Supplement of

Mixing state of refractory black carbon in fog and haze at rural sites in winter on the North China Plain

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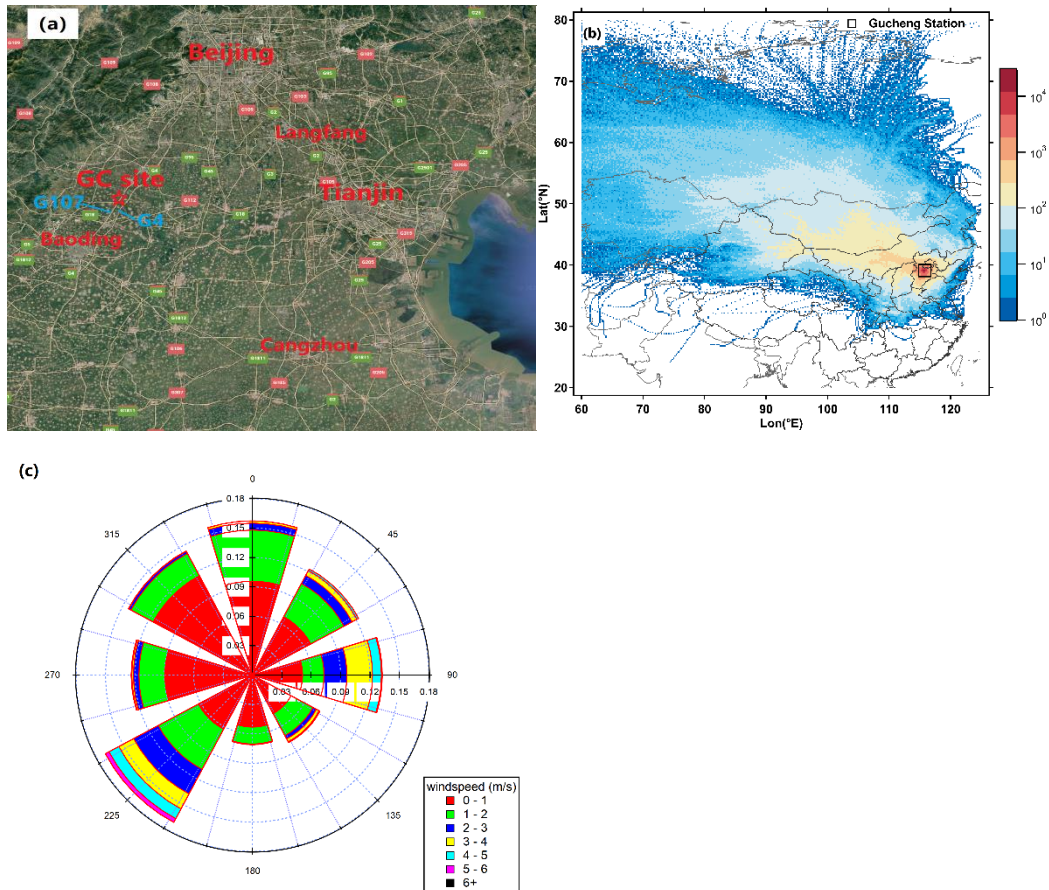*Correspondence to*: Xiaole Pan (panxiaole@mail.iap.ac.cn)

Figure S1: (a) Map of the experimental site (GC) that is located about 120 kilometers southwest of Beijing, adjacent to National Highway 107 (G107) and Beijing-Hong Kong-Macau Expressway (G4); the map was taken from Google Maps (©Google Maps 2021, https://www.google.com/maps, last access: 15 March 2021). **(b)** The sampling site was influenced by the historical air mass during the observation period, back trajectory analysis calculated by NOAA Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT). **(c)** The wind rose shows the frequency distribution of every 10 minutes averaged wind direction and speed throughout the experimental period.
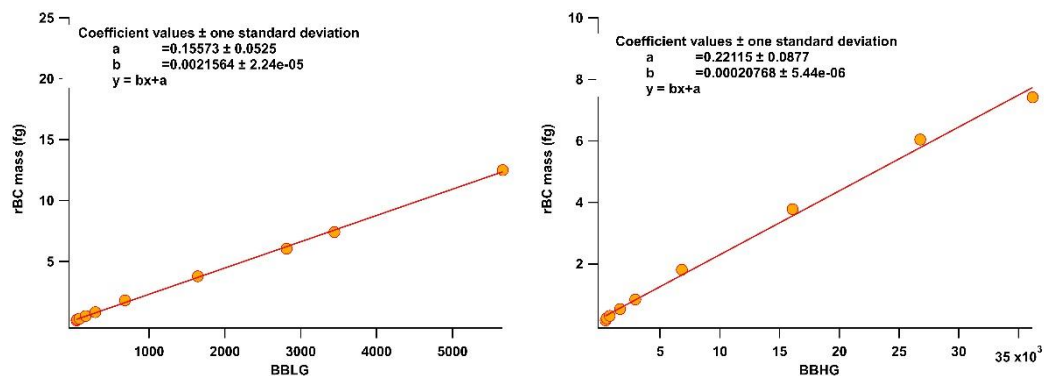

