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Study of Variation in Physical and Optical Properties of Aerosol over an urban area Varanasi

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ABSTRACT

Earth's energy budget is largely influenced by attenuation of solar radiation when it passes through earth's atmosphere and depends on how much extent atmosphere is clear due to presence of aerosol which causes scattering and absorption of incoming radiation. In this paper, annual, seasonal and monthly variation in physical and optical properties of aerosol like Aerosol Optical Depth, Angstrom Exponent and UV Aerosol Index, is analysedby using data derived from the Ozone Monitoring Instrument (OMI) aboard NASA's satellite. Here we have focused over an urban area of Varanasi (25.3176°N, 82.9739°E), Uttar Pradesh, India which is a major holy place and has importance for tourism purpose. The analysis is done on long term basis for the 2009 to 2018.Annual variation of AOD shows its maximum value of 0.924 in 2016 and minimum of 0.7 in 2010, Angstrom exponent have maximum value of 1.55 in 2013 and minimum of 1.2 in 2017 and UV Index have maximum of 1.45 in 2018 and minimum of 1.15 in 2013..Seasonal variation of AOD and angstrom exponent shows its maximum value in winter of 0.97 and 1.64 respectively due to hazy conditions and minimum value in pre-monsoon of 0.69 and 1.04 respectively. UV Index shows its maximum value of 1.71 in pre monsoon due to absence of non-absorbing medium like clouds and minimum value of 0.76 in monsoon. Monthly variation of AOD and Angstrom exponent shows its maximum value in January of 1.07 and 1.7 respectively and minimum value of 0.5 in March and 0.86 in April. UV Index shows its maximum value of 2.19 in May and minimum of 0.77 in August. During summer, wind transport causes the increasing pattern of AOD and angstrom exponent.

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

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1. INTRODUCTION

All particles in state of liquid and solid suspended in air comes under category of aerosol. Aerosol particles not only affect health of living organisms but it also affect the earh's budget by trapping solar radiation due to effect of scattering and absorption.

Since attenuation of radiation depends on denseness, fineness, and size of particles present in the atmosphere in the form of aerosol, hence physical and optical properties like Aerosol optical depth, angstrom exponent and UV aerosol index are having a significance in analysis of aerosol variation.

Aerosol optical depth is the degree which shows the extinction of solar radiation due to effect of absorption and scattering. AOD is a dimensionless number which shows column integrated aerosol presence. The angstrom exponent presents the fineness of aerosol particles in the atmosphere. More the value angstrom exponent more finer will be particles present in the atmosphere UV index shows the presence of absorptive or non-absorptive type of aerosol. Positive or more values of UV index shows absorptive nature and negative or less values shows non absorptive nature of aerosol.

In this study, atmospheric aerosol optical properties are analysed for the city Varanasi which is located at an elevation of 80.71 metres in the eastern part of the state of Uttar Pradesh, India.

2. METHODOLOGY

Daily data of aerosol parameters (like aerosol optical depth, angstrom exponent and UV aerosol index) are taken in the form of 1°×1° grid by OMI (Ozone measuring instrument) over Varanasi (25.3176°N,82.9739°E). All parameters have time series area averaged aerosol data.OMR is NADIR viewing spectrometer which measures solar reflected and backscattered light in UV visible range.

3. DATA COLLECTION

The mean observed data obtained from Ozone measuring instrument over an urban area Varanasi is analysed in the form of monthly mean data and its standard deviation. All collected area averaged data is shown with the help of graphical representation which further shows the variation of aerosol parameters.

Table 1 provides the required data which is used to examine aerosol properties on the monthly basis which is further used for graphical analysis.

Table 1. Monthly mean data using ozone measuring instrumentof all parameters

Month	AOD (Mean ± std dev)	Angstrom exponent (Mean ± std dev)	UV Index (Mean ± std dev)
Jan	1.07102 ±0.5799	1.70902±0.17292	1.10164±0.47001
Feb	0.71432±0.42813	1.53355±0.36271	0.99333±0.36545
March	0.50343±0.19336	1.17313±0.6224	1.25221±0.47029
April	0.50179±0.21945	0.86565±0.63089	1.82593±0.69166
May	0.72113±0.22838	0.9863±0.6505	2.19922±0.73645
June	1.02441±0.38508	1.1342±0.66138	1.65454±0.80697
July	0.92061±0.35151	1.2778±0.53203	0.79115±0.26387
August	0.80124±0.30205	1.55727±0.29361	0.77031±0.2461
Sep	0.6288±0.24803	1.53031±0.28516	0.78811±0.28745
Oct	0.6345±0.23227	1.44195±0.42181	1.14831±0.46293
Nov	0.88247±0.372	1.59428±0.33273	1.51679±0.70536
Dec	1.01255±0.49523	1.65402±0.26964	1.3517±0.75643

4. RESULTS AND DISCUSSION

4.1 Variation of aerosol parameters

In the whole period of analysis (From 2009 to 2018) different parameters including AOD, angstrom exponent and UV index are analysed.

