



To Reveal the Aerosol Vertical Profiles in Terms of Aerosol Number Density

KEYWORDS

aerosols; mesosphere; twilight sounding method (TSM); thermosphere

Dr. Pratibha Bhagavanrao Mane

SERB-Young Scientists, Department of Physics, Shivaji University, Kolhapur, Maharashtra State, India.

ABSTRACT *Aerosol measurements have been carried out at Kolhapur (16°42'N, 74°14'E) by using newly designed Semiautomatic Twilight Photometer. It is observed that, the AND over Kolhapur in volcanically quiescent period declines from 185 particles per cm³ (~6 Km) to about 1 particle per cm³ (~44 Km). The aerosol layer peak occurs at ~20 Km (5 particles per cm³). Mesospheric AND decreases from ~700 particles per dm³ (~50 Km) to ~225 particles per dm³ (~85 Km). Thermospheric AND vary from 225 particles per dm³ (~85 Km) to ~105 particles per dm³ (~250 Km). After ~250km, many deviations noticed up to 350km in between 100-120 particles per dm³. The main aim of this study is to demonstrate the measurement capabilities offered by semiautomatic twilight photometer and it is the first attempt in India made by the author to estimate mesospheric and thermospheric aerosol number density per cubic decimeter (AND/ dm³).*

1. INTRODUCTION

Aerosols affect the progress of twilight, as more the number of aerosols in the atmosphere, more the sky brightness during the twilight period. Hence, the measurements for the twilight sky brightness carried out by using a twilight photometric technique to retrieve the aerosol vertical profiles. During the course of the study, the measurement of the atmospheric aerosols carried out by using semiautomatic twilight photometer during the period of 1 January 2009 to 31 December 2011 at Kolhapur (16°42'N, 74°14'E), Maharashtra state, India. The twilight scattering method yields a reasonable qualitative picture of the vertical distribution of aerosols from about 6 km to a maximum of 350 km. This being a passive technique, clear sky conditions are preferable for obtaining the vertical profile of aerosols.

Logarithmic gradient of the intensity cannot give the information about the aerosol number density (AND). Therefore, an imperial formula was derived with the help of actual Lidar observation and Photometric observations. The main aim of this study is to demonstrate the measurement capabilities offered by semiautomatic twilight photometer and it is the first attempt in India made by the authors to estimate mesospheric and thermospheric aerosol number density per cubic decimeter (AND/ dm³).

2. INSTRUMENTAL SETUP

The instrument, **semiautomatic** twilight photometer, has been newly designed, developed and tested at IITM, Pune, India. The semiautomatic twilight photometer consists of a simple experimental set up. It comprises of a telescopic lens of diameter 15 cm having a focal length of 35 cm, and a red glass filter peaking at 670 nm with a half band width of about 50 nm. The red filter of 2cm diameter and an aperture of 0.6 cm diameter are placed at the focal length of convex lens, provides approximately 10 field of view [(Aperture diameter/Focal length of lens) X 57 = (0.6cm/35cm) X 7 = 0.9771 degree]. A photomultiplier tube (PMT)-9658B is used as a detector. The PMT requires a high voltage i.e. 700Volts and hence a high voltage power supply is used. The output signal (current) of the PMT is of the order of nano to microamperes. The amplitude or strength of this low signal is amplified by using newly designed fast preamplifier. The more details regarding the instrument and Fast pre-amplifier were given elsewhere, (Mane et al., 2012, a and b). The amplifier output recorded by the digital multimeter, Rishcom-100, having an adapter can store the data automatically for every 10secs in the form of date, time and intensity in Volts.

3. RESULTS AND DISCUSSION

The basic principle of the twilight sounding method is given elsewhere, (Mane et al., 2012, c). Thus according to Shah (1970),

$$-(1/I) (dI/dh) \sim -d \log (\text{aerosol number density})/dh \quad \dots (1)$$

Here 'I' is the observed intensity; 'dI' and 'dh' are the differences in intensities and shadow heights, respectively observed at time 't' and '(t+dt)'.

