Supplemental material

Sources of black carbon at residential and traffic environments

Sanna Saarikoski[1], Jarkko V. Niemi[2], Minna Aurela[1], Liisa Pirjola[3,4], Anu Kousa[2], Topi Rönkkö[3], Hilkka Timonen[1]

[1]Atmospheric Composition Research, Finnish Meteorological Institute, Helsinki, FI-00101, Finland
[2]Helsinki Region Environmental Services Authority (HSY), Helsinki, FI-00066, Finland
[3]Aerosol Physics Laboratory, Physics Unit, Tampere University, Tampere, FI-33014, Finland
[4]Department of Automotive and Mechanical Engineering, Metropolia University of Applied Sciences, Vantaa, 01600, Finland

Correspondence to: Sanna Saarikoski (sanna.saarikoski@fmi.fi)

Table S1. The contribution of rBC (the sum of C_2^+, C_3^+ and C_4^+) to the mass spectra of the PMF factors at the residential site.

PMF factor	3 factors	4 factors	5 factors
HOA	0.067	0.049	0.060
BBOA	0.077	0.090	0.079
LV-OOA	0.011	0.017	0.084
SV-OOA		0.041	0.022
LV-OOA-LRT			0.014

Table S2. The contribution of rBC (the sum of C_2^+, C_3^+ and C_4^+) to the mass spectra of the PMF factors at the street canyon site.

PMF factor	3 factors	4 factors	5 factors
HOA	0.139	0.142	0.142
BBOA	0.030	0.011	0.012
LV-OOA	0.086	0.077	0.081
SV-OOA		0.079	0.075
CoOA			0.047

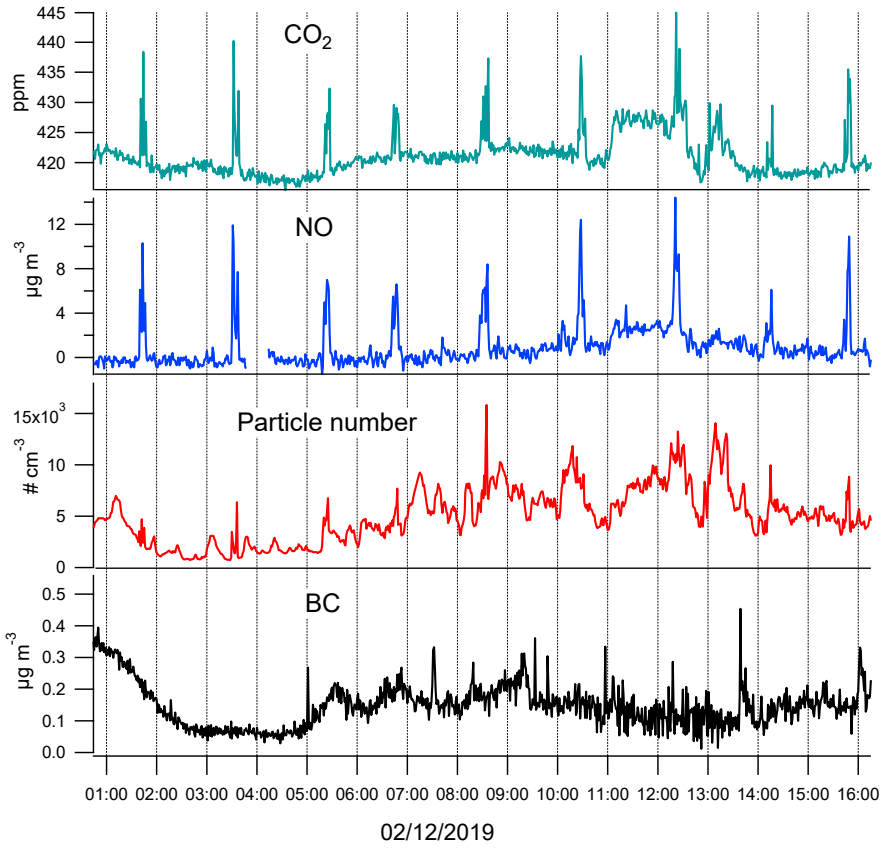

Figure S1. Example of the emissions from oil burning at the residential site. Oil burning emissions can be seen with sharp peaks (~10 minutes) especially for CO_2 and NO. Particle number concentration (>5 nm particles) was measured with the Condensation Particle Counter A20 (Airmodus, Helsinki, Finland).

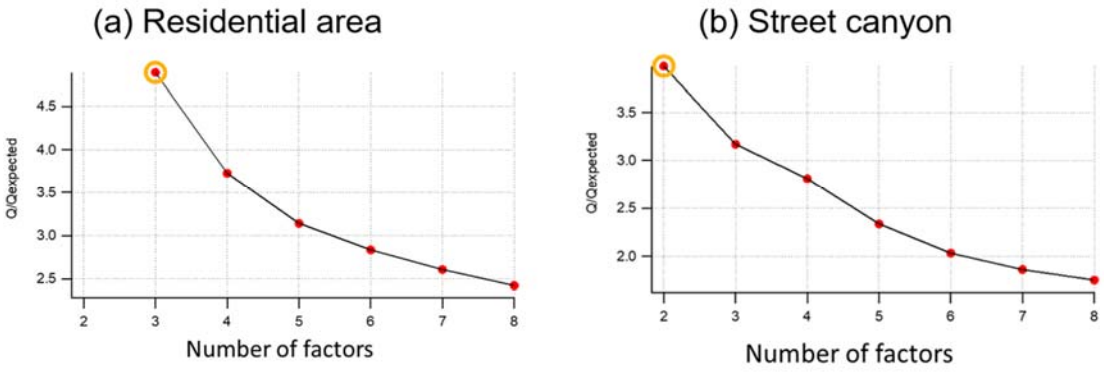

Figure S2. $Q/Q_{expected}$ for the PMF solutions of 2–8 factors for the data measured at the residential area (a) and street canyon (b). For the residential site, two-factor solution was inconclusive.

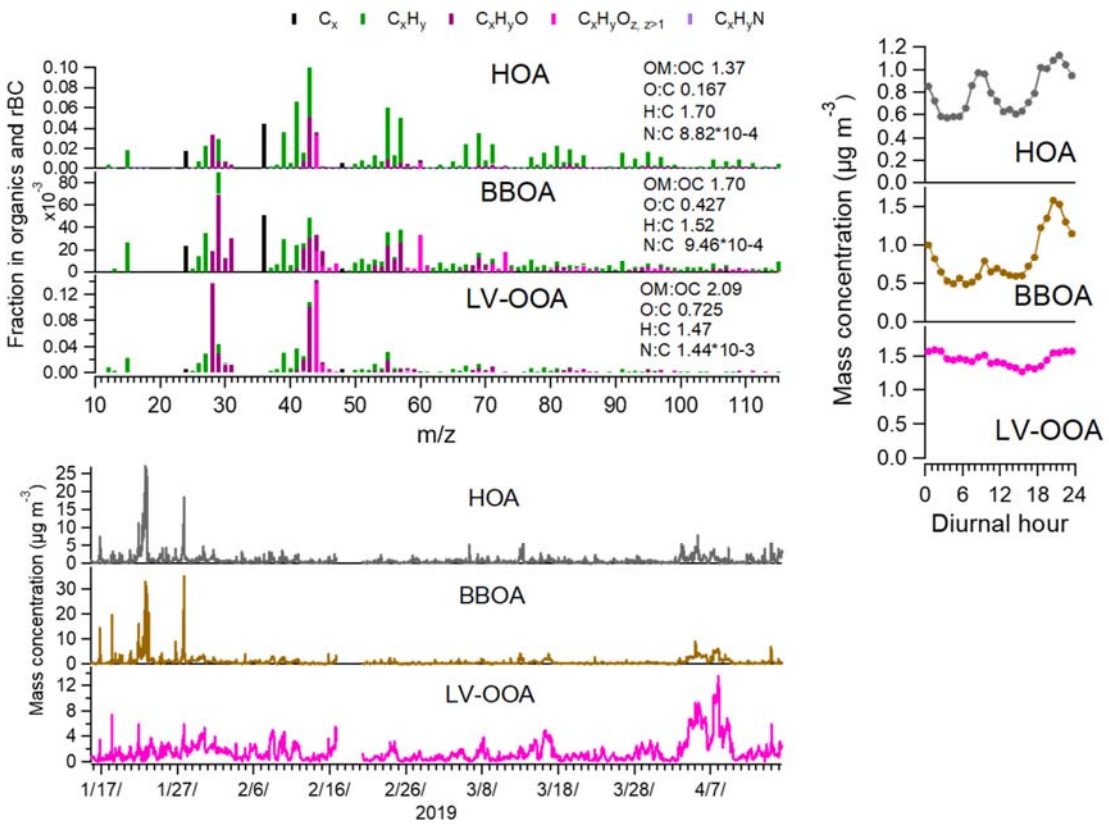

Figure S3. Mass spectra, times series and campaign-average diurnal trends for the three factor PMF solution for organics and rBC at the residential site. Elemental ratios (OM:OC, O:C, H;C and N:C) were calculated to organic mass spectra excluding rBC fragments. Colors in the mass spectra represent different types of organic fragments.

