MAJOR AEROSOL TYPES IN KUCHING USING THRESHOLD CLASSIFICATION TECHNIQUE

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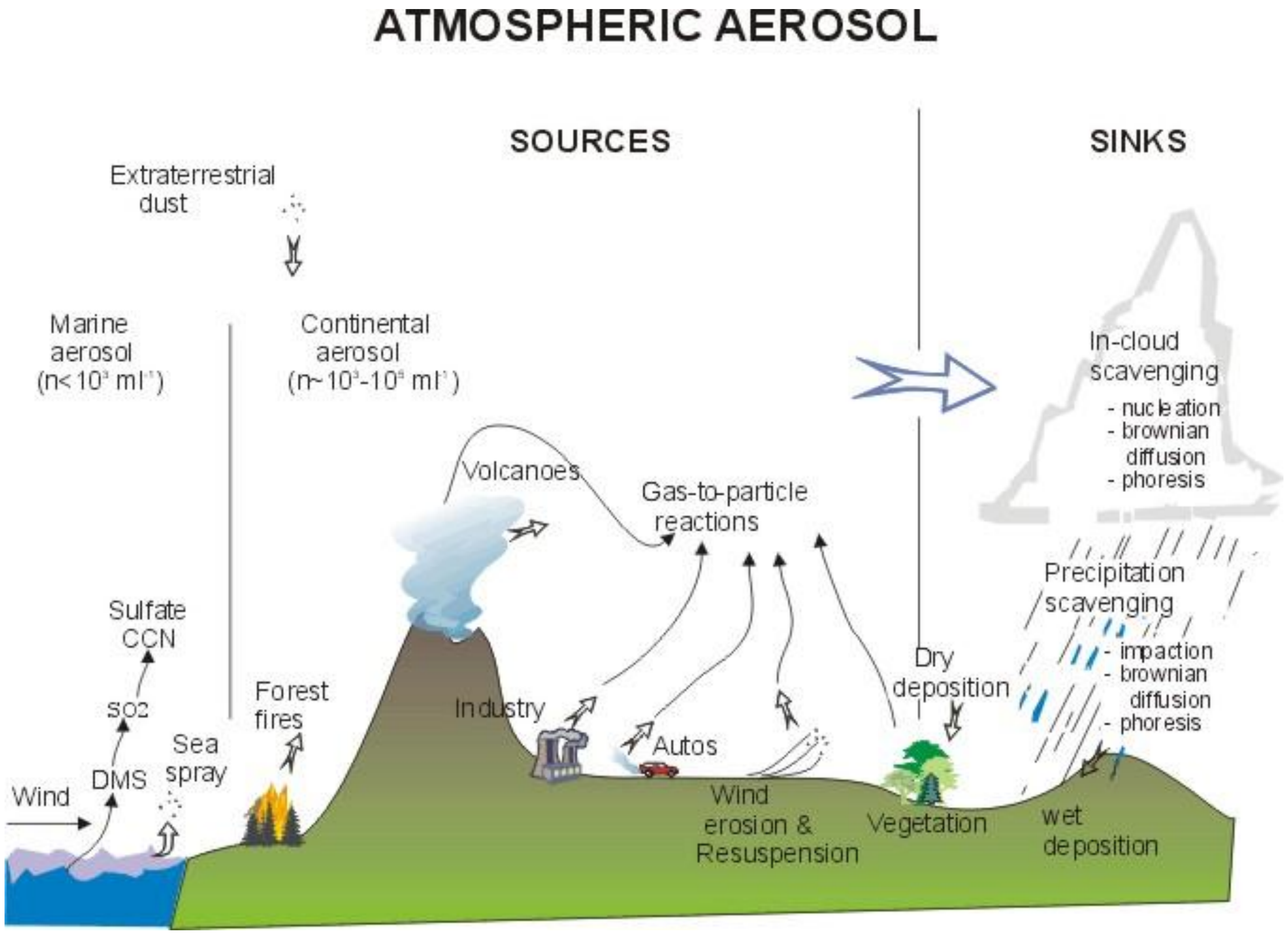
Overview

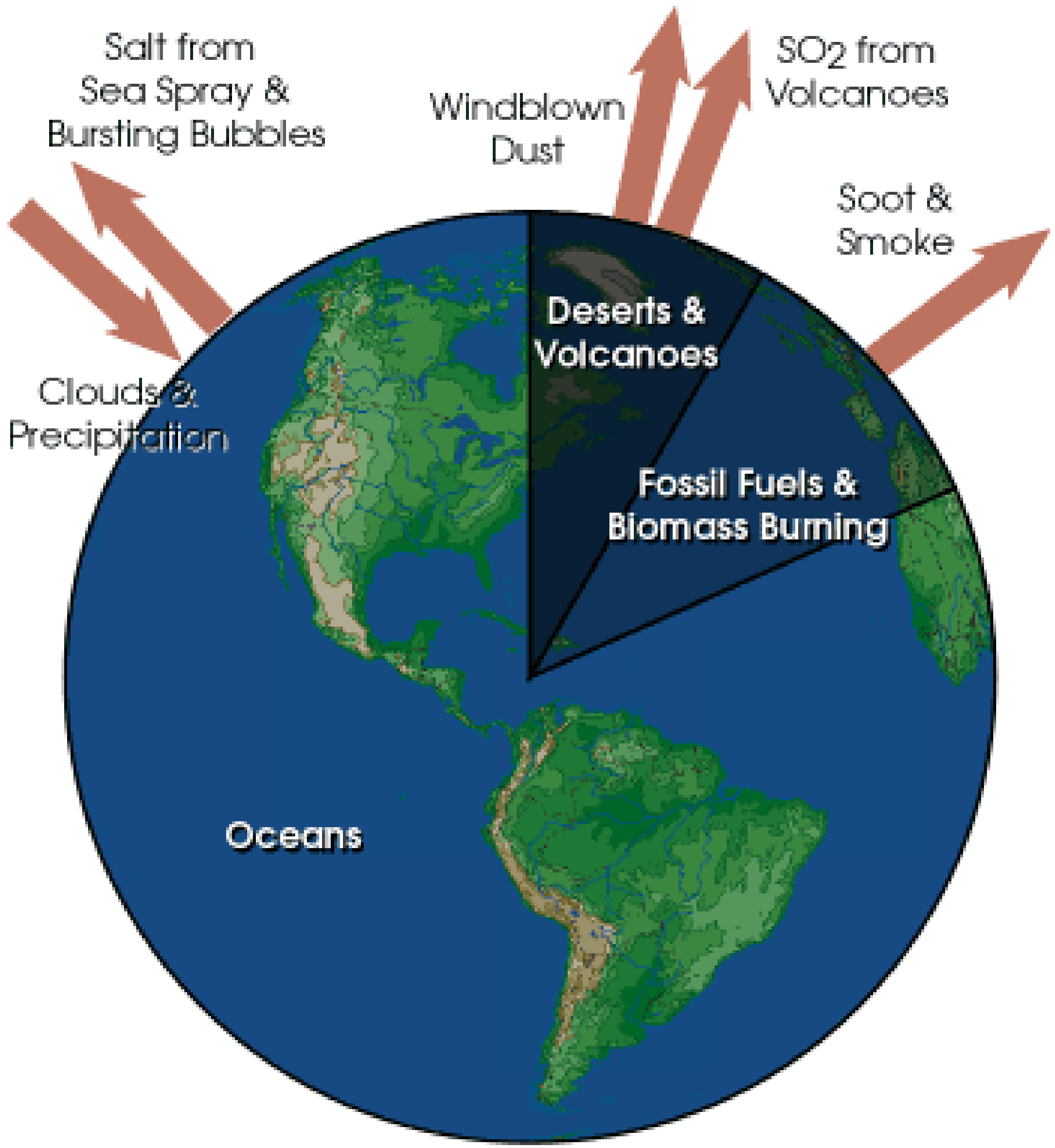
- The Aerosols play important role in the balance of the Earth's climate.
- Due to the increasing anthropogenic emission of aerosols since the industrial revolution, they can also effect the global climate change.
- However, the effects of aerosols on climate are not one-way, moreover excessively uncertain.
- The climate forcing by aerosols can be realized in two ways, basically:

