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TEMPORAL VARIABILITY OF AEROSOLS PARAMETERS OVER A RURAL AERONET OBSERVING SITE AT GANDHI COLLEGE

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Abstract

A compressive measurement of aerosol optical depth (AOD), a particulate matter (PM) and black carbon mass concentration have been carried out over Gandhi College. The measured aerosol data was incorporated in an aerosol optical model to estimate various aerosol optical parameters which were subsequently used for radiative forcing estimation. The impact of aerosol on the global climate system is considered as a medium to low. The effect of atmospheric aerosol particle depends on the spatial and vertical distribution of aerosol. This paper aims on a metropolitan AERONET observing site at Gandhi College in India. The data analysis gives output the existence of large seasonal heterogeneity in the frequency distribution of aod_{500} mm, aod_{1020} mm and corresponding retrieved $ae_{440\text{-}870}$ mm during different season at Gandhi College.

Keyword: *AEROSOL OPTICAL DEPTH (AOD), ANGSTROM EXPONENT (AE), PRECIPITABLE WATER VAPOUR (PWV).*

I. INTRODUCTION

The atmosphere consists of tiny colloidal particles of different chemical composition, dispersed/embedded in a gas, smoke or fog, termed as aerosols [1]. These particles linger in the atmosphere for a long period of time and their lifetime is found to vary considerably depending on their size and composition. The coarse-mode volcanic dust particles injected into the atmosphere during large volcanic eruptions have a short lifetime of about 1–2 months due to their fast removal by gravitational settling [2]. On the other hand, tropospheric sulfate aerosols, mostly in the accumulation-mode size regime have a lifetime of 5–7 days [3]. The worldwide investigations of aerosol optical, microphysical, radiative and compositional properties have established that the aerosols disperse widely both on horizontal and vertical scales by means of circulation patterns in the atmosphere [4]. Aerosols perturb the Earth-atmosphere climate system at a local, regional and global scale through direct and indirect processes. The characterization of aerosols is further complex due to their large spatio-temporal uncertainty, heterogeneity in the nature of particles suspended in the atmosphere and the associated lifetime [5,6,7]. Aerosol mixtures composed of dust, sulfate, black carbon (BC), sea-salt particulates produce a potential challenge to satellite and sub-orbital remote sensing techniques. Hence, aerosols are at the focus of growing interest due to their impact on the air quality, human health and Earth-atmosphere climate system [8].

Investigations reveal that the mixtures of combustion aerosols and desert dust comprise of BC and iron oxides as the most important absorbing particulate species in fine- and coarse-mode dust particles respectively [9]. The iron oxides present in desert dust produce the significantly strong absorption in the ultraviolet and visible spectral regions [10]. The long-term AERosolROboticNETwork (AERONET) data sets have been used in various global studies to delineate spatio-temporal aerosol characteristics, their type discrimination, etc [11]. In the present study, the multiyear AERONET data on the direct Sun measurement and almucantar scan retrievals at Gandhi College have been analysed to investigate heterogeneity in aerosol optical and microphysical properties. For this, monthly/annual cycle of aerosol optical depth ($AOD_{500\ nm}$, $AOD_{1020\ nm}$), Ångström exponent ($AE_{440–870\ nm}$) and precipitable water vapour (PWV).

II. OBSERVATIONAL SITES AND METEOROLOGY

The present study is focused on a rural AERONET observing site at Gandhi College, Ballia in Uttar Pradesh of India. Gandhi College AERONET site (a rural observing station), situated towards east of Kanpur at a distance of 466 km in the Indo-Gangetic Basin (IGB) region, is located in the Ballia district of Utter Pradesh. It has moderate climate and is highly fertile due to deposition of alluvial soil due to frequent flooding of Ganga and Ghaghara rivers. The land use pattern varies seasonally and the predominant use of bio - fuels and biomass burning contribute to the aerosol loading in addition to natural aerosol sources. At Gandhi College, lower temperature (22.7 ± 2.4°C) and wind speed (2.1±1.0 ms^{-1}) occur during winter and the weather is dry due to low RH (43±12%) as compared to post-monsoon (RH = 73±14%) season. Further, RH at Gandhi College is highest (92±8%) as the location receives maximum rainfall (1023±255 mm) during monsoon. Temperature during pre-monsoon season is found to be higher as compared to the rest of the seasons.

The long-term data series considered for analysis at Gandhi College (2006–2014) comprising804 observing day respectively. In a day, at each observing there are about 30 observations per day since the time resolution of Sun-sky CIMEL spectral radiometer (manufactured by CIMEL Electronique) is 15 minutes. Thus, at Pune and Gandhi College AERONET observing site, there are 24000 observations grouped into months/seasons.