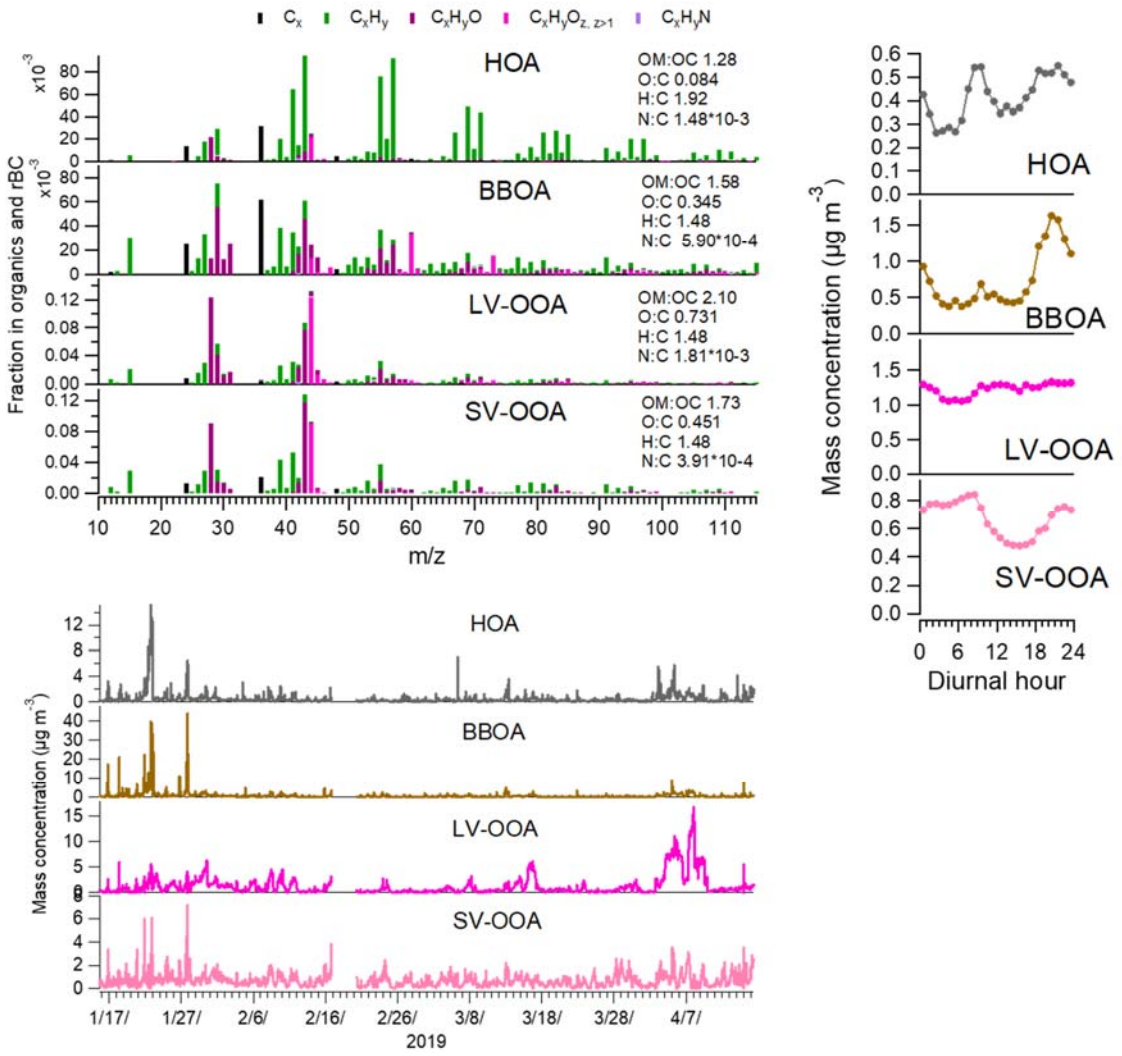

Figure S4. Mass spectra, times series and campaign-average diurnal trends for the four factor PMF solution for organics and rBC at the residential site. Elemental ratios (OM:OC, O:C, H;C and N:C) were calculated to organic mass spectra excluding rBC fragments. Colors in the mass spectra represent different types of organic fragments.

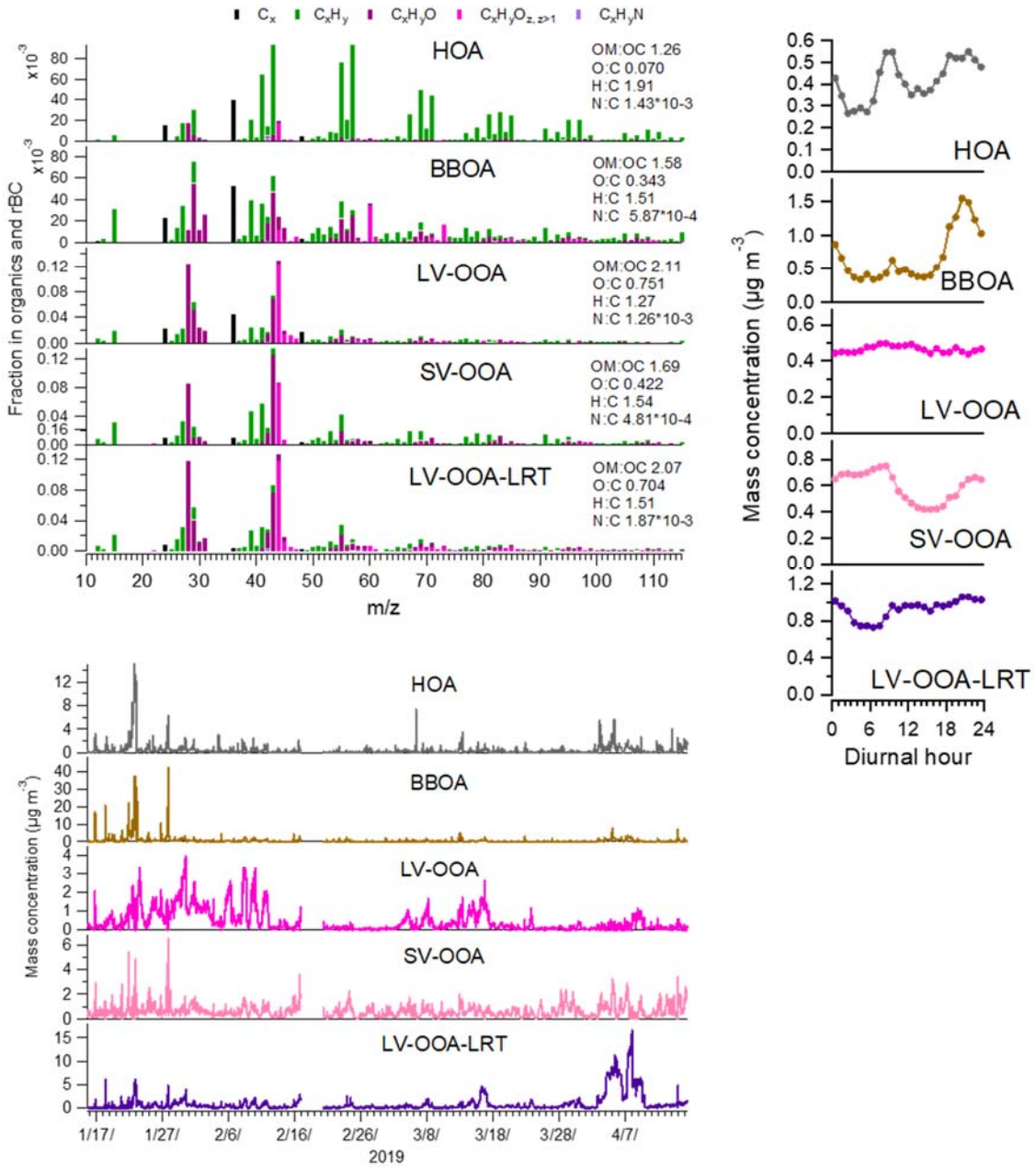

Figure S5. Mass spectra, times series and campaign-average diurnal trends for the five factor PMF solution for organics and rBC at the residential site. Elemental ratios (OM:OC, O:C, H;C and N:C) were calculated to organic mass spectra excluding rBC fragments. Colors in the mass spectra represent different types of organic fragments.

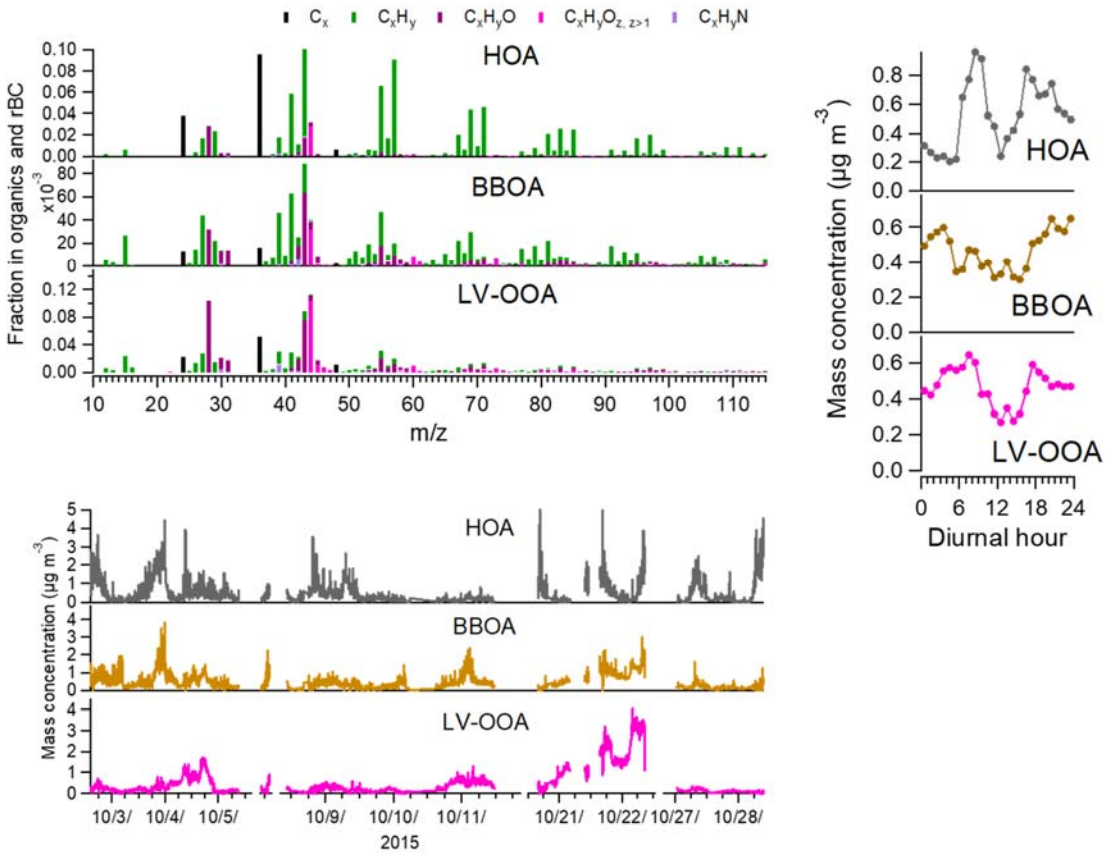

Figure S6. Mass spectra, times series and campaign-average diurnal trends for the three factor PMF solution for organics and rBC at the street canyon. Elemental ratios were not calculated due to the exclusion of CHO^+ from the input matrix. Colors in the mass spectra represent different types of organic fragments.

