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Hygroscopic growth and activation changed submicron aerosol composition and properties in the North China Plain

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Table S1. A summary of differences of mass concentrations between TSP, $PM_{2.5}$ and PM_1, and the fraction of PM_1 in $PM_{2.5}$ and TSP of PM Species and OA factors under different RH levels.

	<60%	60-80%	80%-90%	90-95%	95-99%	>99%
$PM_{2.5}$-PM_1 (μg m^{-3})						
Org	0.4	0.7	1.0	0.5	2.4	2.5
NO_3	0.2	0.5	0.8	1.4	3.3	4.4
SO_4	0.0	0.1	0.3	0.4	0.9	1.1
NH_4	0.1	0.2	0.3	0.6	1.2	1.6
Chl	0.1	0.1	0.1	0.1	0.1	0.1
FFOA	0.2	0.3	0.3	-0.3	0.3	0.1
BBOA	0.1	0.2	0.2	0.0	0.4	0.2
OOA1	0.0	0.1	0.2	0.6	1.2	2.0
OOA2	0.0	0.1	0.1	0.3	0.7	0.8
PM_1/$PM_{2.5}$(%)						
Org	93.8	95.4	94.3	97.1	84.7	83.0
NO_3	96.2	95.1	93.7	90.8	78.0	72.3
SO_4	100.0	95.2	90.0	88.6	75.0	66.7
NH_4	94.7	94.6	93.6	89.5	78.2	71.4
Chl	66.7	85.7	88.9	88.9	85.7	83.3
FFOA	86.7	94.3	95.1	106.1	92.7	97.1
BBOA	88.9	94.6	94.6	100.0	84.6	90.5
OOA1	100.0	97.9	96.3	91.0	82.1	72.6
OOA2	100.0	93.3	95.0	88.5	73.1	69.2
TSP-PM_1 (μg m^{-3})						
Org	0.7	1.0	1.0	0.5	2.5	3.8
NO_3	0.2	0.5	0.9	1.2	3.4	6.4
SO_4	0.0	0.1	0.3	0.3	1.1	1.7
NH_4	0.1	0.2	0.4	0.5	1.3	2.4
Chl	0.1	0.3	0.1	0.1	0.2	0.2
FFOA	0.3	0.3	0.4	-0.2	0.5	0.2
BBOA	0.3	0.2	0.2	0.1	0.4	0.3
OOA1	0.1	0.1	0.2	0.6	1.2	2.7
OOA2	0.0	0.1	0.2	0.3	0.8	1.1
PM_1/TSP(%)						
Org	89.6	93.5	94.3	97.1	84.2	76.3
NO_3	96.2	95.1	93.0	92.1	77.5	64.2
SO_4	100.0	95.2	90.0	91.2	71.1	56.4
NH_4	94.7	94.6	91.7	91.1	76.8	62.5
Chl	66.7	66.7	88.9	88.9	75.0	71.4
FFOA	81.3	94.3	93.5	104.0	88.4	94.4
BBOA	72.7	94.6	94.6	97.0	84.6	86.4
OOA1	97.0	97.9	96.3	91.0	82.1	66.3
OOA2	100.0	93.3	90.5	88.5	70.4	62.1

Table S2. A summary of average mass concentrations (μg m^{-3}) of PM Species and OA factors under different sizes.

Properties measured	PM_1	$PM_{2.5}$	TSP
Org	11.2	12.1	12.4
NO_3	8.7	9.7	9.8
SO_4	1.8	2.1	2.1
NH_4	3.2	3.5	3.6
Chl	0.5	0.6	0.6
FFOA	3.4	3.6	3.7
BBOA	2.2	2.3	2.4
OOA1	4.4	4.7	4.8
OOA2	1.3	1.4	1.5

Table S3. A summary of average mass concentrations (μg m^{-3}) of PM_1 Species and OA factors under different sizes at different RH levels.

