Collection of AOD (Aerosol Optical Depth) 550 nm from Aqua Satellite

Aerosol Optical Depth (AOD) is the measure of aerosols (e.g., urban haze, smoke particles, desert dust, sea salt) distributed within a column of air from the Earth's surface to the top of the atmosphere. The used AOD 550 nm is the dust aerosol optical thickness at 550 nanometers (nm). The satellite AOD (Aerosol Optical Depth) 550 nm data was collected using NASA Giovanni data visualization platform. The available AOD 550 nm product was preprocessed from MODIS (Moderate Resolution Imaging Spectroradiometer) instrument aboard the Aqua Satellite, which passes from South to North poles of the earth. The obtained AOD 550 nm product is basically the level-3 atmosphere daily global product (MYD08_D3), which are derived from four leve-2 MODIS AQUA atmosphere products MYD04_L2, MYD05_L2, MYD06_L2, and MYD07_L2. It contains daily 1 x 1 degree grid average values of atmospheric parameters related to atmospheric aerosol particle properties, total ozone burden, atmospheric water vapor, cloud optical and physical properties, and atmospheric stability indices. The selected shape of the data was Bangladesh, which means obtained AOD 550 nm product were collected and preprocessed by the AQUA satellite using the MODIS instrument while orbiting above Bangladesh. The collected data timeframe was from 2021-03-01 to 2021-03-31. The obtained AOD 550 nm is the mean AOD 550 nm for each day processed by the AQUA MODIS. **DATA SOURCE: https://giovanni.gsfc.nasa.gov/giovanni/**

Collection of ground station PM2.5 data

PM2.5 refers to a category of particulate matter or pollutants that is 2.5 micrometers or smaller in size. The data of PM2.5 raw concentration was obtained from AirNow. AirNow is a partnership of the U.S EPA (Environmental Protection Agency), National Oceanic and Atmospheric Administration (NOAA), National Park Service, NASA, Centers for Disease Control, and tribal, state, and local air quality agencies. The extracted data from AirNow represents the data of Raw concentration of PM2.5 as a unit of $\mu g/m^3$ for Dhaka and the timeframe was from 2021-03-01 to 2021-03-31. The initial data was of the mean raw concentration of PM2.5 per hour for 24 hours of each day, later it was converted to mean concentration of PM2.5 per day to fit with the AOD 550 nm product data obtained from the AQUA MODIS. DATA SOURCE: **AirNow.gov**

Converting AOD 550 nm to PM2.5

The required data to obtained estimated PM2.5 from Aqua satellite are:

- PM2.5 mass concentration from ground monitors
- Satellite derived Aerosol Optical Depth

PM2.5 can be estimated from satellite AOD using multiple methods, among them the mostly used methods are Two-Variable Method (TVM), Multivariable Method, Artificial Intelligence, and Model Scaling (MSC). The Two-Variable Method (TVM) or Simple Linear Regression Model is used here to estimate the PM2.5 from the satellite AOD. Firstly, the AQUA MODIS AOD at 550 nm were correlated with the ground station PM2.5 which shows the R^2 of (0.1202) with a slope of (-52.077) and intercept of (196.31) as shown in figure (1). The slope and intercept were used to estimate the PM 2.5 at ground level with the help of AQUA MODIS 550 at nm measurements.