III. RESULTS AND DISCUSSION

➢ Monthly variability of AOD, $AE_{440–870\ nm}$ and PWV

The monthly variability of AOD, AE440–870 nm and PWV displayed in Figs.1 at Gandhi College respectively exhibit systematic monthly variations. The AOD monthly variability at Gandhi College (Fig. 1) is altogether different both in AOD magnitude and the occurrence of crests and troughs in AOD. It is seen that $AOD_{550\ nm}$ is maximum (0.99±0.46) in January and minimum (0.40±0.33) in July while for $AOD_{1020\ nm}$, peak value (0.52±0.22) is found in June and minimum (0.20±0.20) in July. In general, AODs at Gandhi College are found to be almost two times higher as compared to those observed at Jaipur indicating higher aerosol loading at Gandhi College for the period of observation. This is quite consistent with several earlier ground- and satellite-based AOD studies over IGB region which indicate persistent heavy aerosol loading [12,13].

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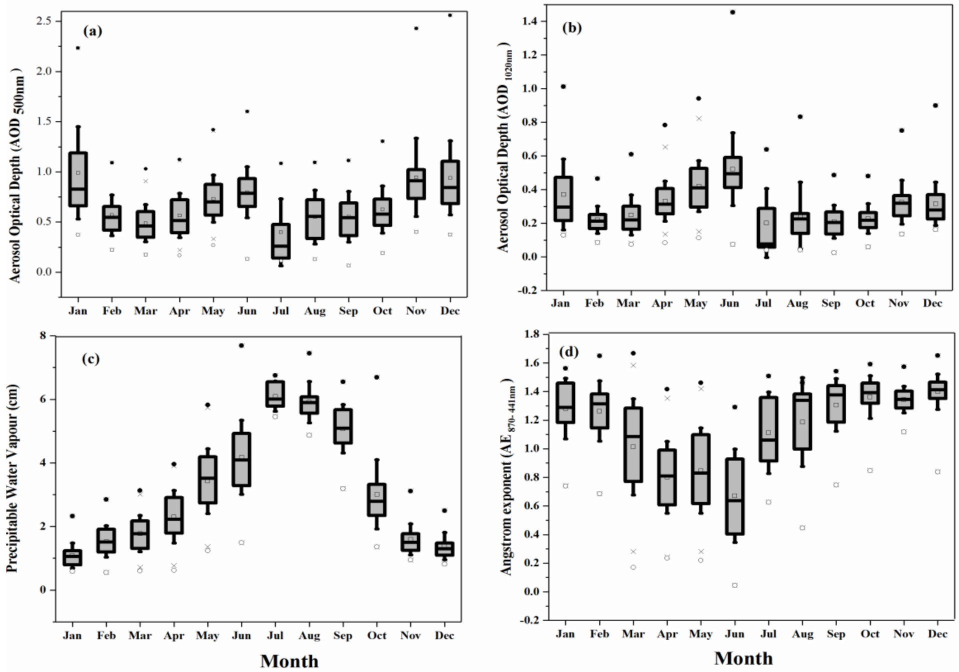

Month	Number of days
JAN	24
FEB	62
Mar	119
APR	137
MAY	163
JUNE	81
JULY	13
AUG	12
SEP	41
OCT	56
NOV	42
DEC	54

Fig. 1: Monthly box-whisker plots of daily mean aerosol optical depth ($AOD_{500\ nm}$, $AOD_{1020\ nm}$), precipitable water vapour (PWV) and Ångström exponent ($AE_{440–870\ nm}$) at Gandhi College (2006 – 2014).

AE monthly variability reveals that at Gandhi College, AE is consistently greater than 1 during winter and post-monsoon seasons (around 1.3–1.4) while it is in range 0.7–1.3 during pre-monsoon and monsoon seasons. This suggests dominance of fine-mode aerosols during winter and post-monsoon and mixed type of aerosols (i.e. a mixture of both fine- and coarse-mode) during pre-monsoon and monsoon seasons. Existence of strong seasonal variability in PWV also prevails at Gandhi College. However, PWV values during monsoon season are found to be greater than 5 cm reaching up to 6.1 cm. Concurrently, AOD values (especially $AOD_{500\ nm}$) lie in the range 0.4 (July) – 0.8 (June) while for August and September $AOD_{500\ nm}$ are around 0.6 each. This correlation between $AOD_{500\ nm}$ and PWV points towards the influence of ambient water vapour/RH on aerosols causing growth fine- as well as coarse-mode aerosols [14,15].

- **Frequency distribution of AOD, $AE_{440–870\ nm}$, and PWV**

As shown in Figs.2 at Gandhi College, the AOD frequency distributions display pronounced variability under different atmospheric conditions. At Gandhi College (Fig.2), similarly, the shapes of $AOD_{500\ nm}$, $AOD_{1020\ nm}$ and AE frequency distributions are found to be different during different seasons with varied ranges of maximum frequency of occurrence for all the three parameters. The spreads in $AOD_{500\ nm}$ frequency distribution during winter, pre-monsoon, post-monsoon and monsoon seasons respectively are: 0.3–1.5, 0.3–1.3, 0.3–1.1 and 0.1–1.3 while corresponding spreads in AE are: 0.95–1.65, 0.25–1.45, 1.15–1.55 and 0.25–1.45. The PWV frequency distributions cover wide range of PWV values during pre-monsoon (0.75–5.25 cm), monsoon (2.25–6.75 cm) and post-monsoon (1.25–5.25 cm) seasons as compared to that for winter season, for which it is narrower (0.75–2.25 cm).

