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Seasonal variability in aerosol optical and physical characteristics over Indo-Gangetic plain: Implications and sensitivity to aerosol radiative effects

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Indo-Gangetic plain (IGP), a regional aerosol hot spot, is one of the largest river basins in the world, densely populated and is one of the highly polluted regions in India. In the present work, a detailed analysis of the spatiotemporal variability of aerosol characteristics is conducted over two environmentally distinct locations in IGP, namely Kanpur (urban location) and Gandhi College (rural site). In this study, Aerosol Robotic Network (AERONET) Sun/sky scanning radiometer measured cloud screened and quality assured data during 2006-2008 are utilized. Aerosol optical depths (AODs) exhibit strong seasonal and wavelength dependence with at least a factor of two higher AOD at 0.34 μm than at 0.87 μm indicating abundant fine mode aerosols over both the locations throughout the year. Fine mode fraction (FMF) and Angstrom exponent (α) are higher over Gandhi College than Kanpur suggesting relatively higher fine mode aerosol concentration over Gandhi College than Kanpur. An analysis of spectral dependence of AOD revealed that the aerosol size distribution is bimodal and dominated by wide range of fine mode fractions or mixture of modes during winter and postmonsoon. This can be attributed to the influence of high anthropogenic emissions over the entire IGP during winter and due to intense crop residue burning during postmonsoon. During premonsoon and monsoon coarse mode aerosols are more abundant over both the locations which could be because of the fact that the entire IGP region remain highly influenced with soil dust during premonsoon and sea salt during monsoon. Spectral variation in Single scattering albedo (SSA) and asymmetry parameter (g) as a function of season indicated presence of fine mode absorbing aerosols during winter and postmonsoon, while during premonsoon and monsoon coarse mode scattering aerosols dominate the IGP. An analysis of SSA and FMF suggests that black carbon aerosols are most frequent during winter and postmonsoon while during premonsoon and monsoon mixture of fine and coarse mode aerosols are more abundant. Seasonal variation in aerosol radiative effects are estimated utilizing the measured optical and physical characteristics of aerosols during the study period and Santa Barbara DISORT Atmospheric Radiative Transfer model. Shortwave aerosol radiative forcing at the top of the atmosphere is <-10 Wm−2 and is ≥-30 Wm-2 at the surface over Kanpur and Gandhi College during all the seasons. Shortwave atmospheric heating due to aerosols is >0.65 K/d over IGP and peaks during premonsoon at 1 K/d. The magnitude of longwave forcing and atmospheric cooling is only about 20% or less to the net (shortwave+ longwave) forcing. The seasonal variation in shortwave and longwave forcing and the atmospheric heating rates as well as their sensitivity to various aerosol inputs, atmospheric parameters and situational variables are also calculated. The results and the implications of this study will be discussed.