PM_1/$PM_{2.5}$/TSP	<60%	60-80%	80-90%	90-95%	95-99%	>99%
Org	6.0/6.4/6.7	14.5/15.2/15.5	16.4/17.4/17.4	16.8/17.3/17.3	13.3/15.7/15.8	12.2/14.7/16.0
NO_3	5.0/5.2/5.2	9.8/10.3/10.3	11.9/12.7/12.8	13.9/15.3/15.1	11.7/15.0/15.1	11.5/15.9/17.9
SO_4	1.0/1.0/1.0	2.0/2.1/2.1	2.7/3.0/3.0	3.1/3.5/3.4	2.7/3.6/3.8	2.2/3.3/3.9
NH_4	1.8/1.9/1.9	3.5/3.7/3.7	4.4/4.7/4.8	5.1/5.7/5.6	4.3/5.5/5.6	4.0/5.6/6.4
Chl	0.2/0.3/0.3	0.6/0.7/0.9	0.8/0.9/0.9	0.8/0.9/0.9	0.6/0.7/0.8	0.5/0.6/0.7
FFOA	1.3/1.5/1.6	5.0/5.3/5.3	5.8/6.1/6.2	5.2/4.9/5.0	3.8/4.1/4.3	3.4/3.5/3.6
BBOA	0.8/0.9/1.1	3.5/3.7/3.7	3.5/3.7/3.7	3.2/3.2/3.3	2.2/2.6/2.6	1.9/2.1/2.2
OOA1	3.2/3.2/3.3	4.7/4.8/4.8	5.2/5.4/5.4	6.1/6.7/6.7	5.5/6.7/6.7	5.3/7.3/8.0
OOA2	0.6/0.6/0.6	1.4/1.5/1.5	1.9/2.0/2.1	2.3/2.6/2.6	1.9/2.6/2.7	1.8/2.6/2.9

Table S4. A summary of average mass concentrations (μg m^{-3}) of OS and lower bounds of ON under different sizes at different RH levels.

	<60%	60-80%	80%-90%	90-95%	95-99%	>99%
ON in PM_1	1.73	2.96	3.38	3.80	2.95	3.03
ON in $PM_{2.5}$	1.81	3.04	3.50	3.75	3.10	3.79
ON in TSP	1.84	3.01	3.52	3.83	3.19	4.05
OS in PM_1	0.14	0.36	0.51	0.71	0.64	0.45
OS in $PM_{2.5}$	0.14	0.37	0.57	0.79	0.85	0.74
OS in TSP	0.15	0.38	0.57	0.78	0.89	0.88