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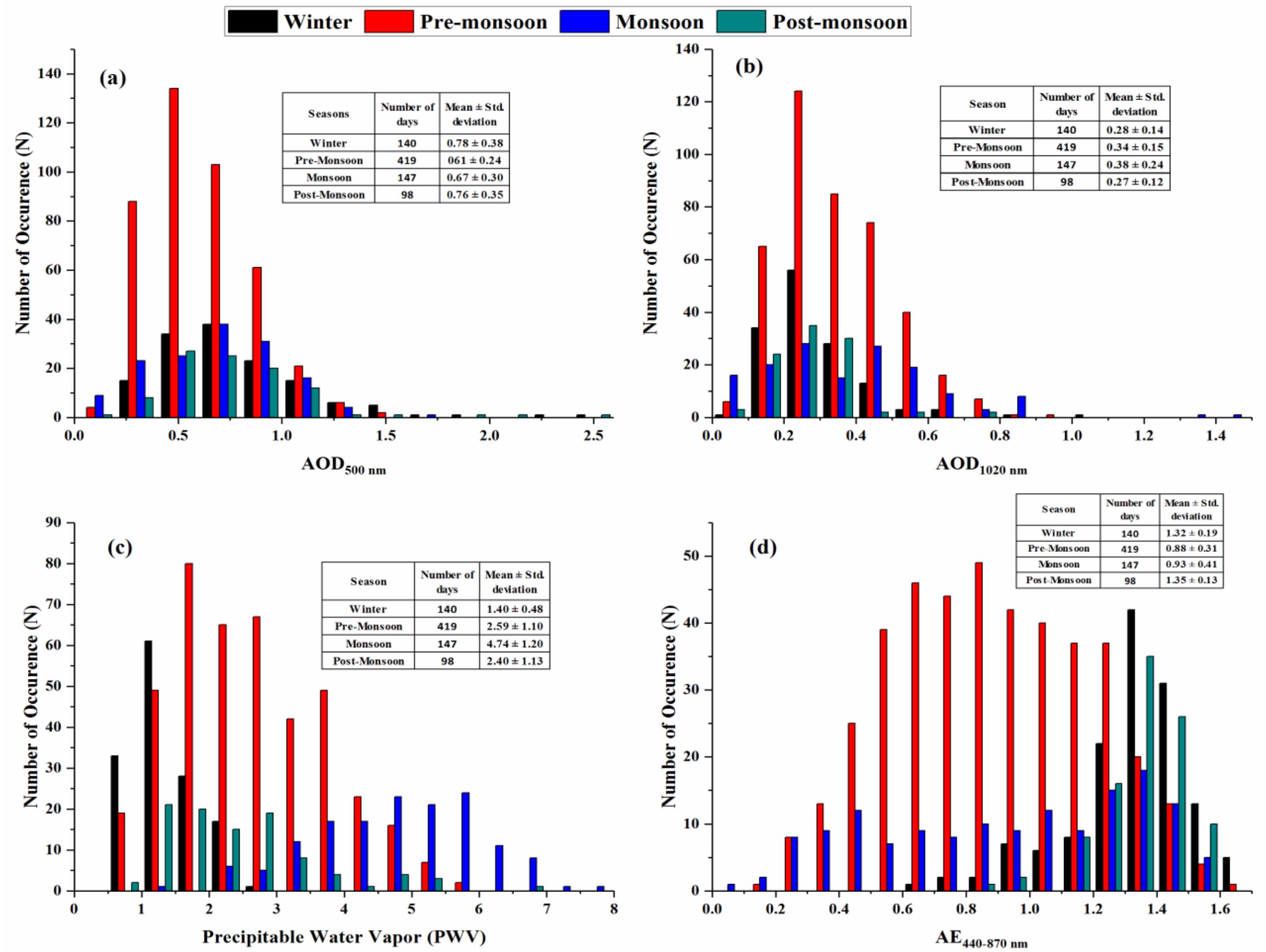

Fig. 2: *Seasonal frequency distribution of daily average aerosol optical depth ($AOD_{500\ nm}$, $AOD_{1020\ nm}$), precipitable water vapour (PWV) and Ångström exponent ($AE_{440–870\ nm}$)at Gandhi College for the period 2006 – 2014.*

The observed large fluctuations in both AOD and AE at Gandhi College, especially the occurrence range and distinct modal values of the distributions during different seasons, once again substantiate the inherent heterogeneity present in these variations. This is indicative of the advection of different aerosol types from a variety of aerosol production sources influenced by the strong changes in anthropogenic activities as well as the perturbations induced by the existing climatic conditions.

IV. CONCLUSION

Analysis of data brings out the existence of large seasonal heterogeneity in the frequency distributions of $AOD_{500\ nm}$, $AOD_{1020\ nm}$ and corresponding retrieved $AE_{440–870\ nm}$ during different seasons at Gandhi College, especially the highest occurrence frequency range and distinct modal values of the distributions. These are indicative of advection of different aerosol types (viz., dust, biomass burning, sea salt, and mixtures thereof) from a variety of production mechanisms influenced by the strong seasonal changes of anthropogenic activities as well as modulations induced by the climatic conditions.

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