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Trends of Aerosol properties over an urban area Varanasi, India using OMI data(2009-2018)

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ABSTRACT

Natural as well as manmade aerosol has a momentous role in affecting regional as well as overall radiation budget. Regarding regional climate, we are discussing here the trends of aerosol parameters (like AOD, angstrom exponent and UV aerosol index) over urban area Varanasi (25.3176°N, 82.9739°E), which is positioned in north-east part of India. AOD shows overall expanding trend of 18.16 % which defines increased amount ofaerosol particles over the year (2009-2018). Here a statistically significant trend of AOD is seen in the long stretches of January and March due to domination of anthropogenic aerosol emission. Angstrom exponent shows an overall diminishing pattern of 3.06% which shows the decreased fineness of aerosol particles. Angstrom exponent shows an increasing trend in the month of March and May while UV index shows an overall expanding trend of 14.94% which shows the excess of absorbing type of aerosol particles during the analyzing time frame.

Keywords;Aerosol optical depth, UV index, angstrom exponent, trend, Varanasi,OMI

1. Introduction

Environmental vaporized altogether influences the atmosphere of earth by aggravating the harmony between approaching radiation and active radiation because of the impact called dispersing and ingestion. Due to presence of atmospheric aerosol which can be characteristic or anthropogenic, rate of scattering and reflection changes abruptly which affects the radiation budget of earth.

Aerosol optical depth (AOD) is how much airborne avoid transmission of light by ingestion and scattering. Value of AOD shows nature of atmosphere i.e. higher value of AOD (>1) shows a hazy condition in the air whereas less value of AOD (<1) shows a perfectly clear sky.

Angstrom exponent is quantitative indicator for fine mode of aerosol particles. Higher values of angstrom exponent (>1) shows presence of finer aerosol particles in the climate whereas lesser values(<1) represents coarser aerosol particles. Since UV index shows absorptive or non-absorptive nature of aerosol particles. Positive values of UV index shows presence of absorptive particles whereas negative or lesser values shows non-absorptive nature of aerosol particles in the climate.

The main purpose of the present work is to find the trends of aerosol parameters like aerosol optical depth(AOD), angstrom exponentand UV aerosol index by linear regression analysis over urban polluted area Varanasi. Although similar type of work has been done over Kanpur, India using aeronet data (Dimitris G Kaskaoutis et al, 2012) but by seeing level of pollution and mode of transportation it is first such type of analysis which is done over Varanasi.

2. Methodology

The aerosol density during winter season due to lesser scattering of light through atmosphere is observed over Varanasi using Ozone Monitoring Instrument (OMI). Since there is nearness of both normal and anthropogenic wellsprings of aerosol particles, trend analysis of $\alpha_{412\text{-}470}$ is done for the examination of finer and coarser aerosol particles in the air.

For all available data series (AOD, angstrom exponent, UV aerosol index) linear regression analysis was applied during the period 2009-2018 using monthly mean based analysis. The rate variety in aerosol properties is determined by using the following formula;

$$x\ \% = \frac{aN}{\bar{X}} \times 100$$

where

$\bar{X}$ = mean value,

a= slope value obtained from the linear regression analysis and

N= no. of days, months or years.

A check is applied on P value for statistically significant variation at confidence level of 95%.

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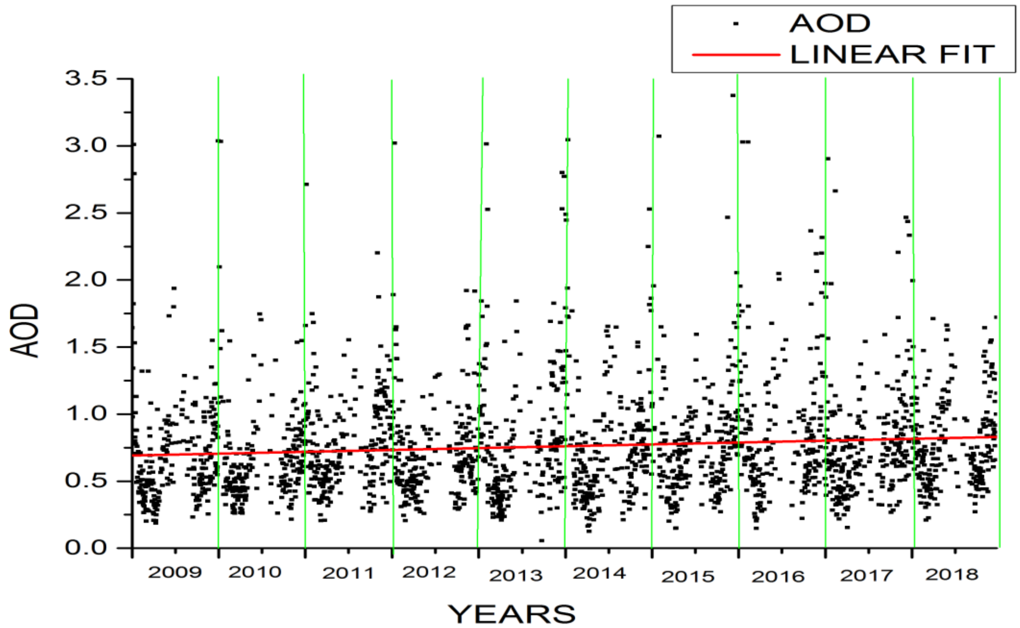