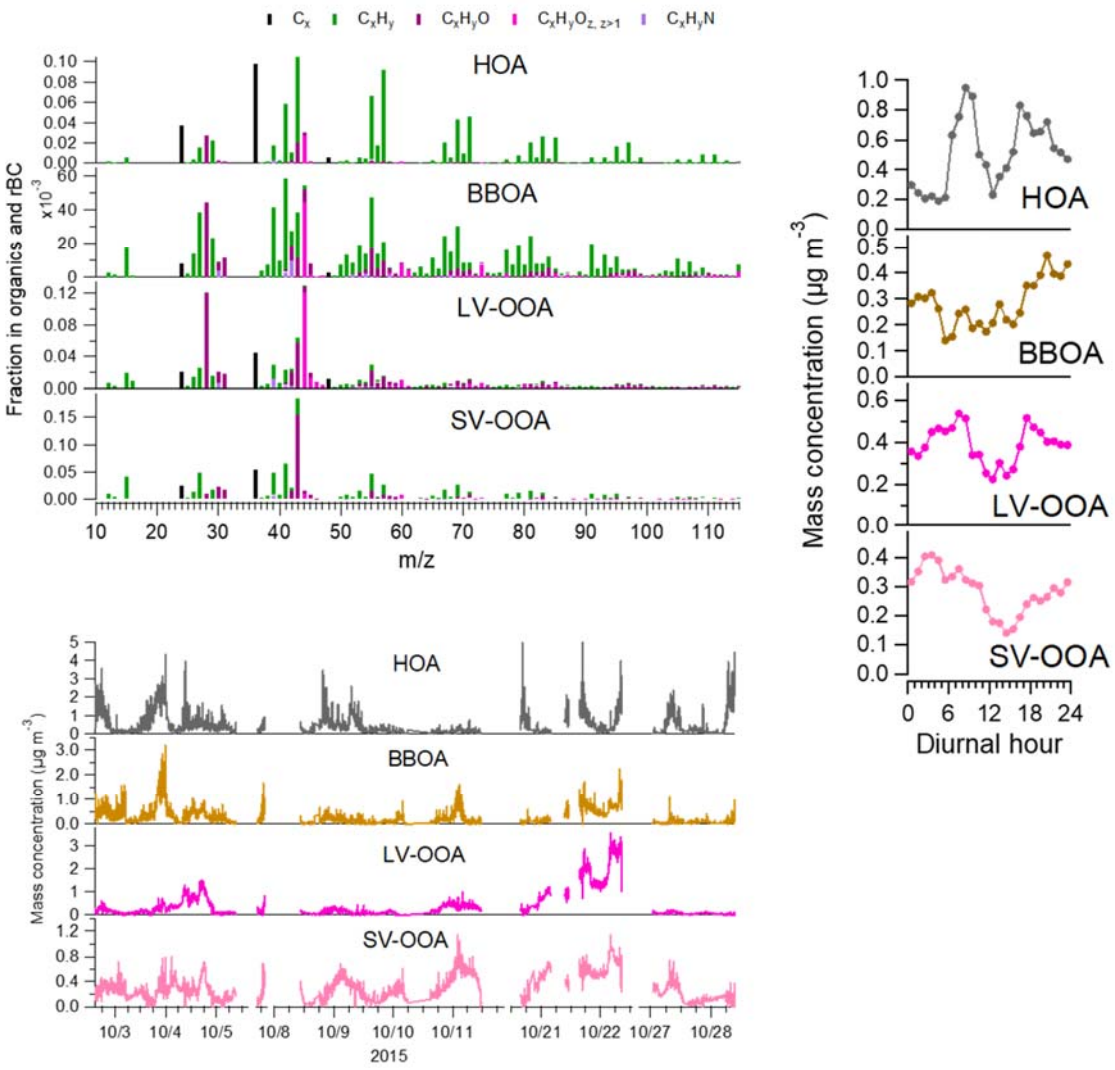

Figure S7. Mass spectra, times series and campaign-average diurnal trends for the four factor PMF solution for organics and rBC at the street canyon. Elemental ratios were not calculated due to the exclusion of CHO^+ from the input matrix. Colors in the mass spectra represent different types of organic fragments.

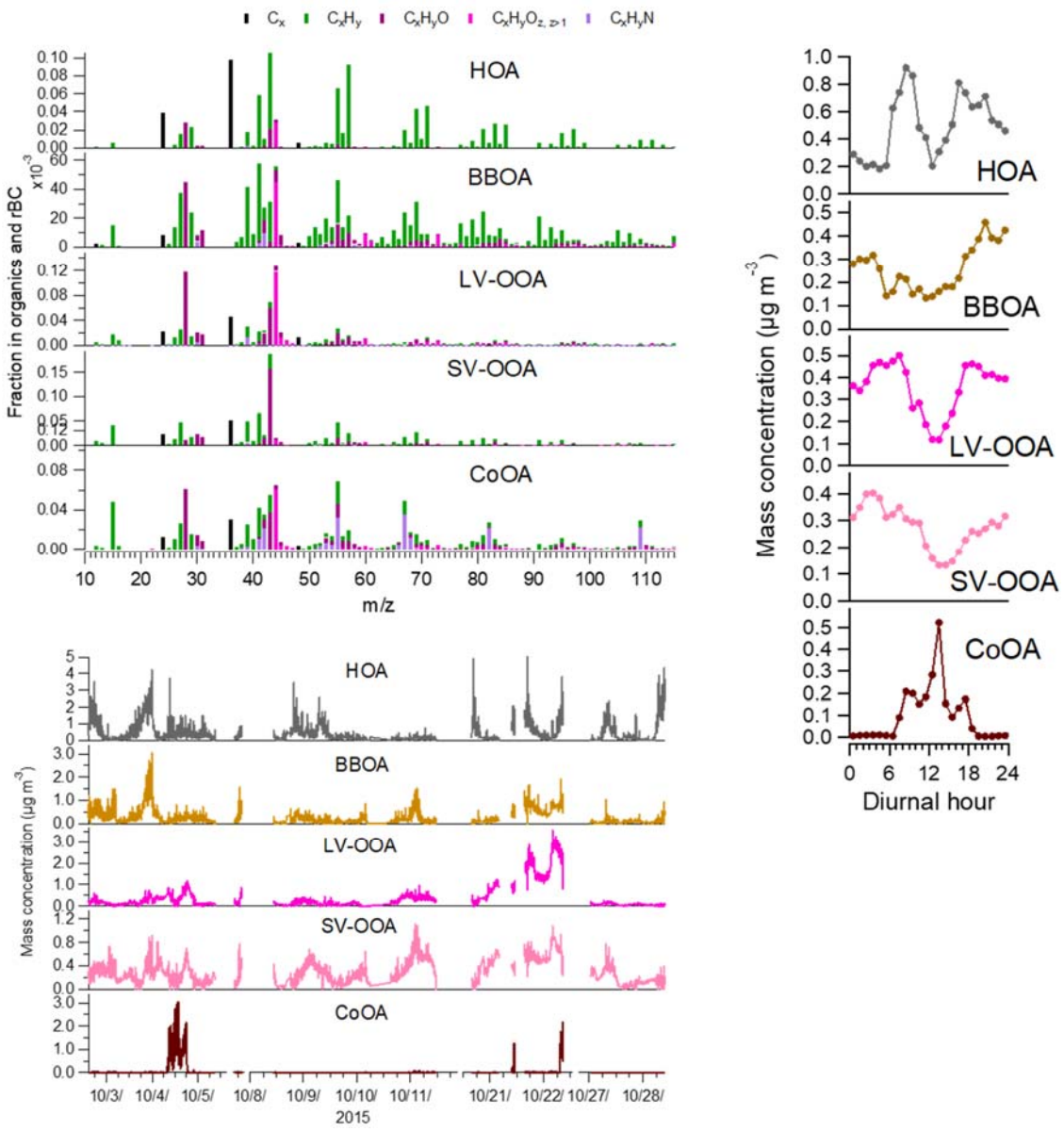

Figure S8. Mass spectra, times series and campaign-average diurnal trends for the five factor PMF solution for organics and rBC at the street canyon. Elemental ratios were not calculated due to the exclusion of CHO^+ from the input matrix. Colors in the mass spectra represent different types of organic fragments.

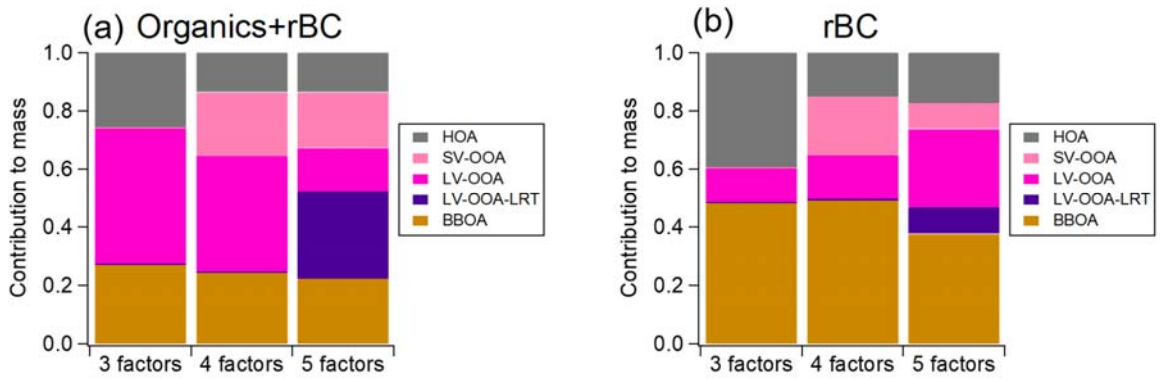

Figure S9. Contribution of 3–5 factors to organics and rBC (a) and rBC (b) at the residential site.