4.1.1 Annual variation of AOD and angstrom exponent

The pattern of variation of AOD and angstrom exponent is similar from 2009 to 2013 and from 2016 to 2018. Angstrom exponent shows a decreasing pattern from 2013 to 2017 and AOD shows almost constant pattern from 2013 to 2015. This graph shows the clear dependency of AOD on angstrom exponent. Approximately similar variation of AOD in the year of 2011,2012 and 2013 shows due to slight change in anthropogenic aerosol.

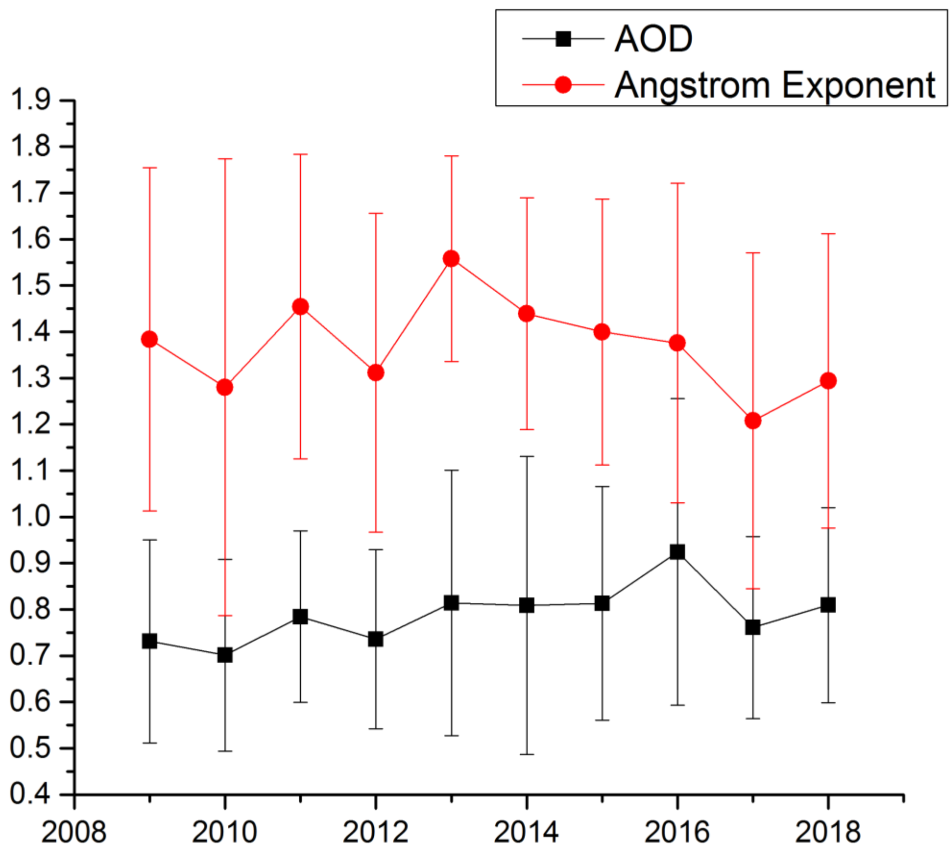

Fig 1. Combined annual variation of AOD and $\alpha_{412\text{-}470}$

4.1.2 Monthly variation of AOD and angstrom exponent

Monthly variation of AOD and angstrom exponent similar pattern from January to April, April to June and August to December. AOD shows a decreasing pattern from June to August due to decrease in temperature in the study area which causes less convection of aerosols present near the earth. Angstrom exponent shows an increasing pattern from June to Augustdue to increase in finer aerosol particles in the atmosphere.

Increasing pattern in AOD and angstrom exponent from October to December caused due to hazy and dense conditions of aerosol parameter.