The aerosol number density was calculated by using an imperial formula derived by actual LIDAR observations and Twilight Photometric observations as stated below:

Aerosol number density per cm³

$$= \text{Antilog}_{10} \{10^{[-1/I (dI/dh)]-1}\} \quad \dots (2)$$

Using equ.-2, aerosol number density per cm³ (AND/ cm³) was calculated for each point of 'shadow height (h)'. Figure-1 shows the typical aerosol vertical profiles with AND plotted against shadow height (h).

3.1. Vertical profiles of the Tropospheric aerosol number density per cm³

The troposphere is the lowest portion of Earth's atmosphere. The average depth of the troposphere is approximately 17 km over tropical station Kolhapur (16.41°N 74.13°E). Figure-2 shows one of the typical vertical profiles with AND (the aerosol number density per cm³) plotted against 'h' (shadow height), over Kolhapur in volcanically quiescent period (3 January 2010-Morning) for troposphere, (Fig2: a). The AND rapidly decreases from 185 particles per cm³ at ~6 Km to about 15 particles per cm³ at ~8 Km (Fig2:b). The AND decreases somewhat slowly from 15 particles per cm³ at ~8 Km to about 5 particles per cm³ at ~9 Km. After this The AND very slowly decreases from 5 particles per cm³ at ~9 Km to about 3 particles per cm³ at ~12 Km (Fig2:c). The AND vary from 3 particles per cm³ (~12 Km) to 2 particles per cm³ (~15 Km). In the tropopause the AND increases from 2 particles per cm³ (~15 Km) to 3 particles per cm³ (~17 Km) (Fig2: d).

In short the aerosol number density in troposphere over Kolhapur in volcanically quiescent period (3 January 2010-Morning) vary from 185 particles per cm³ at ~6 Km to about 2 particles per cm³ at ~15 Km.

3.2. Vertical profiles of the Stratospheric aerosol number density per cm³

The stratosphere is the second major layer of Earth's atmosphere situated between about 17 km and 50 km altitude above the surface of the Earth. Figure-3 shows typical vertical profile for stratosphere, (Fig3: a); which is also divided into three parts. In lower stratosphere, the value of AND starts increasing slightly from 3 particles per cm³ (~17 Km) due to the presence of stratospheric dust layer, also called as Junge layer (Junge et.al., 1961). Two aerosol layer peaks occur at ~20 Km and ~24Km having the aerosol number density of 5 particles per cm³ for each (Fig3:b). After that, the value of AND decreases as the altitude increases. It becomes 1 particle per cm³ at ~44 Km (Fig3: c).

After 45 Km the AND is less than 1 particle per cm³. It is inconvenient to say some fraction of particle per cm³ (i.e. say 0.944 particle per cm³). So the AND for the upper stratosphere is expressed in terms of the aerosol number density per dm³ (AND/ dm³). Thus, it is convenient to say 944 particles per dm³ instead of 0.944 particles per cm³. The AND in the upper stratosphere vary from 944 particles per dm³ (~45 Km) to 722 particles per dm³ (~50 Km) (Fig3: d).

In short the aerosol number density in stratosphere vary from 3 particles per cm³ (~17 Km) to 1 particles per cm³ (~44 Km). The aerosol layer peak occurs at ~20 Km having the aerosol number density of 5 particles per cm³.

Ramachandran et al. (1994) have reported that the particle density over Hyderabad in volcanically quiescent period (22 October 1985) vary from 80 particles per cm³ (at 6 Km) to 9 particles per cm³ (at 32 Km). Also Nighut et al. (1999) have reported that the particle density over location Pathardi in volcanically quiescent period (29 October 1993) vary from 100 particles per cm³ (at 6 Km) to 1 particles per cm³ (at 50 Km). The aerosol number density obtained in present work is supporting the results of earlier workers.

3.3. Vertical profiles of the Mesospheric aerosol number density per dm³

The mesosphere is the third major layer of the Earth's atmosphere located about 50 to 85 kilometers above the Earth's surface. It is the most poorly understood part of the atmosphere. In the present work an attempt is made to calculate the mesospheric aerosol number density per dm³ (AND/ dm³) by TSM, for the first time in India. All of the earlier workers obtained AND up to stratospheric level only.

