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L E T T E R S

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A STUDY ON LONG TERM VARIATION IN PARTICULATE MATTER AND BLACK CARBON AEROSOL OPTICAL THICKNESS OVER MYSURU, INDIA : A SATELLITE DATA APPROACH

1. Aerosol Optical Thickness (AOT) is a measure of solar spectral extinction. Long term AOT data analysis gives a picture of air quality for that location. This type of analysis is useful in the study of impact of urbanization on local climate. Aerosols are one of the most important but poorly understood factors that influence global climate change (IPCC, 2001). This calls for a need to regularly monitor the global aerosol distributions and study how they are changing over time. From this one can find out the possible trend in their changing patterns over the years and what effect they will ultimately have on the global climate (Tom *et al*., 2008).The population density in fast growing cities and the related human activities (*e.g.*, construction, transportation, energy generation, industrial production, etc.) pose serious challenge to the ecological environment (Glasow von *et al*., 2013 and Sekovski *et al*., 2012). For example, air and water pollutions associated with human activities have become one of the most forthcoming environmental issues of fast growing cities in recent decades (Kanakidou *et al*., 2011), especially in the developing countries where limited resources are available for addressing the pollution issues. Mysuru (12° 19′ N and 76° 39′ E) being one of the fast growing cities in Karnataka State of India needs attention in monitoring air quality on regular basis because of its increased urbanization. Possessing long-term ground based data is a difficult task. However, usage of satellite data can provide almost accurate long term data for any location. In the present study an attempt has been made to analyze a ten year AOT data at 550 nm wavelength for the south Indian location Mysuru, Karnataka collected from NASA's Giovanni site and the results of the study have been discussed in this paper.

2. Mysuru is a tropical (12° 19′ N and 76° 39′ E) continental station in the Indian subcontinent with amean height of about 767 m above mean sea level. It is situated on the Deccan plateau of peninsular India (Fig. 1). Arabian Sea is at a distance of 200 km on the west, Bay of Bengal 400 km away on the east and the Indian Ocean is about 500 km away in the south. The annual mean daily temperatures are 30 °C maximum and 19 °C minimum.

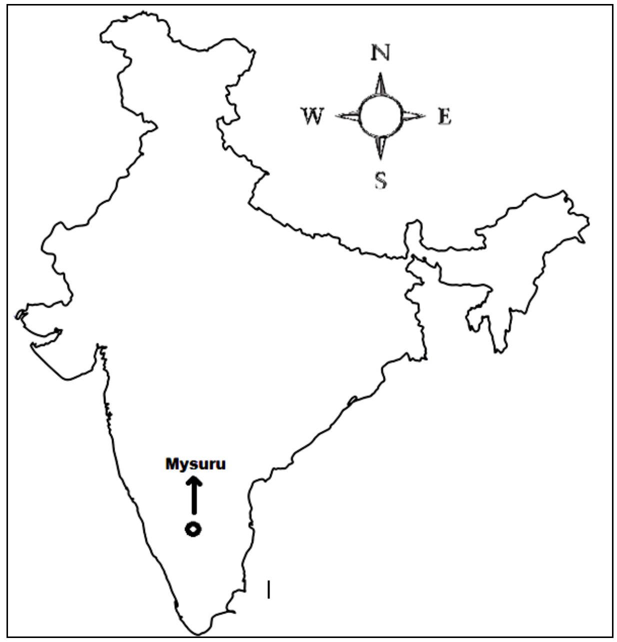

Fig. 1. Geographic identity of Mysuru

Mysuru records about760 mm rain a year, major portion of which is received during monsoon. Winter gets either little rain or no rain. The summer rains are limited to a few days (Ganesh *et al*., 2010).

