atmosphere

Supplementary Information for

Seasonal and day–night variations in carbonaceous aerosols and their light-absorbing properties in Guangzhou, China

Jiannan Su [1,2], Runqi Zhang [1,2], Bowen Liu[3], Mengxue Tong[1,2], Shaoxuan Xiao[1,2], Xiaoyang Wang[1], Qilong Zhao[3], Wei Song[1], Dilinuer Talifu[3] and Xinming Wang [1,2,*]

Table and Figure Captions

Table S1 The species included in the markers for each source.

Table S2 The nearest observation points for BLH of each station.

Table S3 Summary of meteorological parameters including temperature (T), relatively humidity (RH), wind speed (WS) and boundary layer height (BLH) and atmospheric pressure (P), and $PM_{2.5}$ and gaseous pollutants including SO_2, NO_2, O_3, NO and NO_x (NO + NO_2).

Figure S1 Results of independent samples t-test for day/night average value comparisons of OC, EC and SOC concentrations, $b_{abs,BrC,405}$, $b_{abs,BC,405}$, $MAC_{BrC,405}$ and $MAC_{BC,635}$ at the four sites in autumn.

Figure S2 Results of independent samples t-test for day/night average value comparisons of OC, EC and SOC concentrations and $b_{abs,BrC,405}$, $b_{abs,BC,405}$, $MAC_{BrC,405}$ and $MAC_{BC,635}$ at the three sites in winter.

Figure S3 Results of the independent samples Mann-Whitney U test for diurnal data of the corresponding variables for (a) HG and (b) JL in autumn.

Figure S4 Results of the independent samples Mann-Whitney U test for the diurnal data of the corresponding variables for XH, SZ and HKUST in winter.

Figure S5 Results of the one-sided independent samples t-test or Mann-Whitney U test for the corresponding variables of JL and HG in autumn.

Figure S6 Pearson correlation coefficients of OC, EC, SOC concentrations, $b_{abs,BrC,405}$, and $b_{abs,BC,405}$ with source tracers including BSOA, Ca^{2+}, levoglucosan, fatty acids (FA), hopanes, steranes, HMW-PAHs, sterols and DHOPA, and gaseous pollutants including SO_2, NO_2, O_3, NO and NO_x and meteorological parameters including temperature (T), relatively humidity (RH), wind speed (WS) , atmospheric pressure (P) and boundary layer height (BLH).

Figure S7 Pearson correlation coefficients between OC, EC, $b_{abs,BrC,405}$, $b_{abs,BC,405}$ and source marker using (a) daytime data and (b) nighttime data in winter, respectively.

Figure S8. Day-to-day variation of $PM_{2.5}$ carbonaceous aerosols concentration (μg/m^3) and their light-absorbing properties (Mm^{-1}), as well as meteorological factors during the observing period in autumn. Vector arrows indicate wind velocity and direction.

Figure S9. Day-to-day variation of $PM_{2.5}$ carbonaceous aerosols concentration (μg/m^3) and their light-absorbing properties (Mm^{-1}), as well as meteorological factors during the observing period in winter.

Table S1. The species included in the markers for sources.

Markers	Species			Sources
Ca^{2+}	Ca^{2+}			dust
LG	levoglucosan			biomass burning
DHOPA	2,3-dihydroxy-4-oxopentanoic acid			ASOA
BSOA	3-hydroxy-4,4-dimethylglutaric acid	2-methylerythritol	pinic acid	BSOA
	cis-2-methyl-1,3,4-trihydroxy-1-butene	b-caryophyllenic acid	3-methylbutane-1,2,3-tricarboxylic acid	
	3-methyl-2,3,4-trihydroxy-1-butene	2-Methylglyceric acid	cis-pinonic acid	
	trans-2-methyl-1,3,4-trihydroxy-1-butene	2-methylthreitol		
fatty acids	trans-9-Octadecenoic acid	hexadecanoic acid	octadecanoic acid	cooking
	9,12-octadecanedienoic acid	cis-9-octadecenoic acid		
sterols	cholesterol	stigmasterol		
	campesterol	b-sitosterol		
hopanes	22,29,30-trisnorneohopane	17α(H),21β(H)-hopane	31(R)-hopane	vehicle emission
	17α(H)-22,29,30-trisnorhopane	32(S)-hopane	31(S)-hopane	
	17α(H),21β(H)-30-norhopane	33(S)-hopane	32(R)-hopane	
	18a(H)-29-norneohopane	33(R)-hopane		
steranes	27aaa(S)-sterane	27abb(R)-sterane	27abb(S)-sterane	
	27aaa(R)-sterane	28aaa(S)-sterane	28abb(R)-sterane	
	28abb(S)-sterane	28aaa(R)-sterane	29aaa(S)-sterane	
	29abb(R)-sterane	29abb(S)-sterane	29aaa(R)-sterane	
HMW-PAHs	benzo(b)fluoranthene	benzo(k)fluoranthene	perylene	coal combustion
	benzo(j)fluoranthene	benzo(e)pyrene	picene	
	indeno(cd)fluoranthene	indeno(cd)pyrene		
	dibenzo[a,h]anthrancene	benzo(a)pyrene		

Table S2. The nearest observation points for boundary layer height (BLH) of each sampling site.

Sampling site	Geographical location	Nearest point for BLH
HD	23.39 °N, 113.21 °E	23.50 °N, 113.25 °E
JL	23.31 °N, 113.56 °E	23.25 °N, 113.50 °E
SZ	23.13 °N, 113.26 °E	23.25 °N, 113.25 °E
HG	22.82 °N, 113.49 °E	22.75 °N, 113.50 °E
HKUST	22.75 °N, 113.61 °E	22.75 °N, 113.50 °E

Table S3. Summary of meteorological parameters including temperature (T), relative humidity (RH), wind speed (WS), boundary layer height (BLH), atmospheric pressure (P), and $PM_{2.5}$ and gaseous pollutants including SO_2, NO_2, O_3, NO, and NO_x ($NO + NO_2$).

