Supplementary Information

Quantifying the impacts of $PM_{2.5}$ constituents and relative humidity on visibility impairment in a suburban area of eastern Asia using long-term in-situ measurements.

Yu-Chieh Ting[a], Li-Hao Young[b], Tang-Huang Lin[c], Si-Chee Tsay[d], Kuo-En Chang[a,e], Ta-Chih Hsiao[a,e]

[a]Graduate Institute of Environmental Engineering, National Taiwan University, Taipei, Taiwan

[b]Department of Occupational Safety and Health, China Medical University, Taichung, Taiwan

[c]Centre for Space and Remote Sensing Research, National Central University, Taoyuan, Taiwan

[d]NASA Goddard Space Flight Centre, Greenbelt, MD, USA

[e]Research Centre for Environmental Changes, Academia Sinica, Taipei, Taiwan

Corresponding author: Ta-Chih Hsiao (tchsiao@ntu.edu.tw)

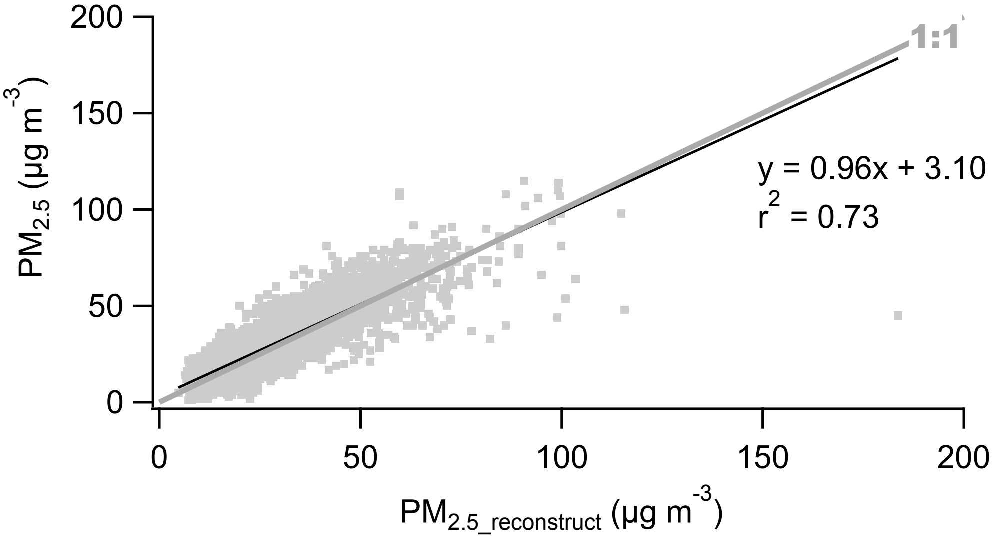

Figure S1. Comparison of $PM_{2.5}$ mass concentrations between the in-situ measurements of $PM_{2.5}$ and $PM_{2.5}$ reconstructed by the chemical compositions.

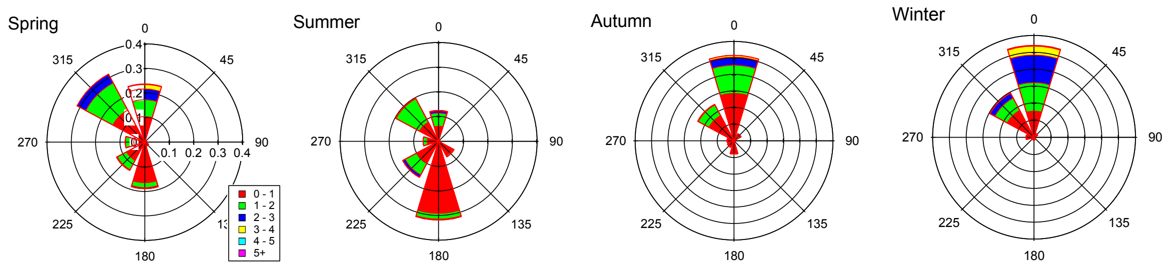

Figure S2. Wind rose plots for each season. Wind speed (m s^{-1}) has been coloured and the scales of the frequencies are 0.1 - 0.4 for spring and summer, 0.1 - 0.6 for autumn and winter, respectively.

Table S1. The hourly average concentrations of air pollutants, meteorological conditions and extinction coefficients over the year.

