Supplement of Atmos. Chem. Phys., 21, 2251–2265, 2021
https://doi.org/10.5194/acp-21-2251-2021-supplement

Atmospheric Chemistry and Physics
Open Access
EGU

Supplement of

Persistent residential burning-related primary organic particles during wintertime hazes in North China: insights into their aging and optical changes

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Table S1. Detailed information on individual particle samples collected at the Gucheng rural and Beijing urban sites.

Location	Date	Local time	Sampling duration (s)	Temp. (°C)	RH (%)	Pressure (hPa)	WS ($m\ s^{-1}$)	Pollution level
Gucheng rural site	21 Nov. 2016	12:00	180	−0.6	100	1018	4	Clean
	22 Nov. 2016	8:06	180	−4.7	97	1012	0.9	Clean
	22 Nov. 2016	19:22	120	−3.8	47	1036	0.6	Heavy (Early stage)
	23 Nov. 2016	10:50	15	0.9	51	1034	0.6	Heavy (Early stage)
	24 Nov. 2016	8:06	15	−6.4	94	1028	0	Heavy (Middle stage)
	25 Nov. 2016	3:00	15	−2.0	79	1022	1.6	Heavy (Middle stage)
	25 Nov. 2016	8:07	10	−4.7	93	1023	0	Heavy (Middle stage)
	25 Nov. 2016	15:19	10	1.4	77	1022	1.6	Heavy (Late stage)
	25 Nov. 2016	20:44	10	1.1	84	1022	1.7	Heavy (Late stage)
	26 Nov. 2016	3:00	8	−1.4	95	1018	0	Heavy (Late stage)
	26 Nov. 2016	8:15	8	−1.9	98	1018	0	Heavy (Late stage)
	26 Nov. 2016	12:27	10	5.5	70	1017	0.8	Heavy (Late stage)
Beijing urban site	22 Nov. 2016	19:00	60	−1.8	33	1039	0.5	Clean
	24 Nov. 2016	19:00	15	2.9	41	1026	0.9	Moderate
	25 Nov. 2016	12:00	20	3.8	42	1026	1.5	Moderate
	25 Nov. 2016	22:00	10	3.1	72	1024	0	Heavy
	26 Nov. 2016	9:00	10	2.4	75	1022	0	Heavy
	26 Nov. 2016	16:00	10	7	45	1019	0	Heavy
	26 Nov. 2016	22:00	10	3.8	71	1020	0	Heavy

Table S2. Summary of the average meteorological parameters and mass concentrations of $PM_{2.5}$, aerosol chemical species, organic aerosol (OA) factors, and gaseous pollutants in different periods at the Gucheng rural and Beijing urban sites.

	Gucheng rural site				*Beijing urban site*		
	Clean	Heavily polluted			Clean	Moderately polluted	Heavily polluted
		Early stage	Middle stage	Late stage			
Meteorological parameters							
T (°C)	−1.5	−2.9	−1.6	0.53	−2.0	2.1	3.9
RH (%)	97	63	65	78	58	48	64
WS ($m\ s^{-1}$)	2.8	0.51	0.53	0.50	1.4	0.38	0.28
P (hPa)	1013.5	1032.6	1026.9	1019.6	1029.1	1026.5	1021.5
$PM_{2.5}$ and chemical components [a] ($\mu g\ m^{-3}$)							
$PM_{2.5}$	39.8	288.3	312.3	396.8	10.8	111.0	281.0
OM	19.8	185.1	175.4	217.2	5.7	44.4	82.8
SO_4^{2-}	2.0	13.6	17.3	41.2	2.0	13.9	51.3
NO_3^-	2.4	11.3	14.7	30.8	1.9	19.7	41.0
NH_4^+	1.4	11.5	13.9	28.2	1.1	9.8	24.2
Cl^-	1.2	11.1	9.8	15.9	0.46	7.2	14.7
EC	1.4	8.9	8.7	10.9	/	/	/
K^+	0.36	1.6	1.5	2.7	/	/	/
Na^+	0.63	0.41	0.42	0.92	/	/	/
Mg^{2+}	0.08	0.18	0.15	0.28	/	/	/
Ca^{2+}	0.75	1.1	0.84	1.8	/	/	/
OA factors [b] ($\mu g\ m^{-3}$)							
FFOA	/	/	/	/	1.0	9.2	15.6
COA	/	/	/	/	1.1	6.5	9.0
BBOA	/	/	/	/	0.20	5.4	15.0
OOA	/	/	/	/	0.74	12.7	24.1
OPOA	/	/	/	/	1.9	7.7	12.2
aqOOA	/	/	/	/	0.24	3.0	10.7
Gaseous pollutants							
CO ($mg\ m^{-3}$)	0.44	2.4	2.9	4.3	0.54	2.8	4.1
SO_2 ($\mu g\ m^{-3}$)	10.3	48.2	55.5	55.9	6.0	23.2	21.8
NO_2 ($\mu g\ m^{-3}$)	25.3	62.7	80.0	94.5	29.0	94.1	130.8
O_3 ($\mu g\ m^{-3}$)	36.1	10.7	10.2	10.5	42.6	11.0	7.6