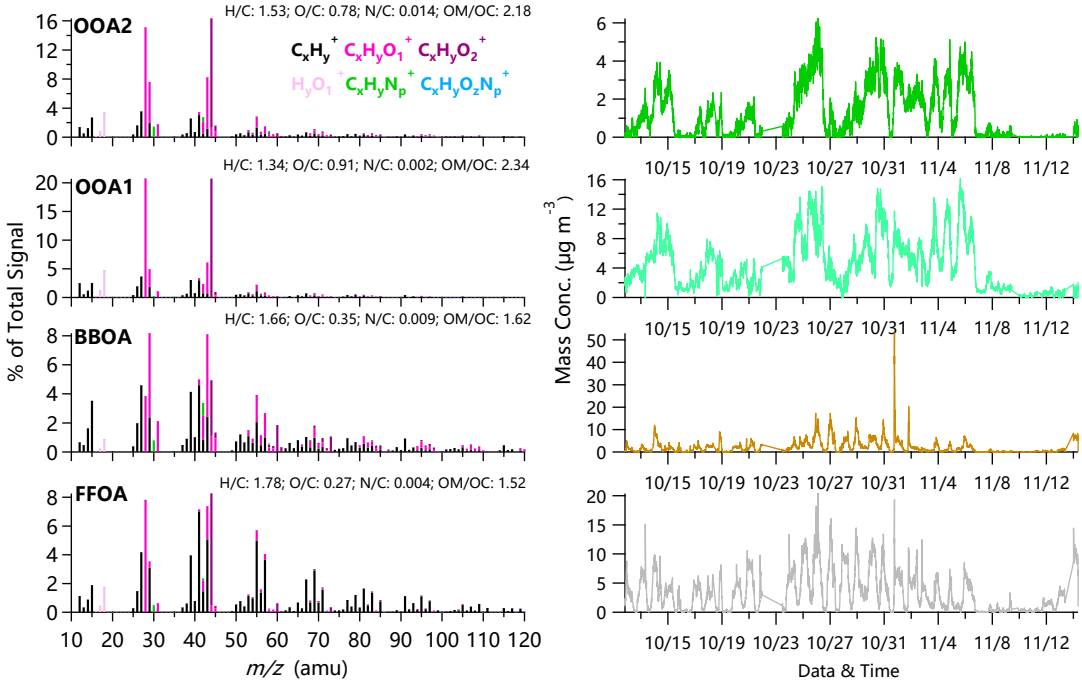

Figure S1. High-resolution mass spectra and mass concentrations of OA factors

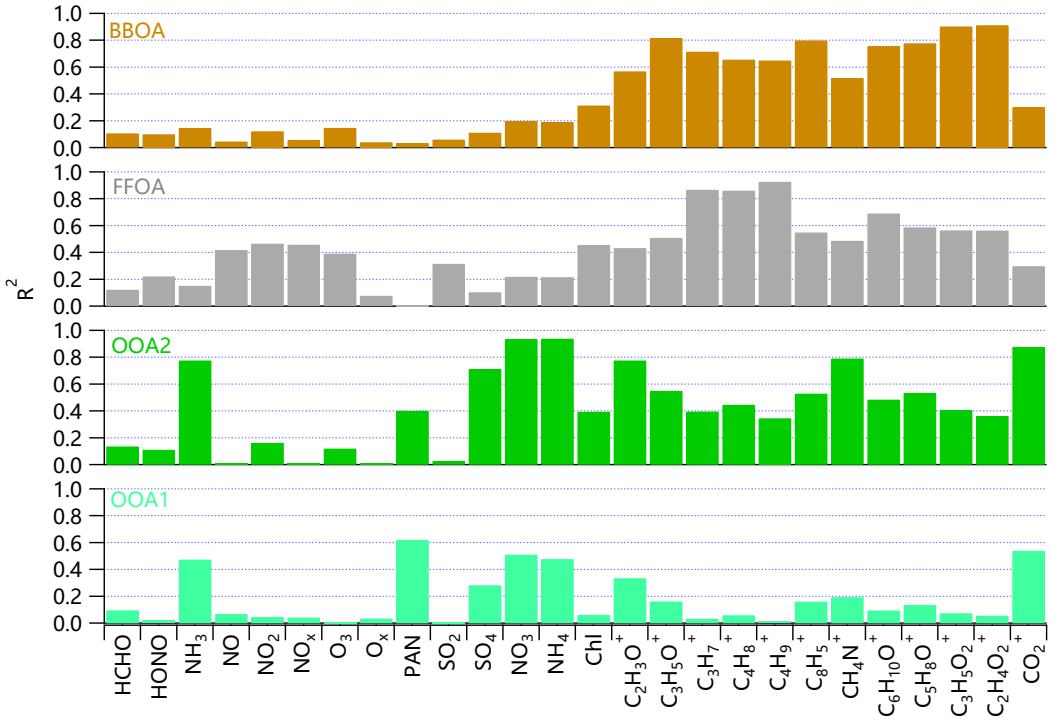

Figure S2. Correlations between OA factors and external species.

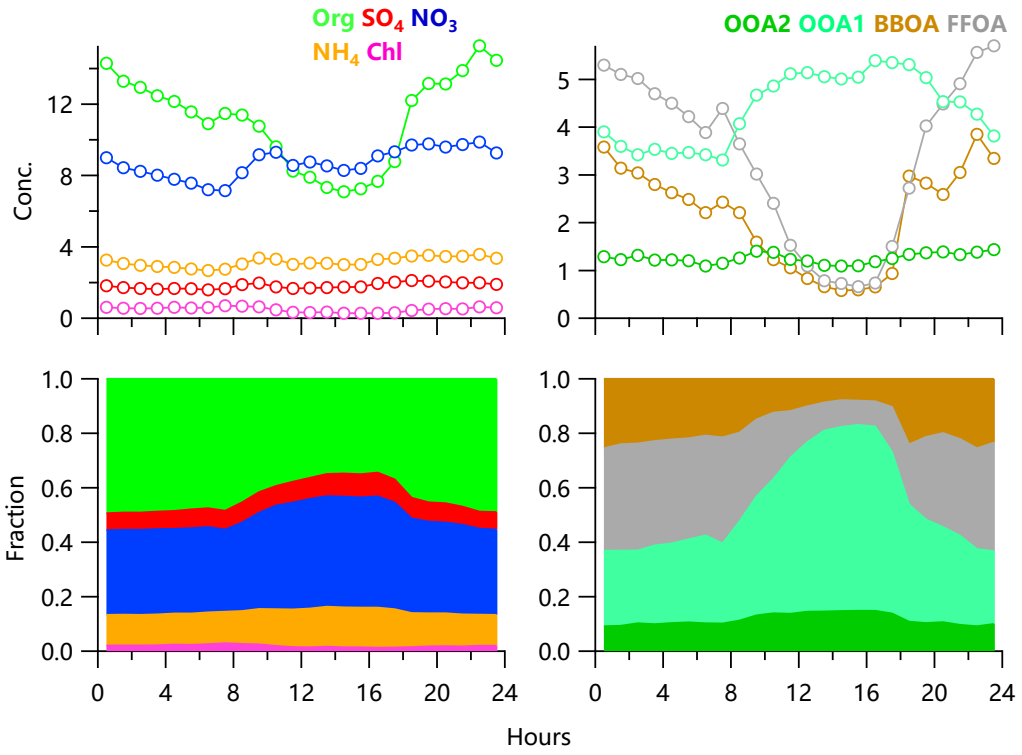

Figure S3. Average diurnal cycles of mass concentrations of PM_1 species and OA factors