Species	Total	Spring	Summer	Autumn	Winter
$B_{ext\_550\ nm}$ ($M\ m^{-1}$)	105.86 ± 75.53	127.2 ± 70.70	70.22 ± 40.42	96.33 ± 73.15	111.66 ± 82.96
$PM_{2.5}$ ($\mu g\ m^{-3}$)	27.17 ± 17.28	34.34 ± 17.25	15.02 ± 9.35	23.43 ± 13.85	35.80 ± 18.27
NO_3^- ($\mu g\ m^{-3}$)	3.99 ± 4.99	5.73 ± 6.50	1.82 ± 2.22	2.75 ± 2.89	5.68 ± 5.67
SO_4^{2-} ($\mu g\ m^{-3}$)	5.35 ± 3.64	7.02 ± 4.24	4.29 ± 3.29	4.32 ± 2.58	5.75 ± 3.49
Cl- ($\mu g\ m^{-3}$)	0.72 ± 0.87	0.85 ± 1.13	0.44 ± 0.54	0.51 ± 0.35	1.12 ± 1.02
NH_4^+ ($\mu g\ m^{-3}$)	4.98 ± 3.39	6.17 ± 3.35	3.21 ± 2.35	4.31 ± 2.55	6.37 ± 4.07
Na^+ ($\mu g\ m^{-3}$)	0.43 ± 0.36	0.49 ± 0.39	0.33 ± 0.30	0.48 ± 0.38	0.41 ± 0.34
K^+ ($\mu g\ m^{-3}$)	0.26 ± 0.69	0.48 ± 0.64	0.18 ± 0.32	0.08 ± 0.15	0.27 ± 1.09
Mg^{2+} ($\mu g\ m^{-3}$)	1.99 ± 1.28	2.60 ± 1.33	3.27 ± 1.53	1.62 ± 0.86	1.27 ± 0.77
Ca^{2+} ($\mu g\ m^{-3}$)	1.91 ± 1.37	1.83 ± 1.19	1.87 ± 1.01	2.86 ± 1.55	0.93 ± 0.67
OC ($\mu g\ m^{-3}$)	4.93 ± 2.28	5.21 ± 2.08	4.24 ± 1.18	4.20 ± 2.14	5.59 ± 2.52
EC ($\mu g\ m^{-3}$)	1.16 ± 0.84	1.31 ± 0.75	0.69 ± 0.74	0.87 ± 0.71	1.45 ± 0.88
CO (ppm)	0.92 ± 0.51	0.99 ± 0.48	0.77 ± 0.32	0.99 ± 0.46	0.91 ± 0.68
NO (ppb)	12.58 ± 13.55	11.97 ± 12.47	7.73 ± 9.06	12.35 ± 12.01	18.35 ± 17.30
NO_x (ppb)	31.84 ± 21.74	34.18 ± 22.91	21.50 ± 14.75	31.60 ± 17.49	40.25 ± 25.91
SO_2 (ppb)	1.81 ± 1.62	2.10 ± 1.85	1.84 ± 2.10	1.58 ± 1.36	1.71 ± 0.81
NH_3 (ppb)	15.91 ± 8.62	19.32 ± 7.81	18.24 ± 8.79	10.37 ± 4.52	15.80 ± 9.69
O_3 (ppb)	26.81 ± 15.30	28.20 ± 16.97	25.30 ± 13.99	29.29 ± 16.08	24.30 ± 13.17
WS ($m\ s^{-1}$)	0.89 ± 0.84	0.90 ± 0.82	0.64 ± 0.63	0.75 ± 0.75	1.29 ± 0.99
Temperature (°C)	22.43 ± 5.91	23.17 ± 4.94	27.22 ± 3.25	23.54 ± 4.14	15.57 ± 4.18
RH (%)	80.21 ± 14.71	75.87 ± 14.25	82.95 ± 12.36	82.13 ± 16.67	79.94 ± 14.14
BLH (m)	412.13 ± 213.38	372.65 ± 232.79	442.16 ± 192.90	428.64 ± 221.89	405.08 ± 196.62

Table S2. Fractions of the main chemical species in $PM_{2.5}$ during the sampling period. (Sum = NO_3^- + SO_4^{2-} + Cl^- + NH_4^+ + OM + EC)

