Supplement of Atmos. Chem. Phys., 23, 6241–6253, 2023
https://doi.org/10.5194/acp-23-6241-2023-supplement

Supplement of

Measurement report: Diurnal variations of brown carbon during two distinct seasons in a megacity in northeast China

Yuan Cheng et al.

Correspondence to: Jiu-meng Liu (jiumengliu@hit.edu.cn)

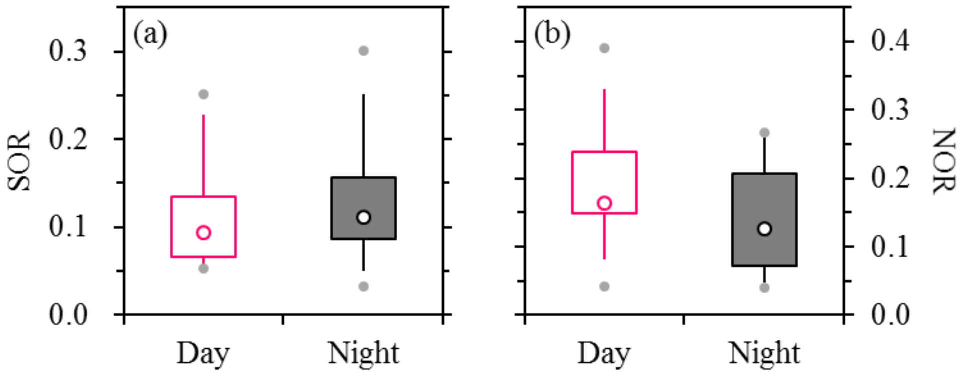

Figure S1. Diurnal variations of **(a)** SOR and **(b)** NOR in spring. NOR were considerably higher during the day, pointing to enhanced photochemistry. Daytime and nighttime SOR were more comparable, presumably due to the rare occurrence of high RH conditions that are favorable for heterogeneous sulfate formation.

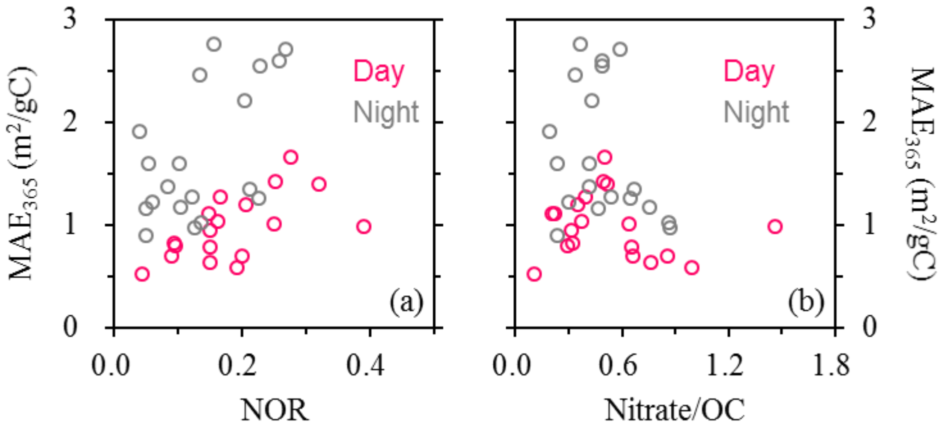

Figure S2. Dependences of MAE_{365} on **(a)** NOR and **(b)** the nitrate to OC ratio in spring. As indicated by the diurnal variations of NOR, nitrate formation was mainly contributed by photochemistry. However, MAE_{365} was independent of NOR or nitrate/OC, suggesting that photochemistry should not be an important influencing factor for the springtime MAE_{365}.

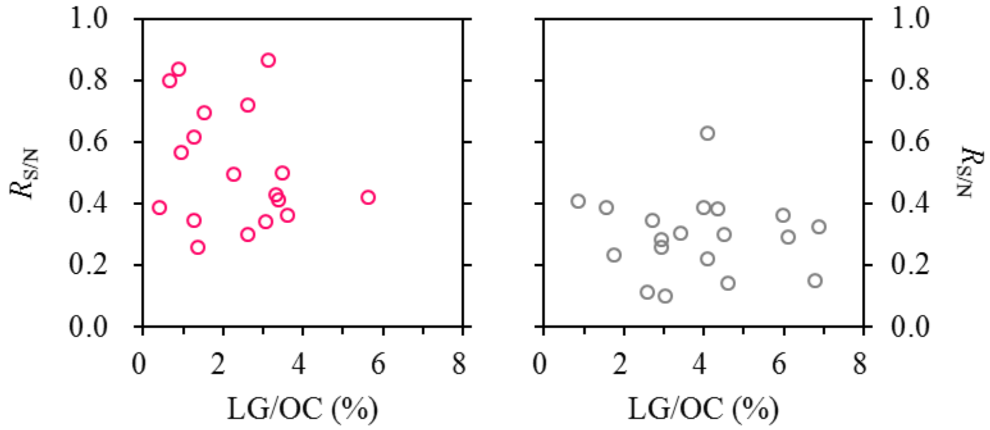

Figure S3. Relationships between $R_{S/N}$ and LG/OC in spring, with daytime and nighttime results shown in the left and night panels, respectively.