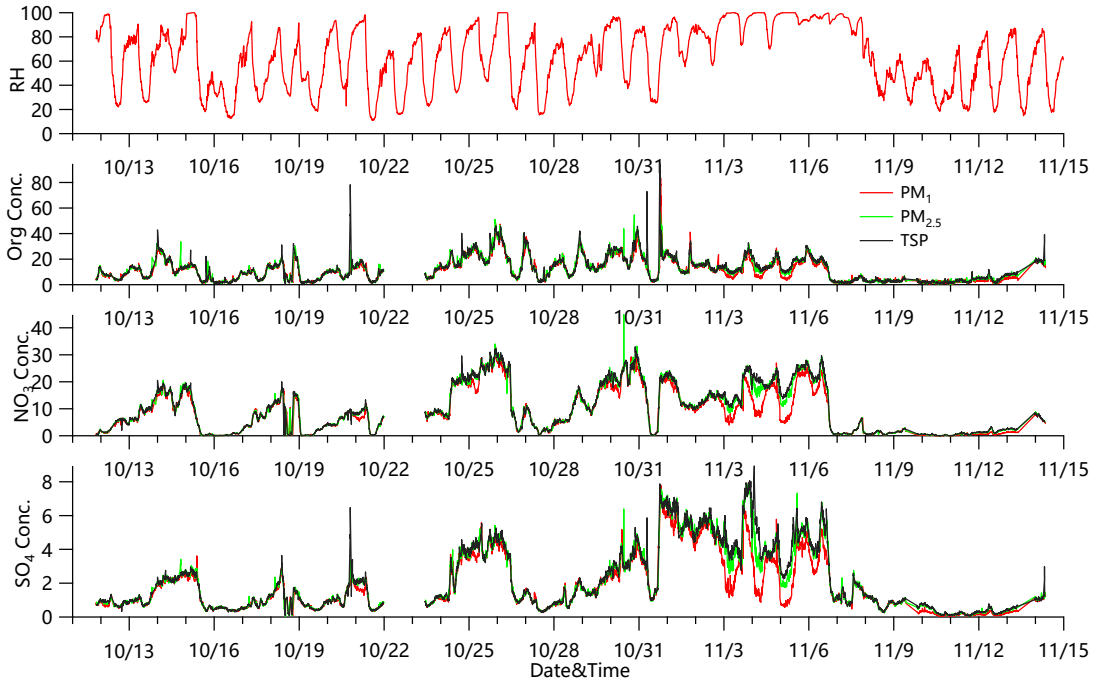

Figure S4. Time series of RH, mass concentrations of organics, nitrate and sulfate under different sizes.

