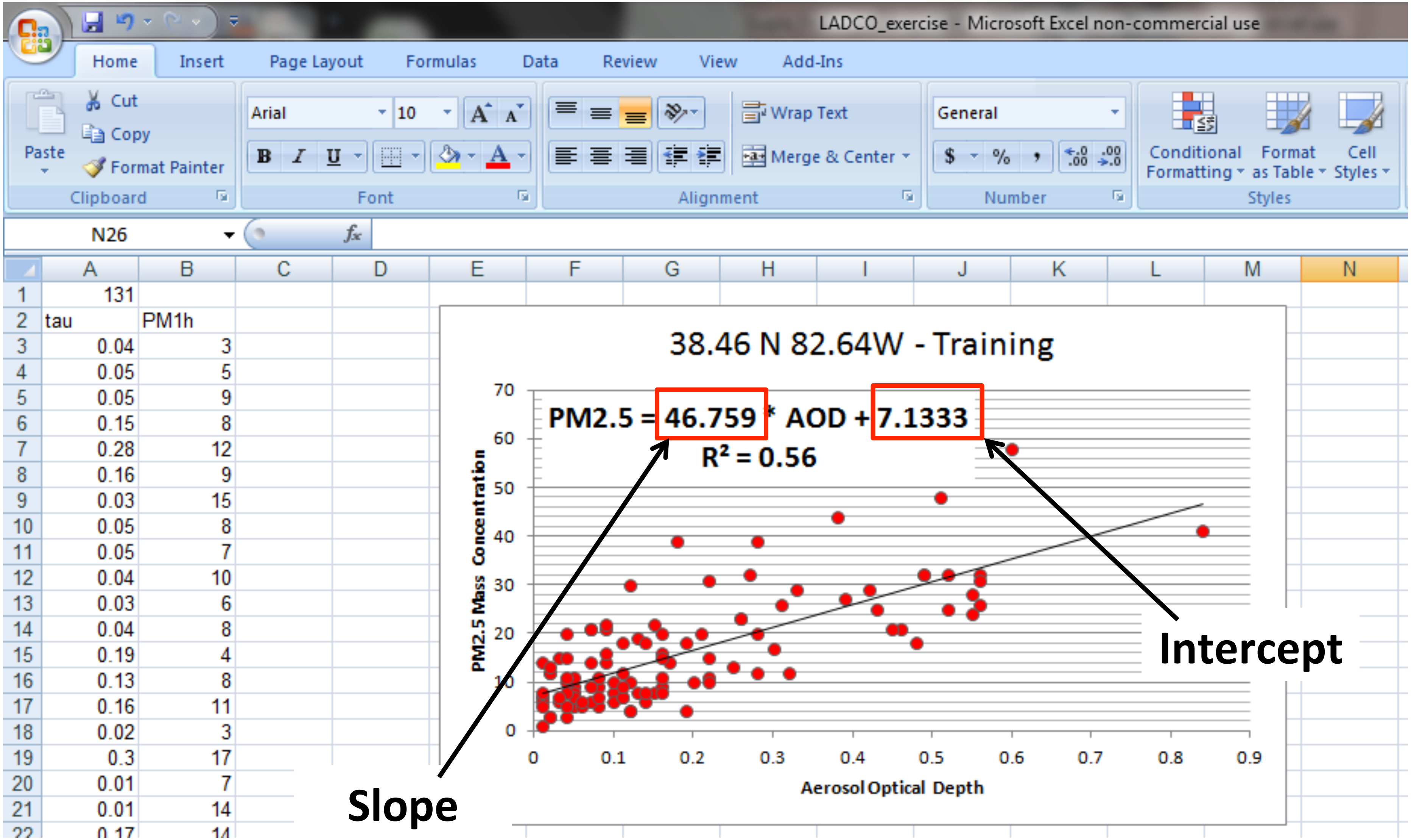
http://arset.gsfc.nasa.gov/sites/default/files/airquality/workshops/Santa_Cruz_2013/read_mod04_map_aqc.zip

- Spatial and Temporal Collocation Methods
    - pick nearest pixel or average over 3x3 or 5x5 pixels
    - pick closest PM2.5 measurement from ground to satellite over pass time. If hourly data is not available then daily mean data can be used as well.