Season	Sample site	diurnal time	T (°C)	RH (%)	WS (m/s)	BLH (m)	P (pa)	$PM_{2.5}$(μg/m³)	SO_2(μg/m³)	NO_2(μg/m³)	O_3(μg/m³)	CO(mg/m³)	NO(μg/m³)	NO_x(μg/m³)
Autumn (Mean± 95% C.I.)	XH	day	32.8 ± 0.5	59.1 ± 1.7	1.1 ± 0.2	616 ± 20	1006 ± 2	37.8 ± 12.9	6.0 ± 0.7	22.9 ± 4	147 ± 28	0.7 ± 0.1	2.9 ± 0.4	27.2 ± 4.2
		night	30.5 ± 0.5	70.4 ± 1.7	0.9 ± 0.1	81 ± 39	1006 ± 1	48.9 ± 11.4	6.1 ± 1.2	47.3 ± 6.7	66.7 ± 19.2	0.9 ± 0.1	2.9 ± 1.1	51.8 ± 7.9
	JL	day	31.4 ± 0.4	58.1 ± 1.9	1.2 ± 0.1	612± 25	1002 ± 2	50.7 ± 12.4	5.0 ± 0.0	32.1 ± 5.3	117 ± 15	0.7 ± 0.1	4.6 ± 1.3	39.0 ± 6.7
		night	27.6 ± 0.5	78.1 ± 0.9	0.9 ± 0.2	110 ± 57	1002 ± 1	57.3 ± 12.6	4.9 ± 0.1	53.6 ± 4.8	20.9 ± 7.7	0.8 ± 0.1	6.7 ± 2.6	64.0 ± 5.9
	SZ	day	32.7 ± 0.4	50.8 ± 1.1	1.0 ± 0.2	644 ± 24	1006 ± 2	49.9 ± 14.8	9.2 ± 0.5	29.0 ± 2.6	169 ± 30	0.7 ± 0.1	3.6 ± 0.8	34.4 ± 3.2
		night	30.5 ± 0.5	61.3 ± 2.4	0.7 ± 0.3	107± 43	1006 ± 1	50.4 ± 16.5	9.1 ± 0.3	36.6 ± 4.0	90.5 ± 21.8	0.7 ± 0.1	2.6 ± 0.7	40.5 ± 4.6
	HG	day	32.1 ± 0.4	54.6 ± 2.1	1.3 ± 0.1	647 ± 32	1008 ± 2	44.5 ± 19.8	15.9 ± 15	25.8 ± 2.1	159 ± 20	0.9 ± 0.1	3.5 ± 0.3	31.4 ± 2.3
		night	29.6 ± 0.6	69.7 ± 1.5	1.0 ± 0.1	182 ± 78	1007 ± 1	33.7 ± 15.2	7.4 ± 0.7	35.4 ± 5.2	65.7 ± 18.0	0.9 ± 0.1	3.3 ± 0.5	40.3 ± 5.9
Winter (Mean± 95% C.I.)	XH	day	17.6 ± 2.3	52.8 ± 4.7	1.2 ± 0.3	644 ± 98	1017 ± 3	35.2 ± 12.0	12.1 ± 1.3	39.3 ± 8.8	77.0 ± 13.8	0.9 ± 0.0	7.0 ± 4.3	49.8 ± 14.9
		night	15.4 ± 2.0	58.4 ± 5.3	1.4 ± 0.5	373 ± 173	1017 ± 3	35.0 ± 13.0	11.0 ± 1.6	54.8 ± 18.7	39.9 ± 14.9	1.0 ± 0.1	6.5 ± 4.0	64.4 ± 24.6
	SZ	day	17.7 ± 2.4	47.7 ± 5.4	1.5 ± 0.5	633 ± 104	1016 ± 3	63.4 ± 15.2	9.5 ± 1.0	51.5 ± 10.4	71.1 ± 19.8	0.9 ± 0.1	11.1 ± 4.7	68.4 ± 15.3
		night	15.8 ± 2.0	51.2 ± 5.4	1.5 ± 0.6	372 ± 154	1017 ± 3	59.0 ± 16.2	9.4 ± 1.1	67.5 ± 20.7	33.5 ± 13.3	1.0 ± 0.1	19.9 ± 13.8	97.5 ± 40.3
	HKUST	day	17.7 ± 2.0	51.1 ± 4.4	1.9 ± 0.3	541 ± 77	1016 ± 2	35.3 ± 10.9	13.7 ± 2.2	48.9 ± 10.4	74.4 ± 22.6	0.9 ± 0.1	10.3 ± 2.4	64.8 ± 13.4
		night	16.8 ± 1.8	56.9 ± 5	1.5 ± 0.4	271 ± 142	1015 ± 2	35.0 ± 10.5	13.3 ± 2.1	72.2 ± 23.4	30.8 ± 13.3	1.0 ± 0.1	15.1 ± 7.7	95.4 ± 33.4

Independent Samples Test

(a) XH

XH		Levene's Test for Equality of Variances F	Sig.	t-test for Equality of Means t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
OC	Equal variances assumed	6.404	.030	-1.030	10	.327	-1.02333	.99364	-3.23729	1.19063
	Equal variances not assumed			-1.030	6.625	.339	-1.02333	.99364	-3.40012	1.35346
EC	Equal variances assumed	.961	.350	-4.149	10	.002	-.53000	.12775	-.81463	-.24537
	Equal variances not assumed			-4.149	9.254	.002	-.53000	.12775	-.81778	-.24222
SOC	Equal variances assumed	3.115	.108	-.056	10	.956	-.04833	.85697	-1.95777	1.86110
	Equal variances not assumed			-.056	7.379	.957	-.04833	.85697	-2.05384	1.95718
absBrC405	Equal variances assumed	4.818	.053	-3.363	10	.007	-3.69333	1.09822	-6.14032	-1.24635
	Equal variances not assumed			-3.363	6.064	.015	-3.69333	1.09822	-6.37371	-1.01296
absBC405	Equal variances assumed	.010	.922	-3.507	10	.006	-8.00333	2.28196	-13.08785	-2.91881
	Equal variances not assumed			-3.507	9.920	.006	-8.00333	2.28196	-13.09341	-2.91326
MACBrC405	Equal variances assumed	5.562	.040	-3.663	10	.004	-.45167	.12329	-.72638	-.17696
	Equal variances not assumed			-3.663	6.132	.010	-.45167	.12329	-.75178	-.15156
MACBC635	Equal variances assumed	4.450	.061	-1.486	10	.168	-1.60167	1.07784	-4.00324	.79991
	Equal variances not assumed			-1.486	7.944	.176	-1.60167	1.07784	-4.09022	.88689

