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Variations of Aerosol Optical Depth in Bhaktapur, Nepal

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Abstract: The study is based on the variations of aerosol optical depth in Bhaktapur, Nepal. Microtops II Sunphotometer, manufactured by solar light inc. USA was used to measure the Aerosol optical depth. The diurnal variations of Aerosol Optical Depth (AOD) in January, 9 at 2.32UT were found to be 1.01, 0.89, 0.81 and 0.61 at 340,440, 500 and 675nm respectively. Besides ozone and clouds, aerosol plays an influencing role to attenuate solar UV radiation reaching the ground. Spectral dependence of AOD possesses higher values at shorter wavelengths and gradually decreases towards longer wavelengths in all seasons. The value of wavelength exponent (α) and aerosols concentration (β) on June 15 and July 25 at Kaushaltar were found to be 0.80, 0.56 and 0.45, 0.57 respectively.

Key words: Sunphotometer, aerosol optical depth, clouds, pollutants, atmosphere

1. Introduction

Tiny solid and liquid particles suspended in the atmosphere are called aerosols. Aerosols can play an effective role to alter the earth's energy balance and hence the climate. Aerosols influence the solar radiation both directly and indirectly through their various sizes and thus their different optical and physical properties. When aerosols are sufficiently large in size, they scatter and absorb sun light; and when these particles are small, they act as cloud condensation nuclei and aid in the formation of clouds [14]. Although the dynamics modifies the aerosol size spectrum during their residence time, the particle pollution highly depends on the strength of their source and sinks mechanisms. As a consequence, concentrations of ambient aerosol differ to a great extent between urban centers and remote areas, and between industrialized and rural regions [13]. On a global scale, the natural sources of aerosols are more important than the anthropogenic aerosols, but regionally anthropogenic aerosols are more important [9].

The aerosols present in the atmosphere can cause adverse effects like headache, eye irritation, dyspnoea, vomiting, skin problems and respiratory problems. Bhaktapur is a major touristic destination area of Nepal. Continuous monitoring of AOD was lacking except for some case studies [2, 6]. However monitoring of AOD is preferred regularly in Bhaktapur (Kausaltar) from April 2008 to March 2010. This study also confirms that the diurnal pattern of AOD is changing drastically. Studies on Aerosols indicate that the magnitude of Aerosol can reduce the solar flux at surface significantly [10]. Moreover the concentration of aerosols is highly variable depending on the number of particles and their physical and chemical properties.

The objective of this paper is to simultaneously retrieve the diurnal and monthly characteristics of aerosol optical depth at Kausaltar for the year 2009. It is well understood that aerosols are not well mixed in the atmosphere hence aerosol particles properties such as the aerosol optical depth (AOD), the Angstrom exponent (alpha) and others would depend on location scenarios that govern emission, transport, atmospheric transformation and removal of aerosol particles. Being a short life time of aerosol particles, their properties vary with time and from one region to another [8]. Thus to monitor aerosol optical depth in Kausaltar is an important part of the study**.**

2. Methodology

Kausaltar (27º40'N, 85º22' E) lies in the eastern region of Kathmandu at an elevation of 1314m from the sea level. The instrument used to monitor Aerosol Optical Depth (AOD) is Microtops II sun photometer, manufactured by solar light Inc, USA. It works on the method of differential optical absorption and scattering. It is a portable multiband instrument, comprising of five different collimators working in ultraviolet (340 nm), visible (440, 500, 675nm) and infrared (870 nm) wavelengths. The bandwidth for channel 340 nm is 2nm and for the rest of the channels are about 10 nm. The sun photometer consists of an interference filter, photodiode and necessary electronic devices. The field of view of the input optics is about 2.5°. During measurement the window of the instrument is directed towards the sun and it measures direct solar irradiance. Data were recorded from sunrise to sunset throughout the day at an interval of about half an hour under clear sky. Due to atmospheric condition, data of different months were missed. The data were monitored in UT which is 5:45 hours behind the local time.