STEP # 2 Cont…
Temporal Collocation
Terra MODIS (10:30)
Aqua MODIS (1:30)
Summer (DJF)
Autumn (MAM)
Winter (JJA)
Spring (SON)
PM2.5 (μgm⁻³)
30
24
18
12
6
0
0
4
8
12
16
20
24
Hours
Spatial Collocation

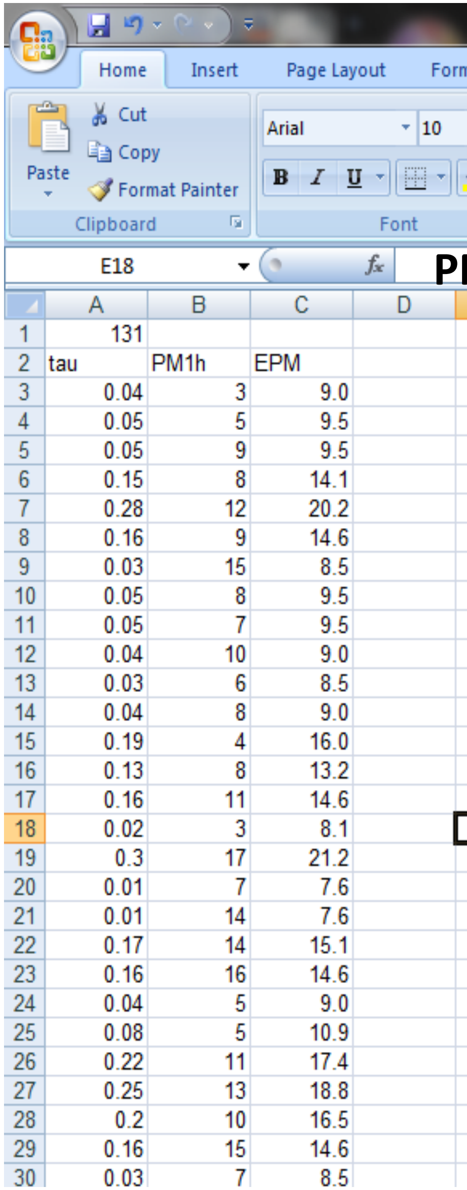
Exercise -1 – Converting AOD to PM2.5 to AQC …

STEP # 3 - Developing Relationship between AOD and PM2.5



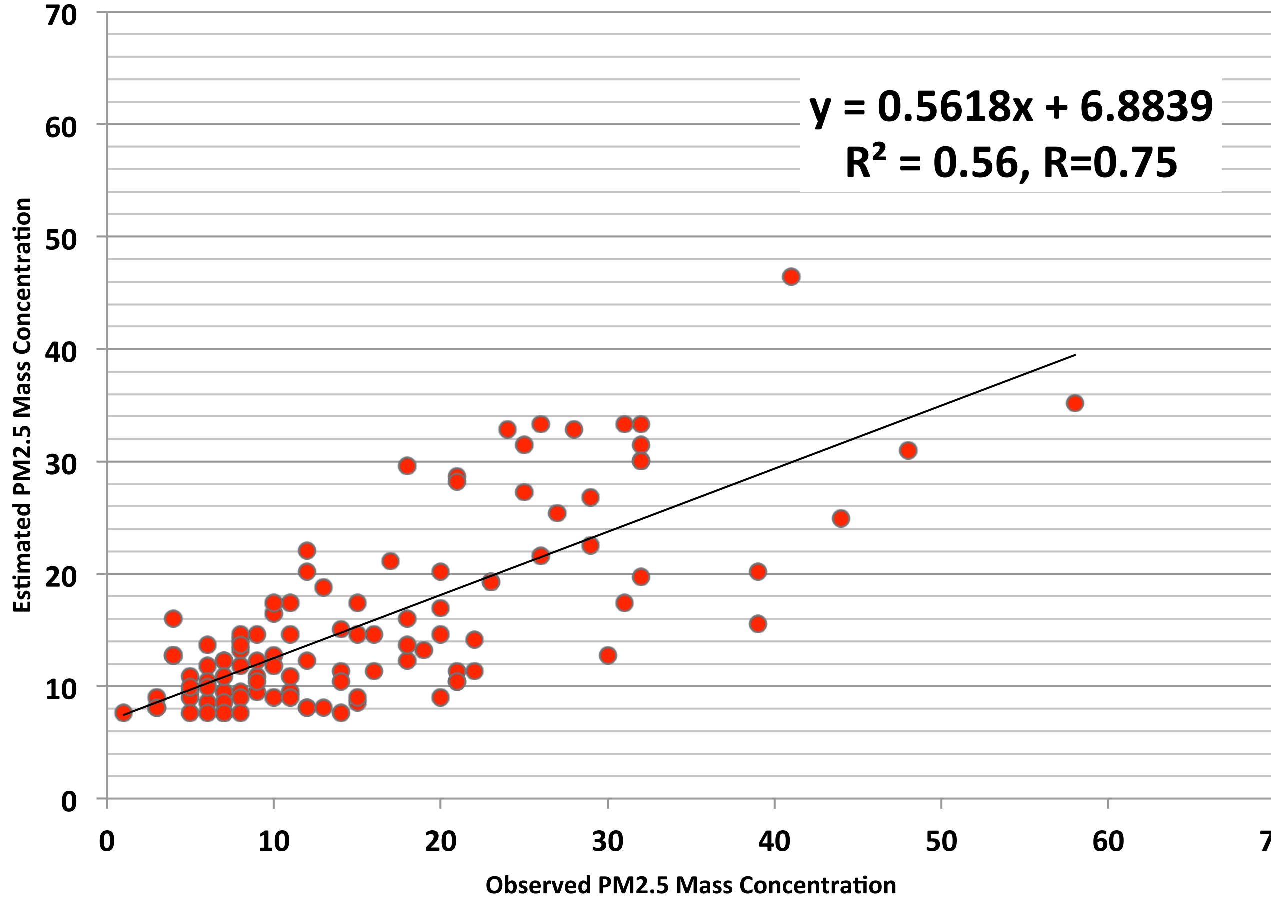
Exercise -1 – Converting AOD to PM2.5 to AQC …