Independent Samples Test

(b) JL

JL		Levene's Test for Equality of Variances F	Sig.	t-test for Equality of Means t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
OC	Equal variances assumed	.043	.841	-1.130	8	.291	-1.37000	1.21257	-4.16619	1.42619
	Equal variances not assumed			-1.130	7.843	.292	-1.37000	1.21257	-4.17598	1.43598
EC	Equal variances assumed	.601	.461	-.841	8	.425	-.14200	.16877	-.53119	.24719
	Equal variances not assumed			-.841	7.586	.426	-.14200	.16877	-.53492	.25092
SOC	Equal variances assumed	.262	.622	-.957	8	.366	-1.11200	1.16138	-3.79014	1.56614
	Equal variances not assumed			-.957	7.516	.368	-1.11200	1.16138	-3.82049	1.59649
absBrC405	Equal variances assumed	1.279	.291	-2.169	8	.062	-5.33000	2.45790	-10.99792	.33792
	Equal variances not assumed			-2.169	5.368	.079	-5.33000	2.45790	-11.52019	.86019
absBC405	Equal variances assumed	3.561	.096	-1.505	8	.171	-6.53600	4.34162	-16.54780	3.47580
	Equal variances not assumed			-1.505	6.510	.179	-6.53600	4.34162	-16.96091	3.88891
MACBrC405	Equal variances assumed	.373	.558	-1.606	8	.147	-.41000	.25529	-.99870	.17870
	Equal variances not assumed			-1.606	7.331	.150	-.41000	.25529	-1.00817	.18817
MACBC635	Equal variances assumed	2.118	.184	-2.047	8	.075	-2.36400	1.15482	-5.02702	.29902
	Equal variances not assumed			-2.047	6.911	.080	-2.36400	1.15482	-5.10187	.37387

(c) SZ

SZ		Levene's Test for Equality of Variances F	Sig.	t-test for Equality of Means t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
OC	Equal variances assumed	.405	.539	.352	10	.732	.44167	1.25343	-2.35115	3.23448
	Equal variances not assumed			.352	9.465	.732	.44167	1.25343	-2.37271	3.25605
EC	Equal variances assumed	.595	.458	-.410	10	.691	-.07500	.18312	-.48302	.33302
	Equal variances not assumed			-.410	9.192	.692	-.07500	.18312	-.48794	.33794
SOC	Equal variances assumed	.102	.756	.602	10	.561	.57167	.94945	-1.54384	2.68717
	Equal variances not assumed			.602	9.768	.561	.57167	.94945	-1.55066	2.69399
absBrC405	Equal variances assumed	1.036	.333	-1.283	10	.228	-.89667	.69897	-2.45406	.66073
	Equal variances not assumed			-1.283	8.437	.234	-.89667	.69897	-2.49408	.70075
absBC405	Equal variances assumed	1.470	.253	-.675	10	.515	-2.39500	3.54934	-10.30342	5.51342
	Equal variances not assumed			-.675	8.786	.517	-2.39500	3.54934	-10.45410	5.66410
MACBrC405	Equal variances assumed	.010	.923	-1.093	10	.300	-.12500	.11439	-.37988	.12988
	Equal variances not assumed			-1.093	9.930	.300	-.12500	.11439	-.38012	.13012
MACBC635	Equal variances assumed	2.950	.117	-.552	10	.593	-.57667	1.04535	-2.90585	1.75252
	Equal variances not assumed			-.552	7.019	.598	-.57667	1.04535	-3.04714	1.89381

(d) HG

HG		Levene's Test for Equality of Variances F	Sig.	t-test for Equality of Means t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
OC	Equal variances assumed	.480	.504	1.880	10	.090	1.89000	1.00544	-.35026	4.13026
	Equal variances not assumed			1.880	8.105	.096	1.89000	1.00544	-.42332	4.20332
EC	Equal variances assumed	.086	.776	.176	10	.864	.03333	.18906	-.38793	.45460
	Equal variances not assumed			.176	9.863	.864	.03333	.18906	-.38872	.45539
SOC	Equal variances assumed	.912	.362	2.618	10	.026	1.83833	.70223	.27366	3.40300
	Equal variances not assumed			2.618	7.492	.033	1.83833	.70223	.19966	3.47701
absBrC405	Equal variances assumed	1.106	.318	1.319	10	.216	1.16000	.87924	-.79906	3.11906
	Equal variances not assumed			1.319	9.435	.218	1.16000	.87924	-.81507	3.13507
absBC405	Equal variances assumed	.199	.665	-.627	10	.545	-1.54500	2.46382	-7.03473	3.94473
	Equal variances not assumed			-.627	9.691	.545	-1.54500	2.46382	-7.05858	3.96858
MACBrC405	Equal variances assumed	.290	.602	.537	10	.603	.07667	.14287	-.24166	.39500
	Equal variances not assumed			.537	9.890	.603	.07667	.14287	-.24214	.39547
MACBC635	Equal variances assumed	.462	.512	-.785	10	.450	-2.60167	3.31241	-9.98218	4.77885
	Equal variances not assumed			-.785	9.205	.452	-2.60167	3.31241	-10.06952	4.86619

Figure S1. Results of independent samples t-test using IBM SPSS Statistics 26 for day/night average value comparisons of OC, EC, and SOC concentrations, $b_{abs,BrC,405}$, $b_{abs,BC,405}$, $MAC_{BrC,405}$ and $MAC_{BC,635}$ at the four sites in autumn ($p < 0.05$ indicates a significant difference, same below).

