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Measurements of scattering and absorption properties of surface aerosols at a semi-arid site, Anantapur

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ABSTRACT

Aerosol optical properties are continuously measured at a semi-arid station, Anantapur from June 2012 to May 2013 which describes the impact of surface aerosols on climate change over the region. Scattering coefficient (σ_{sct}) and absorption coefficient (σ_{abs}) are obtained from integrating Nephelometer and Aethalometer, respectively. Also, the single scattering albedo (ω_0), Scattering/absorption Ångström exponents were examined during the period of study. Diurnal variations of σ_{sct} and σ_{abs} show a bi-peak pattern with two maxima and one minimum in a day. The largest values of σ_{sct} and σ_{abs} are obtained in winter while the lowest values are measured in monsoon. From the measurements σ_{sct}^{550} and σ_{abs}^{550} are found to be 110 ± 12.23 Mm^{-1} and 33 ± 5.2 Mm^{-1}, respectively during the study period. An analysis of the ω_0 suggests that there is a more absorbing fraction in the particle composition over the measurement site. The ω_0 obtained in the surface boundary layer of Anantapur is below the critical value of 0.86 that determines the shift from cooling to warming. A relationship between scattering/absorption coefficients and scattering/absorption Ångström exponent and single scattering albedo is further examined. In order to understand the origins of the air masses in the study region, we performed seven-day back trajectory analyses based on the NOAA HYSPLIT model. These trajectories were computed at several altitudes (3000 m, 1500 m, and 500 m) for June 2012 and May 2013. These results put in evidence the need of efforts to reduce absorbing particles (black carbon) emissions to avoid the possible warming that would result from the reductions of the cooling aerosol only.

1. Introduction

Atmospheric aerosols are a central topic in atmospheric physics and chemistry, with consistent effects on climate and public health. Aerosols consist in solid or liquid particles suspended in the atmosphere in the size range between few nanometers to some tens of microns. Some of aerosol particles occur naturally originating from volcanoes, dust storms, forest fires and also from sea spray. Human activities such as the burning of fossil fuel and change in the natural cover of the surface also generate aerosols. Although aerosols are a small fraction of the atmosphere, they reduce total irradiance and increase the factor that is diffuse in two ways: (1) directly, by absorbing and scattering solar radiation, and (2) indirectly, by altering the properties of clouds.

The determination of the direct effects of aerosols on the earth radiation balance requires quantitative information on aerosol loadings (e.g., aerosol optical depth) and the optical properties (e.g., extinction and absorption coefficients, single scattering albedo, and asymmetry parameter) of atmospheric aerosols with their temporal and spatial variability. Through scattering and absorption of solar radiation, aerosols can cool or warm the Earth's atmosphere and alter the climate. Measuring the scattering variability is a try to understand how the aerosol optical properties vary with time, season and long range transport of pollutants. Moreover, information on the extinction coefficient, which is related to visibility in the atmosphere, is also an important parameter in global climate models. In general, the interaction of a scattering and absorbing aerosol with the radiative flux at various levels in the atmosphere could change the albedo of the earth and the temperature profile of the atmosphere: pure scattering will increase the albedo of the earth and reduce the amount of solar radiation incident on the earth, causing

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a net cooling of the earth-atmosphere system, while absorption of solar and terrestrial radiation by particles could cause a greenhouse effect near the earth's surface. Certain atmospheric aerosols absorb solar radiation, specifically carbonaceous particles and mineral dust. Black carbon (BC), a heat absorbing aerosol, is a product of incomplete combustion of fossil fuel, biomass, agricultural waste and forest fire (Badrinath et al., 2010). This absorption affects the atmosphere by reducing the radiation reaching the surface and increasing the temperature aloft, the reduction of BC emission has been suggested as a short-term global warming mitigation strategy. According to the IPCC, 2007 (Intergovernmental Panel on Climate Change), "*the presence of black carbon and organic carbon from biomass combustion over highly reflective surfaces, such as snow and ice, or clouds, may cause a significant positive radiative forcing*". In this regard, it is worthy to note that the largest uncertainties related to the climate change are associated with the carbonaceous aerosols. Several extensive studies have been reported about aerosol optical properties and associated radiative forcing effects across the globe (Lee et al., 2007; Lyamani et al., 2010; Wang et al., 2011; Babu et al., 2013; Gopal et al., 2014; Reddy et al., 2016; Xin et al., 2016).

In the present study, we present comprehensive details on characterization of ambient aerosols based on optical properties over a semi-arid site, Anantapur from June 2012–May 2013. Nephelometer and Aethalometer have been utilized in deriving suit of aerosol optical properties such as aerosol scattering and absorption coefficient, Ångström exponent and single scattering albedo. Diurnal, seasonal and spectral variations of these properties were discussed in detail. The observed component of the aerosol during different seasons is linked to the long range wind advection based on 7 day back trajectory analysis. It is the first time that such studies presented for the area providing a clear insight of the aerosol scattering and absorption properties of aerosols. The experimental site and the detailed description of the instrumentation were described in Section 2. In Section 3, the seasonal and diurnal variations of aerosol properties were interpreted in light of local anthropogenic activities and correlations between different aerosols optical properties were summarized.