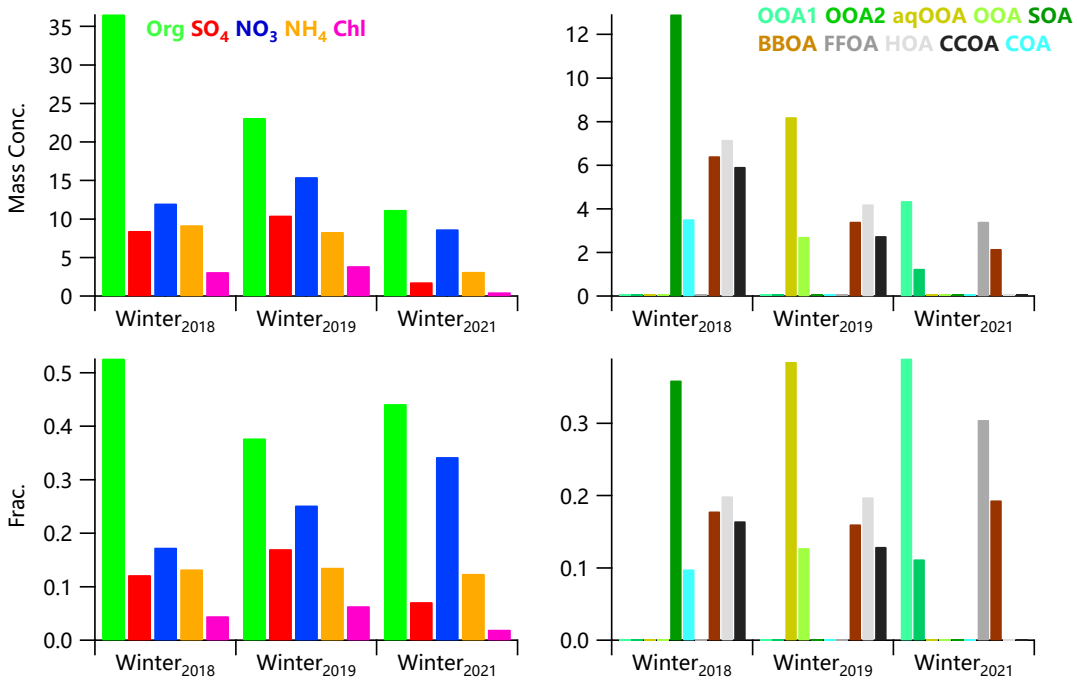

Figure S5. Average concentrations and contributions of PM and OA species in winters of 2018, 2019 and 2021 in Gucheng.

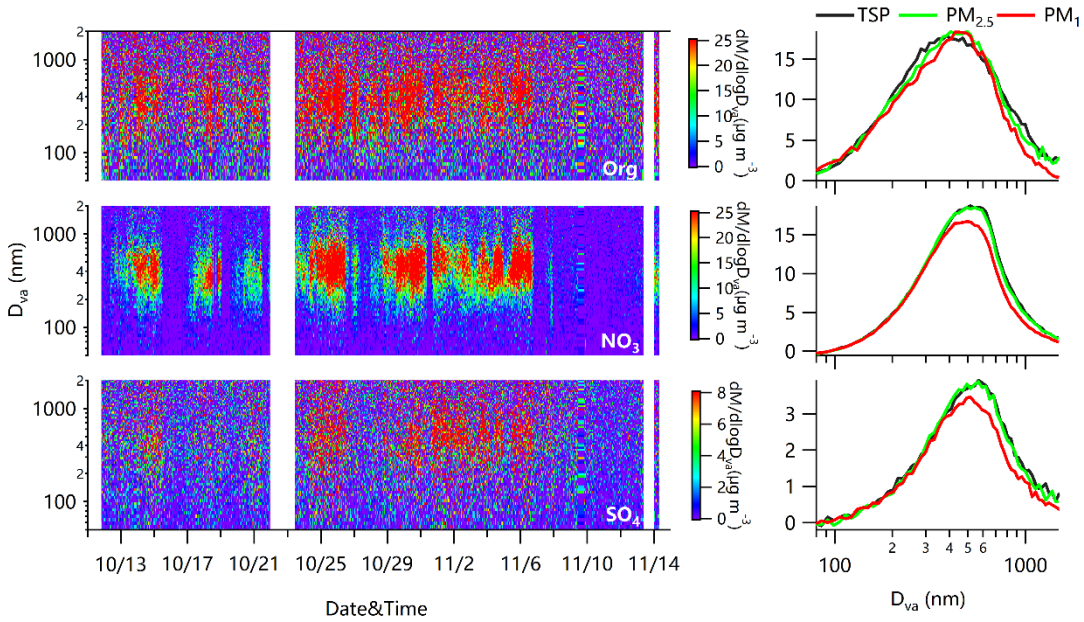

Figure S6. Evolution of size distributions of organics, nitrate and sulfate in Gucheng. Average size distributions of organics, nitrate and sulfate under different are also shown.

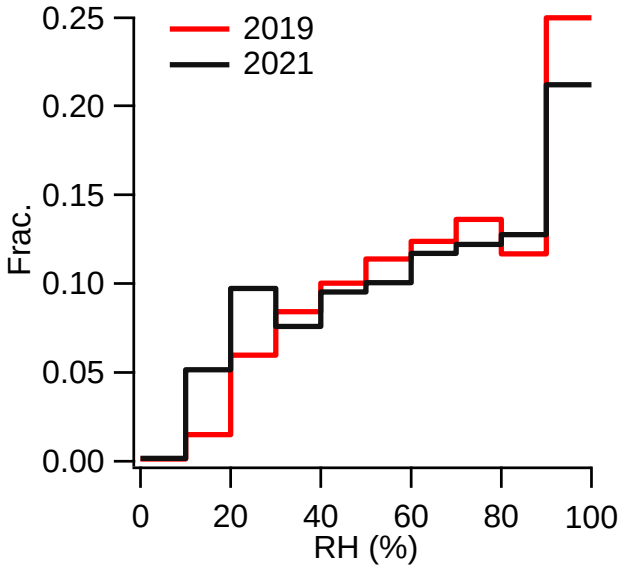

Figure S7. Comparisons of frequencies of RH in winters of 2019 and 2021 in Gucheng.