STEP # 4 - Estimating PM2.5 from Satellite AOD



	A	B	C	D
1	131			
2	tau	PM1h	EPM	
3	0.04	3	9.0	
4	0.05	5	9.5	
5	0.05	9	9.5	
6	0.15	8	14.1	
7	0.28	12	20.2	
8	0.16	9	14.6	
9	0.03	15	8.5	
10	0.05	8	9.5	
11	0.05	7	9.5	
12	0.04	10	9.0	
13	0.03	6	8.5	
14	0.04	8	9.0	
15	0.19	4	16.0	
16	0.13	8	13.2	
17	0.16	11	14.6	
18	0.02	3	8.1	
19	0.3	17	21.2	
20	0.01	7	7.6	
21	0.01	14	7.6	
22	0.17	14	15.1	
23	0.16	16	14.6	
24	0.04	5	9.0	
25	0.08	5	10.9	
26	0.22	11	17.4	
27	0.25	13	18.8	
28	0.2	10	16.5	
29	0.16	15	14.6	
30	0.03	7	8.5	

PM2.5= AOD*46.7 + 7.13



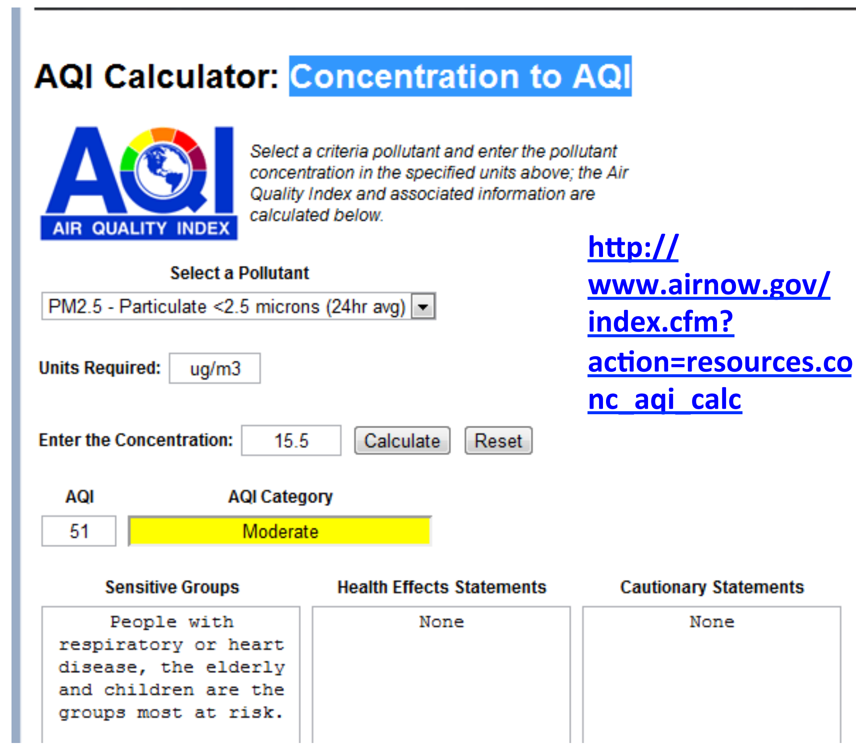
In ideal conditions, two separate data sets should be used to form the relationship and to test/validate the regression equation.