  i) direct and indirect radiative forcing.

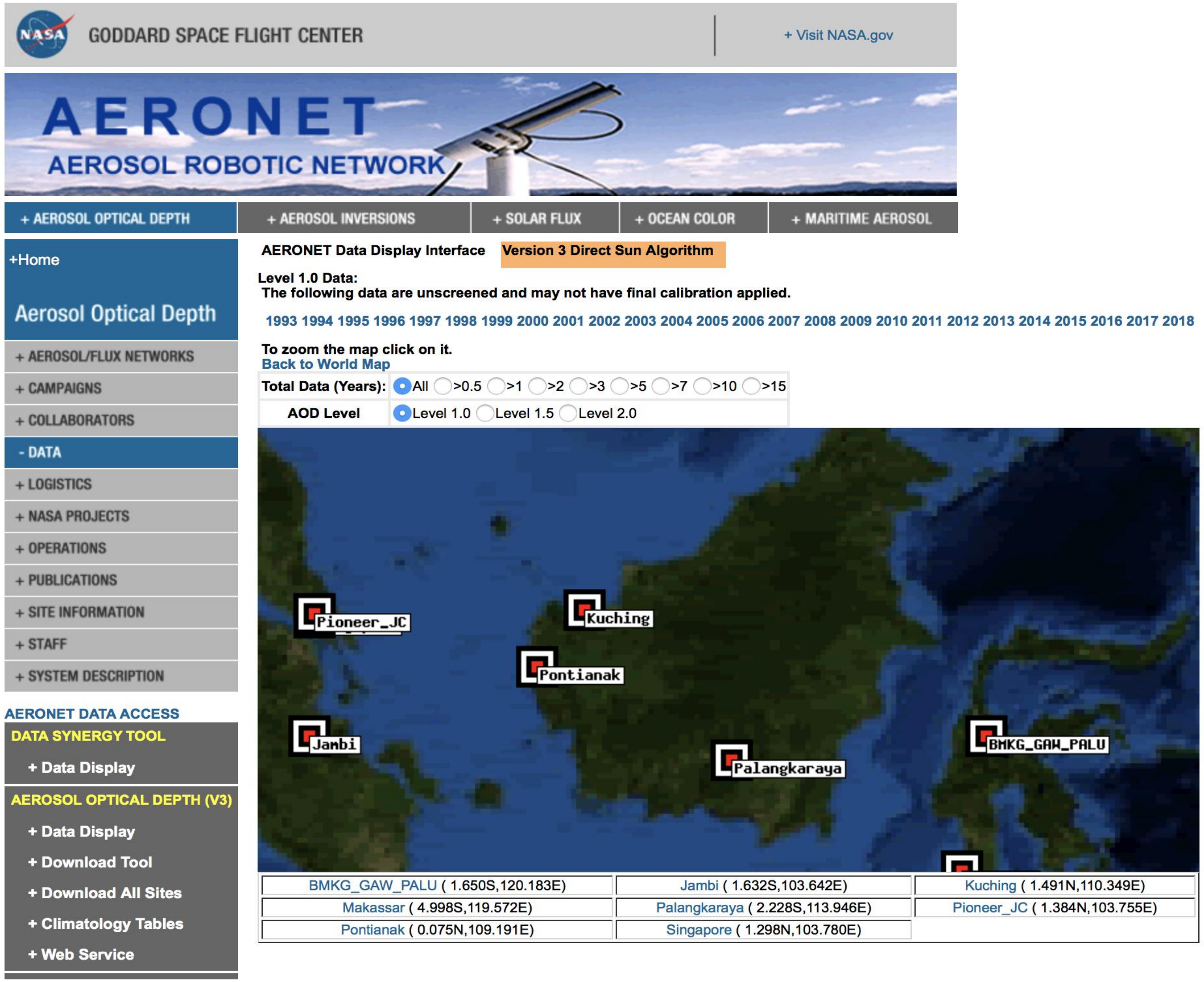


Source

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 instrument (Earth's surface) to the top of the atmosphere.



Aeronet Data



https://aeronet.gsfc.nasa.gov/cgi-bin/data_display_aod_v3?site=Kuching&nachal=2&level=1&place_code=10

AERONET Sun photometer

- 3 parameters used for aerosol sources identification; AOD, Angstrom (α) and Asymmetry Factor (ASY) in Kuching, Sarawak using AERONET.

