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*Supplement of*

## **Vertically resolved characteristics of air pollution during two severe winter haze episodes in urban Beijing, China**

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Table S1. The date and time for each vertical profile measured in this study.

No.	height(m)	Date	Starting time, Up	Ending time, Up	Starting time, Down	Ending time, Down
1	260	11-19-2014	09:13:00	09:44:00	09:46:00	10:12:00
2	260	11-19-2014	12:04:00	12:32:30	12:33:00	12:59:00
3	260	11-19-2014	15:06:30	15:34:50	15:35:05	16:01:00
4	200	11-19-2014	18:05:30	18:27:50	18:28:00	18:48:20
5	200	11-19-2014	22:05:00	22:27:35	22:27:50	22:48:30
6	200	11-20-2014	02:05:00	02:27:20	02:30:25	02:50:45
7	200	11-20-2014	06:05:00	06:27:15	06:27:40	06:48:00
8	260	11-20-2014	10:04:45	10:33:10	10:33:20	10:59:40
9	260	11-20-2014	14:05:15	14:33:35	14:33:50	14:59:02
10	260	11-20-2014	16:23:00	16:51:30	16:51:50	17:18:00
11	200	11-20-2014	20:03:30	20:25:40	20:25:50	20:46:20
12	200	11-20-2014	23:05:00	23:27:15	23:27:30	23:47:50
13	200	11-21-2014	03:05:00	03:27:15	03:27:30	03:47:50
14	260	11-21-2014	07:05:00	07:34:56	07:35:15	08:01:25
15	260	11-21-2014	10:03:20	10:31:55	10:32:10	10:58:18
16	260	11-21-2014	13:17:15	13:45:50	13:46:20	14:12:25
17	260	11-21-2014	16:07:50	16:32:40	16:33:00	16:55:37
18	260	01-12-2015	12:19:15	12:47:54	13:04:05	13:30:15
19	260	01-12-2015	16:18:30	16:47:10	17:04:45	17:30:50
20	200	01-12-2015	20:20:10	20:42:45	21:04:15	21:26:45
21	200	01-13-2015	00:20:00	00:42:24	01:10:00	01:32:50
22	200	01-13-2015	06:20:00	06:45:20	07:10:00	07:33:40
23	260	01-13-2015	10:17:50	10:44:37	11:05:00	11:31:10
24	260	01-13-2015	14:19:15	14:47:04	15:05:00	15:31:10
25	200	01-13-2015	17:19:35	17:47:25	18:04:10	18:30:17
26	200	01-13-2015	20:29:20	20:51:00	21:04:30	21:24:57
27	200	01-14-2015	00:19:10	00:41:00	01:09:42	01:30:05
28	200	01-14-2015	06:20:16	06:41:52	07:09:37	07:30:03
29	260	01-14-2015	10:19:20	10:47:15	11:04:15	11:30:25
30	260	01-14-2015	14:19:05	14:46:30	15:05:20	15:31:30
31	200	01-14-2015	18:19:18	18:41:45	19:11:22	19:32:42
32	200	01-15-2015	00:20:00	00:41:50	01:10:00	01:30:30
33	200	01-15-2015	06:20:00	06:41:45	07:10:00	07:30:30
34	260	01-15-2015	12:19:50	12:47:40	13:04:55	13:31:02
35	260	01-15-2015	16:30:28	16:58:10	17:28:13	17:54:20
36	200	01-15-2015	23:20:00	23:41:40	(01-16) 00:25:00	(01-16) 00:45:20

Table S2. A summary of vertical profiles of Type 1, which includes the number of vertical profile as indicated in Figure 1, traveling direction (up or down), measuring time, slope of extinction vs. height ( $\text{Mm}^{-1}/\text{m}$ ), vertical difference ( $\text{Diff} (\%) = (\text{max}-\text{min})/(2*\text{mean})*100$ ), temperature inversion height (TVH, no values mean no temperature inversions), sampling height (SH, 200 m or 260 m), and mixing layer height (MLH) from ceilometers measurements.