[a]The aerosol chemical components at the Gucheng rural site were obtained by offline analysis of $PM_{2.5}$ filter samples and those at the Beijing urban site were obtained by online analysis of NR-PM_1 using a high-resolution aerosol mass spectrometer (HR-AMS).

[b]OA factors were derived by PMF analysis of HR-AMS data at the Beijing urban site. FFOA–fossil fuel-related OA, COA–cooking OA, BBOA–biomass burning OA, OOA–oxygenated OA, OPOA–oxidized POA, and aqOOA–aqueous-phase OOA.

Table S3. Comparison between the average Mie calculation results acquired by two reported refractive indices of 1.67−0.27*i* and 1.84−0.21*i* in previous studies.

Location	Pollution level	ACS_{actual}[a]	$ACS_{non\text{-}aging}$[b]	E_{abs}[c]	Refractive Index
Gucheng	Heavy (Early stage)	3.09	3.01	1.02	1.67−0.27*i* (Alexander et al., 2008)
	Heavy (Middle stage)	3.97	3.53	1.12	
	Heavy (Late stage)	4.43	3.18	1.39	
Beijing	Moderate	2.06	1.86	1.10	
	Heavy	3.00	2.15	1.39	
Gucheng	Heavy (Early stage)	3.08	3.00	1.02	1.84−0.21*i* (Hoffer et al., 2016)
	Heavy (Middle stage)	3.97	3.51	1.13	
	Heavy (Late stage)	4.47	3.13	1.43	
Beijing	Moderate	2.04	1.85	1.10	
	Heavy	2.99	2.14	1.40	

[a]ACS_{actual} represents the absorption cross section of individual POA-containing particles (including core–shell POA–SIA and bare POA) under the actual scenario;

[b]$ACS_{non\text{-}aging}$ represents the absorption cross section of individual uncoated POA particles (including POA cores without SIA shell and bare POA) under the particle non-aging scenario;

[c]E_{abs} represents the absorption enhancement factor due to particle aging, i.e., ratio of ACS_{actual} to $ACS_{non\text{-}aging}$.