Figure S2: The calibration coefficient values for broadband high gain (BBHG) and broadband low gain (BBLG) of incandescence signals.
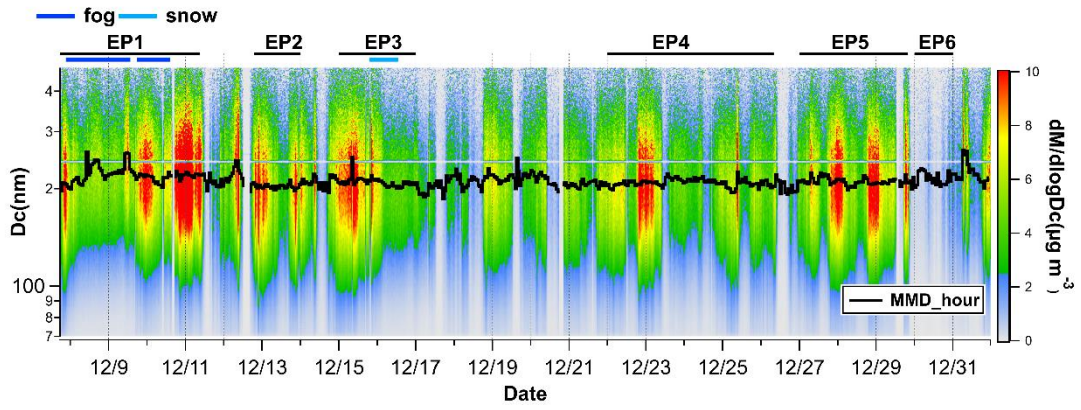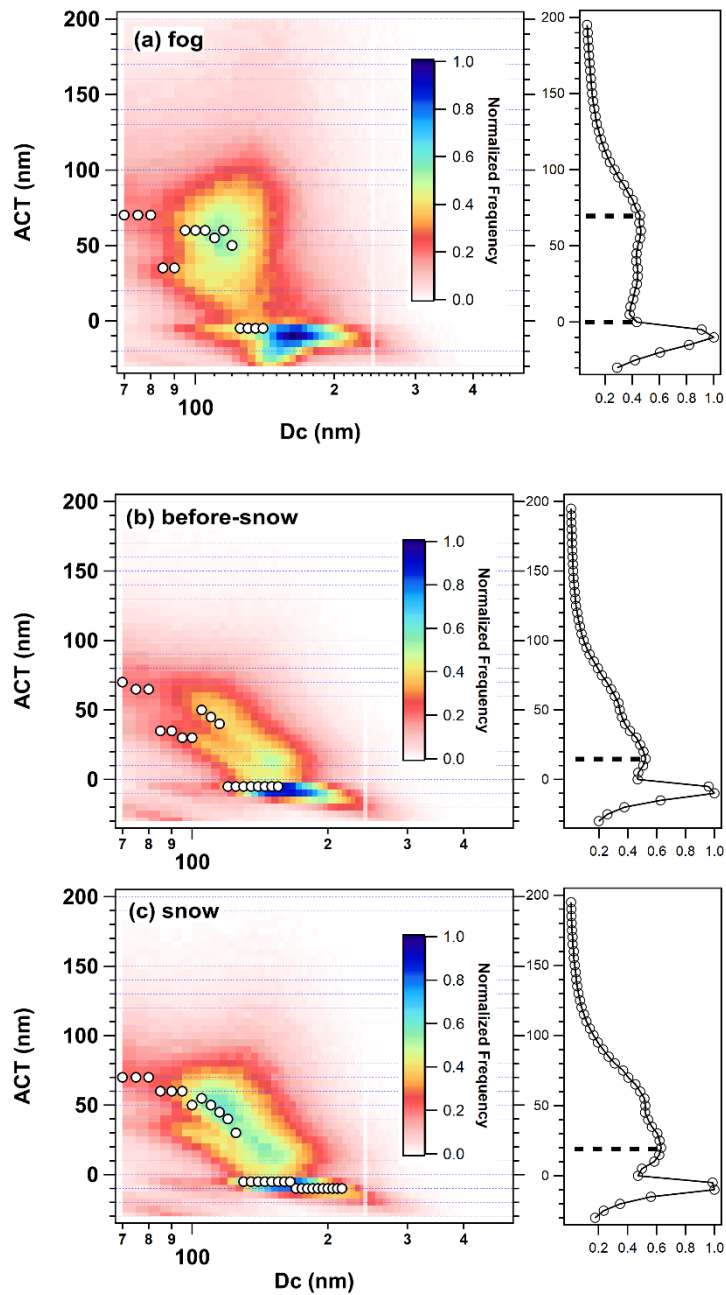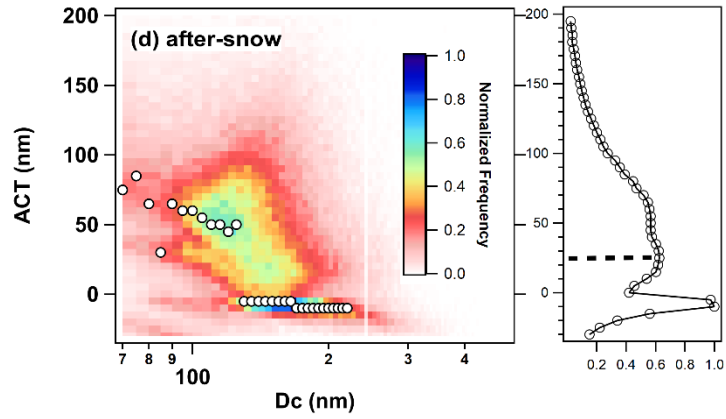
Figure S3: Time series of the mass size distribution of *r*BC, as measured by the SP2. The black line denotes the hourly mass median diameter (MMD).

