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Organic aerosols and inorganic species from post-harvest agricultural-waste burning emissions over northern India: impact on mass absorption efficiency of elemental carbon†

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Atmospheric PM2.5 (particulate matter with aerodynamic diameter of ≤ 2.5 μm), collected from a source region (Patiala: 30.2 °N; 76.3 °E; 250 m above mean sea level) of emissions from post-harvest agricultural-waste (paddy-residue) burning in the Indo-Gangetic Plain (IGP), North India, has been studied for its chemical composition and impact on regional atmospheric radiative forcing. On average, organic aerosol mass accounts for 63% of PM2.5, whereas the contribution of elemental carbon (EC) is ~3.5%. Sulphate, nitrate and ammonium contribute up to ~85% of the total water-soluble inorganic species (WSIS), which constitutes ~23% of PM2.5. The potassium-to-organic carbon ratio from paddy-residue burning emissions (KEC/OC: 0.05 ± 0.01) is quite similar to that reported from Amazonian and savanna forest-fires; whereas non-sea-salt-sulphate-to-OC ratio (nss-SO4 2-/OC: 0.21) and nss-SO4 2-/EC ratio of 2.6 are significantly higher (by factor of 5 to 8). The mass absorption efficiency of EC (3.8 ± 1.5 m2 g−1) shows significant decrease with a parallel increase in the concentrations of organic aerosols and scattering species (sulphate and nitrate). A cross plot of OC/EC and nss-SO4 2-/EC ratios show distinct differences for post-harvest burning emissions from paddy-residue as compared to those from fossil-fuel combustion sources in south-east Asia.

Environmental impact

Emissions from open agricultural-waste burning in the Indo-Gangetic Plain are a dominant source of atmospheric organic aerosols and black carbon in northern India, and are largely responsible for the formation of haze and fog during winter (December–February). Therefore, scattering species (organic aerosols and sulphate) could have a dominant impact on regional atmospheric chemistry and radiative forcing. A systematic decrease in the mass absorption efficiency of elemental carbon (EC) with an increase in the abundance of scattering species (as documented in this study) suggests internal mixing of absorbing EC, which is consistent with single scattering albedo at 500 nm derived from satellite (NASA-GES DISC) measurements. These results have implications in the overestimation of atmospheric radiative forcing due to black carbon over northern India.

1 Introduction

Biomass burning emissions represent a dominant global source of carbonaceous aerosols and gases in the atmosphere.1–3 There has been a continuous interest and effort in the past four decades to characterize carbonaceous aerosols from widely distributed biomass burning emissions, e.g. tropical forest fires and cerrado fires in the Amazon basin in South America,4–6 savanna fires in Africa,7 boreal forest fires in Canada,8,9 chaparral fires in California in North America and agricultural-waste burning emissions in South Asia.9 Open biomass burning emission sources (for example savanna fires, Amazonian forest-fires and agricultural-residue burning emissions) are located largely disproportionately in the tropics.8–12 The predominantly high contribution of organic aerosols in open biomass burning emissions addresses the issue of its potential impact on radiative forcing, in particular over the tropical region. Elemental carbon (EC) absorbs solar radiation, whereas organic carbon (OC), sulphate (SO4 2−) and nitrate (NO3 −) are potential scattering species in ambient aerosols.

Carbonaceous aerosols play a significant role in influencing the radiative forcing of Earth’s atmosphere.13–14 Assessing the impact of carbonaceous aerosols from biomass burning emissions versus fossil-fuel combustion sources in the south-Asian region is gaining increasing importance because of their potential influence on regional climate.15–17 Modeling estimates have shown that carbonaceous aerosols emitted from