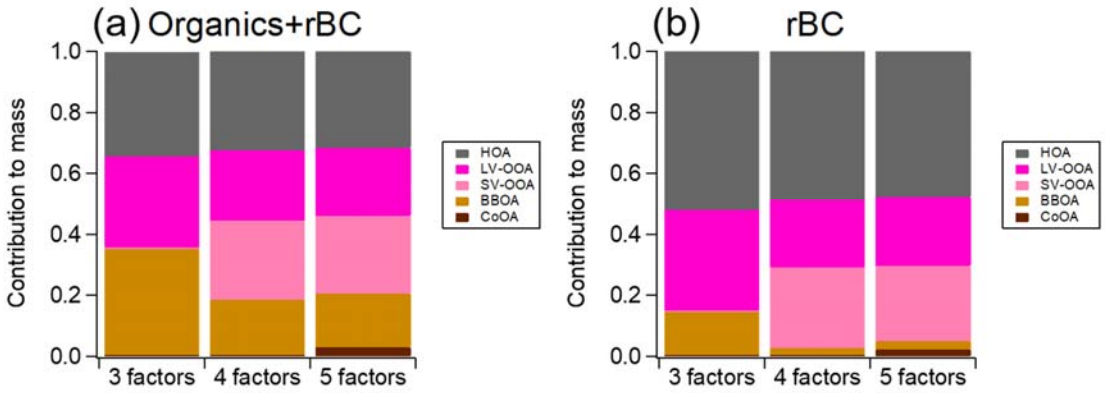

Figure S10. Contribution of 3-5 factors to organics and rBC (a) and rBC (b) at the street canyon.

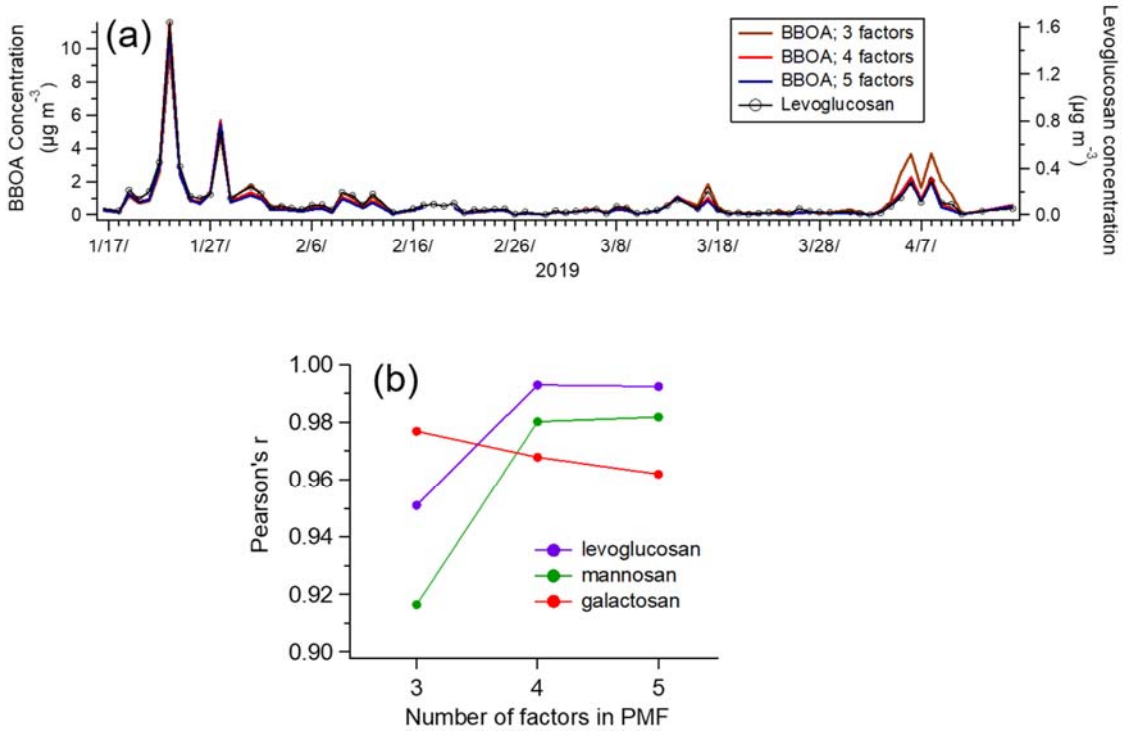

Figure S11. Time series of BBOA in 3–5 factor solutions and levoglucosan analysed from the PM_{10} filter samples (a), and the correlation between the time-series of BBOA in 3–5 factor solutions and levoglucosan, mannosan and galactosan (b). Pearson correlation coefficients.

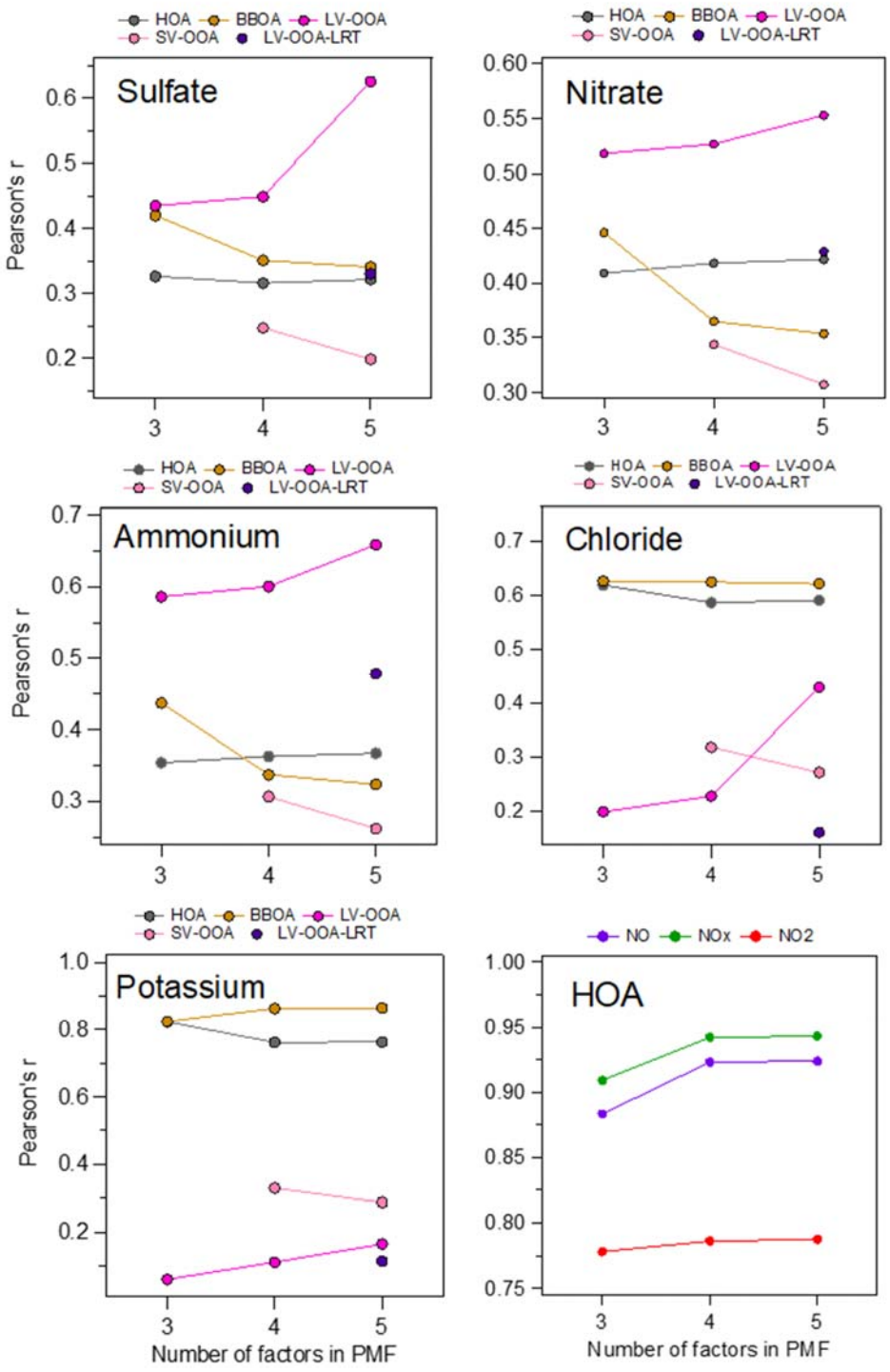

Figure S12. Correlations of the PMF factors with sulfate, nitrate, ammonium, chloride and potassium, and the correlation of HOA with NO, NO_2 and NO in 3–5 factor PMF solutions at the residential site. Pearson correlation coefficients.

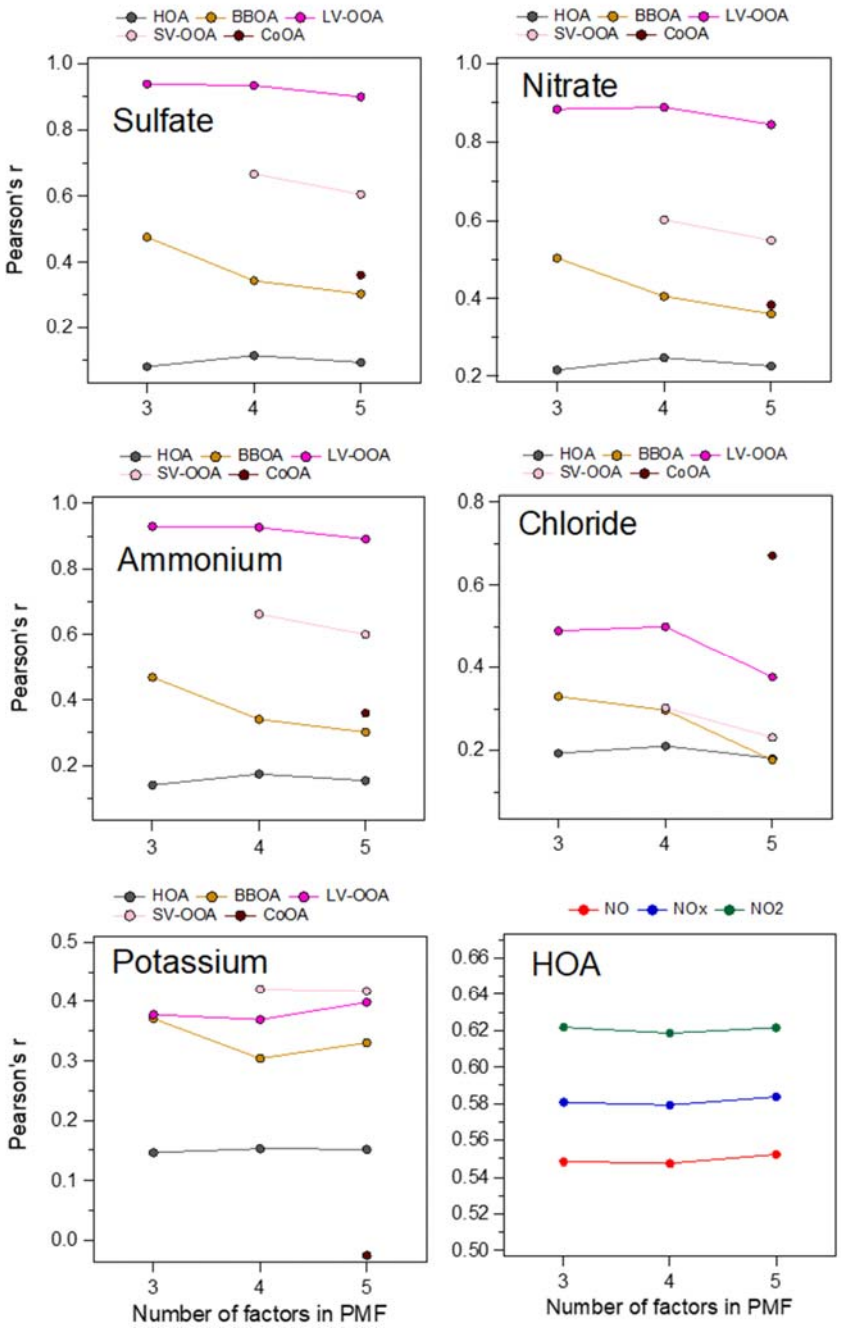

Figure S13. Correlations of the PMF factor with sulfate, nitrate, ammonium, chloride and potassium, and the correlation of HOA with NO_x, NO_2 and NO in 3–5 factor PMF solutions at the street canyon. Pearson correlation coefficients.