Independent Samples Test

(a) XH

XH		Levene's Test for Equality of Variances: F	Sig.	t-test for Equality of Means: t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
OC	Equal variances assumed	1.102	.306	-.501	21	.622	-.98295	1.96159	-5.06230	3.09639
	Equal variances not assumed			-.494	18.323	.627	-.98295	1.98814	-5.15460	3.18869
EC	Equal variances assumed	8.649	.008	-.857	21	.401	-.33288	.38841	-1.14062	.47486
	Equal variances not assumed			-.837	15.324	.416	-.33288	.39791	-1.17944	.51368
SOC	Equal variances assumed	.007	.933	-.273	21	.787	-.36091	1.32114	-3.10837	2.38655
	Equal variances not assumed			-.271	19.871	.789	-.36091	1.33009	-3.13658	2.41476
absBrC405	Equal variances assumed	.861	.364	-.481	21	.636	-1.37508	2.85943	-7.32159	4.57144
	Equal variances not assumed			-.476	19.181	.639	-1.37508	2.88811	-7.41612	4.66597
absBC405	Equal variances assumed	6.891	.016	-.916	21	.370	-5.26515	5.74988	-17.22269	6.69238
	Equal variances not assumed			-.894	15.272	.385	-5.26515	5.89157	-17.80332	7.27302
MACBrC405	Equal variances assumed	.016	.900	.018	21	.986	.00280	.15833	-.32647	.33207
	Equal variances not assumed			.018	20.495	.986	.00280	.15881	-.32795	.33356
MACBC635	Equal variances assumed	.036	.851	-.045	21	.964	-.17886	3.96189	-8.41806	8.06033
	Equal variances not assumed			-.046	20.512	.964	-.17886	3.91830	-8.33923	7.98150

Independent Samples Test

(b) SZ

SZ		Levene's Test for Equality of Variances: F	Sig.	t-test for Equality of Means: t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
OC	Equal variances assumed	2.961	.099	-.484	22	.633	-.95750	1.97769	-5.05898	3.14398
	Equal variances not assumed			-.484	19.710	.634	-.95750	1.97769	-5.08679	3.17179
EC	Equal variances assumed	9.742	.005	-1.382	22	.181	-.48583	.35144	-1.21468	.24301
	Equal variances not assumed			-1.382	15.227	.187	-.48583	.35144	-1.23394	.26228
SOC	Equal variances assumed	.627	.437	-.037	22	.971	-.05083	1.38438	-2.92185	2.82019
	Equal variances not assumed			-.037	21.659	.971	-.05083	1.38438	-2.92447	2.82281
absBrC405	Equal variances assumed	7.797	.011	1.228	22	.232	1.79833	1.46397	-1.23776	4.83443
	Equal variances not assumed			1.228	16.385	.237	1.79833	1.46397	-1.29924	4.89590
absBC405	Equal variances assumed	9.507	.005	-1.210	22	.239	-9.59583	7.92854	-26.03861	6.84695
	Equal variances not assumed			-1.210	14.533	.245	-9.59583	7.92854	-26.54257	7.35090
MACBrC405	Equal variances assumed	3.226	.086	1.240	22	.228	.24833	.20026	-.16697	.66364
	Equal variances not assumed			1.240	19.518	.230	.24833	.20026	-.17006	.66672
MACBC635	Equal variances assumed	.209	.652	.497	22	.624	.64250	1.29392	-2.04092	3.32592
	Equal variances not assumed			.497	20.764	.625	.64250	1.29392	-2.05021	3.33521

(c) HKUST

HKUST		Levene's Test for Equality of Variances: F	Sig.	t-test for Equality of Means: t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
OC	Equal variances assumed	.203	.658	-.256	16	.802	-.40889	1.60031	-3.80139	2.98361
	Equal variances not assumed			-.256	16.000	.802	-.40889	1.60031	-3.80139	2.98362
EC	Equal variances assumed	1.665	.215	-1.239	16	.233	-.35000	.28238	-.94861	.24861
	Equal variances not assumed			-1.239	13.855	.236	-.35000	.28238	-.95623	.25623
SOC	Equal variances assumed	.004	.952	.217	16	.831	.24556	1.12921	-2.14825	2.63937
	Equal variances not assumed			.217	15.623	.831	.24556	1.12921	-2.15296	2.64407
absBrC405	Equal variances assumed	4.731	.045	-.782	16	.445	-1.57333	2.01082	-5.83608	2.68941
	Equal variances not assumed			-.782	12.895	.448	-1.57333	2.01082	-5.92103	2.77436
absBC405	Equal variances assumed	.544	.472	-1.159	16	.263	-8.00667	6.90641	-22.64761	6.63428
	Equal variances not assumed			-1.159	15.574	.264	-8.00667	6.90641	-22.68020	6.66687
MACBrC405	Equal variances assumed	1.440	.248	-.264	16	.795	-.04222	.15963	-.38063	.29619
	Equal variances not assumed			-.264	15.423	.795	-.04222	.15963	-.38166	.29722
MACBC635	Equal variances assumed	.302	.590	-.944	16	.359	-1.42000	1.50420	-4.60875	1.76875
	Equal variances not assumed			-.944	14.657	.360	-1.42000	1.50420	-4.63266	1.79266

Figure S2. Results of independent samples t-test for day/night average value comparisons of OC, EC, and SOC concentrations, $b_{abs,BrC,405}$, $b_{abs,BC,405}$, $MAC_{BrC,405}$, and $MAC_{BC,635}$ at the three sites in winter.

Since the variables at some sites do not conform to a normal distribution, we performed a nonparametric test for these variables again below (Figure S3 and Figure S4).

(a) HG-$MAC_{BC,635}$

Independent-Samples Mann-Whitney U Test Summary

Total N	12
Mann-Whitney U	22.000
Wilcoxon W	43.000
Test Statistic	22.000
Standard Error	6.234
Standardized Test Statistic	.642
Asymptotic Sig.(2-sided test)	.521
Exact Sig.(2-sided test)	.589

(b) JL-$MAC_{BrC,405}$

Independent-Samples Mann-Whitney U Test Summary

Total N	10
Mann-Whitney U	21.000
Wilcoxon W	36.000
Test Statistic	21.000
Standard Error	4.787
Standardized Test Statistic	1.776
Asymptotic Sig.(2-sided test)	.076
Exact Sig.(2-sided test)	.095

Figure S3. Results of the independent samples Mann–Whitney U test for diurnal data of the corresponding variables for (a) HG and (b) JL in autumn.