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Figure S4: The ACT as a function of the *r*BC core diameter during (a) fog, (b) before-snow, (c) after-snow and (d) snow events. The image plot is a 2D histogram, with the color denoting the normalized frequency in each bin. The right panel denotes the normalized (maximum=1) histogram of ACTs.

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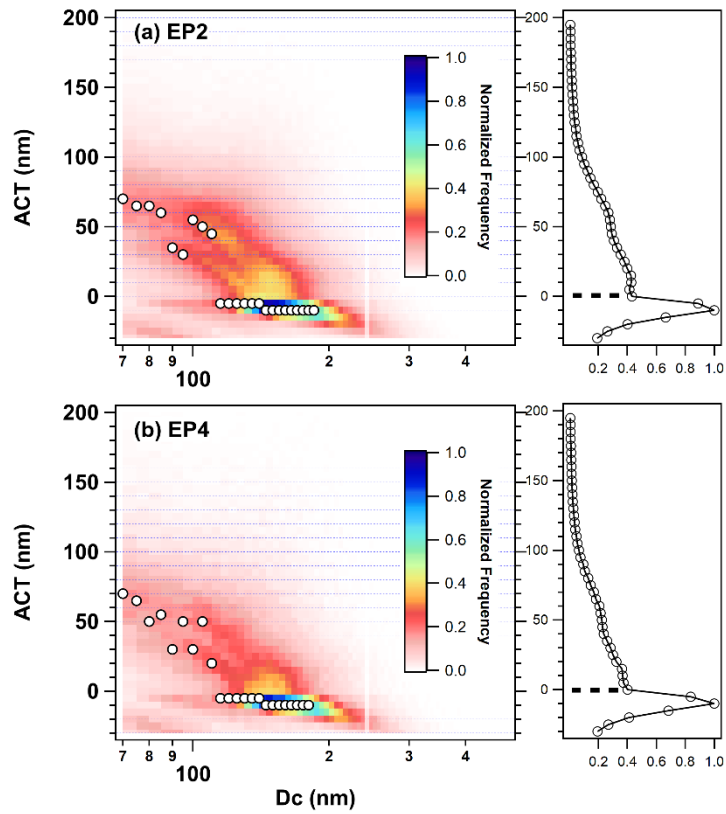