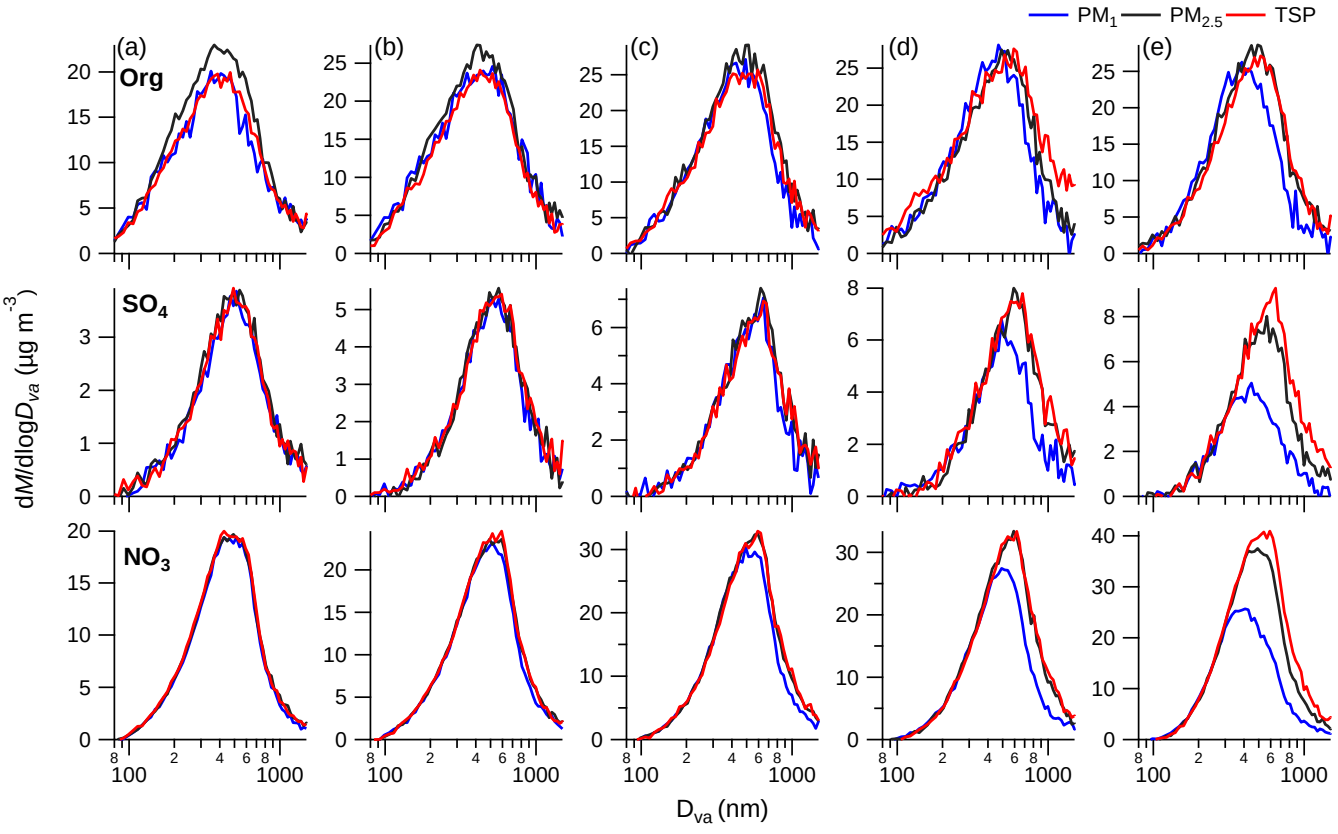

Figure S8. Average size distributions of OA, SO_4 and NO_3 under (a)RH=60-80%, (b)RH=80-90%, (c)RH=90-95%, (d)RH=95-99% and (e) RH>99%.