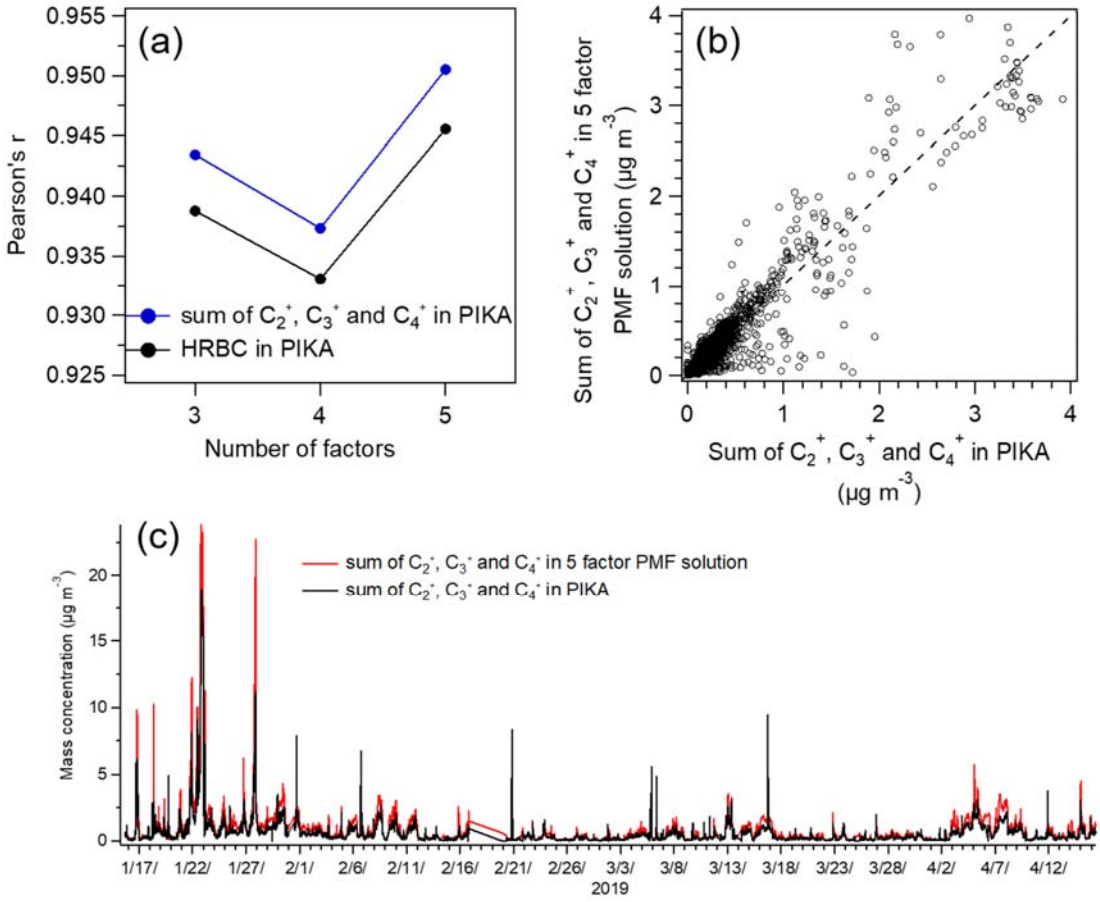

Figure S14. Correlation of the sum of C_2^+, C_3^+ and C_4^+ in 3–5 factor PMF solutions with the sum of C_2^+, C_3^+ and C_4^+ and HRBC in PIKA (a), x,y-plot for the correlation of the sum of C_2^+, C_3^+ and C_4^+ in 5 factor PMF solutions with the sum of C_2^+, C_3^+ and C_4^+ in PIKA (b), and the time-series of the sum of C_2^+, C_3^+ and C_4^+ in 5 factor PMF solutions and in PIKA (c) at the residential site. Dotted line in (b) shows 1:1 line.

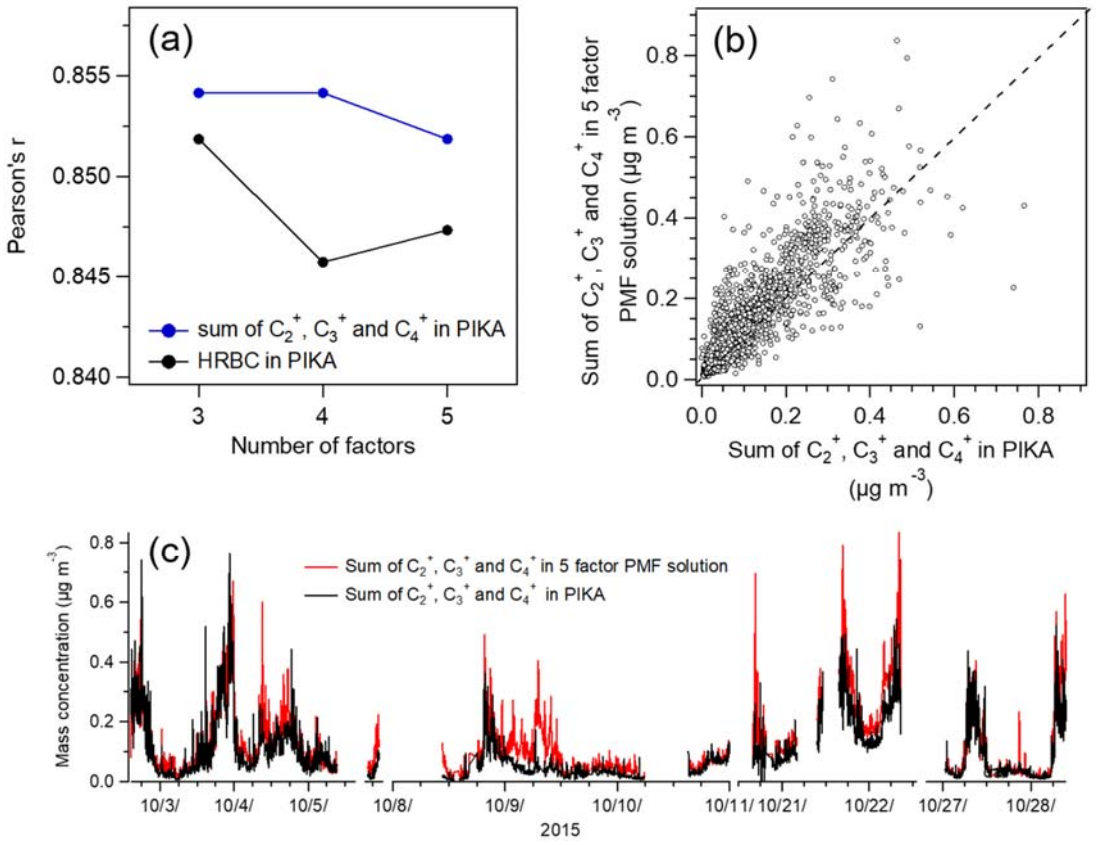

Figure S15. Correlation of the sum of C_2^+, C_3^+ and C_4^+ in 3–5 factor PMF solutions with the sum of C_2^+, C_3^+ and C_4^+ and HRBC in PIKA (a), x,y-plot for the correlation of the sum of C_2^+, C_3^+ and C_4^+ in 5 factor PMF solutions with the sum of C_2^+, C_3^+ and C_4^+ in PIKA (b) and the time-series of the sum of C_2^+, C_3^+ and C_4^+ in 5 factor PMF solutions and in PIKA (c) at the street canyon. Dotted line in (b) shows 1:1 line.

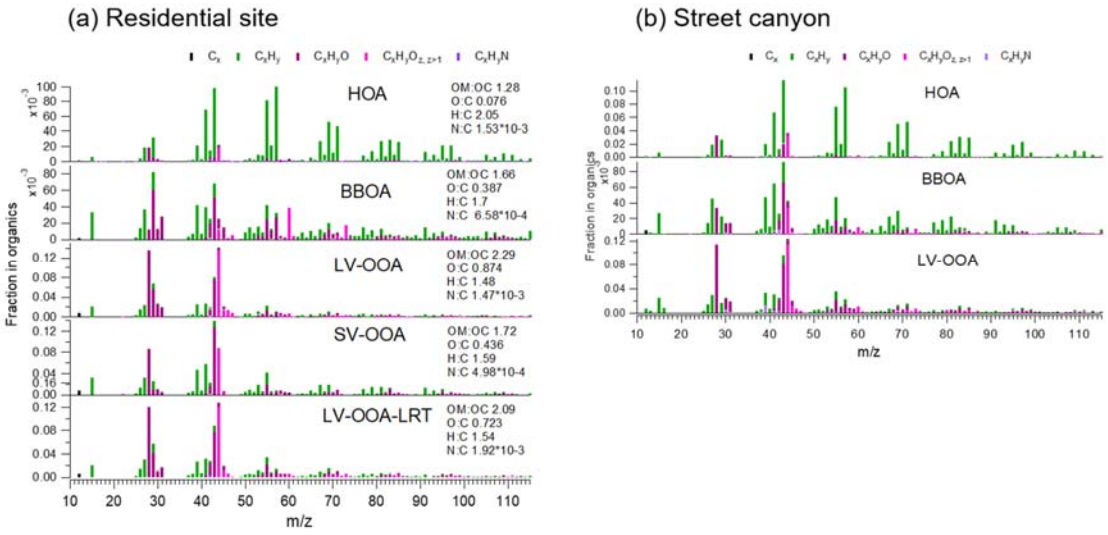

Figure S16. Five-factor PMF solution at the residential site (a) and three-factor PMF solution at the street canyon (b) for organics. Colors in the mass spectra represent different types of organic fragments.