No.	Travel	Time	Slope	Diff (%)	TVH	SH	MLH
<b>November</b>							
2	up	12:04	0.08	4%		260	432
2	down	12:33	-0.31	5%		260	432
3	up	15:06	-0.11	2%		260	577
3	down	15:35	-0.08	2%		260	577
9	up	14:05	-0.08	3%		260	370
9	down	14:33	0.19	4%		260	370
11	up	20:03	-0.12	5%	120	200	212
16	up	13:17	-0.02	5%		260	548
16	down	13:46	-0.09	7%		260	548
<b>January</b>							
18	down	13:04	-0.02	4%		260	895
22	up	6:20	-0.18	6%		200	537
23	down	11:05	0.14	7%		260	528
24	up	14:19	0.00	3%		260	795
24	down	15:05	-0.03	4%		260	938
26	up	20:29	-0.09	3%		200	867
27	down	1:09	-0.11	5%		200	253
28	up	6:20	-0.01	3%		200	
28	down	7:09	0.04	4%		200	
29	up	10:19	0.17	5%		260	
30	up	14:19	0.02	3%		260	1120
31	up	18:19	0.11	2%		200	1138
32	up	0:20	0.02	2%		200	298
35	up	16:30	-0.48	5%		260	307
35	down	17:28	0.00	4%		260	298
36	up	23:20	-0.26	2%	240	200	257
36	down	0:25	-0.10	2%	240	200	228

Table S3. A summary of vertical profiles of Type 2. The statistical parameters are the same as those in Table S2.

No.	Travel	Time	Slope	Diff (%)	TVH	SH	MLH
<b>November</b>							
4	up	18:05	-0.74	6%	280	200	338
4	down	18:28	-1.15	9%	280	200	338
5	up	22:05	-1.28	9%	280	200	238
5	down	22:27	-0.90	6%	280	200	238
8	up	10:04	-0.89	13%	200	260	220
8	down	10:33	-1.01	14%	200	260	220
15	up	10:03	-0.39	11%	200	260	307
15	down	10:32	-0.12	7%	200	260	307
17	up	16:07	-0.10	40%		260	338
17	down	16:33	-0.06	32%		260	338
<b>January</b>							
18	up	12:19	-0.17	10%		260	822
19	down	17:04	-0.92	18%		260	275
20	down	21:04	-1.03	10%		200	283
21	up	0:20	-0.87	8%		200	260
25	up	17:19	-0.37	7%		200	
25	down	18:04	-0.49	7%		200	
29	down	11:04	-0.58	9%		260	
30	down	15:05	-0.38	6%		260	1415
31	down	19:11	-1.45	12%		200	785
34	down	13:04	-2.78	21%		260	546

Table S4. A summary of vertical profiles of Type 3. The statistical parameters are the same as those in Table S2.

No.	Travel	Time	Slope	Diff (%)	TVH	SH	MLH
<b>November</b>							
1	up	9:13	2.13	31%	180	260	297
1	down	9:46	0.52	13%	180	260	297
12	up	23:05	1.03	6%	120	200	220
12	down	23:27	1.54	6%	120	200	220
<b>January</b>							
19	up	16:18	0.58	68%		260	1020
21	down	1:10	0.30	4%		200	270
26	down	21:04	0.37	5%		200	465
27	up	0:19	0.85	10%		200	330
33	up	6:20	0.92	20%	180	200	298
33	down	7:10	0.53	11%	180	200	313
34	up	12:19	0.66	8%		260	648

Table S5. A summary of vertical profiles of Type 4. The statistical parameters are the same as those in Table S2.

<b>No.</b>	<b>Travel</b>	<b>Time</b>	<b>Slope</b>	<b>Diff (%)</b>	<b>TVH</b>	<b>SH</b>	<b>MLH</b>
<b>November</b>							
6	up	2:05	-0.91	8%	120	200	190
6	down	2:30	-1.36	10%	120	200	190
7	up	6:05	-2.83	19%	120	200	173
7	down	6:27	-1.81	15%	120	200	173
13	up	3:05	-1.16	9%	120	200	245
13	down	3:27	-1.26	8%	120	200	245
14	up	7:05	-2.49	26%	120	260	208
14	down	7:35	-1.77	23%	120	260	208
11	down	20:25	-5.01	25%	100	200	212
<b>January</b>							
20	up	20:20	-0.80	17%	180	200	207