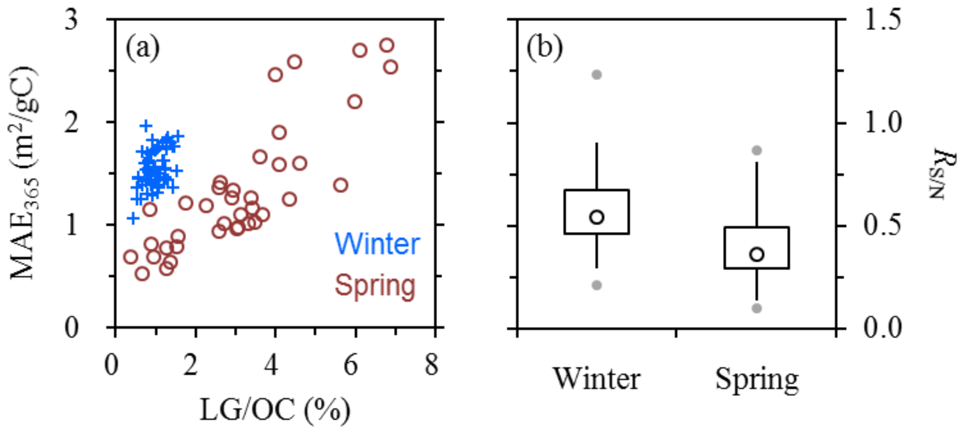

Figure S4. Comparisons of **(a)** the MAE_{365} vs. LG/OC relationship and **(b)** $R_{S/N}$ between winter and spring.

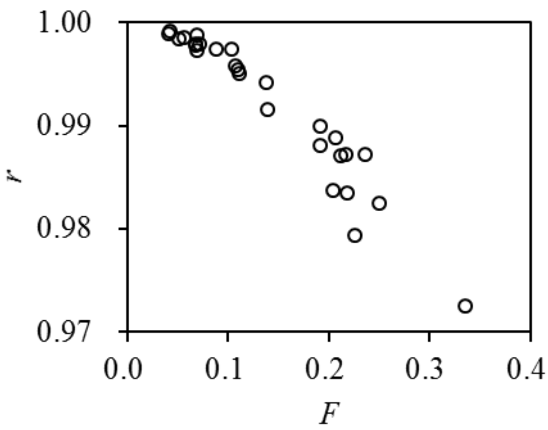

Figure S5. Dependence of *r* on *F* during agricultural fire episodes in spring. *r* was determined by regressing ln(ATN$_{\lambda}$)* on ln(λ), while *F* was a measure of the significance of the ~365 nm absorption peak. *r* showed a clear decreasing trend with the increase of *F*. The same trend was observed when plotting *r* against *K*, another indicator for the significance of the ~365 nm absorption peak.

Table S1. Summary of *t*-test results for the comparisons involved in the main text. A *p* value of below 0.05 indicates statistically significant difference at the 95% confidence level.

Compared parameters	*p* value of *t*-test	Indication
Winter campaign		
Daytime and nighttime MAE_{365}	0.004	More absorbing BrC at night
Daytime and nighttime LG/OC (LG/EC)	0.001 (0.000)	Increased residential burning emissions at night
Daytime and nighttime $R_{S/N}$	0.000	Increased vehicle emissions at night
Daytime and nighttime SOR in the RH range of 70–80%	0.417	Relatively weak influence of photochemistry on sulfate formation
Daytime and nighttime NOR in the RH range of 70–80%	0.005	Relatively strong influence of photochemistry on nitrate formation
Daytime and nighttime AAE	0.000	Stronger wavelength dependence of BrC absorption at night
Daytime and nighttime sulfate/OC	0.011	Decreased SOC/OC ratios at night
Spring campaign		
Daytime and nighttime MAE_{365}	0.000	More absorbing BrC at night
Daytime and nighttime LG/OC	0.006	Increased agricultural fire emissions at night
Daytime and nighttime $R_{S/N}$	0.000	Increased vehicle emissions at night
Daytime and nighttime SOR	0.489	Insignificant diurnal variations of sulfate formation
Daytime and nighttime NOR	0.083	Insignificant diurnal variations of nitrate formation
r values for typical samples and open burning episodes [derived from linear regression of $\ln(ATN_\lambda)^*$ on ln (λ)]	0.000	Agricultural fire-induced non-linearity for BrC's absorption spectra shown on ln-ln scale
Inter-campaign		
LG/K^+ in winter and spring	0.000	Different biomass burning ways in the two seasons (i.e., residential and open burning, respectively)
LG/OC in winter and spring	0.000	Stronger impacts of biomass burning in spring
SOR in winter and spring	0.050	——
NOR in winter and spring	0.012	Significant seasonal variations of nitrate formation
Wintertime MAE_{365} and MAE_{365} of typical samples in spring	0.000	Less absorbing BrC in spring with the absence of agricultural fires

Table S2. Summary of observational results in January, 2021.