  Diurnal patterns for AOD are been observed and aerosol type classification will be analyzed based on the spectral characteristics of the AOD and α data series

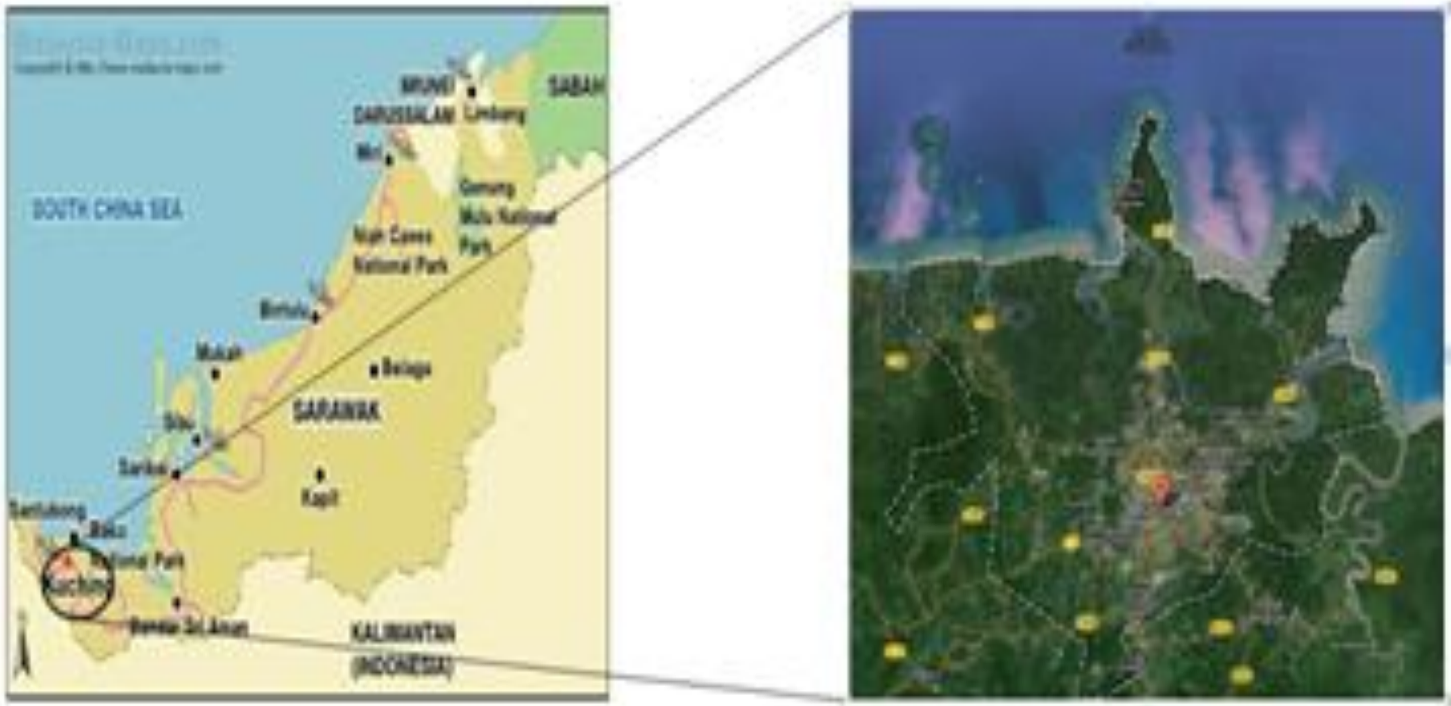
Figure 2: Location of AERONET Sun photometer at Observation Tower of Kuching Meteorological Station

Mounted at the Observation Tower of Kuching Meteorological Station located at the Kuching International Airport, Sarawak (1.491ºN and 110.349ºE with elevation at 28 meters)

What matters us?

Common classification techniques aerosol types by using relationship between two parameters as examples by Toledano et al. (2007), Alam et al. (2011) and Alam et al. (2012).

In this study, several parameters are combined together for better identification of aerosol types and its optical characteristics.



http://www.astroawani.com/video-malaysia/7-juta-kematian-dunia-akibat-pencemaran-udara-303284

METHODOLOGY

Extraction of AERONET Sunphotometer Data

- Data from 2011-2015
- Parameter:
- - AOD at 500nm
- - Angstrom Exponent at 440-870nm
- Statistical analysis by obtaining the mean average

Deriving Optical Properties

- Temporal variations for AOD, Angstrom Exponent and Asymmetry Factor (ASY)

Classification of Aerosol Types

- *Threshold Classification Technique*
- Relationship between AOD and Angstrom Exponent
- Relationship between AOD, Angstrom and ASY

Results

AOD Temporal variations

- Highest AOD - September 2015 at wavelength 440nm with 2.3354±1.032
- Lowest AOD - December 2012 with the range of 0.0321±0.004 at 1020nm.
- Low concentration of AOD (Nov-Apr 2011) - due to heavy rainfalls
- High concentration of AOD (Aug-October 2012) - presence of dry season, biomass burning activities from neighboring countries and urban activities.
- The trends for AOD variations are based on the seasonal monsoon weather.