Figure S5: The ACT as a function of the *r*BC core diameter during(a) EP2, (b) EP4, (c) EP5, and (d) EP6 events. The image plot is a 2D histogram, with the color denoting the normalized frequency in each bin. The right panel denotes the normalized (maximum=1) histogram of ACTs.
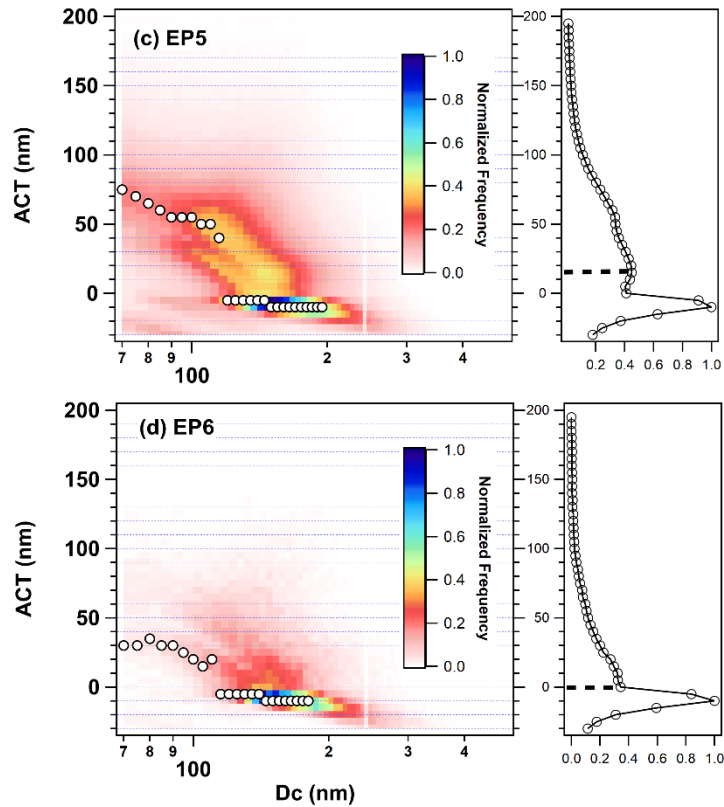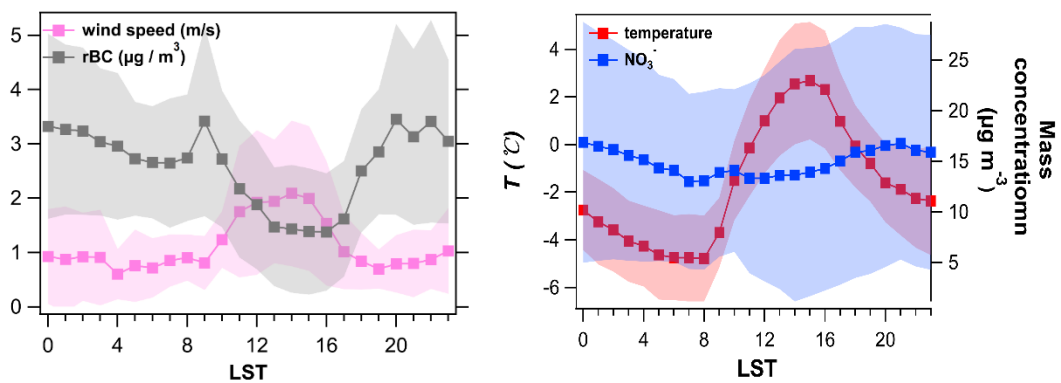

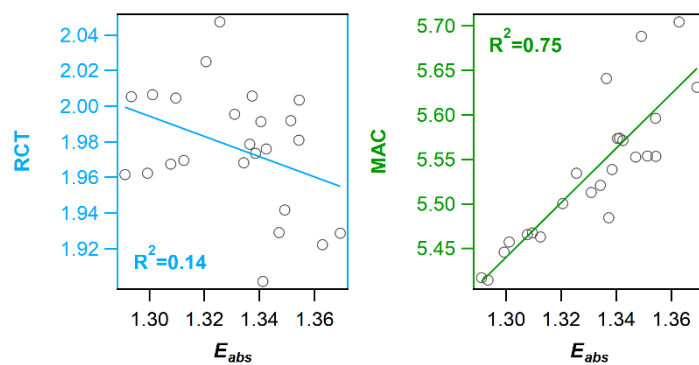**Figure S6: Diurnal variation in rBC mass loading, wind speed, temperature and nitrate (NO3).**