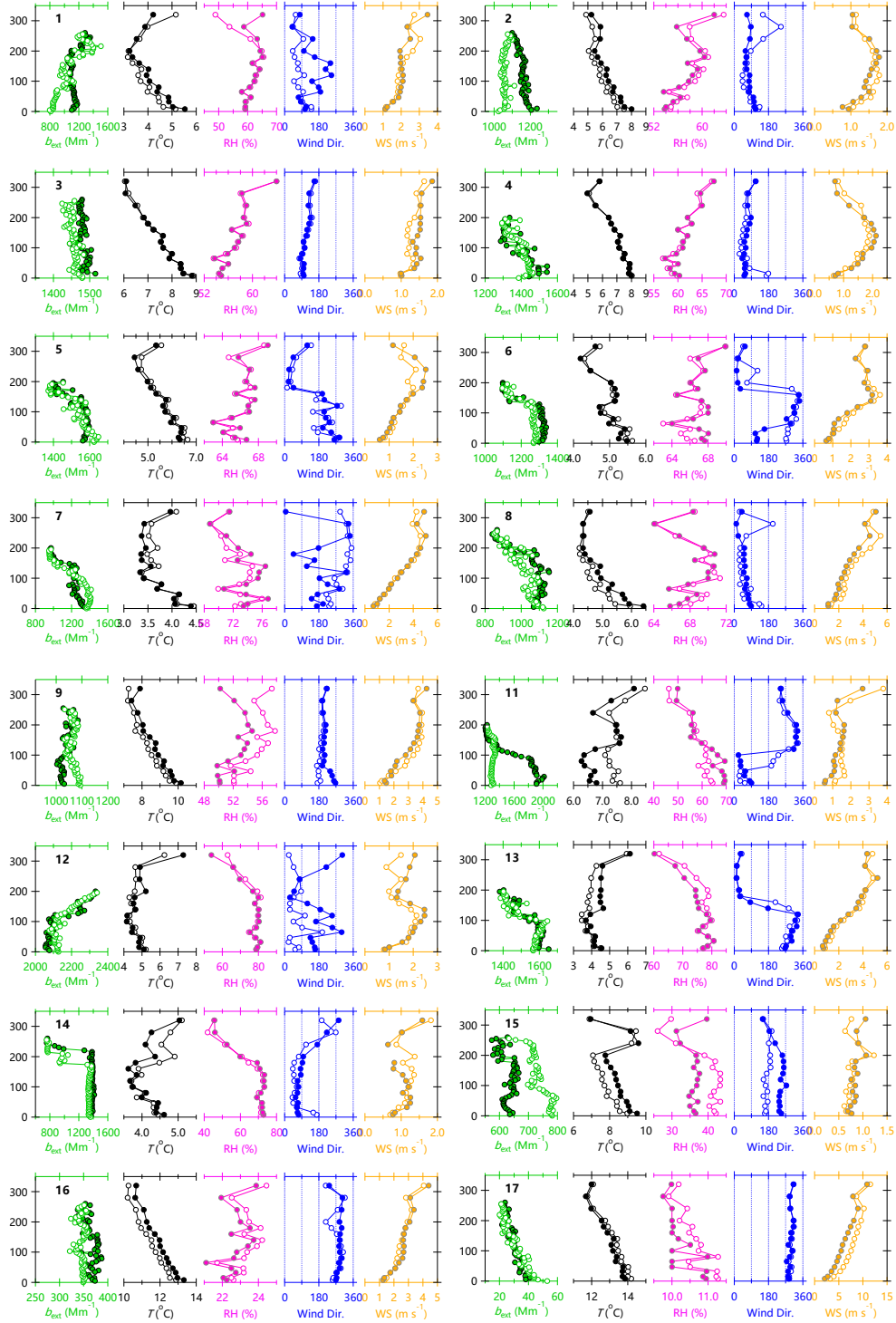


Figure S1. Vertical profiles of  $b_{\text{ext}}$ , Temperature ( $T$ ), relative humidity (RH), wind direction and wind speed (WS) in November. The solid circles represent the down profiles while others are up profiles.