%	Total	Spring	Summer	Autumn	Winter
Sum/ $PM_{2.5\_reconstruct}$	83.2 ± 12.3	84.0 ± 9.8	81.7 ± 10.6	74.6 ± 12.9	91.5 ± 6.7
NO_3^-/ $PM_{2.5\_reconstruct}$	12.8 ± 7.8	16.2 ± 8.9	7.3 ± 4.4	9.0 ± 5.7	15.2 ± 7.2
SO_4^{2-}/ $PM_{2.5\_reconstruct}$	18.2 ± 6.8	19.9 ± 6.7	19.6 ± 9.6	16.8 ± 6.9	17.9 ± 5.9
Cl^-/ $PM_{2.5\_reconstruct}$	2.7 ± 2.1	2.7 ± 2.2	1.9 ± 2.9	2.4 ± 1.8	3.3 ± 2.0
NH_4^+/ $PM_{2.5\_reconstruct}$	17.5 ± 5.9	16.6 ± 4.5	16.1 ± 6.8	16.5 ± 6.5	19.5 ± 5.4
OM/ $PM_{2.5\_reconstruct}$	28.0 ± 8.9	24.7 ± 8.0	33.7 ± 9.4	26.6 ± 7.8	30.7 ± 9.0
EC/ $PM_{2.5\_reconstruct}$	4.0 ± 2.5	3.8 ± 2.2	3.1 ± 3.3	3.4 ± 2.5	4.8 ± 2.3

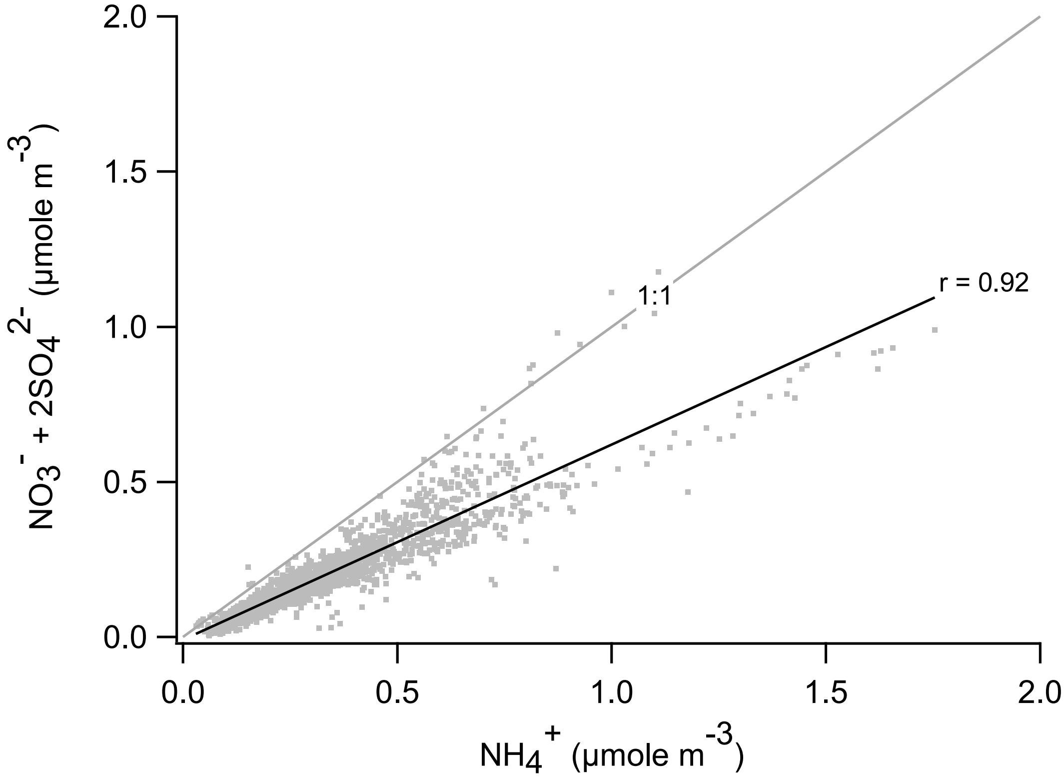

Figure S3. Scatter plot of $[NO_3^-] + 2[SO_4^{2-}]$ versus $[NH_4^+]$ during the observation period.