2.1 Angstrom Coefficient

The wavelength dependence of the aerosol optical depth using the Angstrom's power law approximation [1] is $\tau(\lambda) = \beta \lambda^{-\alpha}$ (1)

where $\tau(\lambda)$ is the AOD at wavelength $\lambda(\mu m)$ and α, β are the Angstrom coefficients. The wavelength exponent α depends on the size distribution parameter of aerosols, and β is directly proportional to the columnar aerosol content and is equal to the AOD measured at 1µm [11, 12]. The Angstrom coefficients α, β were derived using power law approximation on the spectral optical depth in the wavelength range 340-675 nm.

3. Results and Discussion

In Nepal, monsoon begins from the mid of April and may stay up to the end of August. After the monsoon the pollution and dust particles settle down in the ground and it gradually enters the lower atmosphere before the monsoon starts again. The topography of Kathmandu valley has a significant role on trapping the pollutants. The reports show that the wind in the valley is westerly and south westerly. The pollutants drift towards the eastern and north eastern part and flushes out of the valley by strong wind current in the late afternoon [16].

3.1 Diurnal Variation of Aerosol Optical Depth

The spectral variation of Aerosol Optical Depth (AOD) on January 9 is shown in Fig. 1. The values of AOD were found to be 1.01, 0.89, 0.81 and 0.61 at wavelength 340,440,500 and 675 nm respectively at 2.32 UT. Spectral dependence of AOD with wavelength on July 25 is shown in figure 2. It indicates that there is relatively strong dependence of aerosol optical depth at shorter wavelengths that gradually decrease towards longer wavelength irrespective of the seasonal change, attributing to the presence of fine to coarse particles [15]. The AOD values in the morning is high than afternoon at Kaushaltar. The range of AOD in January, 2006 at 500 nm in Dehradun is 0.24-0.34 [15].