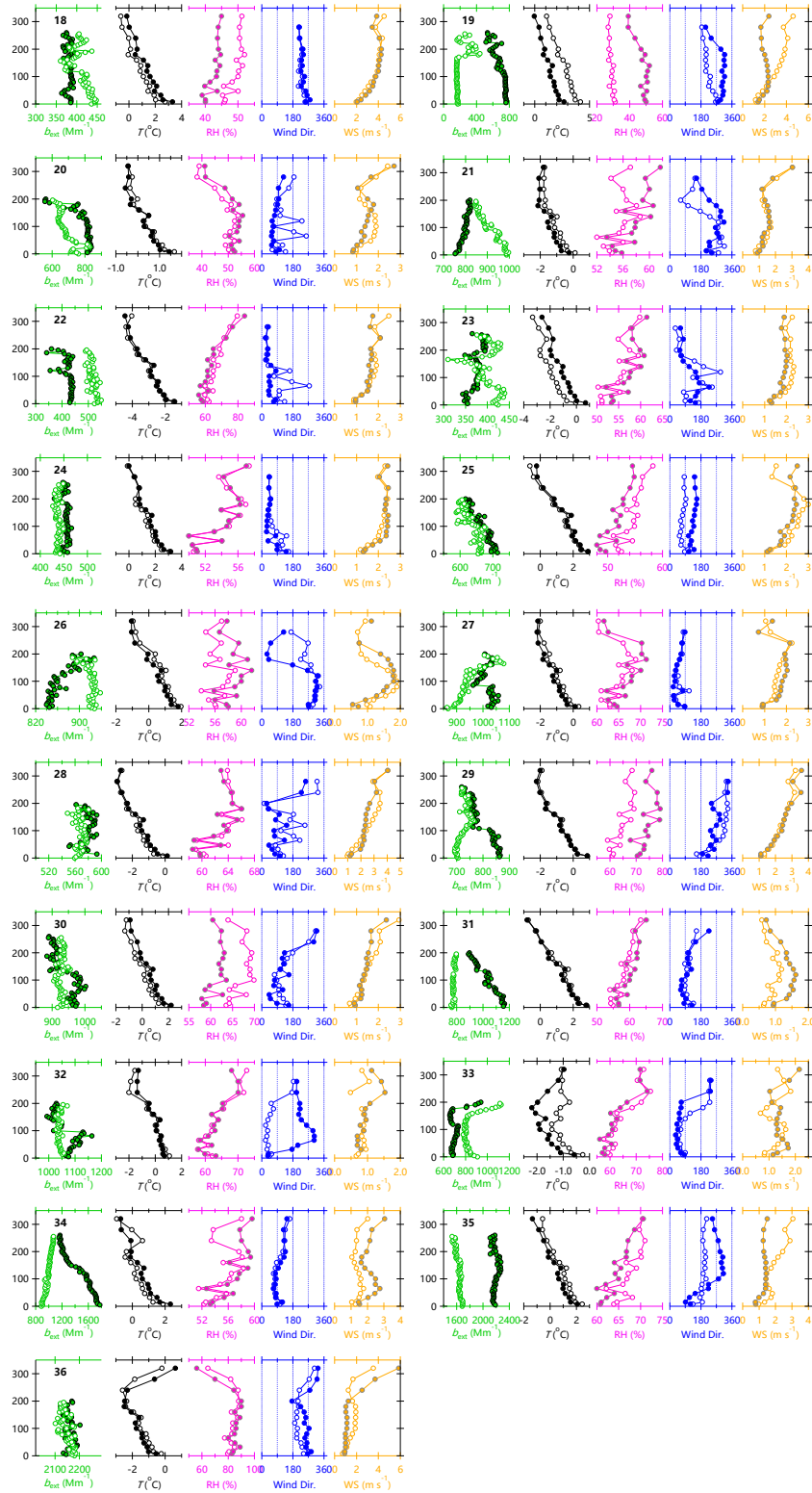


Figure S2. Vertical profiles of  $b_{\text{ext}}$ , Temperature ( $T$ ), relative humidity (RH), wind direction and wind speed (WS) in January. The solid circles represent the down profiles while others are up profiles.