3. Satellite data for solar extinction due to dust particles (AOT) and Black Carbon (AOT-BC) at 550 nm have been collected from the Giovanni site developed by NASA. Giovanni is a short form for the Goddard Earth Sciences Data and Information Services Center (GES DISC) Interactive Online Visualization and analysis Infrastructure. It is a Web-based application developed by the NASA GES DISC and it is easy to use. There's no need to learn data formats, programming, or to download large amounts of data. We will get customized data analyses and visualizations with ease. Visualization of AOT plot on time scale graph have been generated for the location Mysuru for each year from 2006 to 2015. From the graph average AOT and AOT-BC at 550 nm are being worked out for every month of each year (http://giovanni.gsfc.nasa.gov/giovanni/).

4. Analysis of AOT satellite data at 550 nm for ten years (2006-2015) for the location Mysuru, Karnataka, India has resulted in some useful information regarding the air quality at that location. First of all when we consider the monthly variation of AOT, no

TABLE 1

Monthly average values of AOT at 550 nm for ten years

Average AOT values at 550 nm													
* Non availability of data		Summer			Monsoon						Winter		
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
2006	AOT (a)	0.258	0.350	0.321	0.136	*	0.223	0.365	0.291	0.256	0.291	0.179	0.243
	AOT-BC (b)	0.0156	0.0225	0.0149	0.0087	0.0069	0.0085	0.0109	0.0149	0.0129	*	0.0143	0.0133
	[b/a] × 100	6	6	5	6	*	4	3	5	5	*	8	5
2007	AOT (a)	0.371	0.363	0.319	0.094	0.164	0.240	0.298	0.383	0.172	0.214	0.315	0.394
	AOT-BC (b)	0.0296	0.022	0.0156	0.0094	0.0071	0.0081	0.01	0.0184	0.0143	*	0.0196	0.0194
	[b/a] × 100	8	6	5	10	4	3	3	5	8	*	6	5
2008	AOT (a)	0.192	0.242	0.307	0.135	0.275	0.216	0.299	0.232	0.255	0.239	0.282	0.457
	AOT-BC (b)	0.0145	0.0204	0.0145	0.0073	0.0083	0.0104	0.0106	0.016	0.0174	*	0.0206	0.0207
	[b/a] × 100	8	8	5	5	3	5	4	7	7	*	7	5
2009	AOT (a)	0.392	0.373	0.329	0.098	*	0.355	0.416	0.337	0.216	0.371	0.224	0.368
	AOT-BC (b)	0.025	0.02	0.0172	0.0072	0.0058	0.0102	0.0151	0.018	0.012	*	0.0152	0.023
	[b/a] × 100	6	5	5	7	*	3	4	5	6	*	7	6
2010	AOT (a)	0.382	0.381	0.314	0.092	0.161	0.183	0.115	0.269	0.168	0.235	0.369	0.410
	AOT-BC (b)	0.0283	0.0197	0.017	0.0075	0.0069	0.0075	0.01	0.0152	0.0117	*	0.0195	0.0202
	[b/a] × 100	7	5	5	8	4	4	9	6	7	*	5	5
2011	AOT (a)	0.255	0.403	0.309	0.255	0.235	0.297	0.274	*	0.230	0.319	0.226	0.453
	AOT-BC (b)	0.022	0.018	0.0174	0.007	0.007	0.0078	0.0091	0.024	0.0135	*	0.0145	0.023
	[b/a] × 100	9	4	6	3	3	3	3	*	6	*	6	5
2012	AOT (a)	0.393	0.349	0.455	0.361	0.174	0.143	0.401	0.290	0.320	0.253	0.293	0.358
	AOT-BC (b)	0.0253	0.0176	0.0175	0.0075	0.0073	0.0085	0.011	0.0195	0.0214	*	0.0163	0.0184
	[b/a] × 100	6	5	4	2	4	6	3	7	7	*	6	5
2013	AOT (a)	0.385	0.484	0.468	0.272	0.324	0.193	0.195	0.380	0.370	0.282	0.328	0.347
	AOT-BC (b)	0.023	0.0237	0.0198	0.0066	0.0065	0.0077	0.0106	0.0165	0.0193	*	0.0205	0.0173
	[b/a] × 100	6	5	4	2	2	4	5	4	5	*	6	5
2014	AOT (a)	0.250	0.492	0.388	0.221	0.304	0.208	0.536	0.623	0.326	0.351	0.363	0.438
	AOT-BC (b)	0.0221	0.0303	0.0163	0.01	0.0063	0.0077	0.0115	0.0216	0.0231	*	0.0174	0.0233
	[b/a] × 100	9	6	4	5	2	4	2	3	7	*	5	5
2015	AOT (a)	0.299	0.361	0.359	0.130	0.332	0.174	0.382	0.293	0.204	0.253	0.506	0.338
	AOT-BC (b)	0.023	0.0171	0.0164	0.0085	0.0069	0.0082	0.0146	0.0156	0.0126	*	0.0249	0.0184
	[b/a] × 100	8	5	5	7	2	5	4	5	6	*	5	5

