Geophysical Research Abstracts
Vol. 20, EGU2018-317-1, 2018
EGU General Assembly 2018

Change in Brown Carbon Characteristics during Paddy-Residue Burning Over the Indo-Gangetic Plain

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Brown carbon (BrC) has several important climatic implications such as direct radiative forcing by the absorption of incoming solar radiation as well as the semi-direct effect that involves significant warming/heating of cloud water leading to evaporation. BrC can be primary and/or secondary particles from a variety of sources such as biomass burning (BB) and fossil fuel burning (FFB). Emissions from BB are shown to be a large source of BrC regionally and globally; however, their effects on BrC abundances and characteristics are sparse in literature. $PM_{2.5}$ samples were collected using high volume air sampler before, during and after a large scale paddy-residue burning over Patiala (30.2 $^{\circ}$N, 76.3 $^{\circ}$E, 250 m amsl), a site located in the Indo-Gangetic Plain (IGP). Subsequently, levoglucosan, major cations and anions, OC, EC were measured in these samples using standard techniques. BrC absorption spectra was also measured using liquid waveguide capillary cell (path length = 2m) with a portable UV-visible spectrophotometer. $PM_{2.5}$ concentration ranged from $\sim$90 to 500 μg m^{-3}(avg$\pm$sd: 230$\pm$114) during the study period with the average values of 154$\pm$57, 271$\pm$122, 156$\pm$18 μg m^{-3} during pre-burning (T1), burning (T2) and post-burning (T3) periods, respectively. High mass loading during T2 reflects the effect of BB on ambient air quality over the study region. Levoglucosan and K^+ (BB tracers) showed a strong correlation with a slope (0.94$\pm$0.04, r^2=0.87, n=62) different than those reported for domestic wood burning (Levo/K^+ $<$0.2), savanna fires (Levo/K^+ $\sim$20), and biofuel (Levo/K^+=0.37$\pm$0.1) in literature. This ratio (slope) can be used as a fingerprint for the paddy-residue burning over the IGP. Further, the absorption coefficient of BrC at 365 nm (b_{abs_365}), was assessed from absorption spectra of water-soluble ($b_{abs_365_water}$) and methanol-soluble ($b_{abs_365_methanol}$) organic carbon. Subsequently, mass absorption efficiencies (MAE) of light absorbing water-soluble (MAE_{BrC_water}) and methanol-soluble ($MAE_{BrC_methanol}$) organic fraction were estimated. Observed $MAE_{BrC\_methanol}$ was about 2.4, 1.4 and 1.5 times higher than MAE_{BrC_water} during T1, T2, and T3, respectively, suggesting that there is a significant and variable fraction of water-insoluble BrC over the IGP. Further, water- and methanol-soluble BrC during T2 exhibited different characteristics features compared to that during T1 and T3. At longer wavelengths ($>$400 nm), higher absorption was observed. Spectra of these samples showed that wavelength dependent absorption decreases in relatively slower manner, and had a characteristic absorption band in the 380-550 nm range, suggesting contribution from some specific chromophores associated with BB emissions. This absorption band was very prominent in the night samples, and became insignificant in the day samples. This observation was ascribed to photo-bleaching/volatilization of BrC and/or rising boundary layer height. Similarly, the ratios of b_{abs_405}/b_{abs_365} and b_{abs_420}/b_{abs_365}(for methanol soluble extracts) showed significant day/night variability during T2, suggesting that BrC composition was also different in day and night samples.