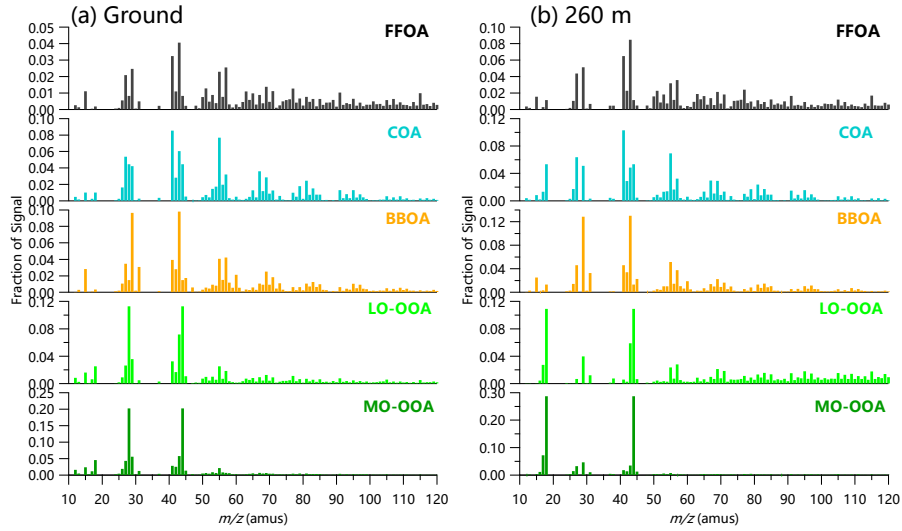


Figure S3. Mass spectral profiles of five OA factors at ground site and 260 m, including fossil fuel related OA (FFOA), cooking OA (COA), biomass burning OA (BBOA), less oxidized oxygenated OA (LO-OOA), and more oxidized OOA (MO-OOA).

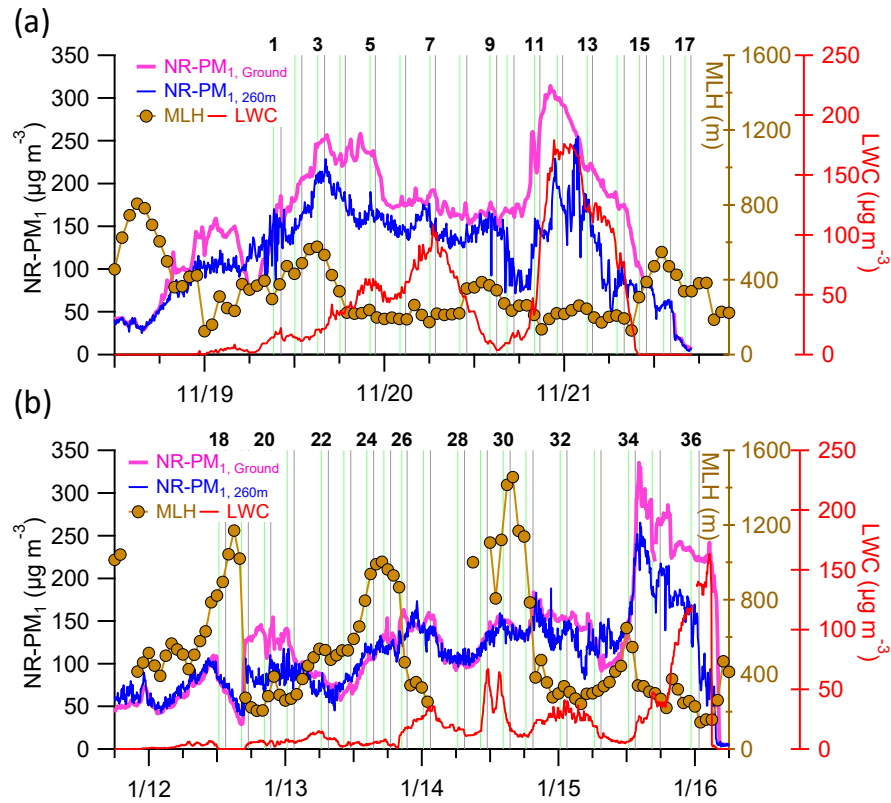


Figure S4. Time series of NR-PM<sub>1</sub> mass concentrations at ground level and 260 m, liquid water content (LWC), and mixing layer height (MLH) during the two haze episodes. The number of vertical profile experiments is also marked in green (up) and gray (down) vertical lines, and the time for each vertical profile is detailed in Table S1.