significant changes were observed over ten years. However, the values of AOT showed a small increase in the magnitude from *December to May* except the monsoon months *June to November*. A close observation into the values of AOT shows an increase of 9.1% during summer and 25.9% during winter on an average scale. Same monthly average values are tabulated in Table 1. Since there is no

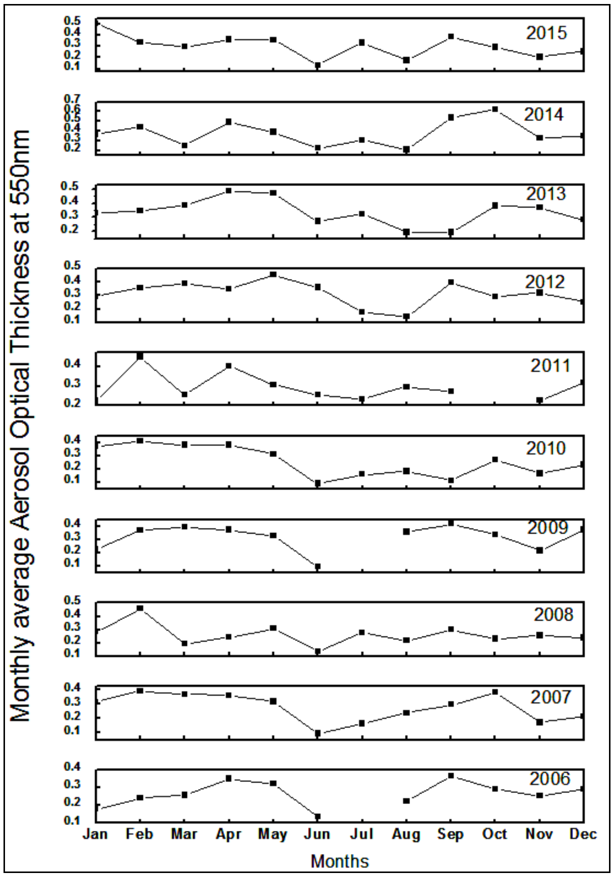

Fig. 2. Monthly average trends of AOT at 550nm over ten years

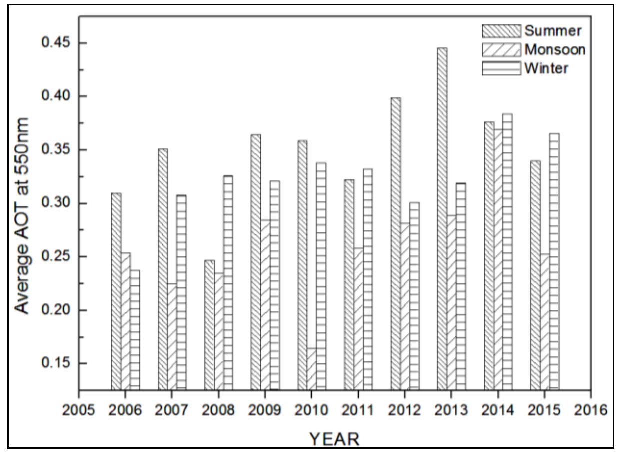

Fig. 3. Seasonal average trends of AOT at 550nm over ten years

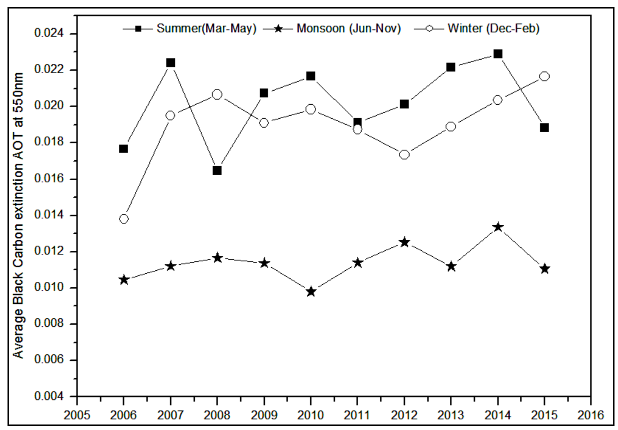

Fig. 4. Average black carbon extinction AOT at 550 nm for ten years

uniformity in the variation of AOT values of monsoon, it is difficult to predict its changes over the years.

Maximum AOT observed during summer has been attributed to increased aerosol input due to increased surface heating and resultant vertical mixing, dry surface conditions and wind-blown dust. Also, during summer high temperature plays an important role in heating and lifting the loose soil with association of wind speed (Niranjan *et al.*, 1995; Pandithurai *et al.*, 1997; Devara *et al.*, 1996 and Ganesh *et al.*, 2008). Low AOT during the months of *June to November* is mainly because of washout of particles due to rain inducing from south–west monsoon as well as north–east monsoon. Small and constant increase as well as decrease in AOT values was observed for the winter season throughout the years of investigation.

An increase in the values of AOT at 550nm over the years (Figs. 2&3) is a consequence of increase in the smaller size particles. As it is known that AOT at 550nm is a measure of small particles present in the atmosphere. Production of small size particles is mainly because of anthropogenic activities. As a supporting fact we have the total vehicles registered in Mysuru during January-2006 as 3,21,000 in number and as per March 2015 it is 8,10,324 (source: www.rto.kar.nic.in). Hence it is clear that by the year 2015, the number of vehicles registered has increased to about 150% when compared to the year 2006.

