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Source apportionment of light absorbing WSOC in South Asian outflow

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Carbonaceous aerosols (CA) formed over South Asia are of special concern for human health and regional climate impacts. Anthropogenic emissions forming CA are generally high throughout the region and particularly over the Indo-Gangetic Plain.

The net effects of CA on radiative climate forcing are still uncertain. One of the components of CA is black carbon (BC), dominated by soot-like elemental carbon, a strong absorber of solar radiation. Another component is organic carbon (OC), traditionally considered as a light scattering particle. However, recent field studies have shown OC to absorb at lower wavelengths. Thus OC, in addition to BC, may also contribute to light absorption and have a positive direct radiative effect on climate. Light absorbing organic aerosol is usually termed brown carbon (BrC). A significant fraction of BrC is water-soluble, therefore its dissolution into clouds could result in absorbing droplets that affect the cloud absorption and thus contributing to the indirect aerosol climate effects.

In this study, light absorption and $\delta^{13}C + \Delta^{14}C$ isotopic measurements of WSOC were studied in fine aerosols (PM 2.5) at two sites during early pre-monsoon season. New Delhi, one of the most densely populated and industrialized urban megacities in South Asia, was chosen to represent a strong source and Maldives Climate Observatory at Hanimaadhoo (MCOH) was chosen as a regional receptor which in wintertime is located downwind of the Indian subcontinent. Sampling in Delhi was done from mid-February to mid-March 2011 and in MCOH during March 2012.

WSOC concentrations were 12 ± 4.5 and 0.71 ± 0.30 $\mu g\ m^{-3}$ in Delhi and MCOH respectively. Whereas in Delhi WSOC contributed $31\pm4\%$ of total organic carbon, this contribution was slightly higher in MCOH ($40\pm12\%$). Light absorption by WSOC exhibited strong wavelength (λ) dependence. In Maldives, WSOC Absorption Ångström Exponent (AAE) was found to be 6.9 ± 0.4 and Mass Absorption Efficiency (MAE) measured at 365 nm was 0.38 ± 0.09 m^2g^{-1}. MAE increased sharply from long to short wavelengths. This evidences that WSOC is constituted of compounds that are light absorbing near ultraviolet wavelengths. WSOC in Maldives would contribute 19% of the total absorption at wavelengths below 400 nm.

Since a substantially absorbing effect by WSOC has been shown here and in other studies, knowledge about WSOC sources is needed. The sources of WSOC in atmospheric aerosols, which may be both of primary and secondary origins, are in general poorly constrained. Biomass burning is a significant primary source of WSOC whereas secondary organic aerosol formation also takes place. Isotopic measurements (stable ($\delta^{13}C$) and radiocarbon ($\Delta^{14}C$)) were applied to inform on the origin of WSOC for both sites. $\Delta^{14}C$ allows quantitative apportionment between fossil fuel versus biogenic and biomass combustion sources. $\delta^{13}C$ is informative of the atmospheric processing of WSOC during long-range transport of aerosols.