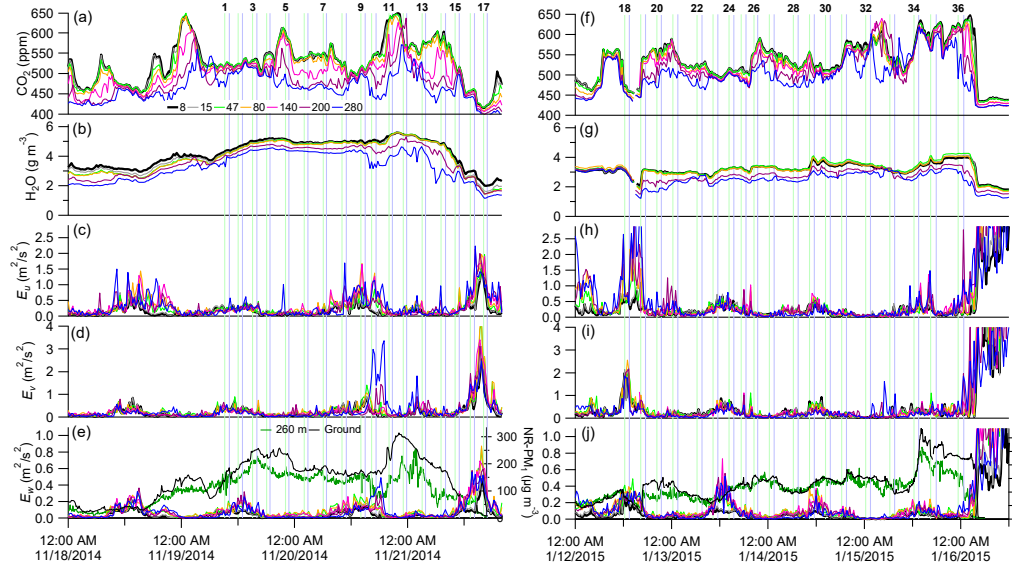


Figure S5. Time series of  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ ,  $E_{it}$ ,  $E_v$ , and  $E_w$  at 7 heights (8, 15, 47, 80, 140, 200, and 280 m) during the two haze episodes. The number of vertical profile experiments is marked as green (up) and gray (down) vertical lines. Also shown is the time series of NR- $\text{PM}_{10}$  mass concentrations at ground level and 260 m.