(a) XH-EC

Independent-Samples Mann-Whitney U Test Summary

Total N	23
Mann-Whitney U	71.000
Wilcoxon W	137.000
Test Statistic	71.000
Standard Error	16.236
Standardized Test Statistic	.308
Asymptotic Sig.(2-sided test)	.758
Exact Sig.(2-sided test)	.786

(b) XH-$b_{abs,BC,405}$

Independent-Samples Mann-Whitney U Test Summary

Total N	23
Mann-Whitney U	69.000
Wilcoxon W	135.000
Test Statistic	69.000
Standard Error	16.248
Standardized Test Statistic	.185
Asymptotic Sig.(2-sided test)	.854
Exact Sig.(2-sided test)	.880

(c) XH-$MAC_{BC,635}$

Independent-Samples Mann-Whitney U Test Summary

Total N	23
Mann-Whitney U	69.000
Wilcoxon W	135.000
Test Statistic	69.000
Standard Error	16.248
Standardized Test Statistic	.185
Asymptotic Sig.(2-sided test)	.854
Exact Sig.(2-sided test)	.880

(d) SZ-$b_{abs,BC,405}$

Independent-Samples Mann-Whitney U Test Summary

Total N	24
Mann-Whitney U	77.000
Wilcoxon W	155.000
Test Statistic	77.000
Standard Error	17.321
Standardized Test Statistic	.289
Asymptotic Sig.(2-sided test)	.773
Exact Sig.(2-sided test)	.799

(e) HKUST-$b_{abs,BC,405}$

Independent-Samples Mann-Whitney U Test Summary

Total N	18
Mann-Whitney U	51.000
Wilcoxon W	96.000
Test Statistic	51.000
Standard Error	11.325
Standardized Test Statistic	.927
Asymptotic Sig.(2-sided test)	.354
Exact Sig.(2-sided test)	.387

(f) HKUST-$MAC_{BC,635}$

Independent-Samples Mann-Whitney U Test Summary

Total N	18
Mann-Whitney U	53.000
Wilcoxon W	98.000
Test Statistic	53.000
Standard Error	11.325
Standardized Test Statistic	1.104
Asymptotic Sig.(2-sided test)	.270
Exact Sig.(2-sided test)	.297

Figure S4. Results of the independent samples Mann–Whitney U test for the diurnal data of the corresponding variables for XH, SZ, and HKUST in winter.

Since the significance differences of some variables were relatively uncertain, we subjected these variables to one-sided independent sample *t*-tests (Figure S5).

one-tailed independent samples t-test					
Object	Equal Variance	Hypothesis	t Statistic	DF	Prob<t
JL-$b_{abs,BrC,405}$	Equal Variance Assumed	daytime<nighttime	-2.16911	8	0.03095
	Equal Variance NOT Assumed (Welch Correction)		-2.16911	5.36831	0.03925
JL-$MAC_{BC,635}$	Equal Variance Assumed	daytime<nighttime	-2.04576	8	0.0375
	Equal Variance NOT Assumed (Welch Correction)		-2.04576	6.91224	0.04027
HG-OC	Equal Variance Assumed	daytime>nighttime	1.88413	10	0.04446
	Equal Variance NOT Assumed (Welch Correction)		1.88413	8.11661	0.04788

one-tailed Mann-Whitney U test					
Object	Hypothesis	U	Z	Exact Prob<U	Asympptotic Prob<U
JL-$MAC_{BrC,405}$	daytime<nighttime	4	-1.67115	0.04762	0.04735

Figure S5. Results of the one-sided independent sample *t*-test or Mann–Whitney U test using Origin 2023 for day–night average value comparisons of the corresponding variables of JL and HG in autumn.

In summary (Figures S1 - S5), variables with significant diurnal differences in autumn at $p < 0.05$ (95% confidence interval) were XH: EC, $b_{abs,BrC,405}$, $b_{abs,BC,405}$ and $MAC_{BrC,405}$; JL: $b_{abs,BrC,405}$, $MAC_{BrC,405}$ and $MAC_{BC,635}$; HG: OC and SOC. No significant differences were found in winter.

