G-O-6

ALTITUDE PROFILES OF AEROSOL OPTICAL DEPTH, SIZE PARAMETER AND MASS CONCENTRATIONS OF BC OVER NAINITAL IN THE HIMALAYAS

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1. INTRODUCTION

The study of atmospheric aerosols has become very important in the recent years because of its potential to alter the radiation budget of the Earth's atmosphere and hence the climate [*Charlson et al.,* 1992]. However, the radiative forcing due to aerosols still remains to be one of the largest sources of uncertainty in estimating the effects of aerosols on climate [*IPCC*, 2001] and predicting the future climate, because of the incomplete knowledge of their macro-physical and microphysical properties. In this paper, we report some interesting results on the altitude profiles of the spectral aerosol optical depths (AOD), mass concentration (M_B) of black carbon and aerosol number density based on the observations taken from a number of places between continental plains and a very tall (~2km) mountain peak adjacent to it, (between Haldwani, at the foothill, and Nainital in the Shivalik ranges of Central Himalayas), during the winters of 2005, 2006 and 2007.

2. EXPERIMENTAL DETAILS AND DATA BASE

Altitude profiles of M_B, (using a 7-channel aethalometer, model AE42 of Magee Scientific, USA; *Pant et al.,* 2006; *Babu et al.,* 2004) and spectral AODs (using a pair Microtops Photometers; *Porter et al.,* 2001; *Ichoku et al.,* 2002) were carried out from Manora Peak (1950 m AMSL); in Central Himalayas to a low altitude station Haldwani (330 m AMSL) at its foothill within an aerial distance of < 10 km during several days under fair weather conditions. Along with these, we also measured the number concentration of particles with diameter >0.3 μm using an optical particle counter (model 1.108 of Grimm, *Pant et al*., 2006). These have been used to study the vertical structure of aerosols at this northern location.

3. RESULTS AND DISCUSSION

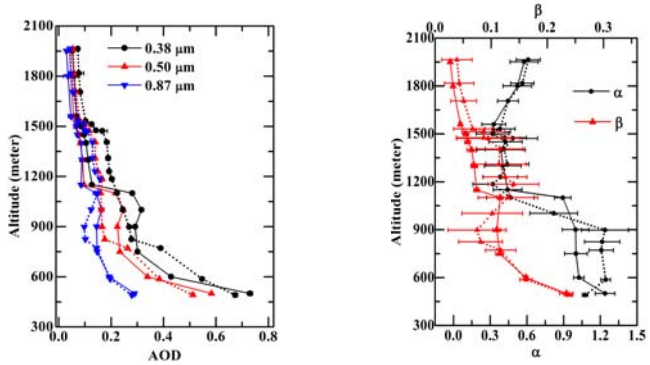

FIGURE 1: - Altitude profiles of (a) AOD at 3 wavelengths and (b) Angstrom parameters for 12th January 2006 (solid lines) and 03rd January 2007 dotted lines.

The typical altitude variations of AODs at a wavelength 0.50 μm are shown in Figure 1 for 12th January 2006 (solid line) and for 03rd January 2007 (dotted line) respectively. The horizontal bars at respective mean values indicate the standard errors. In general, the AODs decrease with increase in altitude and vice versa. The shorter wavelengths respond rapidly to the increasing altitude than the longer wavelengths and above about 1500m, these tend to merge, indicating (i) a decrease in abundance of the particles with altitude and (ii) a change in the spectral dependence of the AOD with altitude.

Following *Ångström* [1964] the spectral variation of AODs can be expressed as, $\tau_{p\lambda} = \beta\lambda^{-\alpha}$, where α is the wavelength exponent, β the turbidity parameter, and λ the wavelength in μm, the Angstrom parameters are estimated by performing a linear regression analysis on the individual AOD spectra (on log-log scale). The altitude variations of α and β on the same days are shown in Figure 1(b). It is clearly observed that (i) at Haldwani, both α and β are very high, indicating a high aerosols loading, with dominance of accumulation mode particles, (ii) up to ~ 1-to-1.5 km the α values are remains nearly steady, suggesting that the reduction occurs in the abundance of accumulation and coarse mode particles almost equally so that the size spectrum is not much affected, (iii) initially β decreases rapidly, showing the large reduction in the loading. These are mainly attributed to the strong thermal convections in the plains, which thoroughly mix the particles of different sizes. Between 1 to 1.5 km α remains low, suggesting a flat spectrum. This approximately would be coinciding with the top of the boundary layer, where the inversion shields the convective eddies from propagating higher. This is supported by the almost altitude invariant nature of β. However, above 1.5 km, α again increases with increasing altitude, and β decreases to very low values, suggesting highly reduced abundance in the "free troposphere"; the concentration above being maintained by the smaller particles that have longer residence time and are also amenable to long-range transport.

Following the *Sasano et al.,* [1982], we have examined the aerosol mixing height (where the normalized gradient peaks sharply) from the normalized vertical gradient of AOD ($\tau_{ng}= (\delta\tau/\delta h)/\tau$), estimated from values of AOD at different altitudes on the same days as discussed above. It was observed that the mixing height is varying between the ranges 1 to 1.5 km, which prevailed around 10 to 12 hours local time on the two days. Form the altitude profile of BC and number density, it is clearly seen that the BC as well as number concentration also show a sharp decrease up to the top of the mixed layer, above which its altitude variation is small. Details will be presented in the paper

4. CONCLUSIONS

The main conclusions of our studies are the following:

1. Spectral aerosol optical depth decreases with increases of altitude. During winter season the aerosols below 1 km contribute a major fraction of columnar aerosol optical depths.
2. Black carbon mass concentration and number concentration of composite aerosols near surface, both decreases as the altitude increases.
3. The aerosol mixing height generally lies in the range between 1 to 1.5 km altitudes, above which the particle concentrations are slowly varying functions of altitude.
4. The Ångström wavelength exponent (α) retrieved from the AOD spectra shows the dominance of accumulation mode aerosols in the well-mixed region, where the abundance decreases with altitude.

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