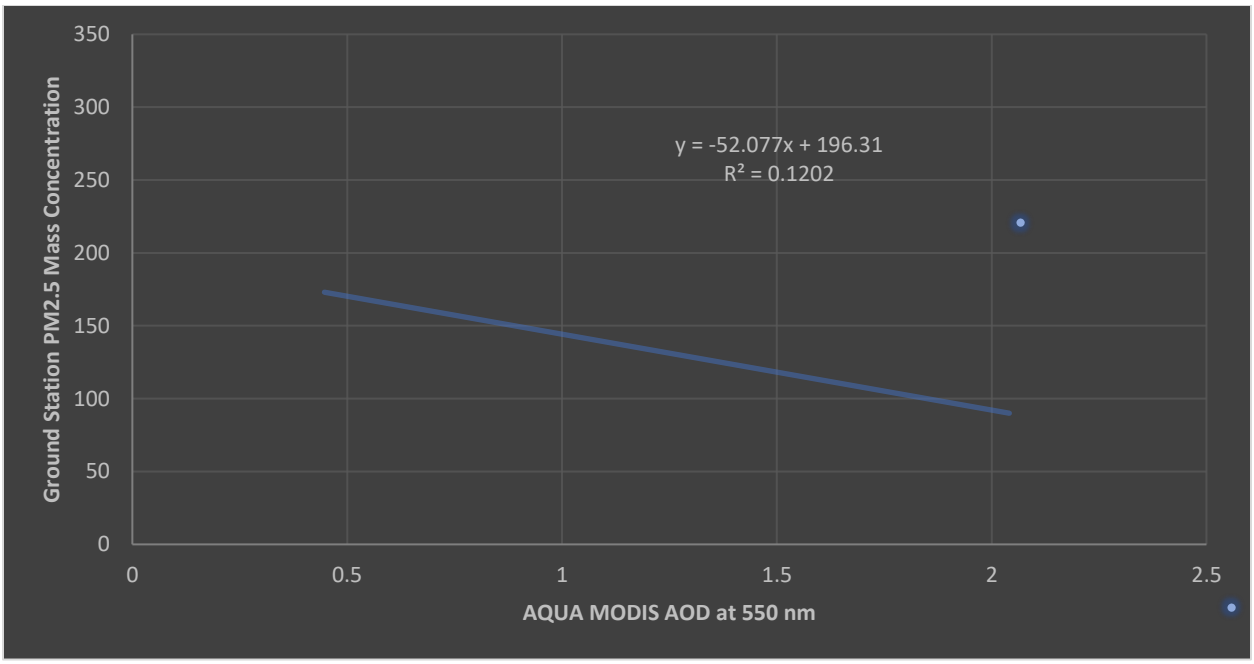

Figure 1: Scatter plot of AQUA MODIS AOD at 550 nm against Ground Station PM2.5 measurements.

The estimated PM2.5 was derived using TVM or simple linear regression model, where the slope and intercepting point were obtained from the correlations of AQUA MODIS AOD at 550 nm and Ground Station PM2.5 Mass Concentration. The equation $\boldsymbol{y = -52.077x + 196.31}$ **– Eq:01** was derived from the correlation and was used to obtain the estimated PM2.5. For each AOD at 550 nm provided a estimated PM2.5.