In addition to this investigation we have also studied the variation of Black Carbon (BC) over ten years. BC is a primary aerosol emitted directly at the source from incomplete combustion processes such as fossil fuel and biomass burning and therefore much atmospheric BC is of anthropogenic origin (IPCC, 2007). Black carbon warms the Earth by absorbing sunlight and heating the atmosphere thereby reducing the albedo. From Fig. 3&4, it is clear that AOT at 550 nm follows the trend of Aerosol extinction due to black carbon at 550 nm. Table 1 gives magnitudes of AOT and AOT-BC at 550 nm with a percentage contribution of AOT-BC towards total solar extinction due to particulate matter. Hence from Table 1 we can have a fair idea of black carbon contribution towards total solar extinction. It is observed from the table that the minimum contribution of AOT-BC starts from 2% to the maximum of 10%. The summer months (Mar-May) show high percentage whereas the monsoon months (Jun-Nov) shows low percentage of AOT-BC.

5. As it is expected, urbanization and increased anthropogenic activities have contributed particulates load into the atmosphere over Mysuru. Since the satellite data through Giovanni web site is available only at 550 nm, a clear picture of AOT at other wavelengths is not available at present to describe the size distribution of particulates in the atmosphere. For most of the years the trend in the variation of AOT is same as that of the trend in AOT-BC at 550 nm. Attempt will be made to collect the AOT data for other wavelength to explain the size distribution of particulates in the atmosphere of Mysuru.

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Disclaimer : The contents and views expressed in this research paper are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

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