	Daytime	Nighttime	All
Temperature (℃)	–16.23 ± 5.13	–21.28 ± 5.54	–18.72 ± 5.87
Relative humidity (%)	70.73 ± 8.10	81.10 ± 5.03	75.83 ± 8.51
OC (μgC/m^3)	21.53 ± 8.54	21.27 ± 11.94	21.40 ± 10.26
MSOC (μgC/m^3)	19.74 ± 7.73	19.56 ± 10.81	19.65 ± 9.29
EC (μgC/m^3)	3.12 ± 1.69	2.62 ± 1.96	2.87 ± 1.83
LG (μg/m^3)	0.45 ± 0.24	0.57 ± 0.44	0.51 ± 0.35
SO_4^{2-} (μg/m^3)	9.49 ± 4.28	7.97 ± 5.03	8.74 ± 4.69
NO_3^- (μg/m^3)	9.53 ± 5.84	9.56 ± 8.24	9.55 ± 7.06
Cl^- (μg/m^3)	2.60 ± 1.22	2.25 ± 1.19	2.43 ± 1.21
NH_4^+ (μg/m^3)	8.10 ± 3.96	7.25 ± 4.80	7.68 ± 4.38
K^+ (μg/m^3)	1.01 ± 0.41	1.08 ± 0.78	1.05 ± 0.62
$(b_{abs})_{365}$ (Mm^{-1})	30.00 ± 13.34	32.48 ± 20.94	31.22 ± 17.39
MAE_{365} (m^2/gC)	1.48 ± 0.18	1.61 ± 0.15	1.55 ± 0.18
AAE[a]	6.76 ± 0.11	7.33 ± 0.14	7.04 ± 0.32
SOR	0.14 ± 0.05	0.16 ± 0.09	0.15 ± 0.07
NOR	0.13 ± 0.05	0.11 ± 0.06	0.12 ± 0.06
$R_{S/N}$	0.69 ± 0.20	0.46 ± 0.13	0.58 ± 0.20
LG/K^+	0.42 ± 0.11	0.50 ± 0.10	0.46 ± 0.11
LG/OC (%)[b]	0.88 ± 0.22	1.10 ± 0.26	0.99 ± 0.26
LG/EC	0.15 ± 0.05	0.22 ± 0.06	0.18 ± 0.07

Note:

[a] Calculated over 310–460 nm;

[b] On a basis of carbon mass.

Table S3. Summary of observational results in April, 2021.

	Daytime	Nighttime	All
Temperature (℃)	13.82 ± 4.47	7.33 ± 4.16	10.58 ± 5.38
Relative humidity (%)	42.65 ± 17.35	62.21 ± 17.43	52.43 ± 19.81
OC (μgC/m^3)	16.64 ± 14.57	22.49 ± 19.99	19.57 ± 17.51
MSOC (μgC/m^3)	14.36 ± 13.06	20.23 ± 18.27	17.30 ± 15.94
EC (μgC/m^3)	1.35 ± 0.94	1.71 ± 0.95	1.53 ± 0.95
LG (μg/m^3)	1.20 ± 1.69	2.53 ± 3.16	1.87 ± 2.59
SO_4^{2-} (μg/m^3)	3.28 ± 2.13	3.38 ± 1.99	3.33 ± 2.03
NO_3^- (μg/m^3)	8.97 ± 9.07	10.79 ± 9.10	9.88 ± 9.01
Cl^- (μg/m^3)	1.79 ± 2.51	4.84 ± 5.88	3.32 ± 4.72
NH_4^+ (μg/m^3)	4.35 ± 3.88	6.33 ± 5.48	5.34 ± 4.79
K^+ (μg/m^3)	1.05 ± 1.21	1.31 ± 1.26	1.18 ± 1.22
$(b_{abs})_{365}$ (Mm^{-1})	17.22 ± 20.53	43.66 ± 53.16	30.44 ± 41.95
MAE_{365} (m^2/gC)	0.98 ± 0.31	1.69 ± 0.65	1.33 ± 0.62
AAE[a]	—	—	—
SOR	0.11 ± 0.06	0.13 ± 0.07	0.12 ± 0.06
NOR	0.18 ± 0.09	0.14 ± 0.08	0.16 ± 0.08
$R_{S/N}$	0.52 ± 0.19	0.30 ± 0.13	0.40 ± 0.20
LG/K^+	0.98 ± 0.45	1.58 ± 0.61	1.28 ± 0.61
LG/OC (%)[b]	2.38 ± 1.36	3.85 ± 1.71	3.11 ± 1.70
LG/EC	0.65 ± 0.46	1.14 ± 1.00	0.89 ± 0.81

Note:

[a] AAE were not provided due to the frequent occurrences of agricultural fires, which could result in distinct peak at ~365 nm for the light absorption spectra of BrC.

[b] On a basis of carbon mass.