(a) autumn

sites	pearson'r	OC	EC	BSOA	Ca^{2+}	LG	FA	hopanes	steranes	PAHs	sterols	DHOPA	SO_2	NO_2	O_3	CO	NO	NO_x	T	WS	WD	P	RH	BLH
XH	OC	1.00	0.63	0.46	0.52	0.48	0.09	0.50	-0.03	0.36	-0.04	0.41	0.36	0.42	0.04	0.66	-0.27	0.38	-0.18	-0.60	0.31	-0.26	0.37	-0.27
	EC	0.63	1.00	0.13	0.55	0.75	0.28	0.86	-0.16	0.72	0.01	-0.13	0.32	0.86	-0.58	0.76	0.10	0.84	-0.74	-0.51	0.03	0.01	0.88	-0.79
	absBC, 405	0.64	0.84	0.42	0.17	0.82	0.39	0.75	-0.08	0.73	-0.08	-0.09	-0.05	0.84	-0.47	0.89	0.01	0.81	-0.50	-0.47	-0.07	-0.22	0.73	-0.70
	absBrC, 405	0.55	0.69	0.37	0.01	0.68	0.36	0.71	-0.13	0.57	-0.12	-0.13	0.19	0.68	-0.38	0.85	-0.41	0.61	-0.50	-0.58	0.22	-0.30	0.69	-0.66
	BLH	-0.27	-0.79	-0.09	-0.23	-0.83	-0.17	-0.90	0.22	-0.76	-0.32	0.54	-0.02	-0.87	0.82	-0.63	-0.08	-0.85	0.87	0.32	0.27	0.09	-0.92	
JL	OC	1.00	0.11	0.50	0.07	0.82	0.24	0.82	0.72	0.71	0.87	0.07	0.34	0.19	-0.16	0.74	0.25	0.23	-0.15	-0.32	-0.40	-0.06	0.30	-0.24
	EC	0.11	1.00	-0.70	-0.08	-0.18	-0.03	-0.08	-0.14	-0.09	-0.04	0.50	-0.33	0.62	0.00	0.02	0.23	0.61	-0.20	-0.33	-0.69	0.57	0.19	-0.06
	absBC, 405	0.42	0.88	-0.44	-0.10	0.06	-0.04	0.21	0.00	0.09	0.11	0.46	-0.06	0.71	-0.18	0.39	0.07	0.64	-0.30	-0.38	-0.73	0.33	0.39	-0.25
	absBrC, 405	0.78	-0.15	0.48	-0.41	0.94	-0.15	0.74	0.46	0.95	0.75	-0.48	-0.07	0.41	-0.66	0.82	0.43	0.48	-0.60	-0.57	-0.52	-0.11	0.70	-0.72
	BLH	-0.24	-0.06	0.09	0.75	-0.52	0.56	-0.30	0.16	-0.68	-0.19	0.62	0.55	-0.79	0.95	-0.64	-0.38	-0.80	0.96	0.62	0.68	-0.06	-0.97	
SZ	OC	1.00	0.90	0.86	0.57	0.53	-0.07	0.01	0.15	0.08	0.08	0.64	0.58	-0.05	0.52	0.75	-0.64	-0.24	0.47	-0.33	0.52	-0.70	-0.12	0.07
	EC	0.90	1.00	0.67	0.31	0.66	-0.20	0.37	0.07	0.32	0.17	0.53	0.63	0.08	0.32	0.76	-0.76	-0.14	0.16	-0.47	0.51	-0.54	0.17	-0.13
	absBC, 405	0.81	0.86	0.65	0.17	0.72	-0.07	0.29	0.18	0.42	0.49	0.48	0.31	0.17	0.24	0.86	-0.66	-0.03	0.10	-0.39	0.15	-0.51	0.24	-0.20
	absBrC, 405	0.15	0.22	-0.03	0.10	0.70	-0.05	0.54	0.16	0.31	0.43	-0.18	0.33	0.60	-0.30	0.28	-0.32	0.51	-0.35	-0.28	-0.04	0.02	0.42	-0.43
	BLH	0.07	-0.13	0.04	0.62	-0.65	0.22	-0.35	0.28	-0.31	-0.21	0.54	0.04	-0.74	0.78	-0.40	0.48	-0.59	0.85	0.29	-0.13	0.11	-0.88	
HG	OC	1.00	0.81	0.77	0.69	0.73	0.69	0.74	0.56	0.25	0.68	0.80	0.27	-0.10	0.66	0.41	0.33	-0.06	0.77	0.06	0.54	-0.58	-0.32	0.36
	EC	0.81	1.00	0.69	0.48	0.71	0.57	0.72	0.48	0.45	0.45	0.50	0.17	0.32	0.24	0.50	0.33	0.34	0.35	-0.32	0.38	-0.67	0.14	-0.12
	absBC, 405	0.64	0.78	0.87	0.08	0.85	0.58	0.45	-0.09	0.53	0.52	0.60	0.17	0.48	0.04	0.76	0.24	0.48	0.19	-0.52	0.64	-0.88	0.38	-0.37
	absBrC, 405	0.81	0.58	0.73	0.30	0.79	0.48	0.43	0.11	0.40	0.52	0.86	0.35	0.08	0.50	0.73	0.29	0.12	0.57	-0.19	0.77	-0.54	-0.19	0.19
	SOC			0.73	0.70	0.66	0.67	0.67	0.54	0.15	0.70	0.84												0.60
	BLH	0.36	-0.12	-0.06	0.60	-0.17	0.10	0.12	0.51	-0.51	0.21	0.39	0.24	-0.84	0.87	-0.44	0.09	-0.78	0.80	0.83	0.05	0.23	-0.96	

(b) winter

sites	pearson'r	OC	EC	BSOA	Ca^{2+}	LG	FA	hopanes	steranes	PAHs	sterols	DHOPA	SO_2	NO_2	O_3	CO	NO	NO_x	T	WS	WD	P	RH	BLH
XH	OC	1.00	0.92	0.70	0.11	0.79	0.89	0.60	0.54	0.80	0.72	0.13	0.13	0.73	-0.08	0.77	0.68	0.75	0.61	-0.61	0.30	-0.64	0.58	-0.56
	EC	0.92	1.00	0.60	0.06	0.71	0.87	0.55	0.47	0.71	0.66	0.05	0.10	0.69	-0.24	0.72	0.74	0.76	0.53	-0.57	0.18	-0.58	0.64	-0.60
	absBC, 405	0.95	0.92	0.58	0.05	0.78	0.92	0.63	0.57	0.87	0.82	0.05	0.09	0.75	-0.19	0.75	0.66	0.75	0.54	-0.58	0.15	-0.60	0.60	-0.60
	absBrC, 405	0.95	0.91	0.77	0.01	0.78	0.77	0.51	0.46	0.67	0.59	0.05	0.19	0.63	-0.10	0.71	0.67	0.68	0.58	-0.61	0.27	-0.60	0.60	-0.53
	BLH	-0.56	-0.60	-0.33	-0.44	-0.53	-0.72	-0.73	-0.63	-0.58	-0.57	0.14	-0.21	-0.81	0.60	-0.63	-0.61	-0.75	-0.34	0.77	-0.11	0.56	-0.64	
SZ	OC	1.00	0.92	0.81	0.57	0.86	0.89	0.88	0.88	0.73	0.72	0.69	0.63	0.68	-0.07	0.49	0.41	0.63	0.65	-0.76	-0.53	-0.68	0.39	-0.72
	EC	0.92	1.00	0.69	0.61	0.90	0.95	0.95	0.95	0.84	0.87	0.48	0.50	0.73	-0.33	0.54	0.38	0.66	0.51	-0.74	-0.47	-0.61	0.46	-0.85
	absBC, 405	0.91	0.95	0.70	0.50	0.90	0.96	0.94	0.93	0.76	0.91	0.63	0.36	0.82	-0.36	0.56	0.50	0.76	0.53	-0.65	-0.57	-0.59	0.51	-0.77
	absBrC, 405	0.10	0.00	0.25	0.30	-0.04	-0.12	-0.16	-0.14	0.00	-0.38	-0.17	0.58	-0.31	0.49	-0.24	-0.18	-0.28	0.22	-0.39	0.29	-0.22	-0.17	-0.09
	BLH	-0.72	-0.85	-0.58	-0.41	-0.81	-0.84	-0.81	-0.85	-0.78	-0.75	-0.22	-0.38	-0.74	0.49	-0.45	-0.34	-0.66	-0.42	0.74	0.51	0.60	-0.51	
HKUST	OC	1.00	0.90	0.79	0.15	0.64	0.69	0.74	0.66	0.70	0.44	0.86	0.55	0.67	0.18	0.81	0.72	0.72	0.57	-0.52	-0.25	-0.51	0.10	-0.51
	EC	0.90	1.00	0.66	-0.01	0.61	0.74	0.92	0.87	0.76	0.66	0.82	0.45	0.84	-0.12	0.88	0.86	0.89	0.64	-0.74	-0.40	-0.66	0.37	-0.76
	absBC, 405	0.89	0.96	0.67	-0.10	0.57	0.74	0.92	0.84	0.71	0.59	0.87	0.46	0.85	-0.07	0.91	0.83	0.88	0.64	-0.75	-0.39	-0.64	0.39	-0.73
	absBrC, 405	0.73	0.71	0.79	0.03	0.65	0.76	0.69	0.67	0.62	0.23	0.74	0.36	0.64	-0.18	0.70	0.52	0.63	0.57	-0.61	-0.48	-0.62	0.41	-0.61
	BLH	-0.51	-0.76	-0.42	0.19	-0.44	-0.68	-0.85	-0.90	-0.60	-0.65	-0.61	-0.27	-0.85	0.45	-0.72	-0.63	-0.82	-0.48	0.82	0.58	0.65	-0.55	