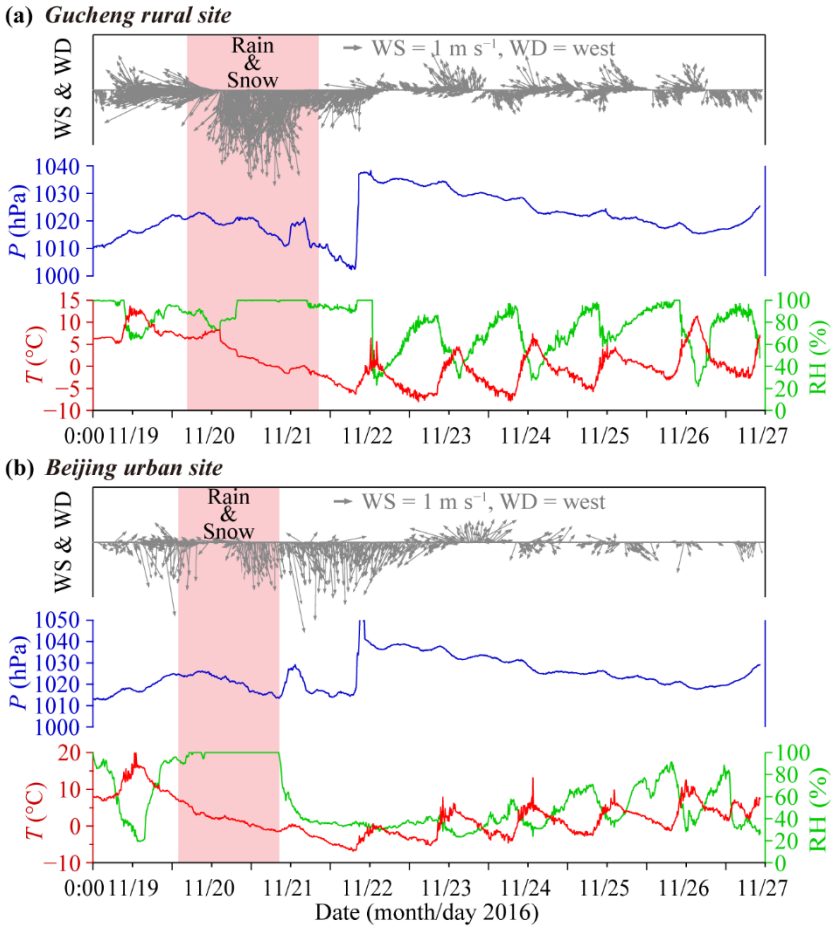

Figure S1. Time series of meteorological parameters including temperature (*T*), pressure (*P*), relative humidity (RH), wind speed (WS), and wind direction (WD) at the (a) Gucheng rural site and (b) Beijing urban site.

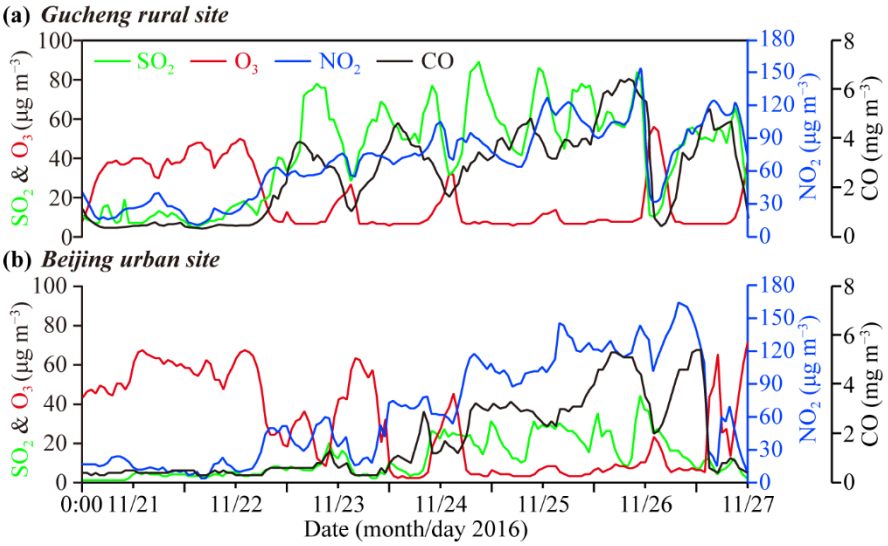

Figure S2. Time series of gaseous pollutants (i.e., CO, SO_2, O_3, and NO_2) at the (a) Gucheng rural site and (b) Beijing urban site. Data at two monitoring stations (i.e., Dingxing government station: 39°15'42" N, 115°48'06" E; Beijing Olympic center station: 40°00'11" N, 116°24'25" E) close to GC rural and BJ urban sites were downloaded from the website of air quality online monitoring and analysis platform (https://www.aqistudy.cn/).