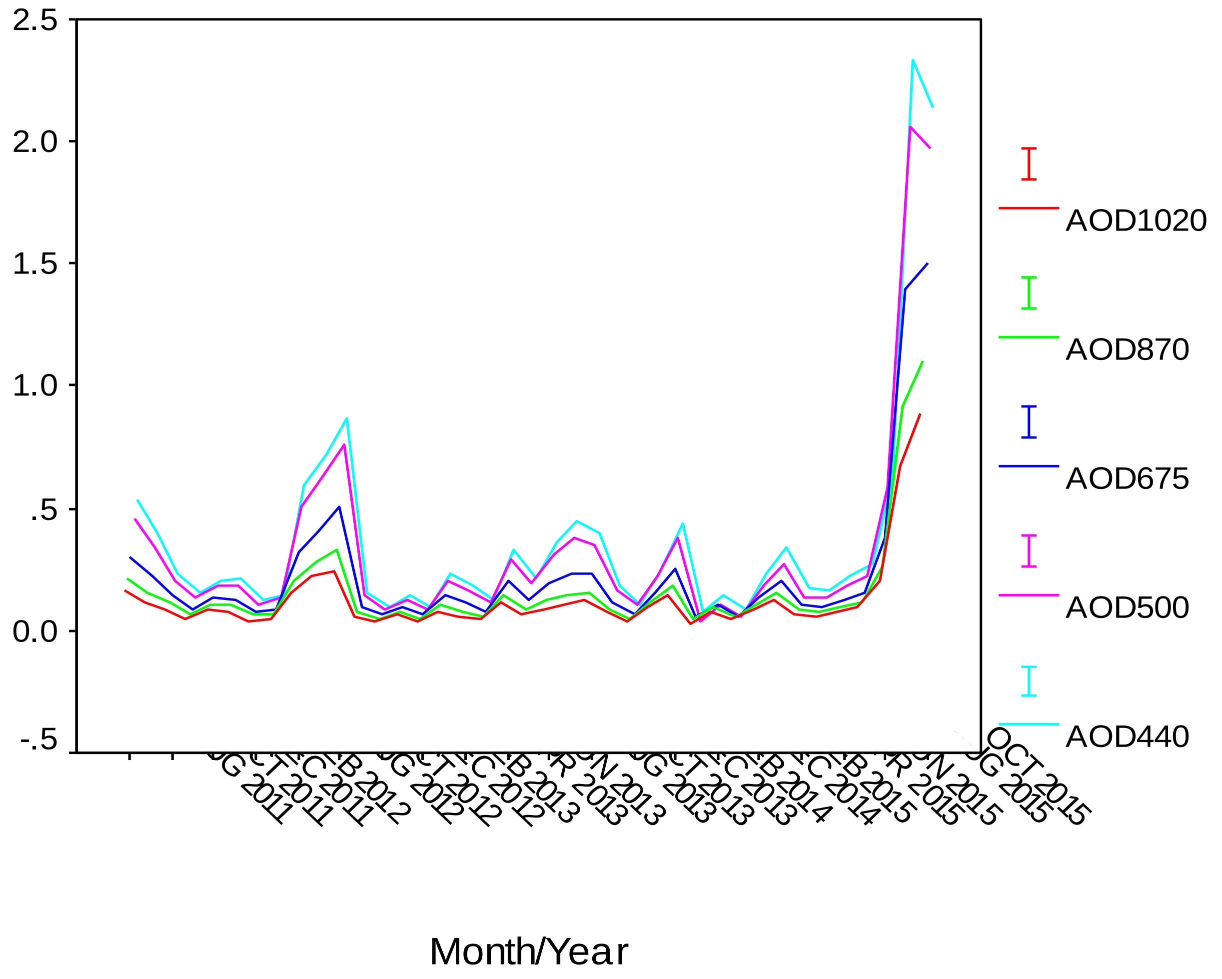
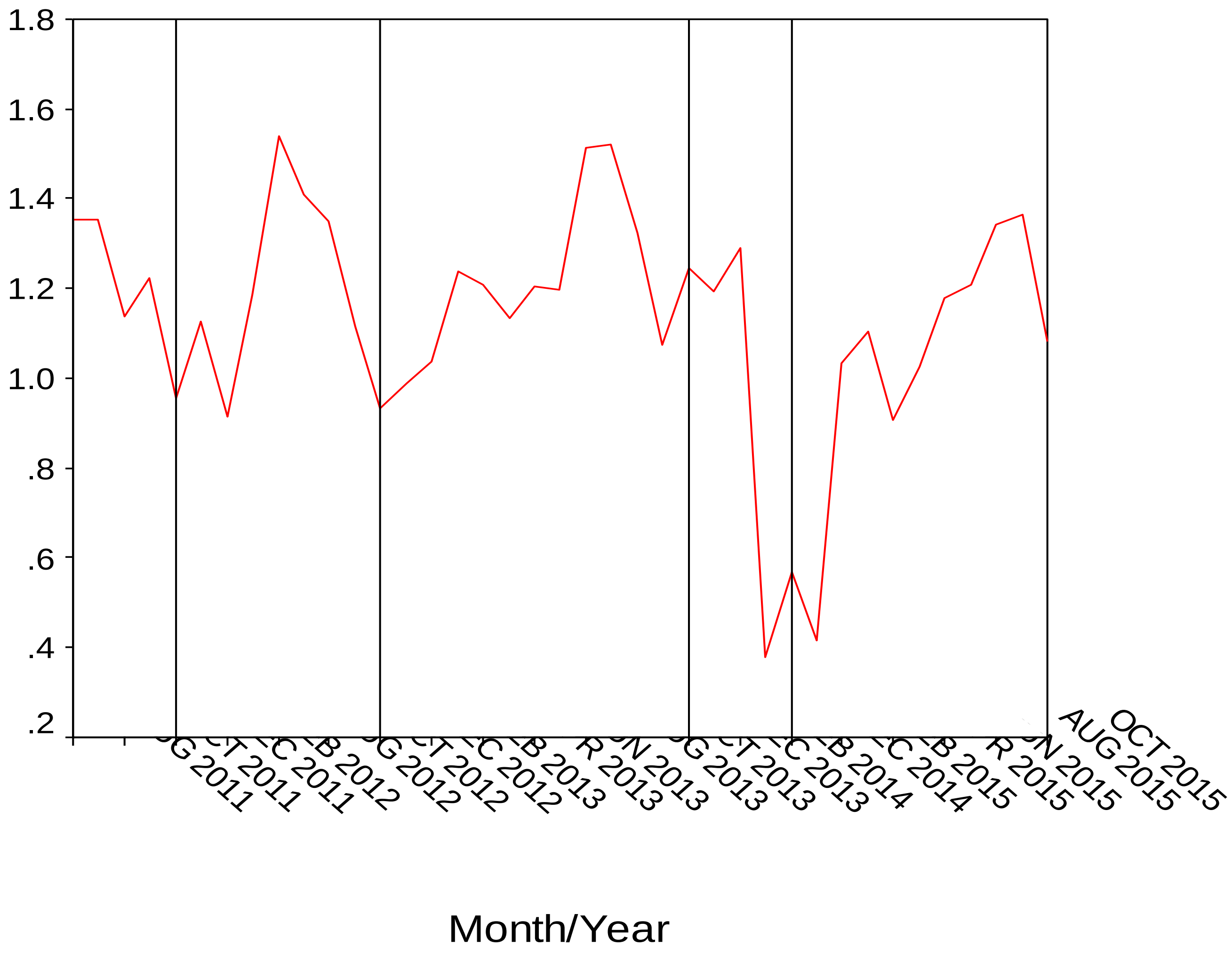