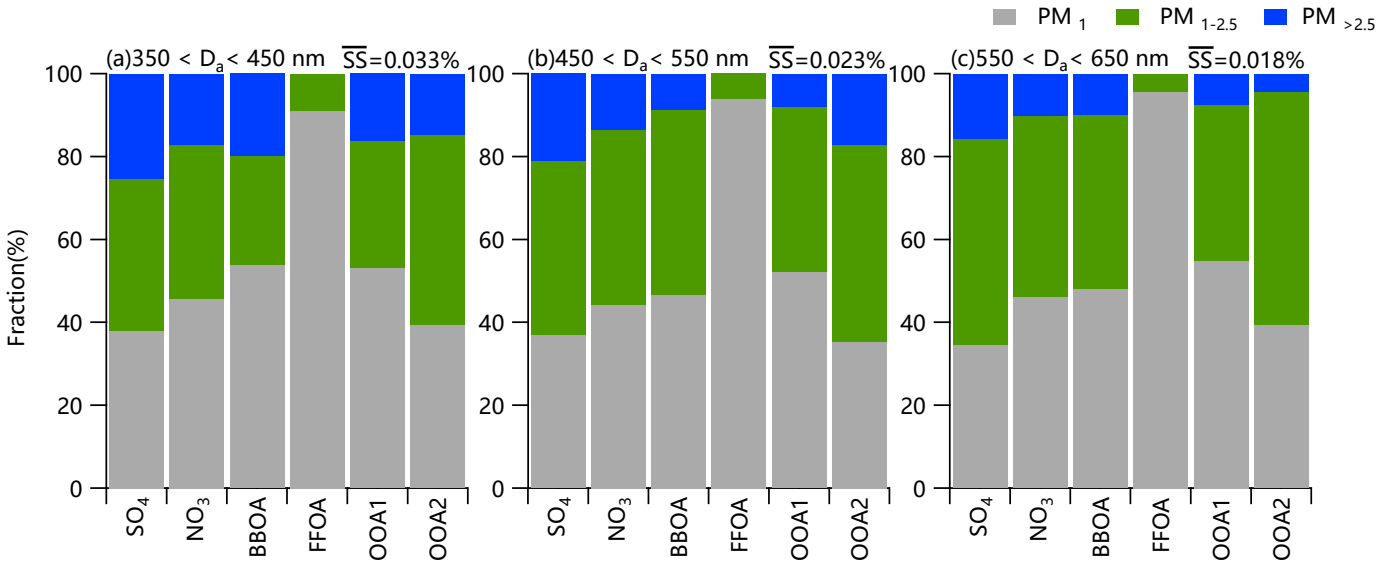

Figure S9. Fractions of aerosol compositions that reside in different diameter ranges under critical activation diameter ranges of (a)350 <Da<450 nm (b) 450 <Da<550 nm (c) 550 <Da<650 nm.

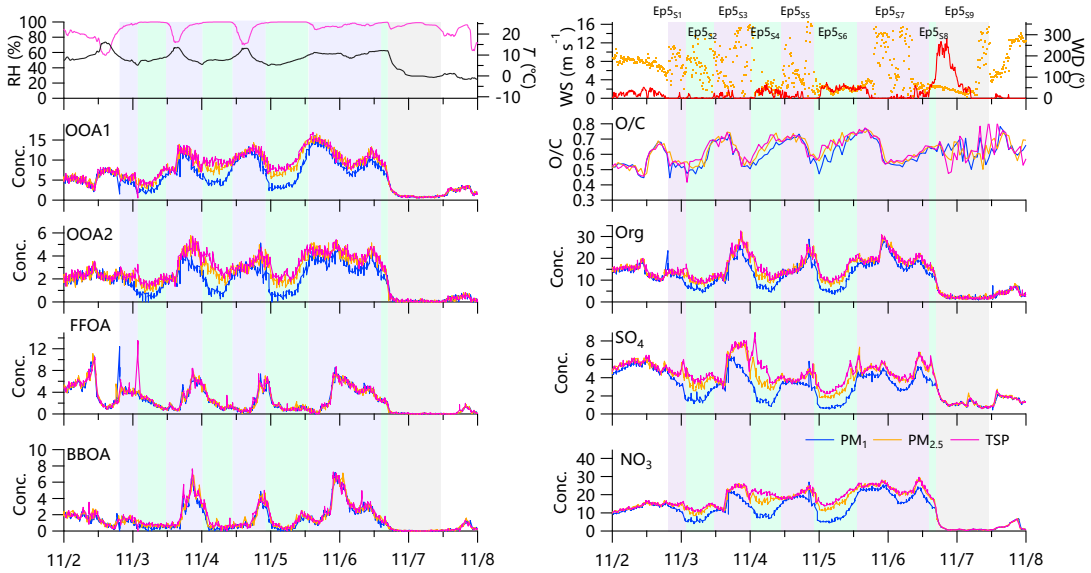

Figure S10. Time series of meteorological variables, chemical species under PM_1, $PM_{2.5}$ cyclones and TSP passage during the foggy episodes.