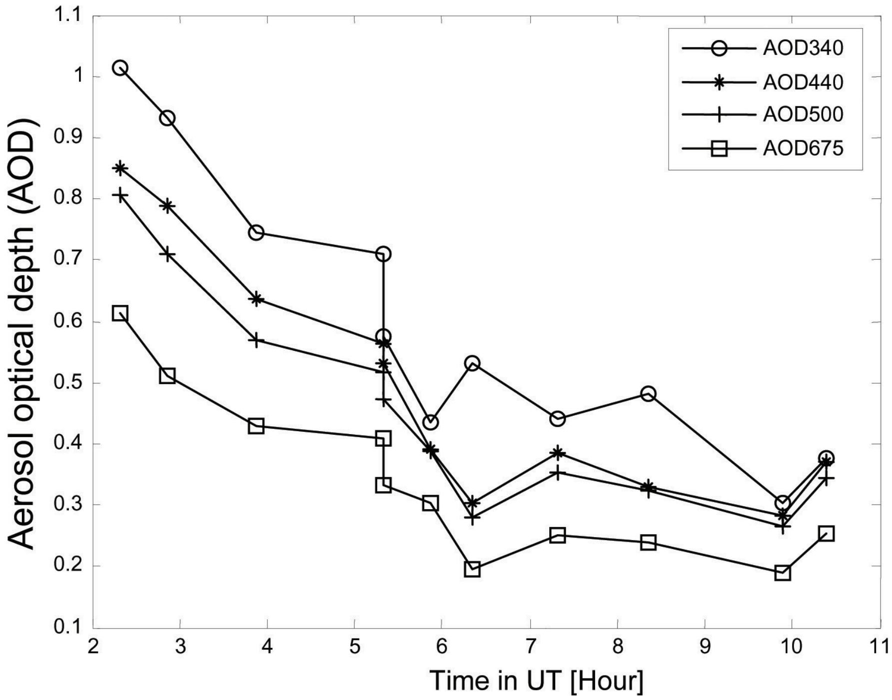

Fig. 1: Spectral dependence of aerosol optical depth in January 9

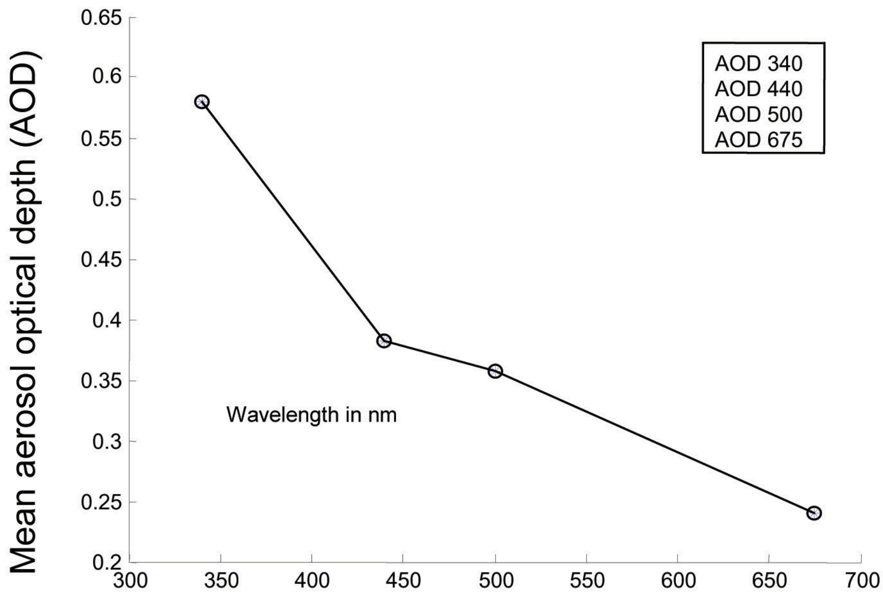

Fig. 2: Variation of aerosol optical depth with wavelength on July 25

3.2 Variation of Angstrom parameters α and β

The Angstrom parameters α and β gives the instantaneous value of the turbidity of the atmosphere [4]. In spite of the poor correlation between the AOD and α parameter [5, 7] values, both quantities must be considered for a realistic analysis. The studies by [3] showed that α value depends strongly on the spectral range. In the present study Angstrom parameters were studied in the spectral range of 340-675 nm. Table 1 presents the variations of wavelength exponent (α) and Aerosols concentration (β). Minimum values of α indicate the presence of coarse-mode aerosol particles whereas its higher values indicate the reduction in concentration of coarse-mode particle as presented in figure 3. This result is similar to the results obtained by [11, 12]. The high value of α is found to be 0.25 and 0.59 during the month of May and March 2005 while the value of β increases from March to June 2005 in Rajkot, India. Value of wavelength exponent (α) and aerosols concentration (β) on June 15, at Kausaltar is 0.80 and 0.45 respectively. It indicates the high accumulation of aerosols particles in Kausaltar.

Table 1: Wavelength exponent (α) and turbidity coefficient (β)

Date	Time [UT]	Wavelength exponent (α)	Aerosols concentration (β)
June 15	06:23:31	0.80	0.45
July 25	06:08:26	0.56	0.57
August 21	07:27:54	0.46	0.67