Figure 3: Monthly Variations of Aerosol Optical Depth at Five Different Wavelengths from August 2011 until December 2015

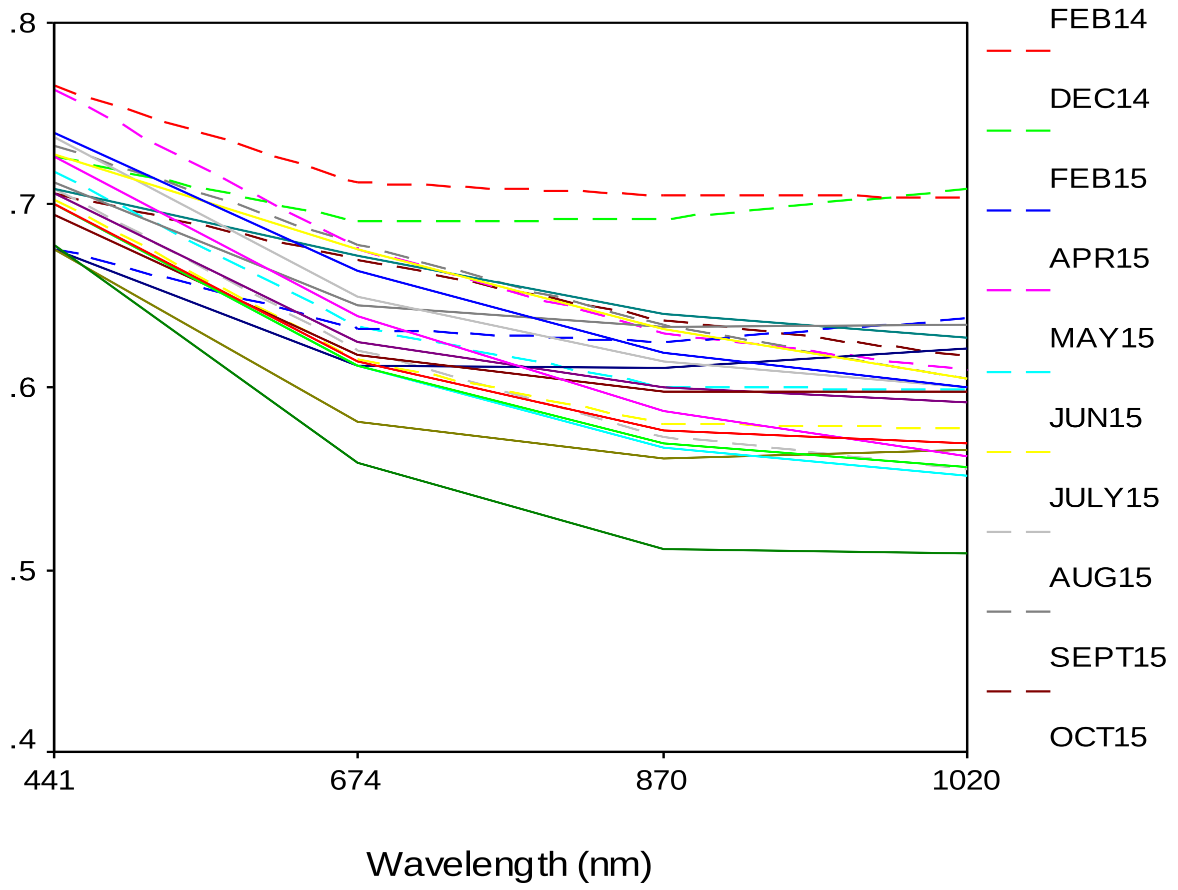
Angstrom Exponent (α)

- Highest α value is 1.5409±0.22 (Aug 2012) and the lowest with 0.3781±0.183 (Nov 2014).
- α>1- contamination from urban or continental aerosol and biomass burning sources.
- For α<1 from Nov 2014 until Jan 2015 with 0.3781±0.183, 0.5682±0.132 and 0.4176±0.238 indicates high presence of coarse mode aerosols such as dust and maritime aerosols.
- α is slightly decreased Wet seasons happen from November to February causes heavy rainfalls and based from the graph it shows for that months the value of

