Measurements of atmospheric parameters during Indian Space Research Organization Geosphere Biosphere Programme Land Campaign II at a typical location in the Ganga basin:

1. Physical and optical properties

S. N. Tripathi,1 Vinod Tare,1 N. Chinnam,1 A. K. Srivastava,1 Sagnik Dey,1 A. Agarwal,1 S. Kishore,1 R. B. Lal,1 Manish Manar,1 Vijay P. Kanwade,1 S. S. S. Chauhan,1 M. Sharma,1 R. R. Reddy,2 K. Rama Gopal,2 K. Narasimhulu,2 L. Siva Sankara Reddy,2 Shilpy Gupta,3 and Shyam Lal3

Received 9 March 2006; revised 9 July 2006; accepted 18 August 2006; published 14 December 2006.

This paper attempts to characterize the physical and optical properties of the aerosols along with relevant meteorological parameters at a typical location in the Ganga basin. The emphasis is on delineating the prolonged foggy/hazy conditions, a phenomenon believed to be of relatively recent origin, faced by millions of people during the winter months of December and January. Collocated measurements of a number of aerosol and atmospheric parameters were made using ground-based instruments as part of an intense field campaign launched under the Indian Space Research Organization Geosphere Biosphere Programme in December 2004. The meteorological conditions suggest limited mixing due to shallow boundary layer thickness and essentially calm wind conditions. Monthly mean aerosol optical depth was high (0.77 ± 0.3 at 0.5 μm wavelength) and showed high spectral variation (first-order Ångström exponent for all wavelengths, α = 1.24 ± 0.24). The second-order Ångström exponent α′ derived for 0.34, 0.5, and 1.02 μm wavelengths showed much higher curvature in the aerosol optical depth spectrum on the hazy/foggy days (0.93 ± 0.36) as compared to that during the clear days (0.59 ± 0.3). Single-scattering albedo (0.87–0.97) showed strong spectral variation. Aerosol mass concentration was high with monthly average 125.9 ± 47.1 μg m⁻³. Fine mode particles (<1 μm) contributed ~75% to the total mass of aerosols. Similarly, aerosol number concentration was found to vary in the range 1.5–2 × 10⁻⁶ cm⁻³, with fine mode particles contributing to ~99.6%. The hazy/foggy conditions typically prevailed when higher daytime relative humidity, lower maximum temperature, and higher fine/accumulation mode particles were observed. The companion paper suggests that the rise in aerosol mass/number concentration could be attributed to the aqueous-phase heterogeneous reactions mediated by anthropogenic pollutants and the associated reduction in boundary layer thickness and suppressed mixing.


1. Introduction

Some parts of northern India, particularly plains of the Ganges basin, are experiencing colder winters with prolonged and enhanced foggy/hazy conditions over the last decade. On the other side, the extreme dry and hot periods seem to be shrinking while the onset of sultry conditions appears to be advancing during the summers. Rapid increase in population, urbanization, and industrial growth has resulted in increased anthropogenic aerosol loading in the last few decades. The extremely high aerosol loading over the Ganga basin has been reported on the basis of satellite [Goloub et al., 2001; Chu et al., 2003; Girolamo et al., 2004; Ramanathan and Ramana, 2005] and ground-based observations [Mönkkonen et al., 2004; Singh et al., 2004; Dey et al., 2005]. Long-term measurements by the Central Pollution Control Board (CPCB), India, have revealed very high annual average concentrations (>150 μg m⁻³), critical range according to the air quality standard in India) of

---

1Department of Civil Engineering, Indian Institute of Technology, Kanpur, India.
2Department of Physics, Sri Krishnadevaraya University, Anantapur, India.
3Physical Research Laboratory, Ahmedabad, India.

Copyright 2006 by the American Geophysical Union.
0148-0227/06/2006JD007278