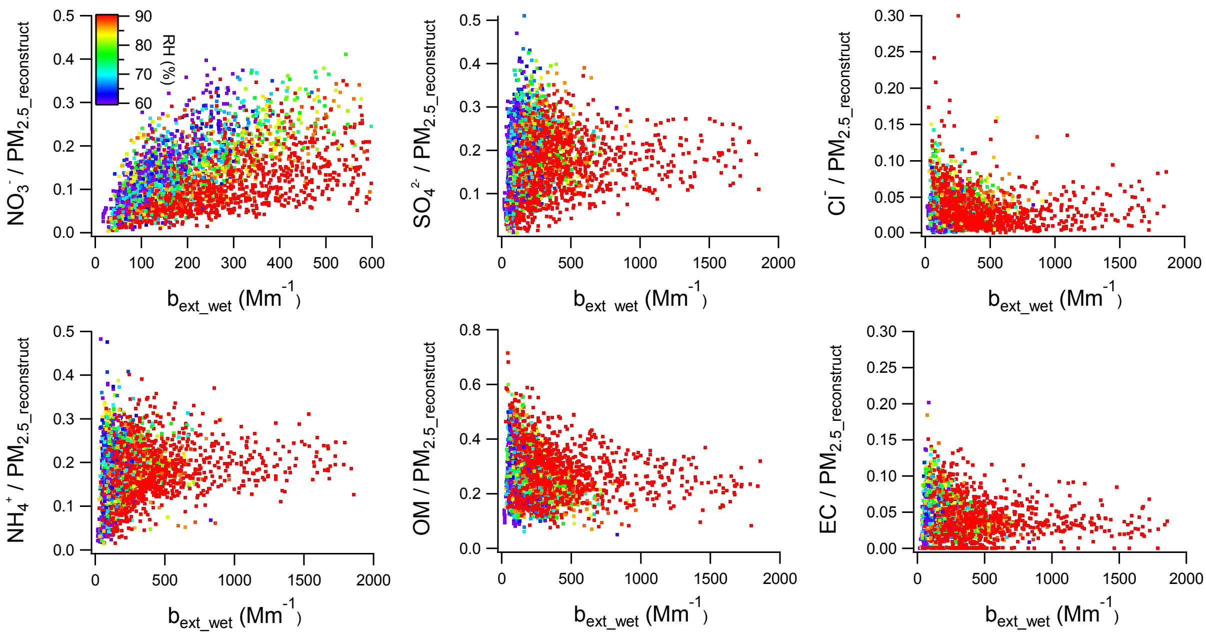

Figure S4. The fractions of chemical compositions in $PM_{2.5\_reconstruct}$ as a function of b_{ext_wet} coloured by RH over the year.

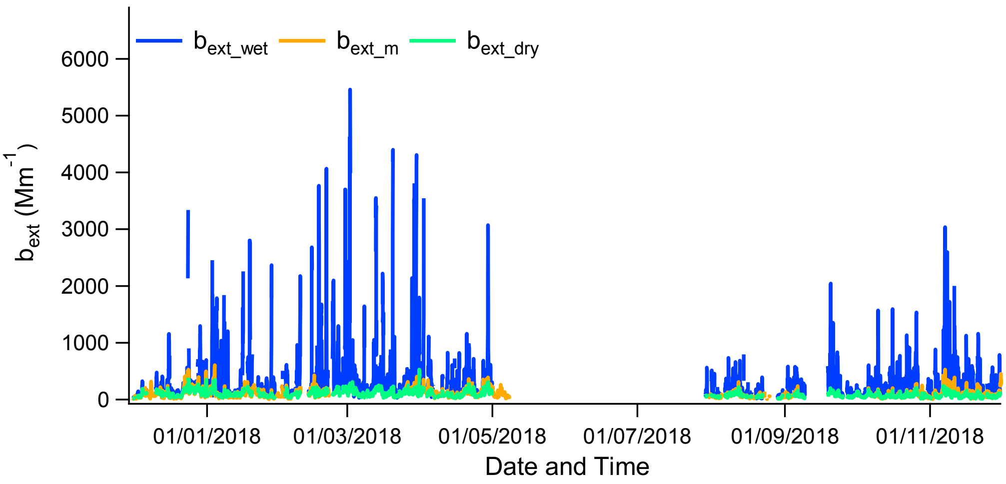

Figure S5. Comparison among the b_{ext_m}, b_{ext_dry} and b_{ext_m}.