Fig 1. Inter-annual variation and trend of the AOD_{550} daily values over Varanasi for 2009–18

3. Results and discussion

Fig 1 represents an overall variation of AOD_{550} from 2009 to 2018 which clearly shows the value of AOD largely within0.3 and 1 which is indication of highly polluted and dense atmosphere over the years (2009-18). Table 1 shows anannual mean trend of AOD, $\alpha_{412-470}$ and UV aerosol index. AOD and α show overall expanding trend of 18.69% and 14.94% respectively while UV index is showing a diminishing trend of 3.06% annually.

In the table 2 monthly trends of aerosol data is shown with P value which shows the confidence value of linear regression analysis. AOD_{550} shows statistically significant increase of 2.88% and 1.98% in the

Table 1. Trend values and % variation of aerosol parameters over Varanasiduring the analyzing time frame(2009–18) using the yearly mean.

Yearly mean trends		
	Trend/year	**%**
AOD	0.0000379477	18.1659
$\alpha_{412-470}$	-0.0000114316	-3.06409
UV index	0.0000577217	14.94097

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Table 2. Statistical parameters for the regression analysis in the monthly time series of the examined aerosol parameters. The statistically significant trends at the confidence level of 95% are presented in bold. (N: number of available days for each month)

	Trend/day (%)	P	N		Trend/day (%)	P	N
	January				**February**		
AOD	**0.000099(2.88)**	**0.014**	213	AOD	0.00066(26.06)	0.139	239
$\alpha_{412\text{-}470}$	-0.00044(-8.11)	-0.24	247	$\alpha_{412\text{-}470}$	-0.00045(-8.31)	-0.104	246
UV index	0.000637293(17.93)	0.12772	171	UV index	0.000810333(23)	0.18314	150
	March				**April**		
AOD	**0.000032(1.98)**	**0.015**	296	AOD	0.00068(40.71)	0.273	241
$\alpha_{412\text{-}470}$	**0.000052(1.39)**	**0.0075**	267	$\alpha_{412\text{-}470}$	0.00042(14.79)	0.058	257
UV index	0.00049(12.19)	0.098	190	UV index	0.0016(27.6)	0.214	226
	May				**June**		
AOD	0.00032(13.79)	0.124	188	AOD	0.00061(17.93)	0.14	115
$\alpha_{412\text{-}470}$	**0.000028(0.89)**	**0.0038**	273	$\alpha_{412\text{-}470}$	0.00063(16.77)	0.085	143
UV index	0.00077(10.89)	0.092	243	UV index	-0.0021(-38.98)	-0.2142	174
	July				**August**		
AOD	-0.00066(-22.32)	-0.157	57	AOD	-0.0002(-7.74)	-0.058	66
$\alpha_{412\text{-}470}$	-.0024(-58.95)	-0.391	15	$\alpha_{412\text{-}470}$	-0.00088(-17.6)	-0.304	26
UV index	-0.00055(-21.6)	-0.179	78	UV index	0.00039(15.83)	0.138	64
	September				**October**		
AOD	0.00033(15.77)	0.12	145	AOD	**-0.000017(-0.84)**	**-0.006**	255
$\alpha_{412\text{-}470}$	-0.00024(-4.72)	-0.072	103	$\alpha_{412\text{-}470}$	-0.00176(-37.83)	-0.37	239
UV index	0.00035(13.49)	0.103	95	UV index	0.0012(34.55)	0.255	166
	Nov				**December**		
AOD	0.00047(16.21)	0.113	284	AOD	0.0011(33.67)	0.208	261
$\alpha_{412\text{-}470}$	-0.00081(-15.34)	-0.185	250	$\alpha_{412\text{-}470}$	-0.00046(-8.76)	-0.157	282
UV index	0.0019(37.97)	0.192	212	UV index	0.0012(29.35)	0.255	212

months of January and March while it shows diminishing trend of 0.84% in the span of October. Significant rising trend in α value of 1.39% and 0.89% are seen in the span of March and May. UV aerosol index shows its highest diminishing trend of 38.98% in the part of June due to monsoon season because clouds which give negative or small value of UV index while it shows an increasing trend of37.97% in the month of November (winter season) due to hazy conditions of atmosphere.

4. Conclusions

Linear regression analysis and statistical significance tests are used for examination of robustness of the trends in the daily and monthly aerosol mean data. Significant variation and trends in AOD, angstrom exponent and UV aerosol index are observed depending on the month and year. The AOD_{550} increased significantly in the span of January and march and decreased in the month of October and it shows maximum increasing trend in the part of April due wind transported dust in the environment. Similarly angstrom exponent increased in the span of March and May due to dust accumulated in the environment from March to July in the Varanasi region.Rising trend of UV index from August to December is indication of nearness of engrossing aerosol like dust, soot due to larger vehicular and industrial activities in the surrounding area of Varanasi.

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