Biomass Burning Induced Carbonaceous Aerosols: Mass Distributions, Radiative Effects and Climatic Feedbacks in South Africa

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Biomass Burning (BB) activities are an important regional source of atmospheric trace gases and aerosols in southern Africa. Using a series of multi-year simulations with a coupled regional climate-chemistry model, the present study investigates the mass distributions, radiative effects and climatic feedbacks of BB induced Carbonaceous Aerosols (CAs) [BC, OC and Total Carbon (TC=BC+OC)] in South Africa. The results show that during the southern Africa peak BB season (July–October) higher loads of CAs (up to: BC ~ 1 mg/m^2, OC ~ 7 mg/m^2 and TC ~ 8.1 mg/m^2) are found in eastern parts of South Africa. All-sky net radiative forcing demonstrates that BB induced CAs reduce net radiation absorbed by the surface (up to: BC ~ -2.1 W/m^2, OC ~ -1.95 W/m^2 and TC ~ -4.1 W/m^2), via enhancing radiative heating within the atmosphere (up to: BC ~ +2.8 W/m^2, OC ~ +0.9 W/m^2 and TC ~ +3.7 W/m^2). This is attributed to short-wave absorption primarily by BC and slightly by OC aerosols. These radiative perturbations of CAs instigate alterations on thermal and dynamical fields of the atmosphere. This resulted changes in background aerosol concentrations, hence promoted climate signals of CAs in areas far away from their loading zones. The inclusion of radiatively interactive CAs resulted both positive and negative changes on Net Atmospheric Heating Rate (NAHR: from -0.4 to +0.62 K/day). Areas which experience NAHR reduction showed column integrated Cloud Cover (CC) enhancement. However, the NAHR positive feedback increase atmospheric instability, accordingly: CC over arid areas decreased (up to ~ -4%) and over wet/semi-wet regions increased (up to ~ +6%). The CAs induced changes on surface temperature (from -0.9 to +0.45 K) and surface sensible heat flux (from -19 to +10.5 W/m^2), are more closely correlated with CAs' semi-direct effect induced CC alterations than their direct radiative forcing. Furthermore, the CAs radiative feedbacks induced convection process and thermodynamic adjustments also consequence changes on boundary layer height (from -40 to +32 m), surface pressure (from -0.04 to +0.05 hPa) and surface wind fields. Overall, the present contribution underscores the importance of BB induced CAs radiative feedbacks on thermodynamic structure and cloud fields – which both play a far-reaching role in moderating other climatic anomalies.