Exercise -1 – Converting AOD to PM2.5 to AQC …

STEP # 5 - PM2.5 to Air Quality

Category	AQI Estimated 24-hour avg. µg/m³
Good (0 - 50)	0 to 15.4
Moderate (51 - 100)	15.5 to 40.4
Unhealthy for Sensitive Groups (101 - 150)	40.5 to 65.4
Unhealthy (151 - 200)	65.5 to 150.4
Very Unhealthy (201 - 300)	150.5 to 250.4
Hazardous (301 - 500)	>250.4

Online Tool



http://www.airnow.gov/index.cfm?action=resources.conc_aqi_calc

This is based on US EPA's Definition of AQI, which can be different in other countries

Exercise -1 – Converting AOD to PM2.5 to AQC …

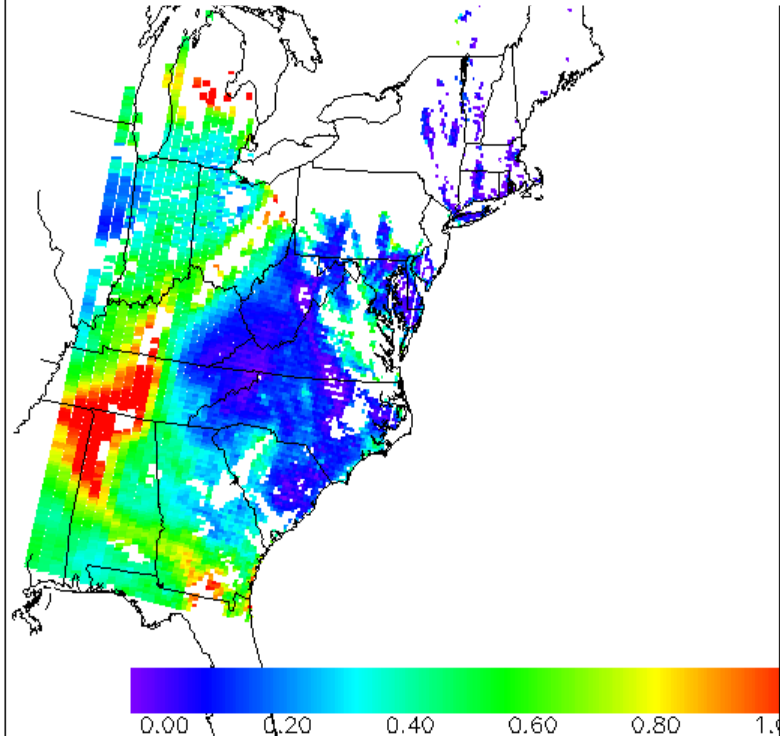
STEP # 5 - PM2.5 to Air Quality

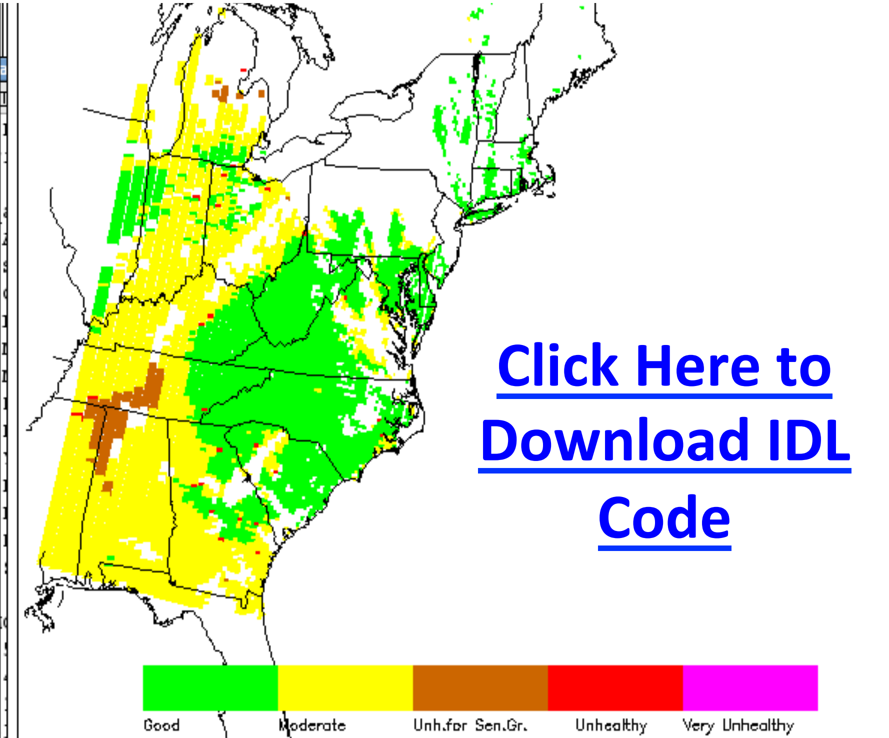
	A	B	C	D	E
7	0.28	12	20.2	Good	Moderate
8	0.16	9	14.6	Good	Good
9	0.03	15	8.5	Good	Good
10	0.05	8	9.5	Good	Good
11	0.05	7	9.5	Good	Good
12	0.04	10	9.0	Good	Good
13	0.03	6	8.5	Good	Good
14	0.04	8	9.0	Good	Good
15	0.19	4	16.0	Good	Moderate
16	0.13	8	13.2	Good	Good
17	0.16	11	14.6	Good	Good
18	0.02	3	8.1	Good	Good
19	0.3	17	21.2	Moderate	Moderate
20	0.01	7	7.6	Good	Good
21	0.01	14	7.6	Good	Good
22	0.17	14	15.1	Good	Good
23	0.16	16	14.6	Moderate	Good
24	0.04	5	9.0	Good	Good
25	0.08	5	10.9	Good	Good
26	0.11	18	12.3	Moderate	Good
27	0.02	12	8.1	Good	Good