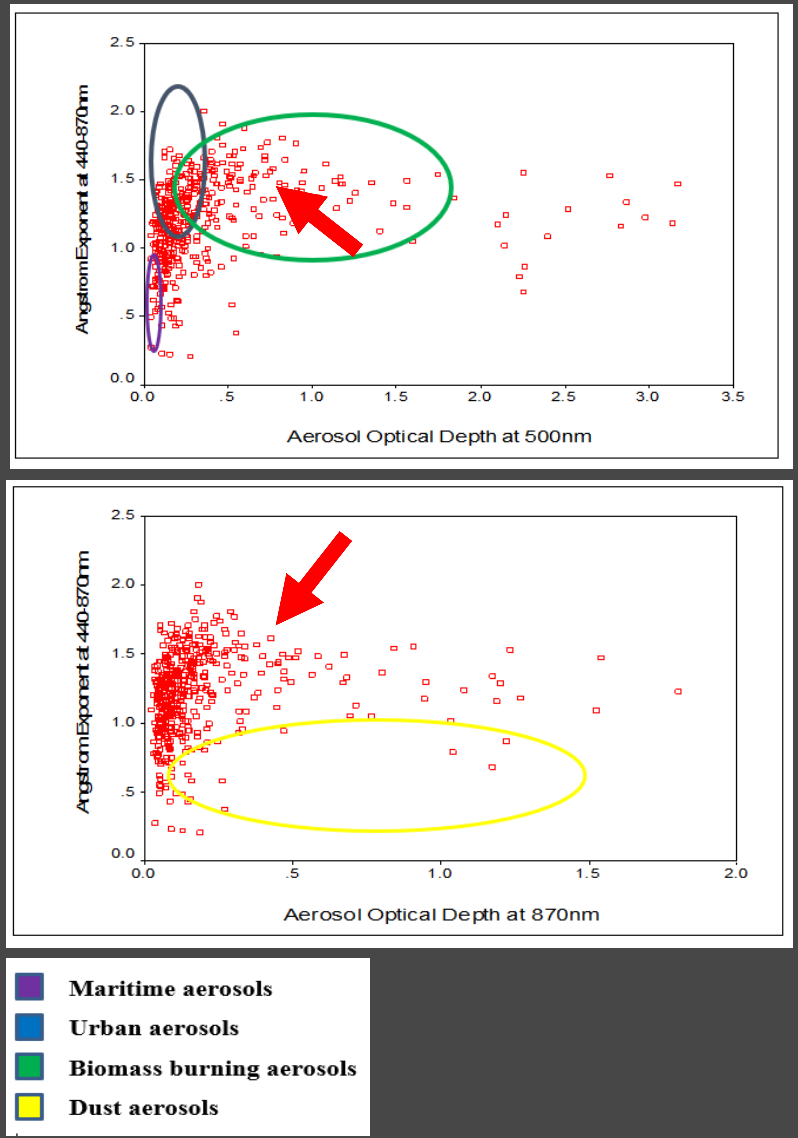


Asymmetry Factor (ASY)

- The range value for ASY is between -1 to 1 with ASY value near to -1 corresponds to back scattering direction with θ=180º and the light is being scattered entirely in a forward direction (θ = 0º).
- ASY value is decreasing with increasing wavelength bands - dominance of fine mode aerosols and mostly the lights scattered in forward scattering aerosols
- Highest ASY value with 0.7652 at 441nm and the lowest ed during July 2013 at 1020nm with 0.5087.
- Range of ASY between 0.64 and 0.83 with the averaged at 0.72 indicates for dry aerosol particles depending on the aerosol types and seasonal variability.
- Decrease in ASY in the visible region and then slightly increases in the near IR region. It is corresponding to the influence of coarse mode particles for those particular months



Monthly Variations for Asymmetry Factor at Different Wavelengths from 2011 until 2015

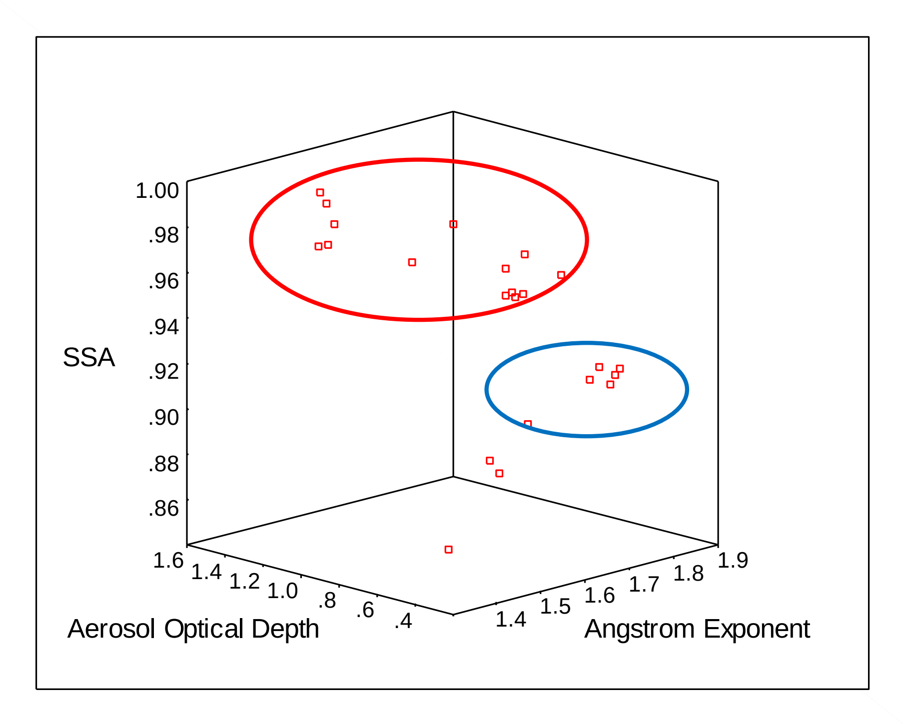


The purpose of using AOD and α parameter it will help to identify aerosol types based on frequency distributions of AOD and aerosol size distribution. AOD wavelength band at 500nm and α value at 440-870nm

CLASSIFICATION OF AEROSOL TYPES (2 parameters)

- AOD at two different wavelength bands are used firstly is at 500nm because optically 500nm is an effective visible wavelength that is very suitable for aerosol characteristics study (Stone et al. 2002; Tan et al. 2015) and give more clarification on fine mode aerosols (Ranjan et al. 2007).
- The other one is AOD at 870nm because as explained earlier in AOD variations at different wavelengths 870nm is very useful to classify coarse mode aerosols (Toledano et al. 2007).
- The value concentrated <0.5 for AOD and <1.5 for α.
- The maritime aerosols is at AOD ≤ 0.1 and α ≤ 0.9.
- Most of the value was highly concentrated at AOD≤0.4 and at α value ≥ 1.2 indicates the presence of urban aerosol.
- The presence of biomass burning aerosol with AOD ≥0.4 and α ≥ 1.
- At AOD more than 0.2 and α less than 0.8 show the identification of dust aerosols.

CLASSIFICATION OF AEROSOL TYPES (3 parameters)

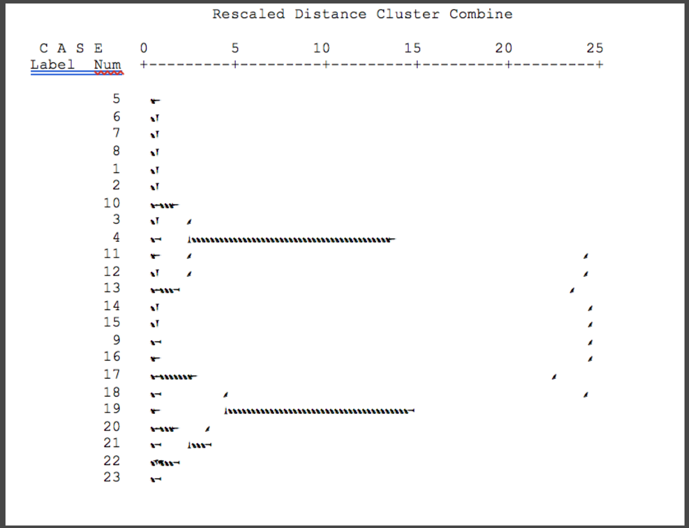


3D scatter plot for AOD, Angstrom Exponent and SSA

- Most of the classification of aerosol types used the relationship between two parameters in aerosol optical properties.
- In this study, three parameters were used which are AOD, Angstrom Exponent and SSA to analyze the relationship and after that characterize aerosol types at study area.
- The purpose of using these three parameters simultaneously is to analyze the dependence of aerosol loading towards particle size and also its

1) Hierarchical cluster analysis

cluster analysis is to maximize the similarity of cases within each cluster while maximizing the dissimilarity between groups.