Figure-4 shows some typical vertical profiles of AND for mesosphere. The AND in mesosphere vary from 722 particles per dm³ (~50 Km) to 234 particles per dm³ (~85 Km) over location Kolhapur (16°42' N, 74°14' E) in volcanically quiescent period (3 January 2010-Morning). In general the mesospheric AND decreases with altitude from ~700 particles per dm³ (~50 Km) to on an average of 225 particles per dm³ (~85 Km).

3.4. Vertical profiles of the Thermospheric aerosol number density per dm³

Figure-5 shows some typical vertical profiles of AND for Thermosphere. The AND in thermosphere decreases rapidly from 300 particles per dm³ (~85 Km) to 125 particles per dm³ (~150 Km) [fig5: a]. After words it decreases slowly from 125 particles per dm³ (~150 Km) to 105 particles per dm³ (~250 Km) [fig5: b]. After ~ 250km, many deviations noticed up to 350km in between 100-120 particles per dm³ [fig5:c].

4. SUMMARY AND CONCLUSIONS

The measurements using the twilight sounding method presented in this paper suggest the following,

- I. The newly designed **Semiautomatic** twilight photometer yields a reasonable qualitative picture of the vertical distribution of aerosol number density (AND) from about 6 km to a maximum of 350 km.
- II. Tropospheric aerosol number density over Kolhapur in volcanically quiescent period (3 January 2010-Morning)

vary from 185 particles per cm³ at ~6 Km to about 2 particles per cm³ at ~15 Km.

- III. Stratospheric aerosol number density vary from 3 particles per cm³ (~17 Km) to 1 particles per cm³ (~44 Km). The aerosol layer peak occurs at ~20 Km having the aerosol number density of 5 particles per cm³.
- IV. Mesospheric AND decreases with altitude from ~700 particles per dm³ (~50 Km) to on an average of 225 particles per dm³ (~85 Km).
- V. Thermospheric AND vary from 300 particles per dm³ (~85 Km) to 105 particles per dm³ (~250 Km). After ~ 250km, many deviations noticed up to 350km in between 100-120 particles per dm³.

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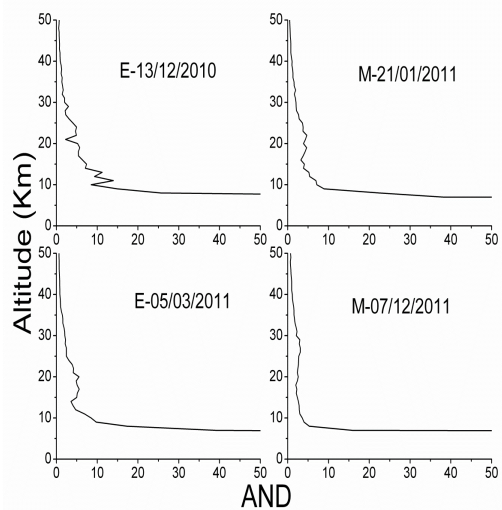