28	0.52	32	31.4	Moderate	Moderate
29	0.56	32	33.3	Moderate	Moderate
30	0.46	21	28.6	Moderate	Moderate
31	0.43	25	27.2	Moderate	Moderate
32	0.32	12	22.1	Good	Moderate
33	0.48	18	29.6	Moderate	Moderate
34	0.11	7	12.3	Good	Good
35	0.11	7	12.3	Good	Good
36	0.56	26	33.3	Moderate	Moderate
37	0.84	41	46.4	Unhealth for Se	Unhealthy for Sensitive Group

AQC - Obs

AQC - Est

Creating Air Quality Category Map





Click Here to Download IDL Code

```
MAP_CONTINENTS.
of Ground Monitor: 35
Enter the Longitude of Ground Monitor: -85
There are           9 AOD (10km) pixels in your area of Interest
% Compiled module: MAP_2POINTS.
Enter Intercept Value: 5
NO Valid AOD Value Found in the File: MOD04_L2.A2011155.1555.051.2011156021058.hdf
% Program caused arithmetic error: Floating illegal operand
IDL>
```

Provide MODIS AOD file, slope and intercept to this code – will create AQC map

Multiple Linear Regression Method

$$\boldsymbol{PM2.5} = \beta_{\boldsymbol{0}} + \alpha * \tau + \sum_{\boldsymbol{n=1}}^{\boldsymbol{m}} (\beta_{\boldsymbol{n}} * \boldsymbol{M_n})$$

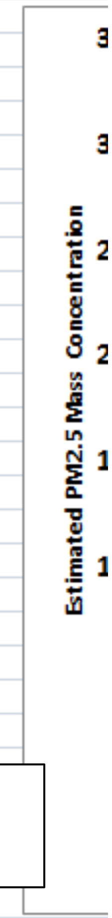
Required AOD and Meteorological Fields – more data processing, more expertise but most of the time product more accurate PM2.5 estimation