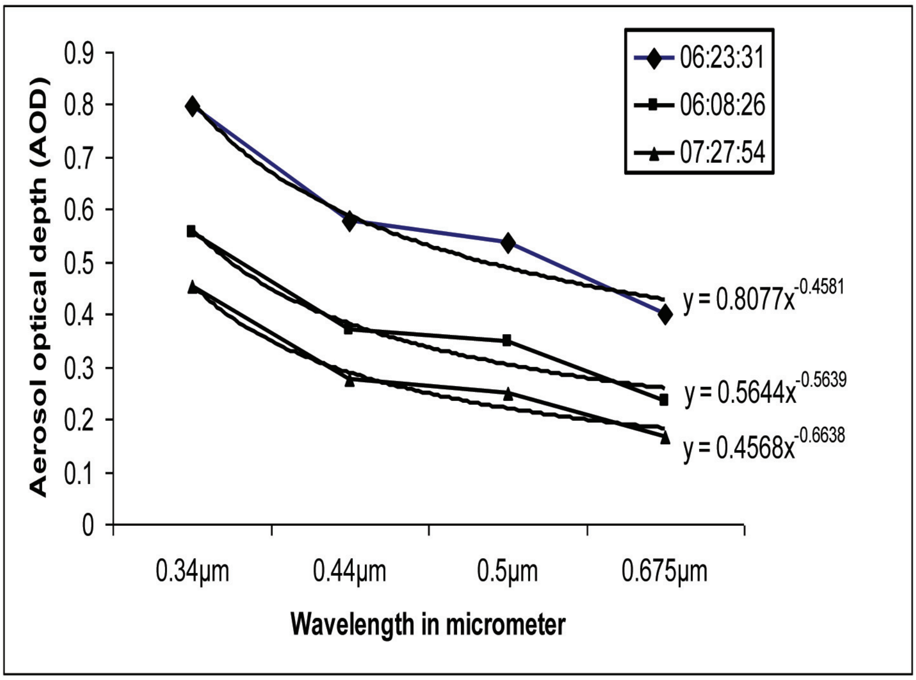

Fig. 3: Variations of aerosol optical depth in June 15, July 25 and August 21, 2009 at Kausaltar

3.3. Monthly variations of AOD

The monthly variation of mean aerosol optical depth (AOD) is shown in figure 4. The high and low values of AOD were found to be 1.12 and 0.38 in April and August respectively. The maximum value of AOD in April at 500 nm in Bangalore is 0.5 [17]. Increasing aerosol input in April causes to increase aerosol optical depth. It is also due to dry surface conditions and wind blown dust. The cloud contamination may be one of the important reasons for higher AOD. Low AOD in August is attributed to the removal of aerosols because of monsoon rains and lowering the ground surface aerosol input which is similar to low AOD value in January at Rajkot [11, 12]. Limited observations could be made in January and February because of cloudy days.

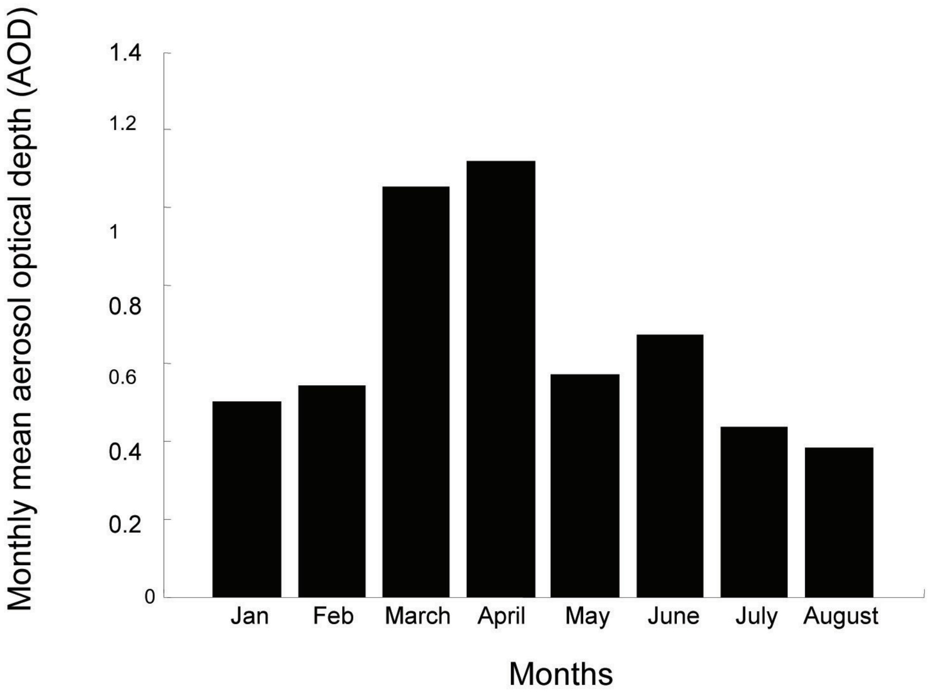

Fig. 4: Variations of monthly mean AOD at 500 nm

4. Conclusions

The aerosol optical depth (AOD) at Kausaltar was studied. The high and low values of AOD were found to be 1.12 and 0.38 in April and August respectively. Spectral dependence of AOD showed higher values at shorter wavelengths and gradually decreases towards longer wavelengths in both spring and summer season. The value of wavelength exponent (α) and aerosols concentration (β) on June 15 and July 25 at Kaushaltar were found to be 0.80, 0.56 and 0.45, 0.57 respectively. The monthly variations of AOD showed higher values in April and lowest in August under study.

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