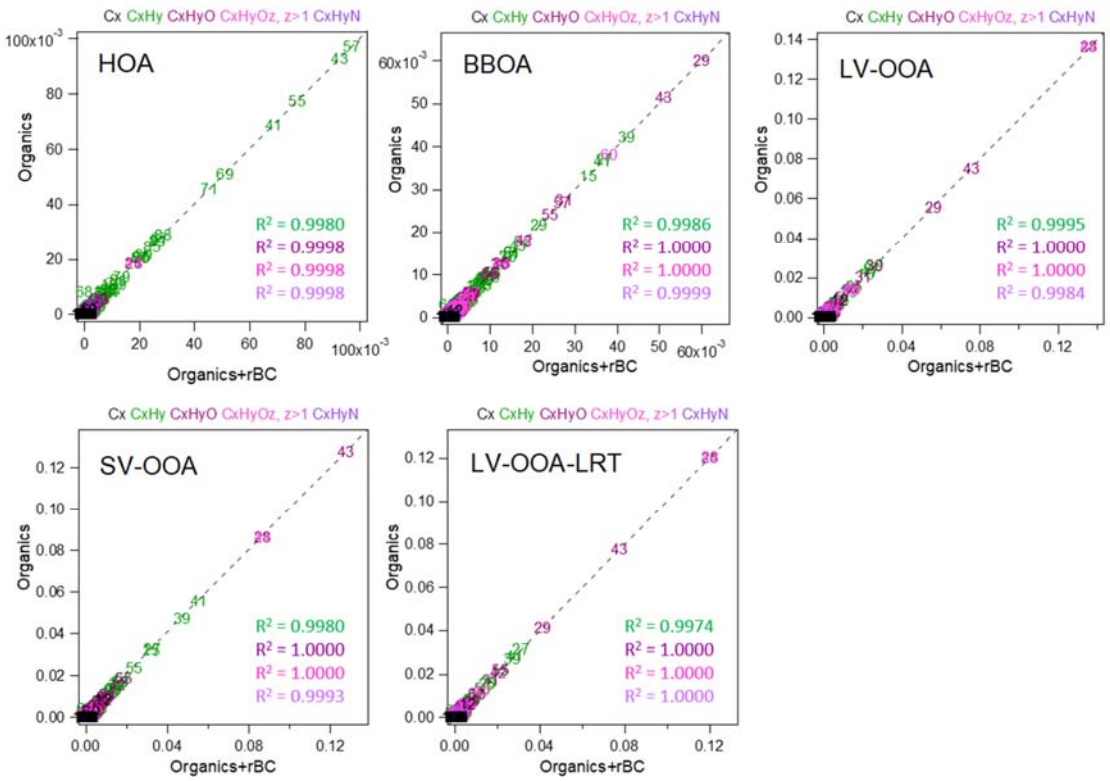

Figure S17. Comparison of mass spectra between the PMF solution with Organics+rBC and organics for five factor solution at the residential site. x-and y-axis units are fraction in organics. R^2 is the coefficient of determination in linear regression. Dotted line shows 1:1 line. Colors represent different types of organic fragments.

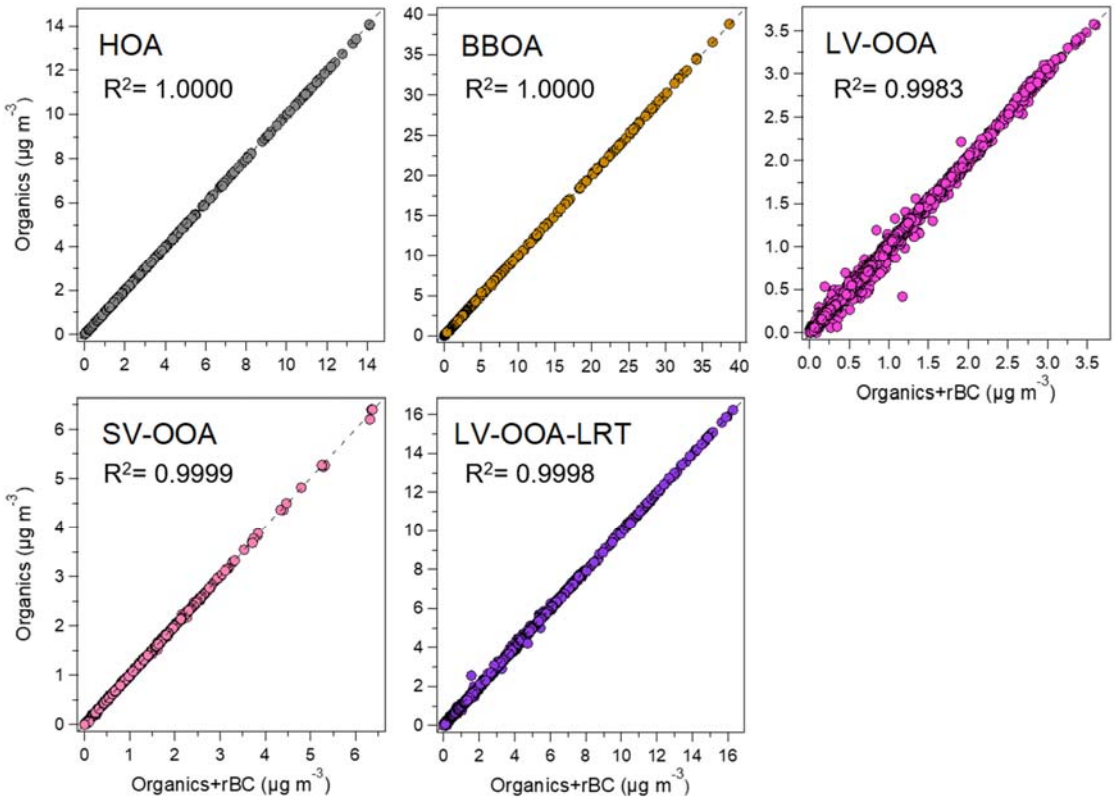

Figure S18. The comparison of time series between the PMF solution with Organics+rBC and organics for five factor solution at the residential site. R^2 is the coefficient of determination in linear regression. Dotted line shows 1:1 line.

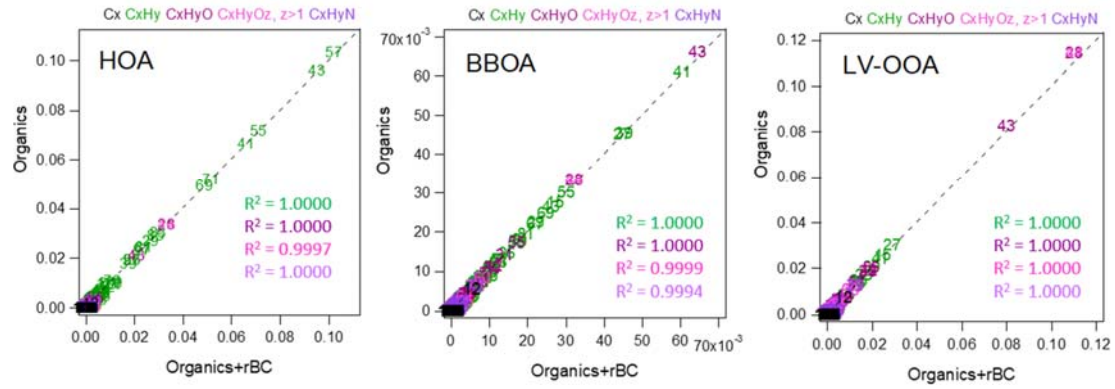

Figure S19. Comparison of mass spectra between the PMF solution with Organics+rBC and organics for three factor solution at the street canyon. x-and y-axis units are fraction in organics. R^2 is the coefficient of determination in linear regression. Dotted line shows 1:1 line. Colors represent different types of organic fragments.

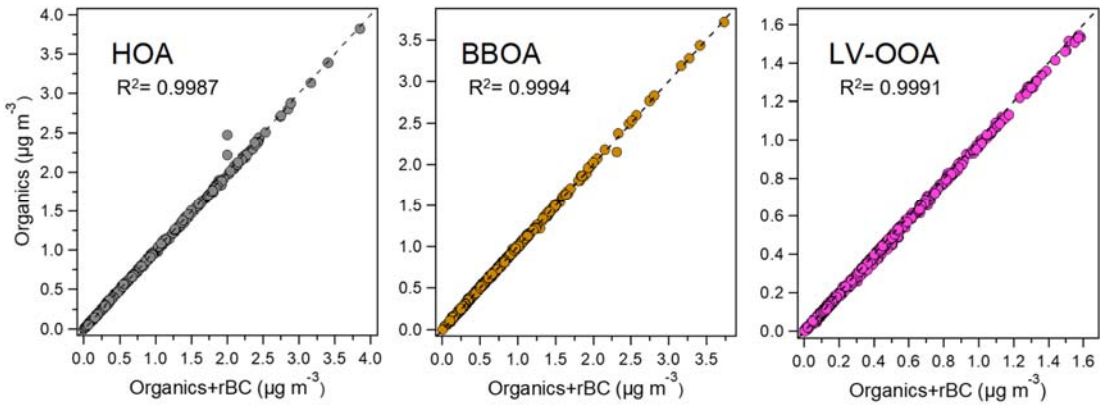

Fig. S20. The comparison of time series between the PMF solution with Organics+rBC and organics for three factor solution at the street canyon. R^2 is the coefficient of determination in linear regression. Dotted line shows 1:1 line.