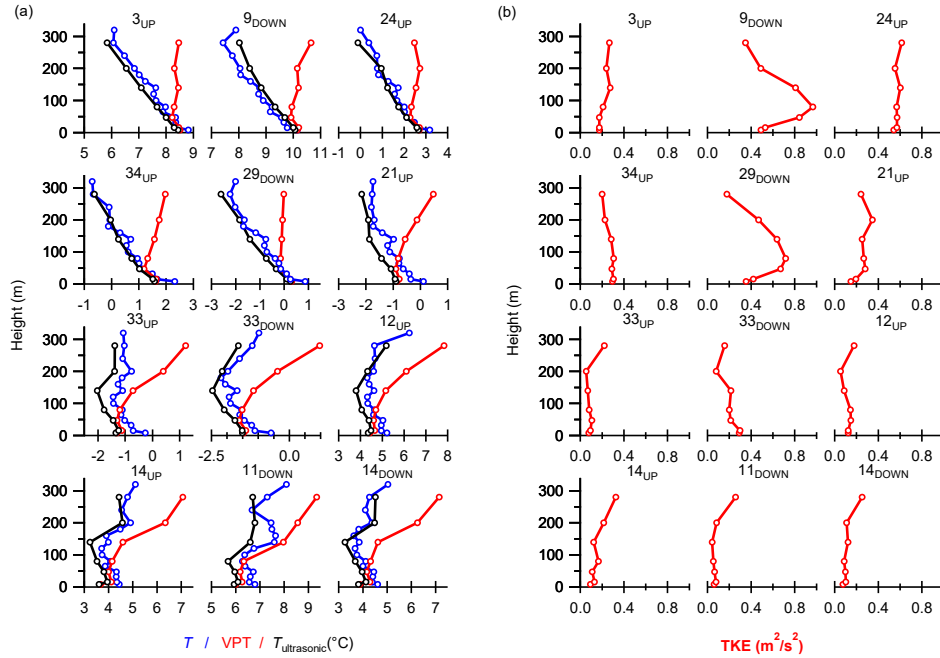


Figure S6. Comparisons of vertical profiles of  $T$ ,  $VPT$ ,  $T_{\text{ultrasonic}}$ , and  $TKE$  for four types of vertical profiles. “UP” and “DOWN” indicate the vertical profiles measured during the up and down experiments, respectively. Note that the temperature measured at 15 heights with the standard meteo probe (model HC2-S3, ROTRONIC) is systematically higher than that measured at 7 heights with ultrasonic anemometers (Gill Instruments Limited, Lymington, UK), but the differences are generally less than  $1^\circ\text{C}$ .

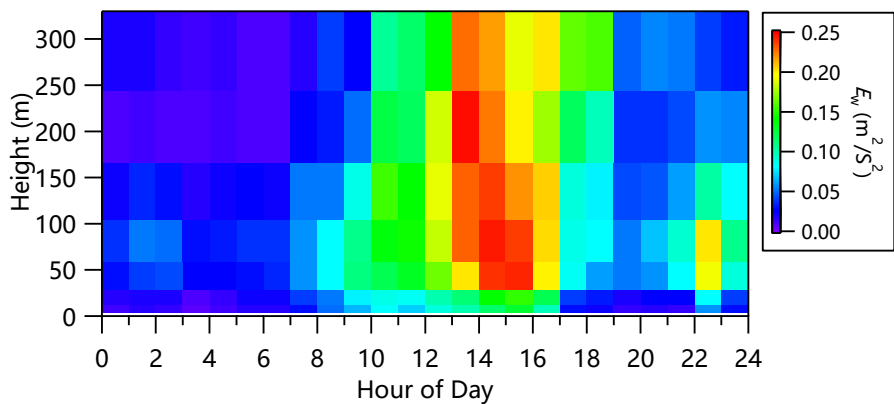


Figure S7. Diurnal cycle of  $E_w$  at 7 heights during the haze episode in November.

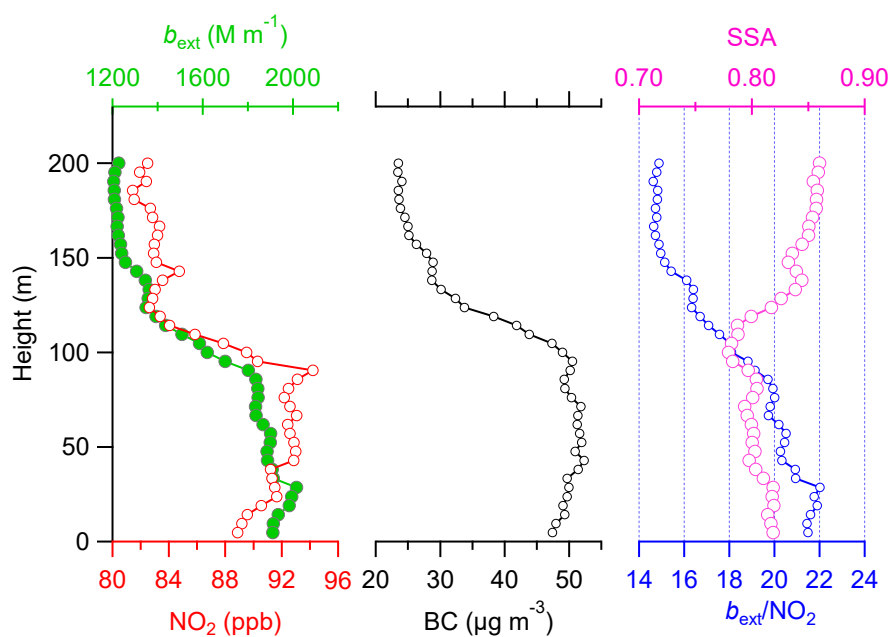


Figure S8. Vertical profiles of  $b_{ext}$ ,  $\text{NO}_2$ ,  $\text{BC}$ ,  $b_{ext}/\text{NO}_2$ , and  $\text{SSA}$  for V11.