Multiple Linear Regression Method

N3 =17.02*A3+1.14*D3-0.92*E3+0.44*F3-0.95*G3+1.04*H3-0.04*I3-0.31*J3-0.031*K3-0.0022*L3-177.26

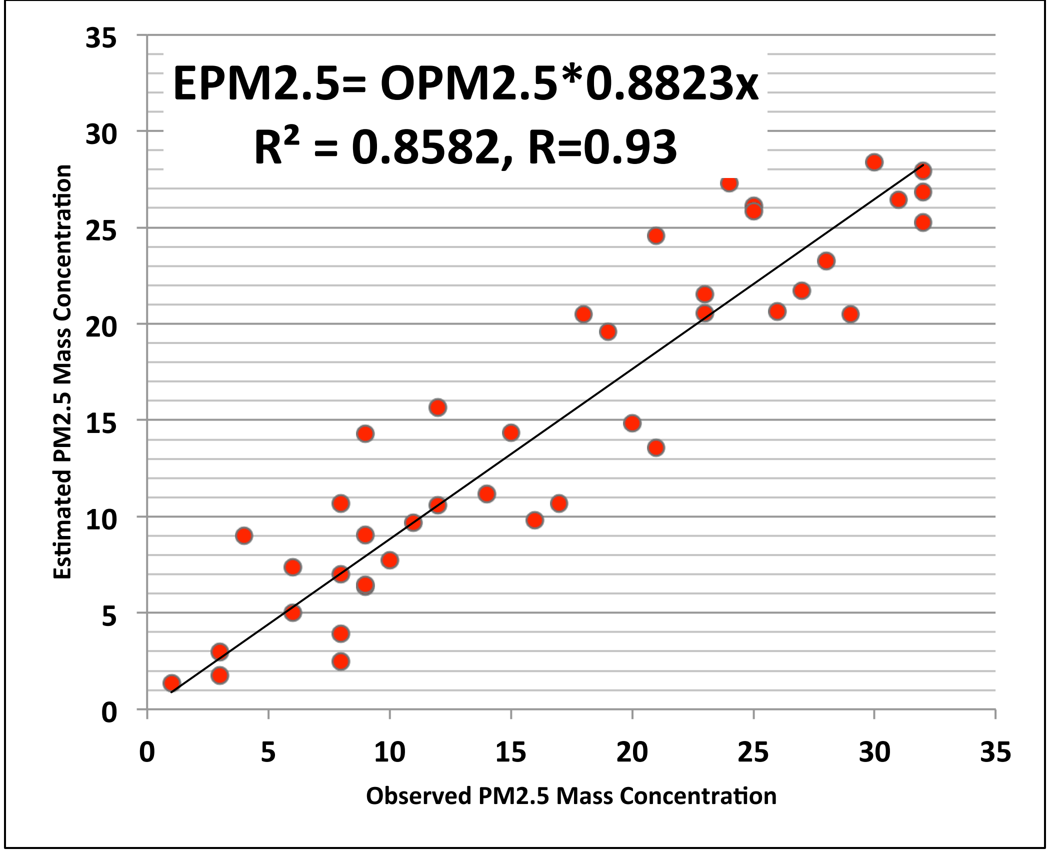
Latitude = 38.46, Longitude = -82.64

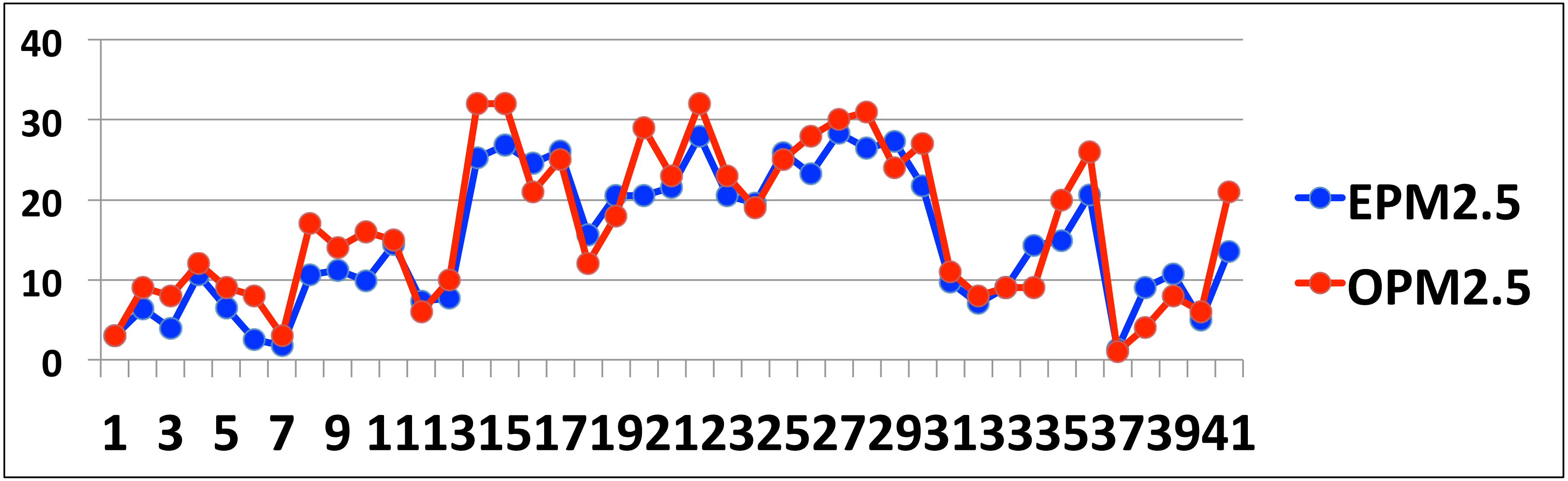
	C	D	E	F	G	H	I	J	K	L	M	N
2	PM1h	tmp0	tmp1000	tmp700	rh0	rh1000	rh700	ws0	ws925	hpbl		EPM2.5
3	3	277.47	277.4	266.05	71.26	71	70.32	4.14	16.22	63.33		2.995254
4	9	287.25	285.97	270.8	28.95	29.41	39.34	2.76	1.41	623.5		6.35489
5	8	274.13	273.1	260.93	63.01	63.56	17.28	4	8.79	675.67		3.911136
6	12	287.43	286.53	269.72	46.23	46.52	23.82	3.64	9.04	800.67		10.58439
7	9	275.9	275.85	264.3	59.98	60.34	11.2	3.39	5.76	53		6.47774
8	8	283.18	281.67	265.93	35.44	35.57	79.54	0.65	2.47	676.83		2.494904
9	3	286.07	283.98	265.25	36.55	36.66	42.77	4.46	9.49	1325.83		1.748084
10	17	297.03	297.98	275.33	52.06	51.57	81.85	4.04	13.09	925.5		10.67131
11	14	296.88	294.37	274.78	29.43	29.35	27.39	2.18	6.37	1633.33		11.1627
12	16	297.05	295.72	275.03	25.06	25.43	44.91	4.98	16.45	914.83		9.828424
13	15	299.85	297.52	275.25	42.4	42.92	42.66	3.17	6.19	1281.5		14.36151
14	6	289.07	287.65	269.45	57.64	58.14	68.48	4.43	34.55	478.83		7.372424
15	10	295.3	293.57	273.68	42.91	43.34	88.06	3.94	17.43	1226		7.74657
16	32	301.9	299.88	282.63	51.67	51.79	32.02	2.83	9.8	585.17		25.24983