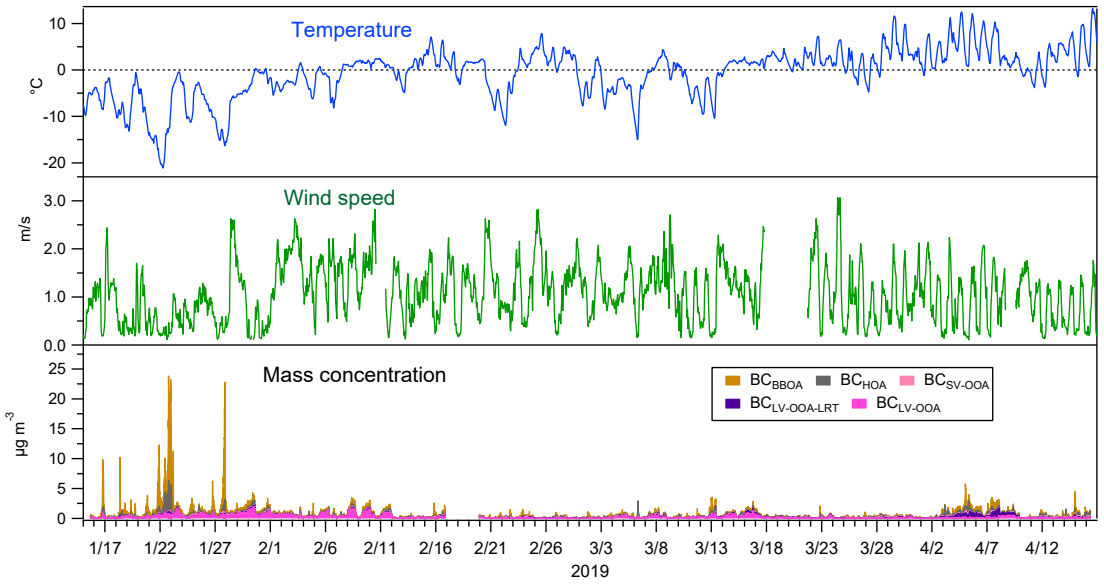

Figure S21. Time-series of ambient temperature, wind speed and the PMF factors at the residential area from January 16 to April 16 2019.

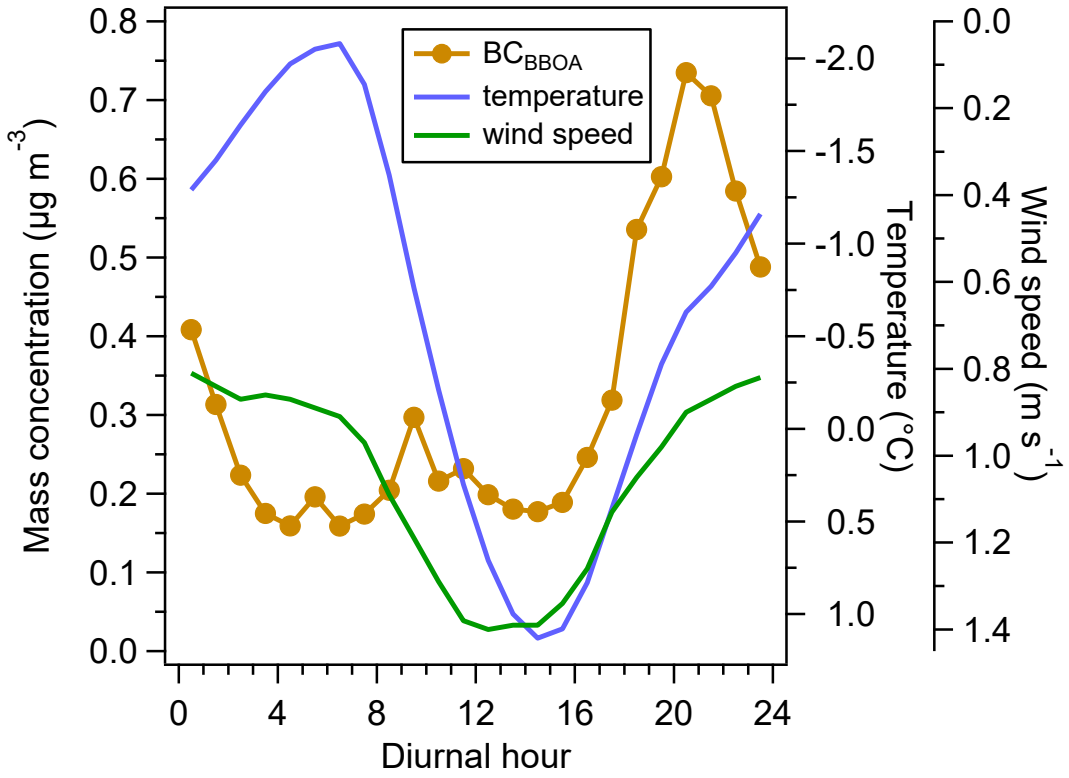

Figure S22. Diurnal variation of BC_{BBOA}, ambient temperature and wind speed. Note that the values shown in left and right y-axes are on opposite direction.

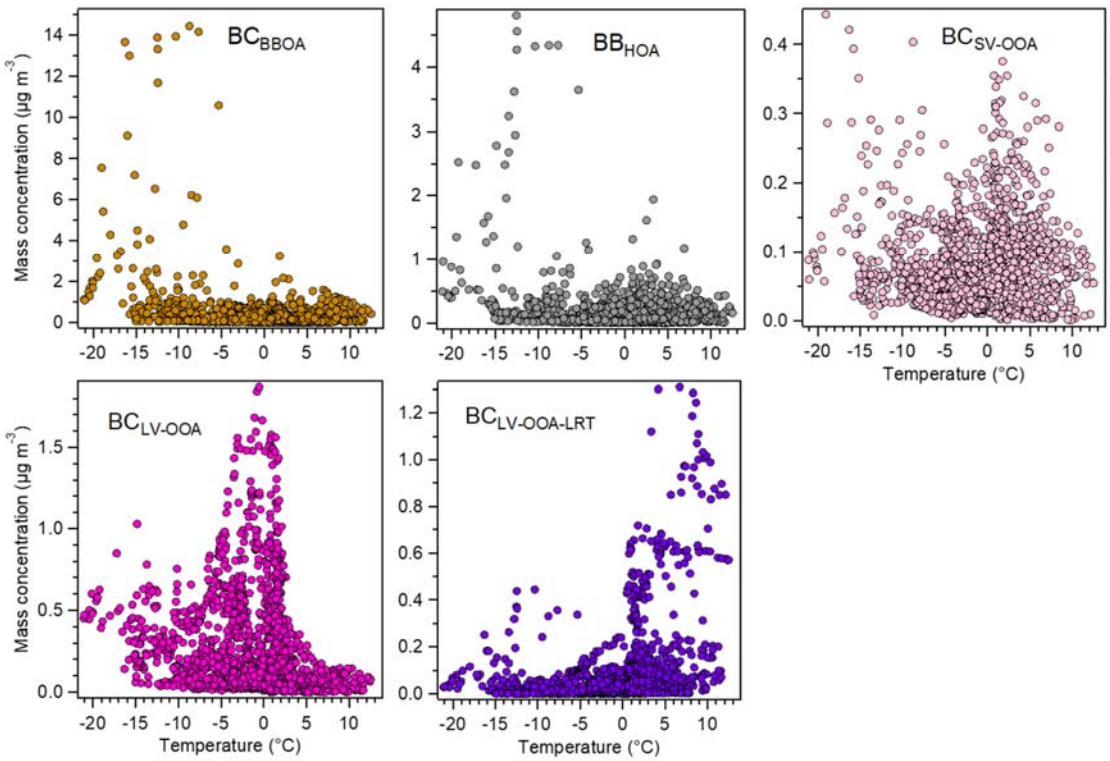

Figure S23. Correlation of the mass concentrations of the PMF factors with ambient temperature.

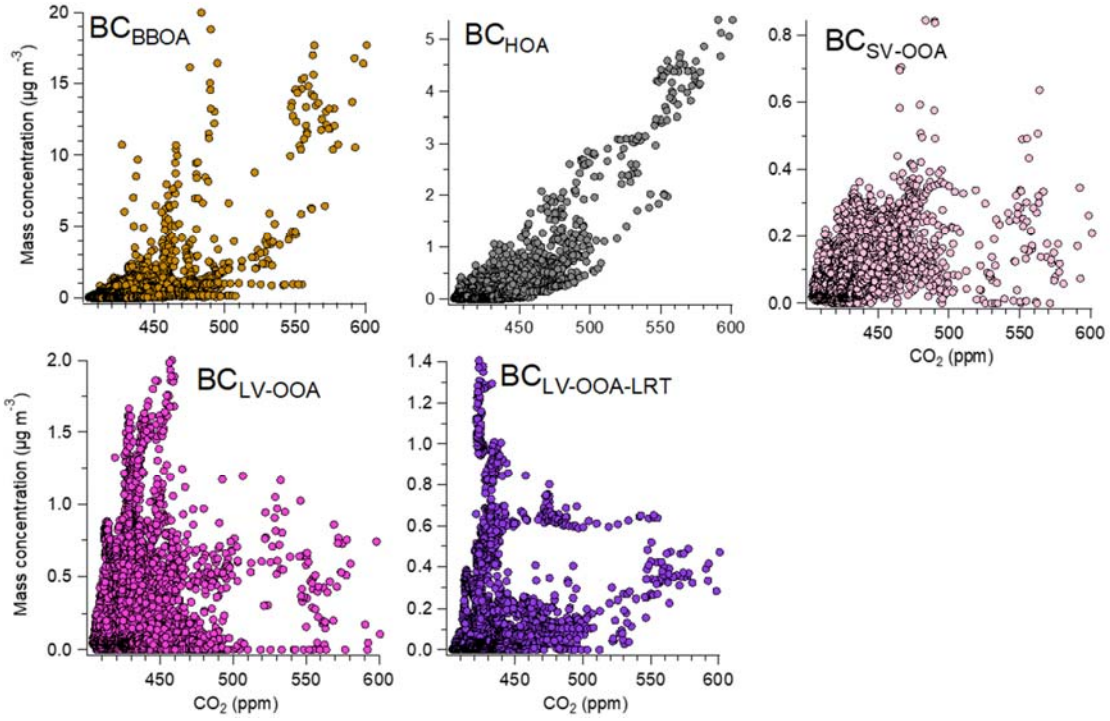

Figure S24. Correlation of PMF factors with the measured CO_2 concentrations at the residential site.