Pearson'r 1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0.0 -0.1 -0.2 -0.3 -0.4 -0.5 -0.6 -0.7 -0.8 -0.9 -1.0

Figure S6. Pearson correlation coefficients of OC, EC, SOC concentrations, $b_{abs,BrC,405}$ and $b_{abs,BC,405}$ with source tracers including BSOA, Ca^{2+}, levoglucosan (LG), fatty acids (FA), hopanes, steranes, HMW-PAHs (PAHs), sterols and DHOPA, and gaseous pollutants including SO_2, NO_2, O_3, NO and NO_x and meteorological parameters including temperature (T), relative humidity (RH), wind speed (WS) , atmospheric pressure (P) and boundary layer height (BLH).

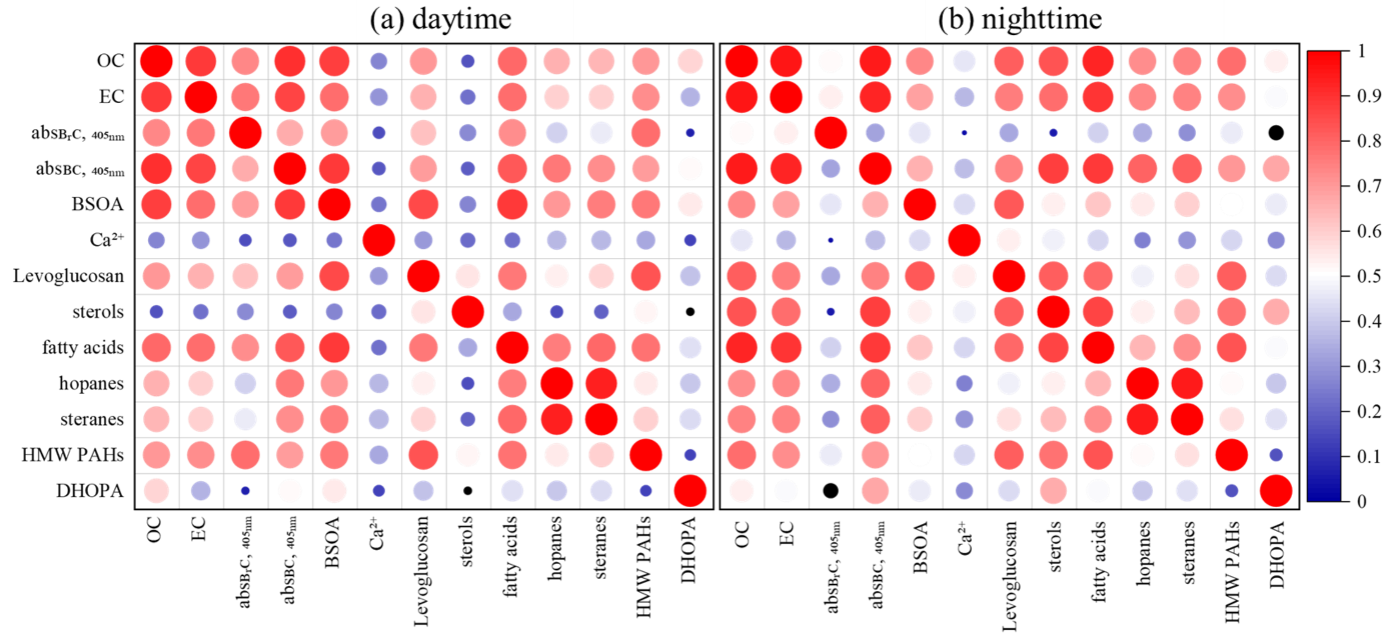

Figure S7. Pearson correlation coefficients between OC, EC, $b_{abs,BrC,405}$, $b_{abs,BC,405}$, and source marker using (a) daytime data and (b) nighttime data in winter, respectively.