Figure-1: The typical aerosol vertical profiles in terms of AND

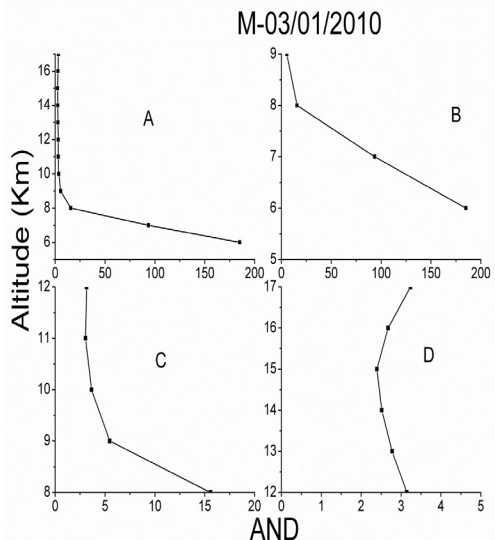


Figure-2: One of the aerosol vertical profiles with AND for Thermosphere

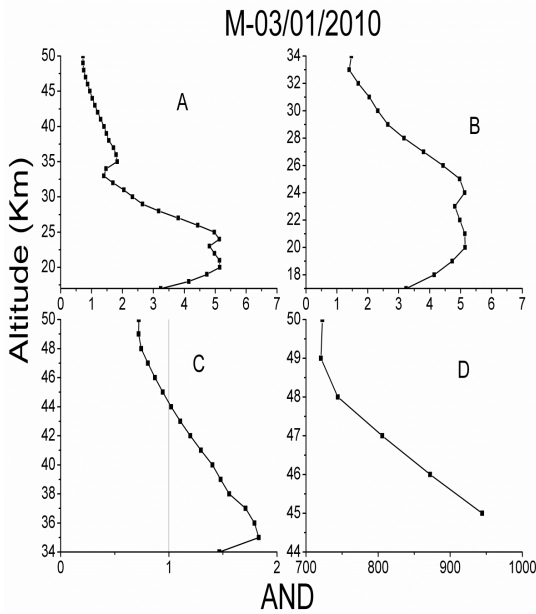


Figure-3: One of the aerosol vertical profiles with AND for Stratosphere

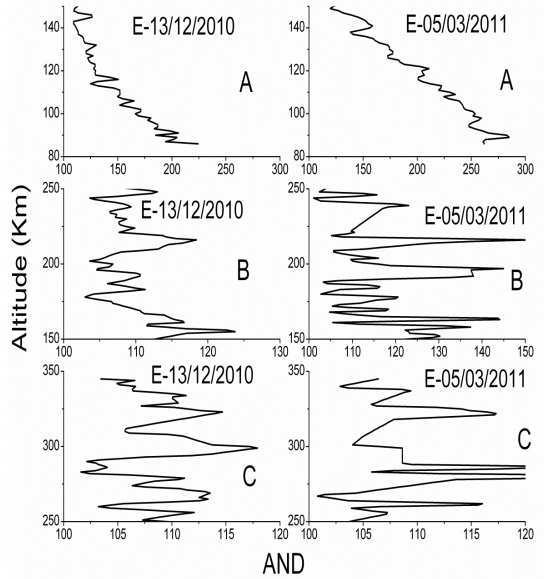


Figure-5: Some aerosol vertical profiles with AND for Thermosphere

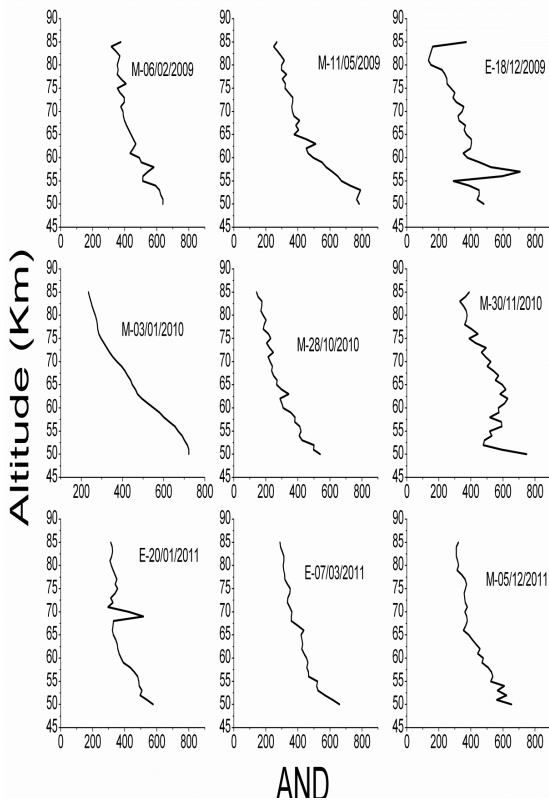


Figure-4: Some aerosol vertical profiles with AND for Mesosphere

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