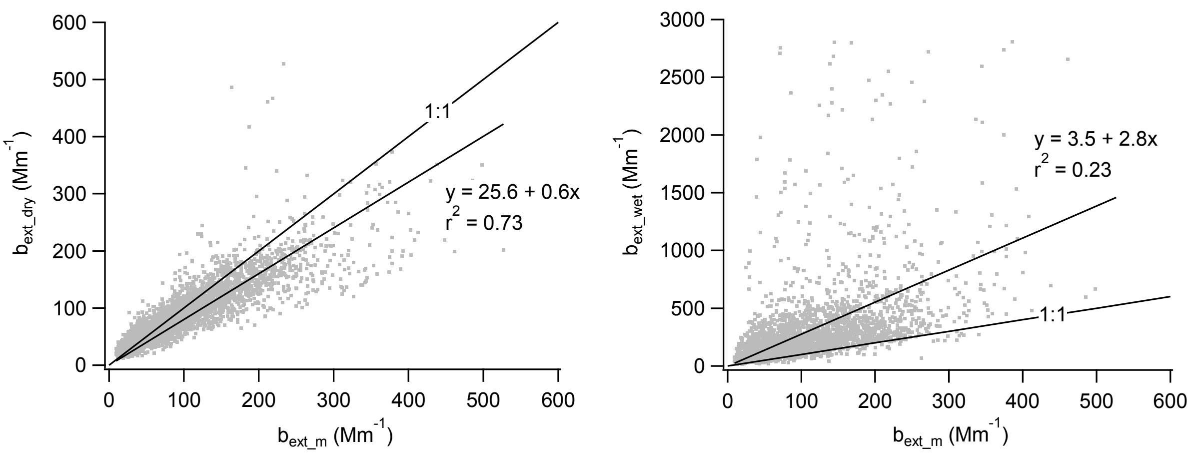

Figure S6. The linear regression analysis between (left panel) b_{ext_dry} and b_{ext_m}, and (right panel) b_{ext_wet} and b_{ext_m}.

Table S3. Mass concentrations of chemical compositions in $PM_{2.5}$, RH, NOR, SOR and BLH of clusters for each season. Percentage (%) means the fractions of the trajectories in total for each season.

Cluster	$PM_{2.5}$	NO_3^-	SO_4^{2-}	Cl^-	NH_4^+	OM	EC	RH	NOR	SOR	BLH	$Vis_{\_wet}$
Spring	$\mu g\ m^{-3}$							%			m	km
C1 (17%)	25.55	3.57	5.92	0.78	5.64	7.51	1.04	78.70	0.07	0.43	384.25	13.4
C2 (22%)	41.51	7.97	8.68	1.01	7.50	9.77	1.71	75.91	0.11	0.50	249.76	8.1
C3 (11%)	16.62	2.43	5.66	0.33	6.08	9.89	1.15	76.68	0.08	0.49	460.69	8.0
C4 (28%)	29.75	3.23	4.78	0.64	3.98	6.51	0.93	73.98	0.06	0.44	461.17	17.0
C5 (22%)	45.89	9.57	9.50	1.23	7.85	9.43	1.54	76.01	0.13	0.50	333.56	7.8
Summer												
C1 (12%)	18.46	2.36	5.12	0.37	3.52	nan	nan	78.87	0.06	0.48	447.12	nan
C2 (29%)	21.71	3.22	6.82	0.51	5.15	7.43	1.14	79.86	0.07	0.47	367.36	9.7
C3 (25%)	14.11	1.38	4.44	0.38	3.35	7.38	0.44	79.25	0.05	0.36	392.53	13.5
C4 (34%)	9.48	0.86	2.18	0.44	1.69	6.22	0.43	88.47	0.03	0.29	508.74	23.6
Autumn												
C1 (27%)	26.83	3.99	5.76	0.49	5.61	7.98	1.16	86.56	0.08	0.43	317.53	9.2
C2 (32%)	22.45	2.67	3.83	0.52	4.10	6.32	0.87	85.24	0.05	0.39	358.77	12.8
C3 (24%)	16.75	1.34	3.25	0.53	3.11	5.00	0.54	81.02	0.03	0.41	590.62	19.5
C4 (2%)	25.19	3.25	3.46	0.45	7.15	nan	nan	78.25	0.06	0.26	246.95	nan
C5 (15%)	28.08	2.59	4.48	0.50	3.71	8.17	0.91	71.92	0.05	0.41	457.25	18.2
Winter												
C1 (41%)	31.59	4.66	4.86	0.91	5.73	8.51	1.35	83.11	0.08	0.43	373.96	11.5
C2 (16%)	34.78	4.45	5.66	0.80	5.68	8.94	1.51	72.16	0.09	0.41	551.14	13.9
C3 (18%)	28.85	3.37	5.38	0.89	4.92	6.98	1.02	76.05	0.07	0.44	629.53	17.8
C4 (21%)	48.48	10.04	7.35	1.84	8.69	11.17	1.89	84.47	0.12	0.45	224.60	7.1
C5 (4%)	48.02	7.77	8.15	1.47	7.90	11.94	1.89	71.22	0.09	0.46	129.37	9.8