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# Aerosol characterization during the summer monsoon period over a tropical coastal Indian station, Visakhapatnam

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[1] Columnar optical depth and near-surface mass concentration of aerosols over Visakhapatnam, an urban location along the east coast of India during the summer monsoon period (May–August 2005), were measured simultaneously along with chemical sampling for water-soluble ionic species ($NH_4^+$, $Na^+$, $K^+$, $Mg^{2+}$, $Ca^{2+}$, $Cl^-$, $NO_3^-$, $SO_4^{2-}$, and $HCO_3^-$). The mean aerosol optical depth (AOD) (0.5 $\mu$m) and Angstrom parameters ($\alpha$, $\beta$) during this period were obtained as $0.72 \pm 0.39$ and $0.88 \pm 0.39$, $0.48 \pm 0.36$, respectively. The total surface aerosol mass concentration varied from 95 to 128 ($\mu g/m^3$), out of which coarse mode dominated by 45%. While $Cl^-$, $Na^+$, $K^+$, and $Mg^{2+}$ (sea salts) contributed nearly 56%, $SO_4^{2-}$ and $NO_3^-$ (anthropogenic constituents) contributed 33% in surface aerosol constituents. During this period, high spectral variability in AOD, negative curvature of second-order Angstrom coefficient ($\alpha^1$), abundance of columnar submicron aerosols, role of air mass trajectories as tracers of long-range transport, cation deficiency, and sea-salt dependence on wind speed are some of the observations over Visakhapatnam. The synergy of the results from these complementary measurements can be reflected while computing the aerosol radiative forcing.

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## 1. Introduction

[2] Atmospheric aerosols produced by both natural and anthropogenic processes are major players within Earth's climate system [*Intergovernmental Panel on Climate Change* (*IPCC*), 2001] affecting the radiation budget, cloud processes and surface air quality. As their life time is of the order of days, aerosols are inhomogeneous in time and in space, with much higher concentrations near the sources and hence are predominantly regionally distributed. Different particle origins result in mixture of chemical species with different optical properties [*d'Almeida et al.*, 1991]. These have strong bearing on the seasonal variation of the solar heating of the surface, prevailing circulations and related boundary layer processes which influence transfer of flux from the higher regions to lower levels of the atmosphere and vice versa [*Stull*, 1988]. Aerosol physical properties at a given location are largely governed by the local processes that lead to aerosol formation, which are modified by the prevailing meteorology, besides transport of aerosols from sources of nonlocal origin. Marine aerosols produced in the surf zone at high concentrations are immediately available for heterogeneous chemical reactions and influence the composition of aerosols at coastal locations [*Vignati et al.*, 2001]. *Zhang et al.* [1993] reported that aerosol chemical composition, particle size distribution and air mass back trajectories can serve as tracers for the origin of the air mass sampled.

[3] Size distribution and chemical composition of aerosols are most important properties as far direct and indirect radiative effects are concerned [*IPCC*, 2001]. Near-surface aerosol contribution to the columnar abundance is significant when the transport process becomes trivial. Thus while estimating the radiative impact of aerosols, the link between the properties of near-surface aerosols and columnar spectral optical depths needs to be understood. Over the Indian landmass, studies focusing on the spatial heterogeneity of aerosol properties during premonsoon and monsoon season are scarce. However, such data are essential to assess the complex response of the hydrological cycle to regional aerosol radiative forcing and also to delineate the temporal changes. Direct and indirect aerosol effects are largely influenced by ambient RH, aerosol water solubility and chemical composition of the water-soluble material. Water-soluble aerosol compounds, such as ammonium ($NH_4^+$), nitrate ($NO_3^-$), chloride ($Cl^-$) and sulphate ($SO_4^{2-}$) play a major role in the nucleation and growth of cloud droplets [*Roberts et al.*, 2002].

[4] As atmospheric aerosols are highly heterogeneous and poly dispersive in nature, no single technique or group of techniques is adequate for entire characterization of atmospheric aerosol properties over the extremely wide

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