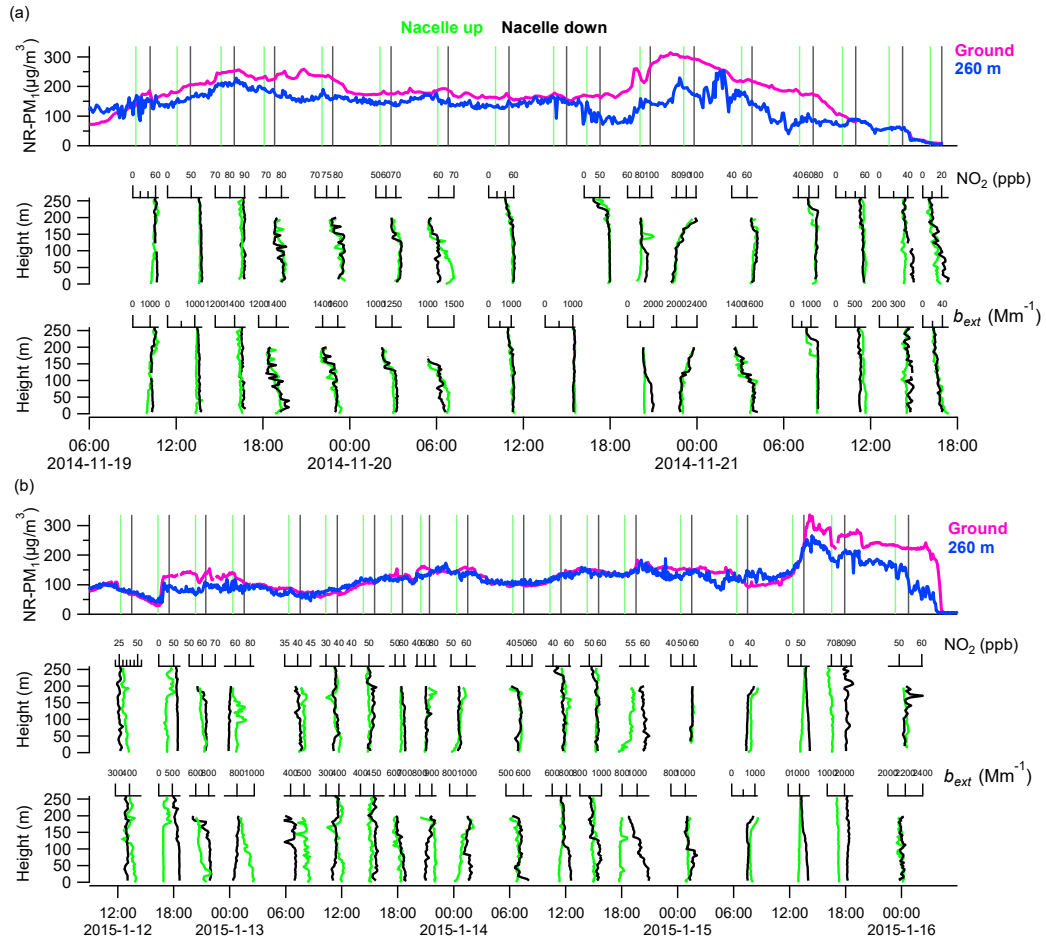


Figure S9. Vertical profiles of  $b_{ext}$ , NO<sub>2</sub> and the time series of NR-PM<sub>1</sub> mass concentrations at ground level and 260 m. The time range of each vertical profile experiment is marked on the time series of NR-PM<sub>1</sub> mass concentrations as light green (up) and gray (down) vertical lines, the green lines represent the up profiles while the black lines are down profiles.