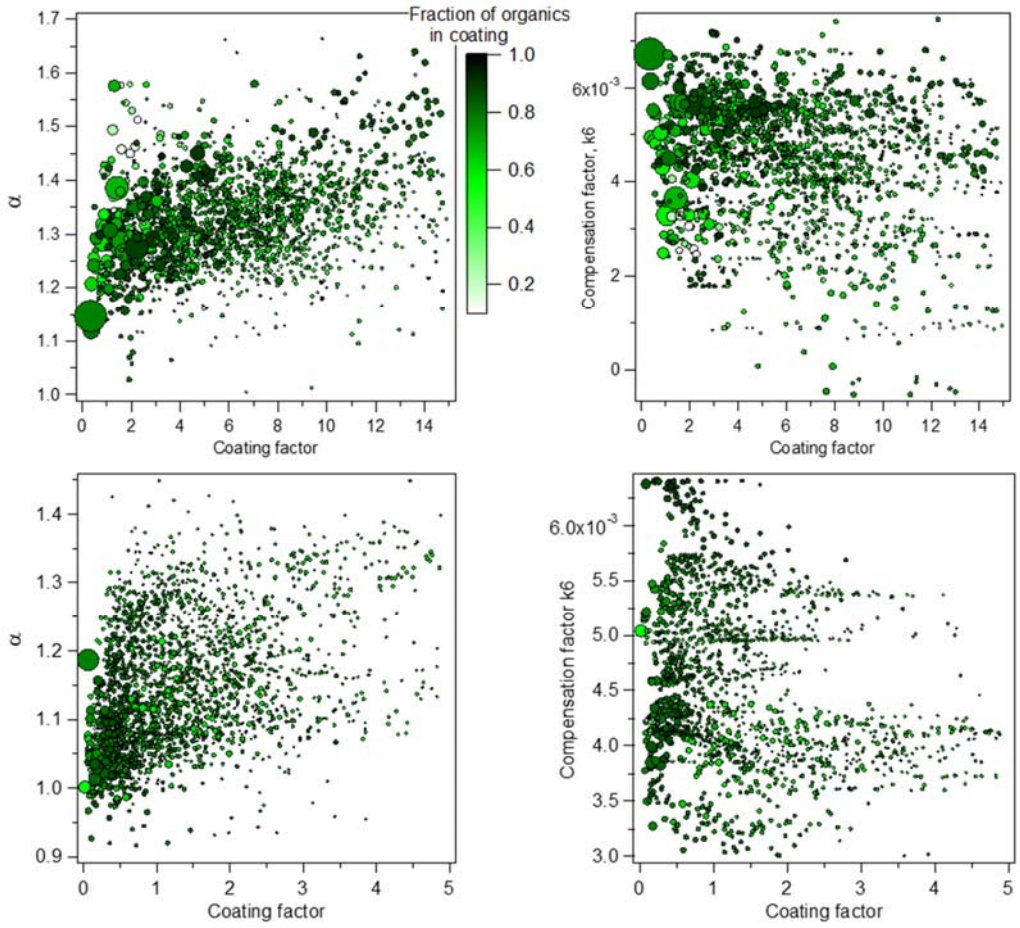

Figure S25. Absorption Ångström exponent (α) and compensation factor at 880 nm (k6) plotted against the coating factor at the residential (a–b) and street canyon (c–d) site. α was calculated as the ratio of 470 nm to 950 nm. Color presents the contribution of organics in the coating. Marker size displays ambient BC concentration.

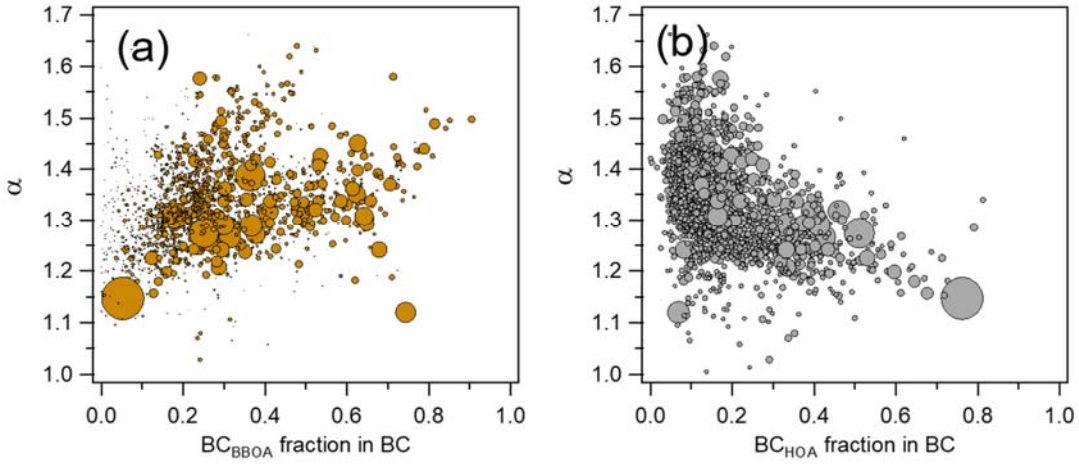

Figure S26. Absorption Ångström exponents plotted against BC_{BBOA} (a) and BC_{HOA} (b) fractions in total BC at the residential site. α was calculated as a ratio of 470 nm to 950 nm. Marker size displays BC concentration.

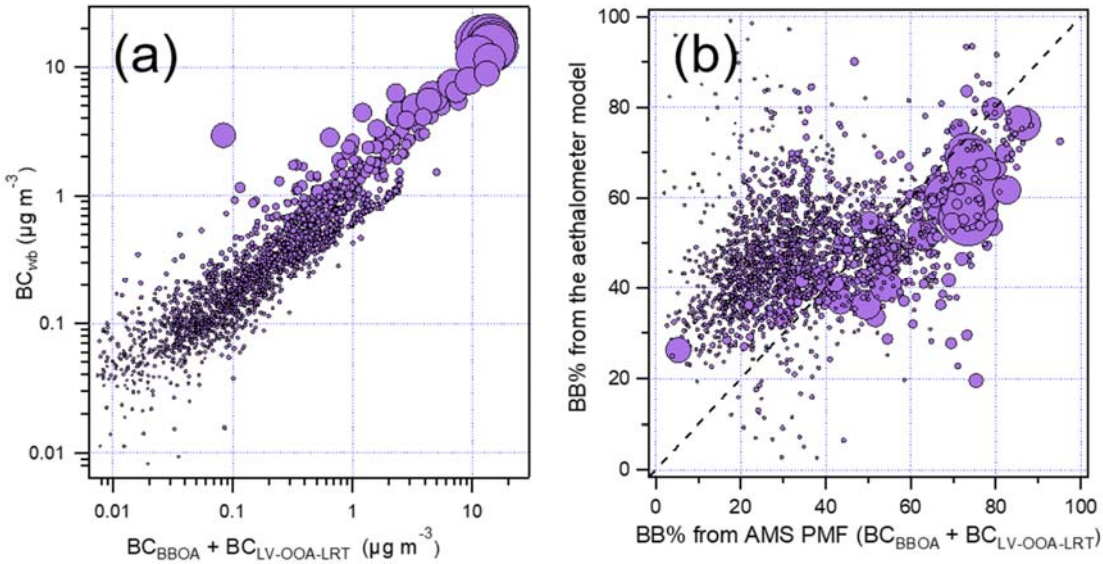

Figure S27. The comparison of BC_{wb} from the aethalometer model and the sum of BC_{BBOA} and $BC_{LV\text{-}OOA\text{-}LRT}$ from AMS-PMF at the residential site. Concentrations (a) and BB% (b). BC_{wb} was calculated by using $\alpha_{ff} = 0.9$ and $\alpha_{wb} = 1.68$. 1-hour time-resolution. Marker size illustrates the total BC concentration. Dotted line in (b) shows 1:1 line.

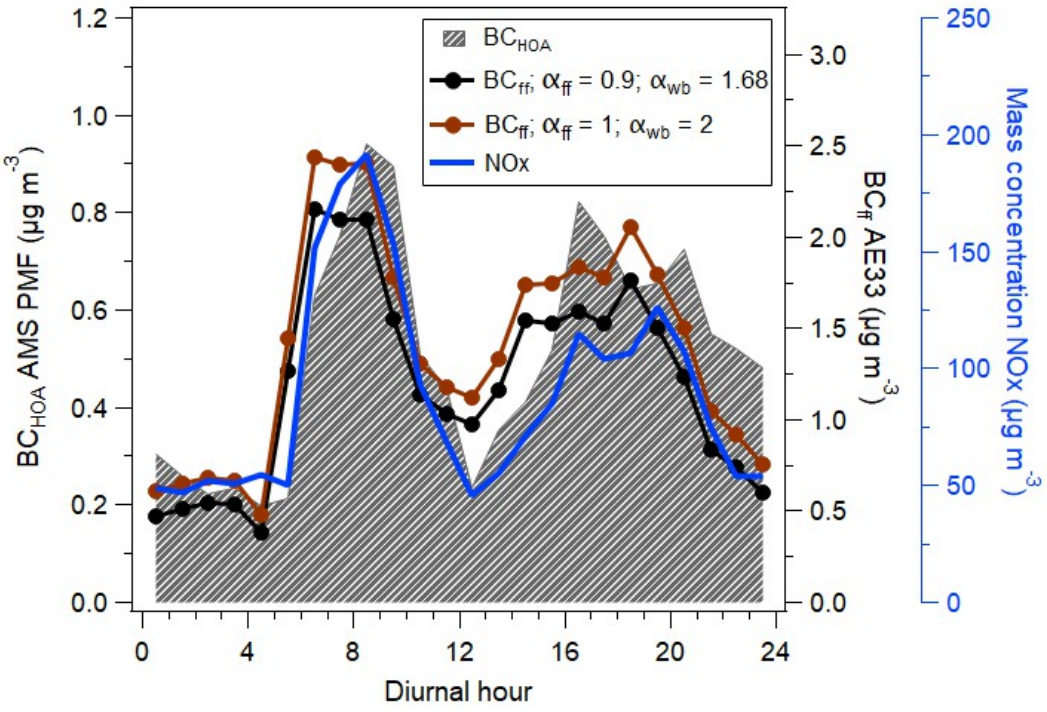

Figure S28. The comparison of diurnal patterns of BC_{ff} from the aethalometer model and BC_{BBOA} from AMS-PMF at the street canyon. BC_{ff} was calculated by using $\alpha_{ff} = 0.9$ and $\alpha_{wb} = 1.68$. Also the diurnal pattern of NOx is presented.