2. Site description and instrumentation

The observations have been carried out on the roof of building at a height of 12 m from the ground at the Department of Physics, Sri Krishnadevaraya University (SKU) campus in Anantapur (14. 62° N, 77.65° E, 331 m asl) for the period between June 2012 and May 2013. Anantapur located in southeast India, represents a very dry semi-arid, rain shadow and continental region of Rayalaseema in Andhra Pradesh. The measurement site is located in the southern edge of Anantapur town at a distance of 10 km (Fig. 1). Within a 50 km radius, this region is surrounded by a number of cement plants, lime kilns, slab polishing and brick making units. These industries which are situated in the north to southwest side and the national highways (NH 7 and NH 205) passes close to the sampling site release large quantities of particulate matter every day into the atmosphere. The seasonal biomass burning activities in adjacent hilly area are the other possible sources of aerosol loading (Kumar et al., 2011; Reddy et al., 2012). Ancillary data of meteorological parameters such as wind speed, wind direction, temperature and relative humidity are obtained from sensors mounted on a meteorological tower (~8 m above ground level). Daily total rain fall was also measured from the same meteorological facility which is installed within the campus near to the sampling site. The continental conditions prevailing hot and humid summers (March–April–May) and dry winter (December–January–February), humid during the monsoon (June–July–August) and the post-monsoon (September–October–November). Most of the rainfall occurs during the monsoon and post-monsoon from southwest and northeast monsoons, respectively. This region receives very little rain fall, and the average annual rainfall is of order of 450 mm (which is about 300 mm due to southwest monsoon and 150 mm from northeast monsoon).

2.1. Nephelometer

The total aerosol scattering and hemispheric backscattering coefficients were measured at three different wavelengths 450 nm, 550 nm, and 700 nm using a TSI Model 3563 three wavelength integrated

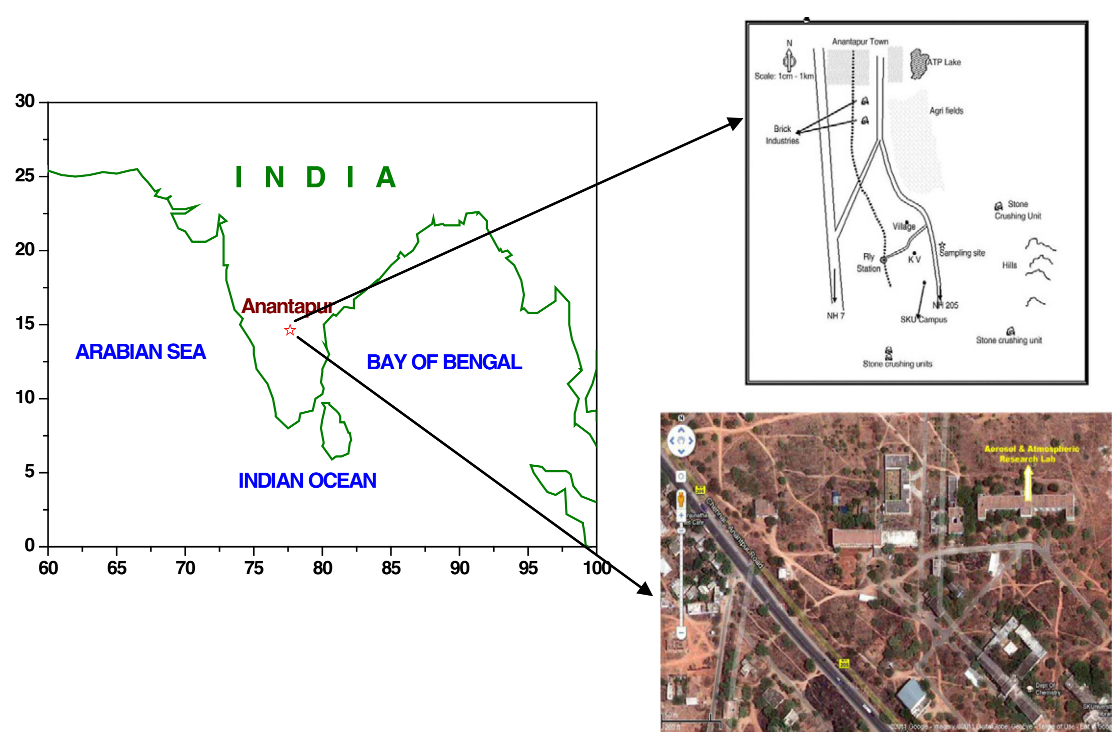

Fig. 1. Location of the measurement site Anantapur over the Indian subcontinent.