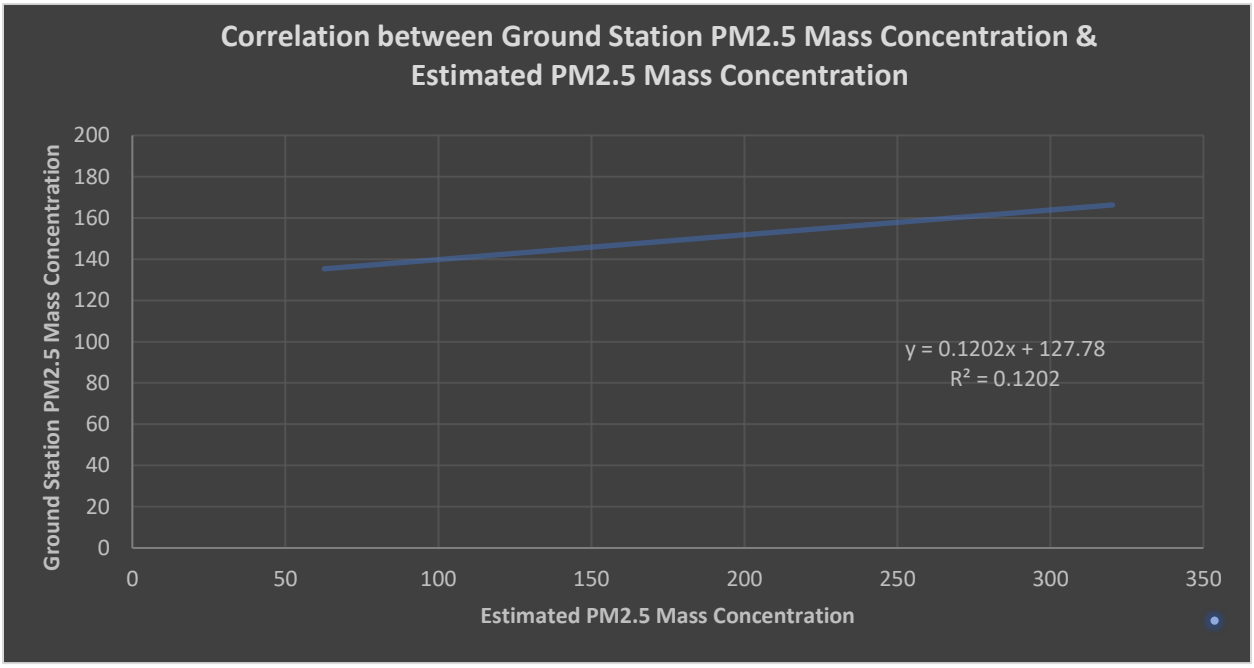

Figure 2: Scatter plot between Estimated and Ground Station PM2.5 Mass Concentration from AOD model

Later, the correlation of estimated PM2.5 which was measured by the AQUA MODIS AOD with the ground station PM2.5 which shows the R^2 of (0.1202) with a slope of (0.1202) and intercept of (127.78) as shown in figure (2). Here, a low R^2 value indicates that the independent variable (Ground Station PM2.5 Mass Concentration) is not much effective in the variation of the dependent variable (Estimated PM2.5 Mass Concentration) from which we can interpret that there might be more independent variables affecting the dependent variable.

Calculating AQI from PM2.5 Mass Concentration

For each PM2.5 Mass Concentration a AQI was obtained using the AQI equation:

$$AQI_{PM\text{-}2.5} = \left(\frac{(I_{high} - I_{low})}{(C_{high} - C_{low})} * (C_P - C_{low})\right) + I_{low} \qquad \textbf{– Eq:02}$$

These variables are the following:

$\boldsymbol{C_P}$**:** The concentration of pollutant *P*.

$\boldsymbol{C_{low}}$**,** $\boldsymbol{C_{high}}$**:** The low/high concentration breakpoints that contain C_P. These breakpoints are defined by the EPA in the figure (3).

$\boldsymbol{I_{low}}$**,** $\boldsymbol{I_{high}}$**:** The low/high index range associated with concentration breakpoints for C_P.

Example: For $PM_{2.5}$ mass concentration of 89.7 µg/m^3 average pollution over a 24-hour period, then this reading falls in the 55.5--150.4 range for $PM_{2.5}$ concentrations, associated with the 151--200 index range (this is in the row of the table labeled "Unhealthy"). Thus, the AQI formula for this pollutant becomes:

$$AQI_{PM\text{-}2.5} = \left(\frac{(I_{high} - I_{low})}{(C_{high} - C_{low})} * (C_P - C_{low})\right) + I_{low}$$

$$AQI_{PM\text{-}2.5} = \left(\frac{(200 - 151)}{(150.4 - 55.5)} * (89.7 - 55.5)\right) + 151$$

$$AQI_{PM\text{-}2.5} = 168.66$$

$$AQI_{PM\text{-}2.5} = 169$$

Category	AQI	PM2.5 (µg/m3) 24hr avg
Good	0--50	0--12.0
Moderate	51--100	12.1--35.4
Unhealthy for Sensitive Groups	101--150	35.5--55.4
Unhealthy	151--200	55.5--150.4
Very Unhealthy	201--300	150.5--250.4
Hazardous	301--500	250.5--500.4

