In the present study, integrated modeling approaches were developed to examine potential emission flux to aerosol pollutants, distribution of aerosol constituents and emissions of black carbon (BC) over India. A combined source-receptor approach through an application of fuzzy c-mean clustering to back trajectory data in conjunction with emission flux and residence time weighted aerosols analysis was developed to evaluate the potential emission flux to winter-monsoon (WinMon) aerosols over Bengal Gangetic plain urban (Kolkata, Kol) and semi-urban atmospheres (Kharagpur, Kgp). WinMon mean aerosol optical depth (AOD) and °Angstr¨om exponent (AE) at Kol were respectively slightly higher than and nearly equal to that at Kgp. Distinct features of emission flux contribution potential (EFCP) to aerosol pollutants were identified over Bengal Gangetic plain. While the surface layer (SL) of urban atmosphere (Kol) was inferred having a higher influence from anthropogenic emissions than that of semi-urban atmosphere (Kgp), the elevated layer (EL) of both atmospheres were found being equally influenced from anthropogenic emissions; the EL of Kol, unlike that of Kgp, had also a predominant influence from dust. Specific hotspot of EFCP zones of aerosol constituents at SL and EL were identified over the Indo-Gangetic plain (IGP). Though the Africa (AFR) cluster was constituted of significantly high emission flux source potential of dust emissions, the EFCP of dust from northwest India (NWI) was comparable to that from AFR at Kol SL/EL.

The newly formulated constrained aerosol simulation (constrsimu) which resulted from a fusion of measured AOD and simulated aerosol characteristics from a free running aerosol model with the general circulation model (GCM) led to obtain the most concurred estimates of aerosol constituents with observations during pre-monsoon and winter-monsoon season, including their sources during the Tigerz experiment. Estimates of constrsimu (GCM) simulation was mostly 70–100% (20–50%) of the measured BC, organic carbon (OC), and sulfate. The constrsimu estimates also captured a higher value of pre-monsoon and winter-monsoon mean surface concentration and AOD due to anthropogenic aerosol constituents over the IGP than the rest of India. Spatial distribution of aerosol surface concentration during winter-monsoon in contrast to that during pre-monsoon, was predominated by a higher contribution from anthropogenic aerosols than dust. Spatially and temporally resolved gridded constrained BC emissions over India was estimated in a strategic integrated modeling approach; this was done extracting information on base BC emissions (using India emission inventory implemented in a GCM) and atmospheric BC concentration from a GCM simulation in conjunction with the receptor modeling approach. Constrained BC emission rate obtained was about seven times the base emissions in GCM. Sensitivity analysis between BC emissions and its atmospheric concentration simulated in Weather Research Forecast model coupled with Chemistry (WRF-Chem) was done. A significant increase in coherence of simulated BC concentration with observations was obtained with the constrained emissions compared to base emissions.