Figure S7: Correlation of E_{abs} with RCT and MAC in diurnal cycle pattern.
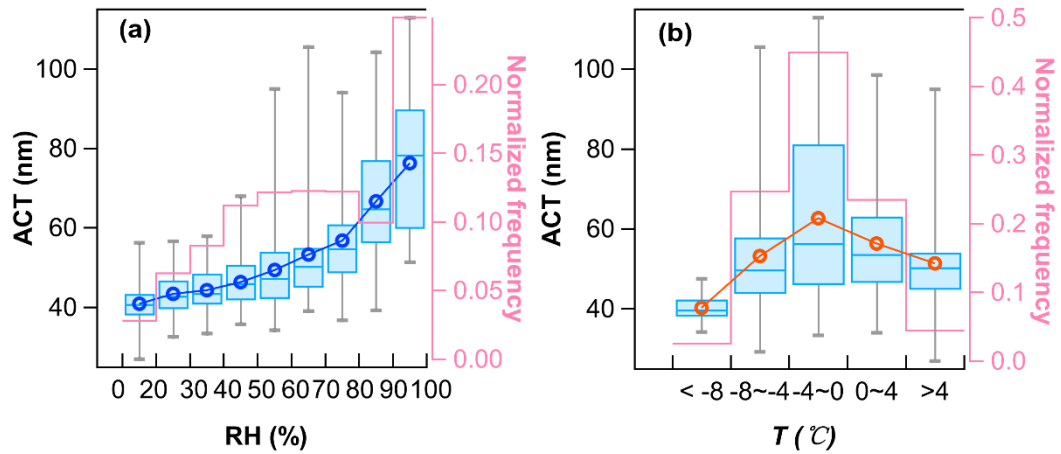
Figure S8: ACT dependency on RH (a) and temperature (b). Blue and red circles represent the average values. The line inside the box indicates the median. The upper and lower boundaries of the box represent the 75th and 25th percentiles; the whiskers above and below each box represent the max and min values. The pink lines represent the normalized frequency of data points in each bin.

Table S1. Representative cases of different episodes in Gucheng.

Selected cases	Month/Day/ time	rBC mass loading ($\mu g\,m^{-3}$)	MMD (nm)	CMD (nm)	RCT(ACT) (Dc@170-190nm)	E_{abs}	MAC (m^2/g)	RH (%)	T (°C)	Wind speed ($m\,s^{-1}$)
Fog	12/7/21:10-12/9/13:30 12/9/17:30-12/10/14:20	3.09 ± 0.95	220	131	2.04 ± 0.27 (92.71 ± 23.84)	1.23 ± 0.08	5.41	100	-3.32 ± 1.07	0.63 ± 0.72
Before-snow	12/15/00:00-12/15/18:50	4.70 ± 0.65	213	120	1.44 ± 0.05 (39.91 ± 3.62)	1.23 ± 0.07	5.43	60.99 ± 10.05	-0.24 ± 2.52	0.62 ± 0.32
Snow	12/15/19:00-12/16/13:00	2.82 ± 1.14	210	126	1.52 ± 0.05 (46.85 ± 4.45)	1.34 ± 0.03	5.86	96.99 ± 4.85	0.09 ± 0.33	0.74 ± 0.31
After-snow	12/16/13:10-12/17/00:00	1.88 ± 0.20	206	129	1.68 ± 0.05 (61.29 ± 4.65)	1.41 ± 0.03	6.31	96 ± 1.87	0.66 ± 0.63	0.85 ± 0.52
EP2	12/12/19:00-12/14/00:00	3.44 ± 1.40	203	118	1.47 ± 0.10 (42.33 ± 9.39)	1.21 ± 0.06	5.41	50.44 ± 12.49	-0.4 ± 4.17	0.84 ± 0.46
EP4	12/22/00:00-12/26/08:00	1.2 ± 1.16	202	116	1.65 ± 0.14 (58.60 ± 12.69)	1.26 ± 0.05	5.70	81.04 ± 13.13	-1.83 ± 2.54	0.97 ± 0.82
EP5	12/27/00:00-12/29/20:00	3.35 ± 1.34	211	122	1.55 ± 0.16 (48.86 ± 14.06)	1.25 ± 0.06	5.56	62.42 ± 14.67	-1.4 ± 3.46	1.05 ± 0.74
EP6	12/30/00:00-12/31/00:00	0.46 ± 0.34	216	122	1.41 ± 0.11 (37.00 ± 9.48)	1.11 ± 0.04	5.18	22.66 ± 7.71	-4.8 ± 2.34	2.27 ± 1.23