Figure 3: AQI Breakpoint Table

Date	AQUA MODIS AOD 550 nm	Ground PM2.5	AQI Ground	AQI Category	Estimated PM2.5	Estimated AQI	Estimated AQI Category
3/1/2021	0.621923075	89.7	169	Unhealthy	163.9	214	Very Unhealthy
3/2/2021	0.44706523	102.4	175	Unhealthy	173	223	Very Unhealthy
3/3/2021	0.479187056	126.1	187	Unhealthy	171.3	222	Very Unhealthy
3/4/2021	0.576767895	142.3	196	Unhealthy	166.2	217	Very Unhealthy
3/5/2021	0.855233195	115.6	182	Unhealthy	151.7	202	Very Unhealthy
3/6/2021	0.825564444	77.5	162	Unhealthy	153.3	204	Very Unhealthy
3/7/2021	1.25258258	90.9	169	Unhealthy	131	190	Unhealthy
3/8/2021	1.16718272	130.6	190	Unhealthy	135.5	192	Unhealthy
3/9/2021	1.91480311	79.1	163	Unhealthy	96.5	172	Unhealthy
3/10/2021	1.47957444	62.6	155	Unhealthy	119.2	184	Unhealthy
3/11/2021	1.16871349	96.5	172	Unhealthy	135.4	192	Unhealthy
3/12/2021	1.1684171	154.6	205	Very Unhealthy	135.4	192	Unhealthy
3/13/2021	1.62215327	149.2	199	Unhealthy	111.8	180	Unhealthy
3/14/2021	0.828912805	95.7	172	Unhealthy	153.1	204	Very Unhealthy
3/15/2021	0.656754169	153.6	204	Very Unhealthy	162.1	212	Very Unhealthy
3/16/2021	0.488711245	320.3	370	Hazardous	170.8	221	Very Unhealthy
3/17/2021	0.54776322	152.6	203	Very Unhealthy	167.7	218	Very Unhealthy
3/18/2021	0.652457109	232.2	282	Very Unhealthy	162.3	213	Very Unhealthy
3/19/2021	0.705899459	245.8	295	Very Unhealthy	159.5	210	Very Unhealthy
3/20/2021	1.33915197	215.6	266	Very Unhealthy	126.5	188	Unhealthy
3/21/2021	0.751072169	318.4	368	Hazardous	157.1	208	Very Unhealthy
3/22/2021	0.694079068	188.1	238	Very Unhealthy	160.1	211	Very Unhealthy
3/23/2021	1.07608067	87.6	168	Unhealthy	140.2	195	Unhealthy
3/24/2021	1.2399527	195.7	246	Very Unhealthy	131.7	190	Unhealthy
3/25/2021	0.508000238	127	188	Unhealthy	169.8	220	Very Unhealthy

3/26/2021	0.657984872	147.3	198	Unhealthy	162	212	Very Unhealthy
3/27/2021	0.646923759	149	199	Unhealthy	162.6	212	Very Unhealthy
3/28/2021	0.975679124	146.4	198	Unhealthy	145.4	197	Unhealthy
3/29/2021	1.65575138	157.6	208	Very Unhealthy	110	179	Unhealthy
3/30/2021	2.04113359	74.7	161	Unhealthy	90	169	Unhealthy
3/31/2021	1.35735422	76.1	162	Unhealthy	125.6	187	Unhealthy

Figure 4: Data Table for Aqua MODIS AOD 550 nm, raw and estimated PM2.5 mass concentration, and AQI.

The data table in figure (4) shows the AQUA MODIS AOD at 550 nm and Ground PM.25 data which is derived to obtain the estimated PM2.5 using **Eq:01** and AQI Ground and Estimated AQI is obtained using **Eq:02**, the AQI Category is determined according to figure (3).