EGU21-10899
https://doi.org/10.5194/egusphere-egu21-10899
EGU General Assembly 2021

Chemical characteristics and optical properties of brown carbon aerosol in Karlsruhe during winter

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Brown carbon (BrC) aerosol has significant climatic impact due to its ability to absorb solar radiation in the near-ultraviolet and visible spectral range. However, chromophores responsible for light absorption in atmospheric aerosol particles are not well understood in urban areas. Therefore, optical properties and chromophore composition of brown carbon were characterized during March 2020 in downtown Karlsruhe, a city of 300000 inhabitants in southwest Germany.

In this study, total non-refractory particle mass was measured with a high-resolution time-of-flight aerosol mass spectrometer (HR-TOF-MS; hereafter AMS). Furthermore, Aerosol particles were collected on filters and analyzed in the laboratory. Filter samples were extracted by methanol and the corresponding solutions were analyzed by excitation-emission spectroscopy (AquaLog), resulting in characteristic light absorption and fluorescence spectra. Furthermore, filters were analyzed by a filter inlet for gases and aerosols coupled to a high-resolution time-of-flight chemical ionization mass spectrometer (FIGAERO-HR-TOF-CIMS; hereafter CIMS) employing iodide ions, which results in the molecular composition of oxygenated organic aerosol compounds.

Our results show that the average light absorption and mass absorption efficiency of brown carbon at 365 nm were (2.8±1.9) Mm^{-1} and (1.1±0.2) m^2 g^{-1} respectively. Parallel factor (PARAFAC) analysis allowed for identification of four types of fluorescence in methanol-soluble organic compounds. HULIS-like compounds contributed 47%, road dust-like compounds 19%, biomass burning-like compounds 25%, and protein-like compounds 9%. Positive matrix factorization (PMF) analysis of organic detected by AMS led to five characteristic organic compound classes. Of these five classes, the biomass burning organic aerosol showed a correlation coefficient of r2=0.7 with the biomass burning like factor from the fluorescence analysis. Oxygenated organic aerosol components had potentially lower fluorescence intensity and mass absorption coefficiency. Furthermore, five nitroaromatic compounds were identified by CIMS ($C_7H_7O_3N$, $C_7H_7O_4N$, $C_6H_5O_5N$, $C_6H_5O_4N$, and $C_6H_5O_3N$) which contributed 0.2%-0.9% to total organic mass, but can explain 3%-6% of the absorption at 365 nm.