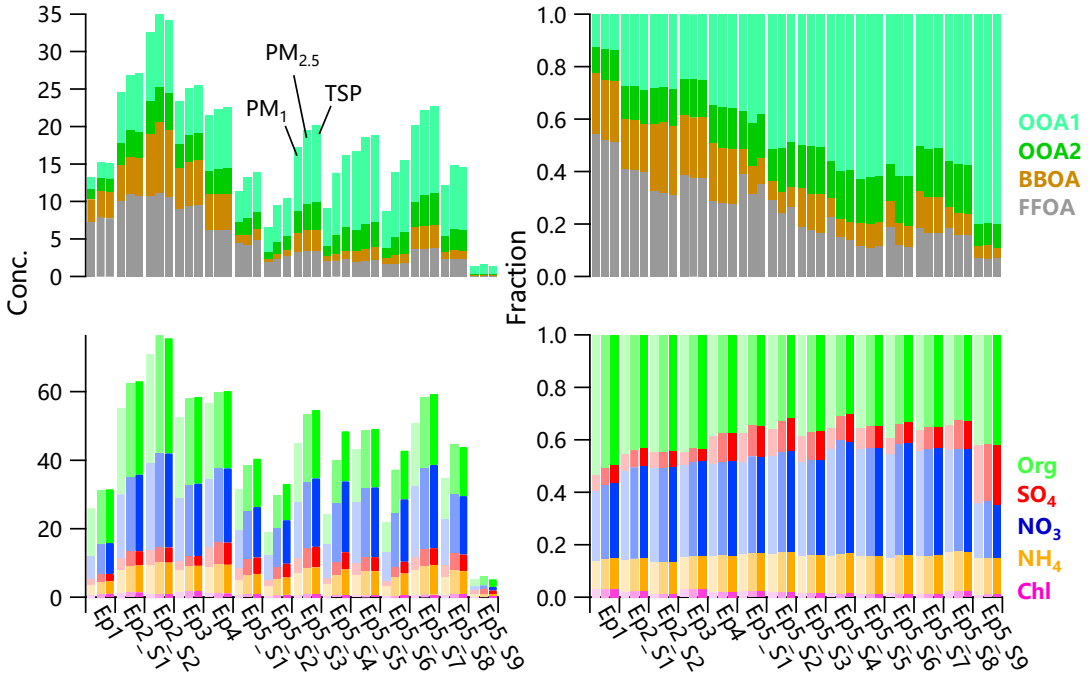

Figure S11. Average concentrations and contributions of PM and OA species under different sizes in different stages during foggy periods.

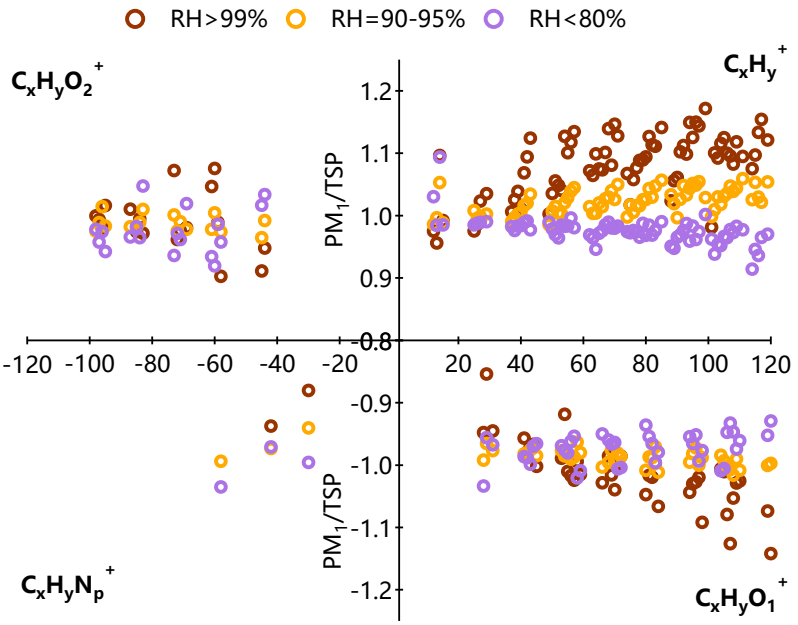

Figure S12. The ratios of fraction of $C_xH_y^+$, $C_xH_yO_1^+$, $C_xH_yO_2^+$, $C_xH_yN_p^+$ family under PM_1 cyclone to TSP passage.