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SEASONAL VARIATIONS OF CARBONACEOUS AEROSOLS OVER CENTRAL HIMALAYAS

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1. INTRODUCTION

The studies of aerosols black carbon (BC) is important because of its strong absorbing potential and contribution to greenhouse warming on the one hand and the predominantly anthropogenic form of its generation on the other. Though, it contributes only a few percent to the total aerosol mass, its radiative effects are significant [*Jacobson*, 2001; *Babu et al.*, 2004]. The high altitude locations have a special significance in this context because they are far away from potential sources and represent a free atmosphere during most of the time. With the above considerations, extensive measurements of the mass concentrations of BC were carried out, during the period November 2004 to December 2006, at the high altitude location, Manora Peak, Nainital.

2. EXPERIMENTAL DETAILS AND DATA BASE

The experimental site (29.37°N; 79.45°E) is located in the Shivalik ranges of Central Himalayas at an altitude of 1950 m above mean sea level and hence is above the planetary boundary layer for most of the time [*Pant et al.*, 2006]. The geographical location and topography of the observational site over the Indian subcontinent is given in Figure 1(a) and more details are available in earlier papers [eg. *Pant et al.*, 2006]. Regular and near-real-time measurements of the mass concentration (M_B) of BC were carried out, using an Aethalometer (model AE42 of Magee Scientific). The Aethalometer has been operated at a timebase of 5 minutes, round the clock, at a flow rate of 5 LPM. More details regarding the instrument, principle of observations and data analysis are given elsewhere [*Babu et al.*, 2004; *Pant et al.*, 2006].

3. RESULTS AND DISCUSSION

Being a high altitude location, the aethalometer measurements need to be corrected for the reduced ambient pressure and its consequence of the pumping speed. The aethalometer was operated in standard mass-flow settings and as such the true BC concentrations were retrieved from the instrument-measured values by applying the corrections described in *Moorthy et al.* [2004]. A colour composite of these corrected concentrations is shown in Fig. 1(b) for the two-year period.

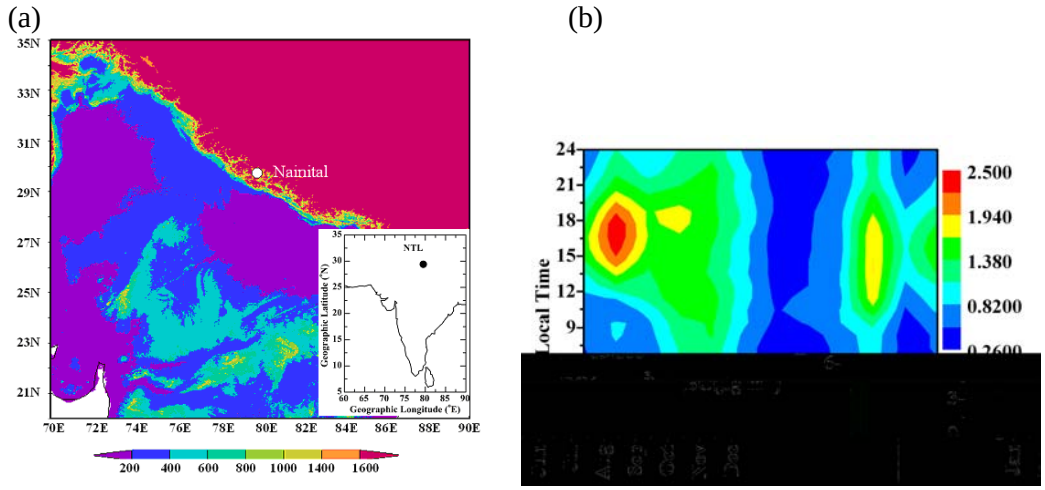

FIGURE 1: - (a) The geographical location of the study area over the Indian subcontinent. Color code in the figure shows the altitudes in meters above the mean sea level. **(b)** The monthly mean diurnal variation of black carbon aerosol during January to December 2005 and 2006.

The figure shows two important features:

1. Diurnal variations, relatively low values (<500 ng m^{-3}) during the night and early morning hours, reaching a peak value, exceeding 1200 ng m^{-3}, in the afternoon and decreasing gradually to the nighttime level. This diurnal pattern is quite opposite to those reported at several locations in the plains [*Babu et al.*, 2004]. The diurnal variations are quite conspicuous during October to April, while they are insignificant during May to September.
2. An annual variation with a monsoon (June-August) minimum and winter (Jan-Mar) maximum with a maximum to minimum ratio >5.

The diurnal variations are attributed to the increase in the ABL depth due to solar heating after the sunrise, the convective eddies associated with which lifts the morning capping inversion [*Stull*, 1989], taking along with it the pollutions confined within the nocturnal ABL of the valley regions at the foothill. As day progressed, the ABL deepens and would reach up to higher altitudes, and there by plays a significant role in the vertical transport of aerosols and pollutants from the valley to this high altitude station. This leads to the afternoon raise in the BC concentrations at the mountaintop. During the night times the shallow nocturnal boundary layer acts as a cap, confining the aerosols in the valley itself. The human activity atop the hill is practically insignificant and hence the low levels of BC prevail during nighttime.

The above processes are distinctly strong during winter season, when the solar heating itself is low and a weak low-level anticyclone prevails over the Indo-Gangetic plains. As summer advances, the land heating becomes stronger and the resulting convective eddies are strong enough to transport the aerosols to much higher altitudes. Similar diurnal variations of BC are reported by *Bhugwant et al*, [2001], from a high altitude (~2.5 km msl) location in La Reunion Island, and which was attributed to the upward transport of BC from the underlying valley regions by the evolving of boundary layer dynamics. The intense rainfall associated with the summer monsoon, removes a

significant portion of the BC by wet removal processes, leading to a highly depleted concentration during June to September.

4. CONCLUSIONS

The main conclusions of our studies are as follows:

1. The monthly mean diurnal variation of BC mass concentration at Manora Peak shows low values during night and early morning hours. BC mass concentration increases gradually after the sunrise and attains a peak at the afternoon hours. The diurnal variation of aerosol black carbon is strongly associated with the evolutions of atmospheric boundary layer dynamics.
2. The diurnal variation of BC mass concentration is prominent during the months of January, February, March, October, November and December, while it is insignificant during the months of July and August.
3. The Monthly or seasonal variation of black carbon aerosols showed high concentration during the dry winter seasons and low concentration during the monsoon seasons.

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REFERENCES

1. Babu et al., *Geophys. Res. Lett,* Vol 31, L06104, doi: 10.1029/2003GL018716, 2004.
2. Bhugwant et al, *Atmos. Res.,* Vol 57, 105-121, 2001.
3. Jacobson, *Nature,* 409, 695-697, 2001.
4. Moorthy K K et al., *Geophys. Res. Lett,* Vol. 31, doi:10.1029/2004GL021336, 2004
5. Pant et al., *J. Geophys. Res.,* Vol., 111, D17206, doi: 10.1029/2005JD006768, 2006.
6. Stull, R., *Springer, New York,* pp-620, 1989.