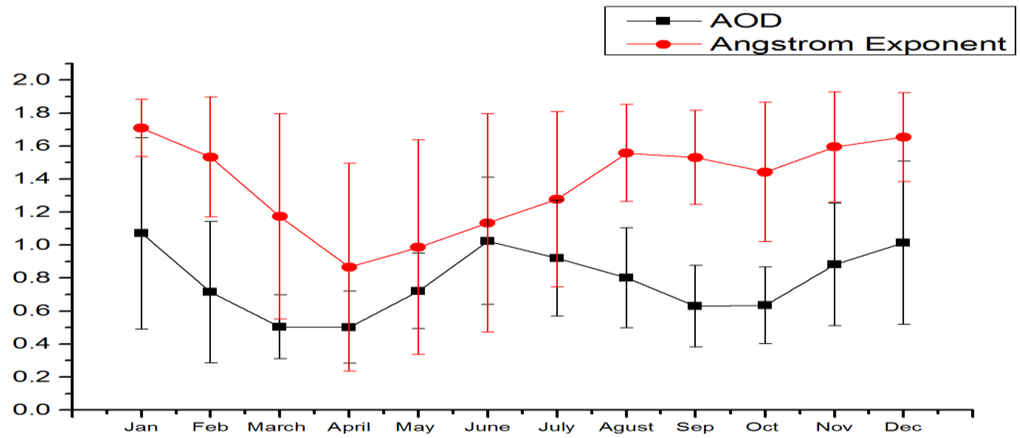

Fig 2. Combined monthly variation of AOD and $\alpha_{412\text{-}470}$

4.1.3 Seasonal variation of AOD and angstrom exponent

Seasonal variation of AOD and angstrom exponent shows similar trend in all seasons. There is a decreasing pattern from Winter to Pre- Monsoon season and it is showing increasing pattern from Pre-Monsoon to Post –Monsoon season. Both parameters are showing maximum mean value in winter season due to hazy conditions.

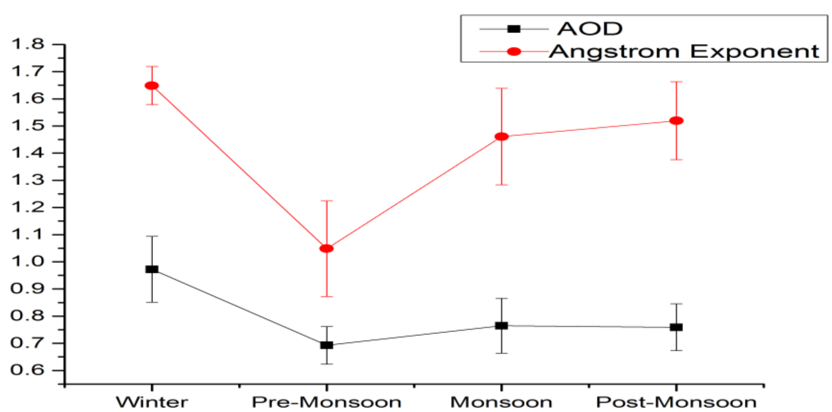

Fig 3. Combined seasonal variation of AOD and $\alpha_{412\text{-}470}$

4.1.4 Variation of UV aerosol index

Annual variation shows its maximum value in 2018 and minimum value in 2013. It shows peak value in the month of May and minimum value in August. Monthly variation shows almost constant pattern from July to September. Seasonal variation shows its peak in Pre-Monsoon season and lowest value in Monsoon season.Peak of UV index is caused due to presence of absorbing aerosol.

5. CONCLUSIONS

Aerosol optical properties in the city of Varanasi which is located at an elevation of 80.71 metres including AOD, angstrom exponent and UV aerosol index are studied using data obtained by OMI.

The annual variation of AOD is between 0.70 and 0.92 for wavelength 550 nm. The maximum mean and standard deviation of AOD is 0.92436± 0.33122 in 2016 whereas angstrom exponent have its maximum value of 1.55815± 0.22194 in 2013 and UV index have its maximum mean value of 1.45987± 0.60298 in 2018.

In the analysis of monthly variation AOD have its maximum value of 1.07102± 0.5799 in January. Angstrom exponent varies from 0.86565± 0.63089 to 1.70902± 0.17292 having maximum value in January and minimum in April. UV Index have its maximum value of 2.19922± 0.73645 in May and minimum value of 0.77031± 0.2461 in August.

Seasonal variation shows that AOD have its maximum value of 0.9724± 0.12146 in winter due to very less dispersion because of hazy atmosphere. Angstrom exponent is having maximum value of 1.64865± 0.07057 in winter. An exponential dependence of α on AOD in winter and Pre-Monsoon indicates that the dust aerosols are major contributors of atmospheric turbidity in Varanasi.

In seasonal variation analysis, UV aerosol index have its maximum value of 1.71764± 0.2173 in Pre-Monsoon season due to presence of absorbing aerosol and it has minimum value of 0.76351± 0.05879 in Monsoon season due presence of non-absorbing aerosol like clouds.

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