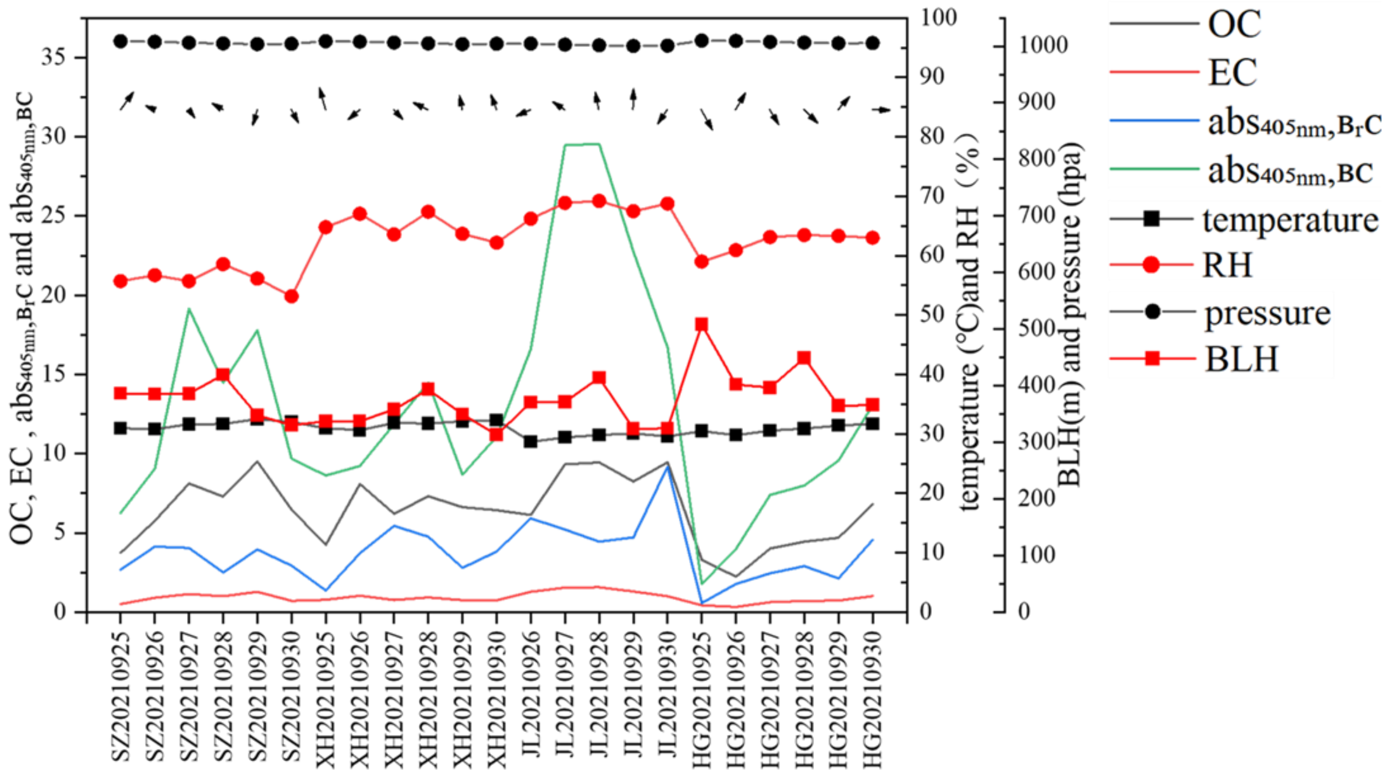

Figure S8. Day-to-day variation in $PM_{2.5}$ carbonaceous aerosol concentration (μg/m³) and their light-absorbing properties (Mm^{-1}), as well as meteorological factors during the observing period in autumn. Vector arrows indicate wind velocity and direction.

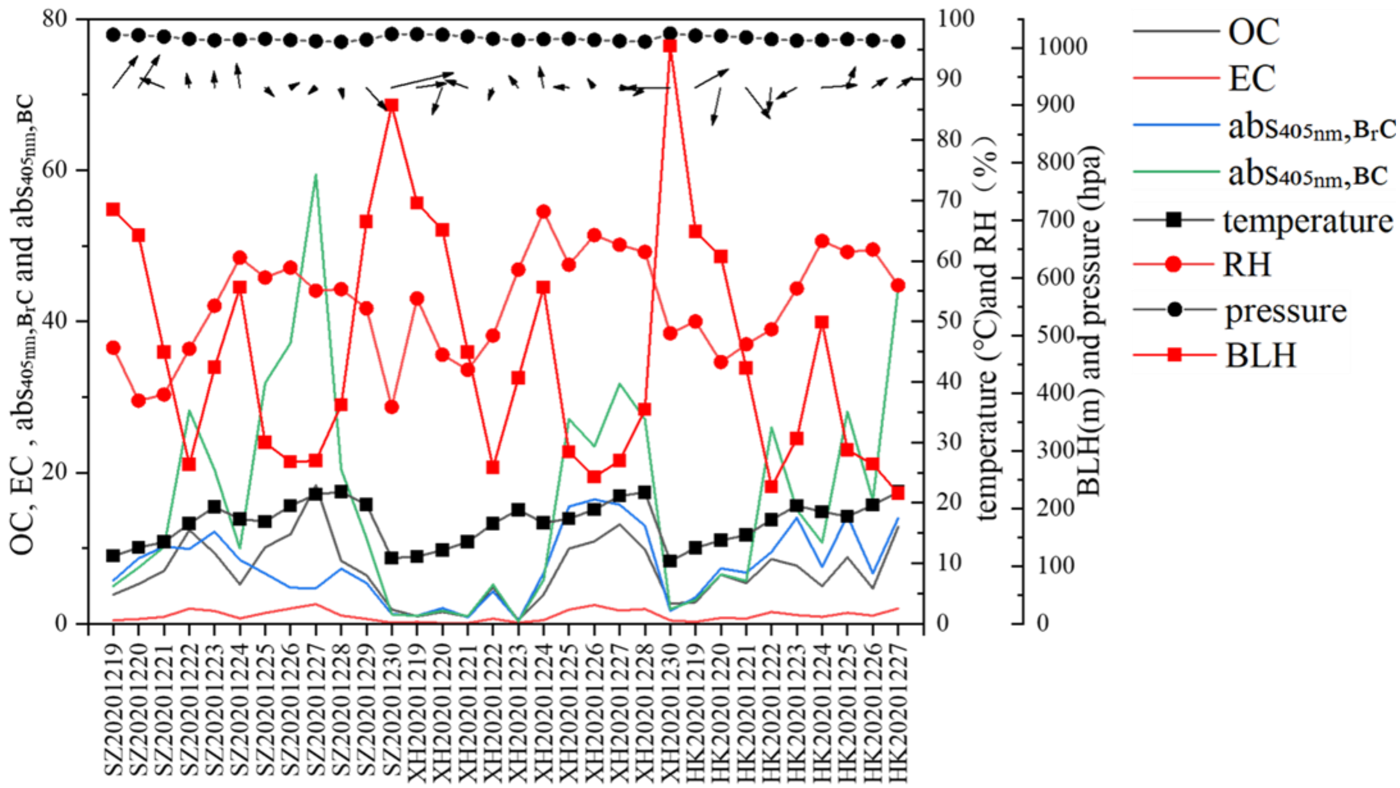

Figure S9. Day-to-day variation in $PM_{2.5}$ carbonaceous aerosol concentration (μg/m^3) and their light-absorbing properties (Mm^{-1}), as well as meteorological factors during the observing period in winter.