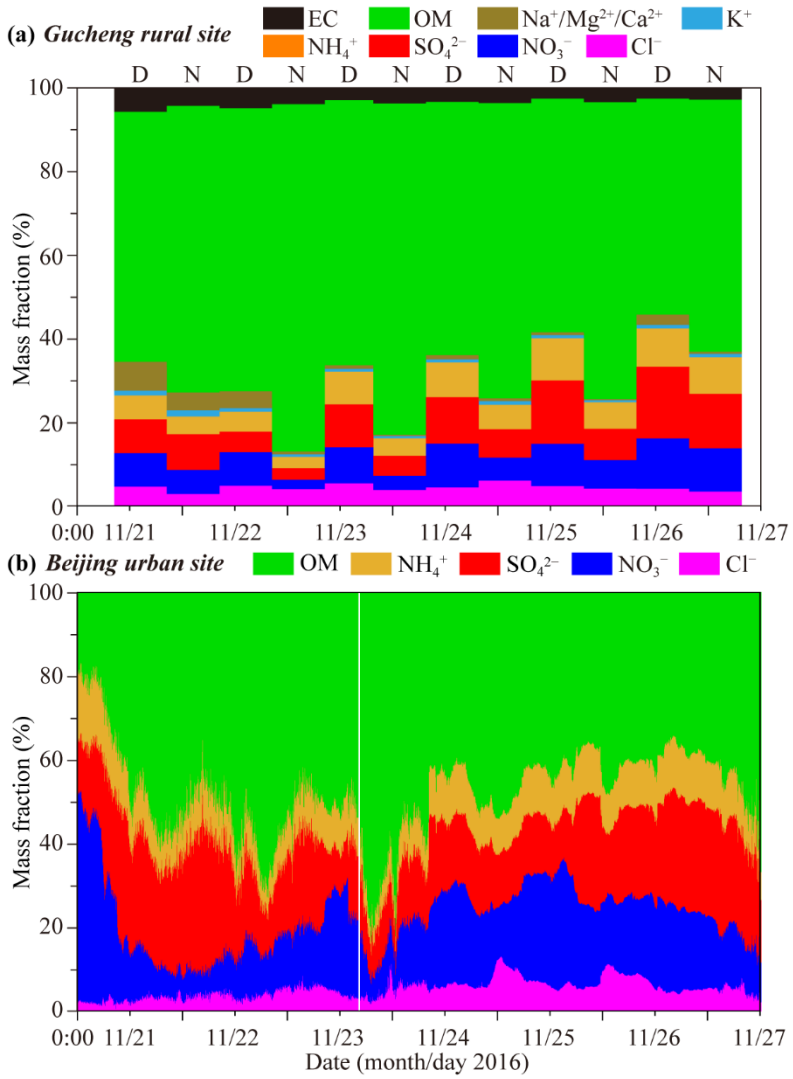

Figure S3. Relative mass fractions of major chemical species in $PM_{2.5}$ at the Gucheng rural site (a) and in NR-PM_1 at the Beijing urban site (b).

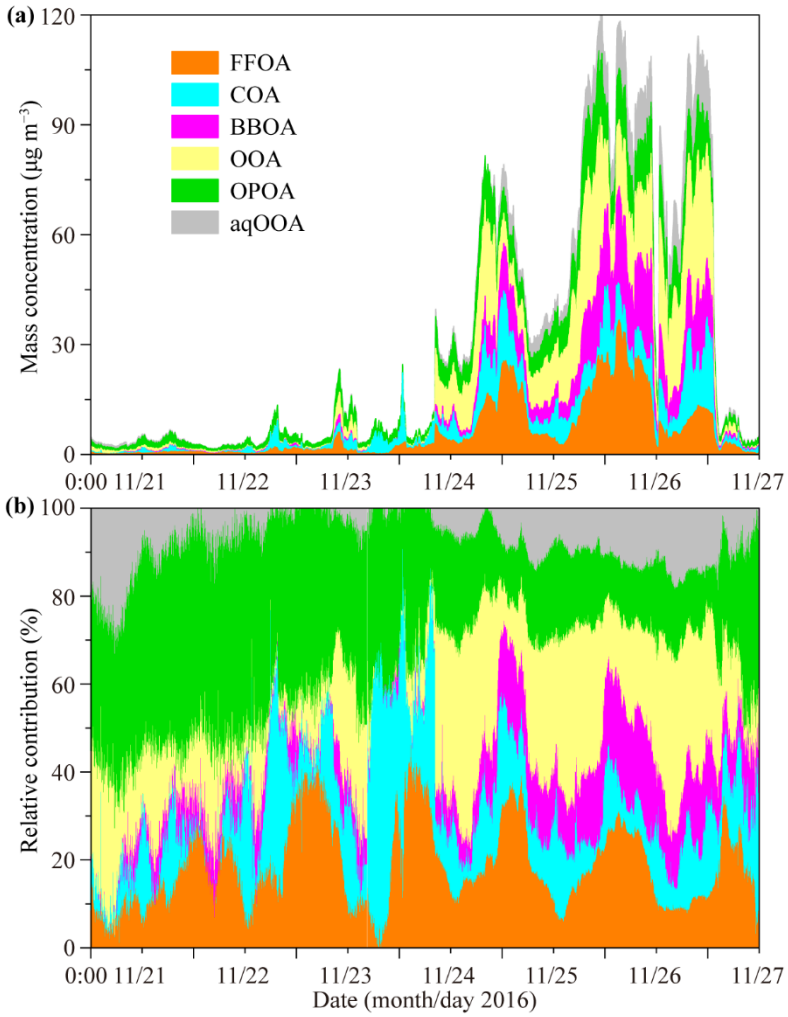

Figure S4. Absolute (a) and relative (b) contributions to organic aerosol (OA) in NR-PM_1 from different factors (i.e., FFOA–fossil fuel-related OA, COA–cooking OA, BBOA–biomass burning OA, OOA–oxygenated OA, OPOA–oxidized POA, and aqOOA–aqueous-phase OOA) at the Beijing urban site.