From the result, the changes from 2.077 to 0.340 shows the larger differences therefore it shows the demarcation point and make the number of cluster for this analysis is two clusters. To justify the occurrence for number of cluster, endrogram was applied

i. Ward Method

The important parameter that should be focused on is coefficients value.

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	5	6	.000	0	0	6
2	11	12	.000	0	0	8
3	19	20	.000	0	0	10
4	14	15	.001	0	0	13
5	1	2	.001	0	0	12
6	5	7	.001	1	0	9
7	16	17	.001	0	0	15
8	11	13	.002	2	0	17
9	5	8	.002	6	0	16
10	19	21	.003	3	0	19
11	22	23	.004	0	0	19
12	1	10	.007	5	0	14
13	9	14	.013	0	4	17
14	1	3	.025	12	0	16
15	16	18	.042	7	0	21
16	1	5	.081	14	9	18
17	9	11	.122	13	8	20
18	1	4	.181	16	0	20
19	19	22	.367	10	11	21
20	1	9	.567	18	17	22
21	16	19	.907	15	19	22
22	1	16	2.984	20	21	0

Number of Clusters	Agglomeration Last Step	Coefficients This Step	Change
2	2.984	0.907	2.077
3	0.907	0.567	0.340
4	0.567	0.367	0.200
5	0.367	0.181	0.186

Hierarchical cluster analysis

ii. Centroid clustering

Centroid clustering is another cluster method used in hierarchical clustering analysis. Agglomeration schedule produced by using centroid clustering was shown in Table 4.9.

ii. Median clustering

Number of Clusters	Agglomeration Last Step	Coefficients This Step	Change
2	0.376	0.250	0.126
3	0.250	0.114	0.136
4	0.114	0.086	0.028
5	0.086	0.044	0.042

Table shows that there are larger differences in gaps between cluster 3 and 4 with differences from 0.136 to 0.028. Therefore, the demarcation point for centriod clustering is at 0.136 and the number of clusters derived is three clusters .

Number of Clusters	Agglomeration Last Step	Coefficients This Step	Change
2	0.584	0.254	0.330
3	0.254	0.104	0.150
4	0.104	0.073	0.031
5	0.073	0.060	0.013

From the change value in Table 4.12, it shows that there are larger differences in gaps between cluster 3 and 4 with differences from 0.150 to 0.031. Therefore, the demarcation point for median clustering is at 0.150 and the number of clusters derived is three clusters

2) K-mean cluster analysis

Cluster 1: the value for SSA is 0.9224, AOD is 0.5138 and α value is 1.6380 which shows the presence of urban aerosols.

Urban aerosols provides AOD value between 0.2 to 0.5 with α value higher than 1 corresponds to fine mode aerosols and SSA value for urban aerosols at the range of 0.90 to 0.98.

	Cluster		
	1	2	3
Single Scattering Albedo	0.9224	0.9627	0.9796
Aerosol Optical Depth	0.5138	0.9073	1.2905
Angstrom Exponent	1.6380	1.6612	1.4807

Cluster 2 SSA at 0.9627, AOD at 0.9073 and α value is 1.6612. This information indicates the presence of biomass burning aerosols over Kuching area. The characterization of biomass burning aerosols gives AOD value more than 0.7 with α>1.

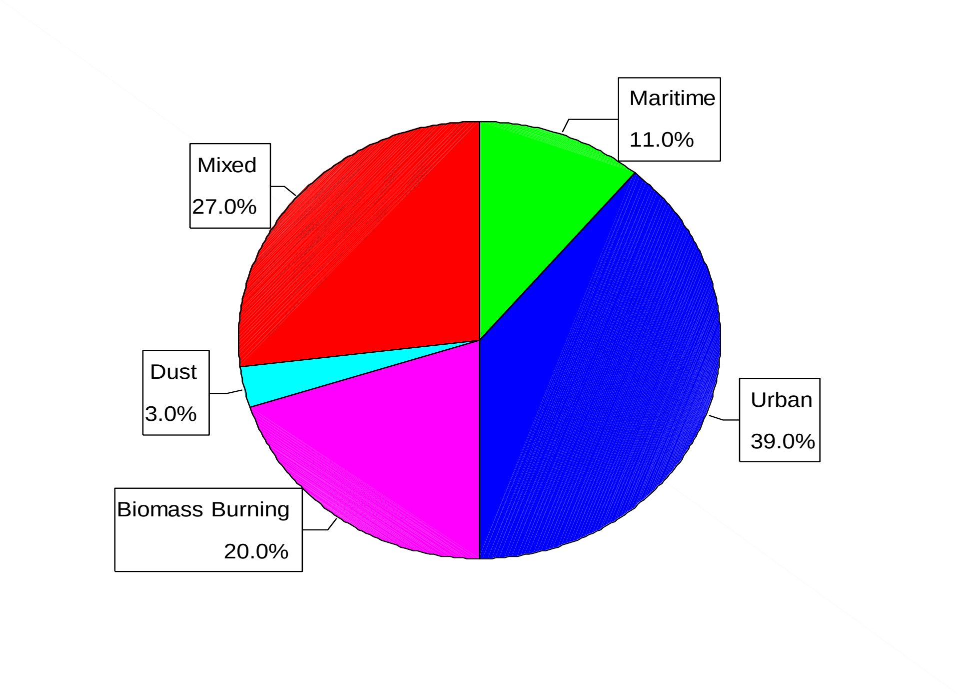
Cluster 3 indicate the presence of mixture aerosols consists of dust aerosol and maritime aerosols. The value for SSA is 0.9796 with AOD at 1.2905 and α value at 1.4807. It can be concluded that high presence of urban aerosols over Kuching with 61%, followed by dust and maritime aerosols with 22% and lastly biomass burning aerosols with 17%.

