



Source apportionment of carbonaceous aerosols in Xi'an, China: insights from one-year measurement of radiocarbon and stable carbon isotope

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Sources of organic carbon (OC) and elemental carbon (EC) in Xi'an, China are investigated based on one-year radiocarbon and stable carbon isotope measurements. The radiocarbon results demonstrate that EC is dominated by fossil sources throughout the year, with a mean contribution of $83 \pm 5 \%$ ($7 \pm 2 \mu\text{g m}^{-3}$). The remaining $17 \pm 5 \%$ ($1.5 \pm 1 \mu\text{g m}^{-3}$) is attributed to biomass burning, with higher contribution in the winter ($\sim 24 \%$) compared to the summer ($\sim 14 \%$). Stable carbon isotopes of EC ($\delta^{13}\text{C}_{EC}$) are enriched in winter ($-23.20 \pm 0.35\%$) and depleted in summer ($-25.94 \pm 0.46\%$), indicating the influence of coal combustion in winter and liquid fossil fuel combustion in summer. By combining radiocarbon and stable carbon signatures, relative contributions from coal combustion and liquid fossil fuel combustion are estimated as 45% ($29\text{--}58 \%$, interquartile range) and 31% ($18\text{--}46 \%$) in winter, respectively, whereas in other seasons more than one half of EC are from liquid fossil combustion. In contrast with EC, the contribution of non-fossil sources to OC is much larger, with an annual average of $54 \pm 8 \%$ ($12 \pm 10 \mu\text{g m}^{-3}$). Clear seasonal variations are seen in OC concentrations both from fossil and non-fossil sources, with maxima in winter and minima in summer, because of unfavorable meteorological conditions coupled with enhanced fossil and non-fossil activities in winter, mainly biomass burning and domestic coal burning. $\delta^{13}\text{C}_{OC}$ exhibited similar values with $\delta^{13}\text{C}_{EC}$, and showed strong correlations ($r^2 = 0.90$) in summer and autumn, indicating similar source mixtures with EC. In spring, $\delta^{13}\text{C}_{OC}$ is depleted ($1.1\text{--}2.4 \%$ compared to $\delta^{13}\text{C}_{EC}$), indicating the importance of secondary formation of OC (e.g., from volatile organic compound precursors) in addition to primary sources. Modelled mass concentrations and source contributions of primary OC are compared to the measured mass and source contributions. There is strong evidence that both secondary formation and photochemical loss processes influence the final OC concentrations.