17	32	303.42	300.45	282.27	50.19	50.36	23.46	2.64	6.74	833.5		26.84926
18	21	299.68	297.82	279.97	80.46	80.25	68.37	2.38	6.51	75		24.58039
19	25	304.13	301.87	283.48	64.15	64.42	31.91	3.5	6.1	541.17		26.09083
20	12	295.48	295.2	276.62	64.84	63.68	18.02	4.36	6.28	849.83		15.65489
21	18	300.6	297.15	276.12	45.32	45.23	21.52	1.03	2.05	1799.67		20.49068
22	29	302.4	299.1	279.78	60.49	60.86	47.22	3.41	5.88	1457.67		20.51765
23	23	303.7	300.62	282.55	60.82	60.86	12.18	2.56	6.53	1655.67		21.5245
28	28	304.92	303.35	283.4	63.96	63.78	81.48	2.4	6.46	1561.83		23.25351
29	30	302.98	302.9	281.58	59.39	59.84	94.25	3.08	6.66	1391.33		28.37551
30	31	301.35	300.05	282.43	60.76	60.4	33.71	2.94	7.29	89.33		26.44508
31	24	305.43	302.2	280.67	55.96	56.51	23.92	2.29	3.24	1058.83		27.27383



AOD, PM2.5 and Meteorological Data

Multiple Linear Regression Method Results





!!! Caution !!!

Regression analysis provides the first approximation of surface PM2.5 mass concentration and air quality; its accuracy depends on training data and varies in space and time. Careful data quality control/testing and validations should be performed before using this method for the quantitative analysis. The method works best when boundary layer is well mixed, no significant aerosol aloft, and in the small particle dominated regions.