- The classification using three parameters which are **AOD, α, and ASY** have improved in classifying the aerosols types.
- Dust particles contribute minimally to the emissions in Malaysia because the geographic location has no desert dust and is a great distance away from desert areas.
- However, in this results amount of DA particles present in the data is believed to be caused by vehicles and construction activities especially when the sensor was installed at the airport

Percentage Comparison for Different Types of Aerosols by Using Different Optical Properties

Aerosol Types/Parameters (%)	AOD and α	AOD, α, and ASY
Urban Aerosols	34.7	39
Biomass Burning Aerosols	23.8	20
Maritime Aerosols	4.0	11
Dust Aerosols	3.7	3.0
Mixed Aerosols	18	27

Aerosol Classification Based on Relationship between Aerosol Optical Depth, Angstrom Exponent and Asymmetry Factor

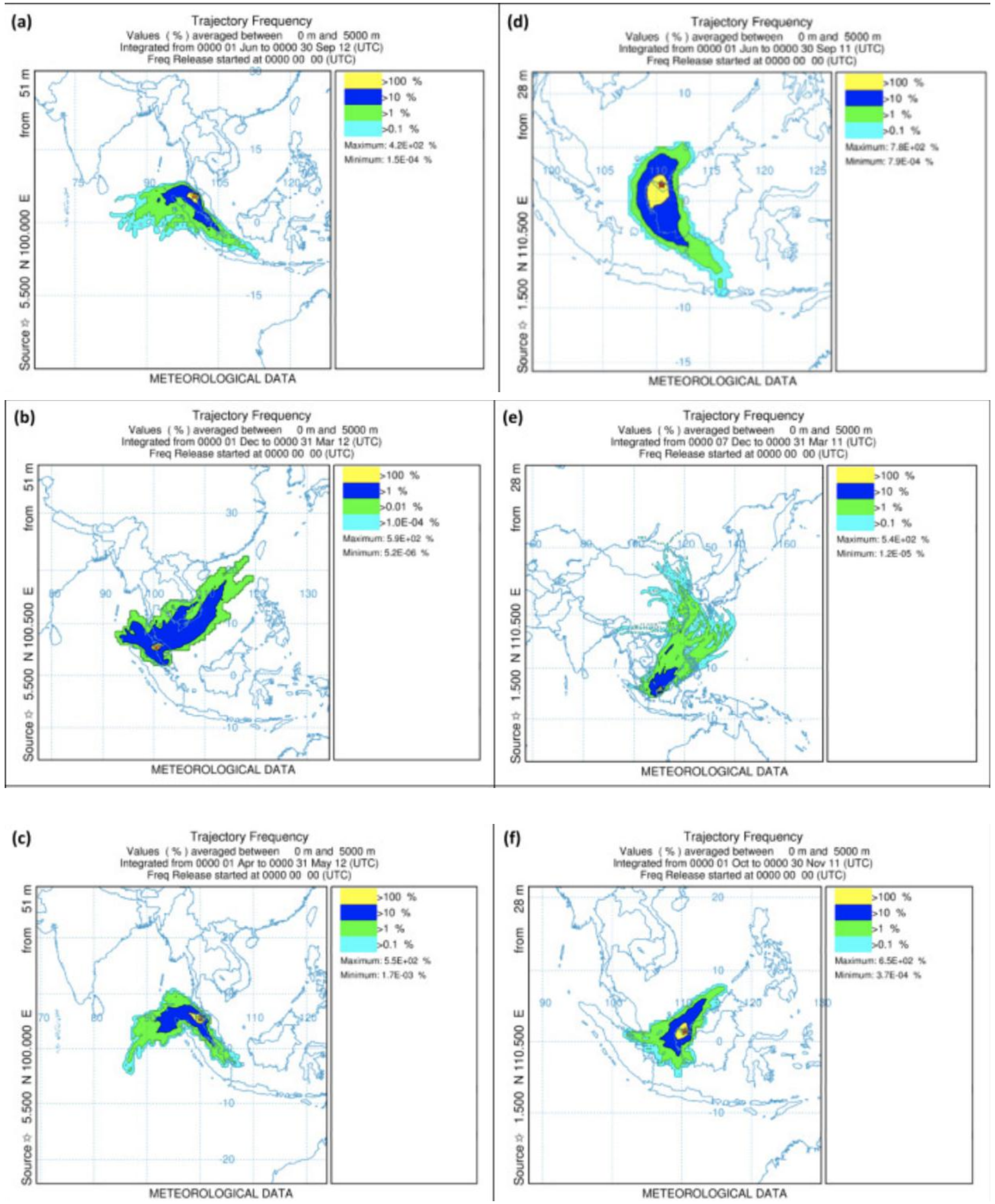


- The combination of these three parameters help to classify different types of aerosols based on aerosol loading, size of aerosol particles and the scattering direction of aerosols.
- ASY parameter is a very important parameter because it regulates the aerosol radiative forcing and as similar with SSA, ASY value is also dependent on the size and composition of aerosol particles (Ramachandran and Rajesh (2008); Srivastava et al. 2011).
- The highest percentage observed was for urban aerosols with 39% followed by mixed aerosols at 27%, 20% for biomass burning aerosols, 11% for maritime aerosols and lastly dust aerosols was observed at 3%.
- When using the relationship between three parameters it will help to reduce the observations for mixed aerosols types from 35.7% to 27%.

Back–trajectory frequency seasonal plot by HYSPLIT_4 model

From the 7 day back–trajectory frequency seasonal plot by HYSPLIT_4 model

The air parcel flow patterns are illustrated for each monsoon season in the value of percentage averaged in between ground surface to 5 000 m altitude



Conclusions

- Aerosol has potential to be used in determining the air pollutant source
- The combination of these three parameters help to classify different types of aerosols based on aerosol loading, size of aerosol particles and the scattering direction of aerosols.
- Urban aerosol and mixed aerosol observed is not necessarily a major aerosol type for these sites. However, urbanization and high development rates have marked the effects.

Thank You