atmosphere

Supplementary Materials: Contributions of Ammonia to High Concentrations of $PM_{2.5}$ in an Urban Area

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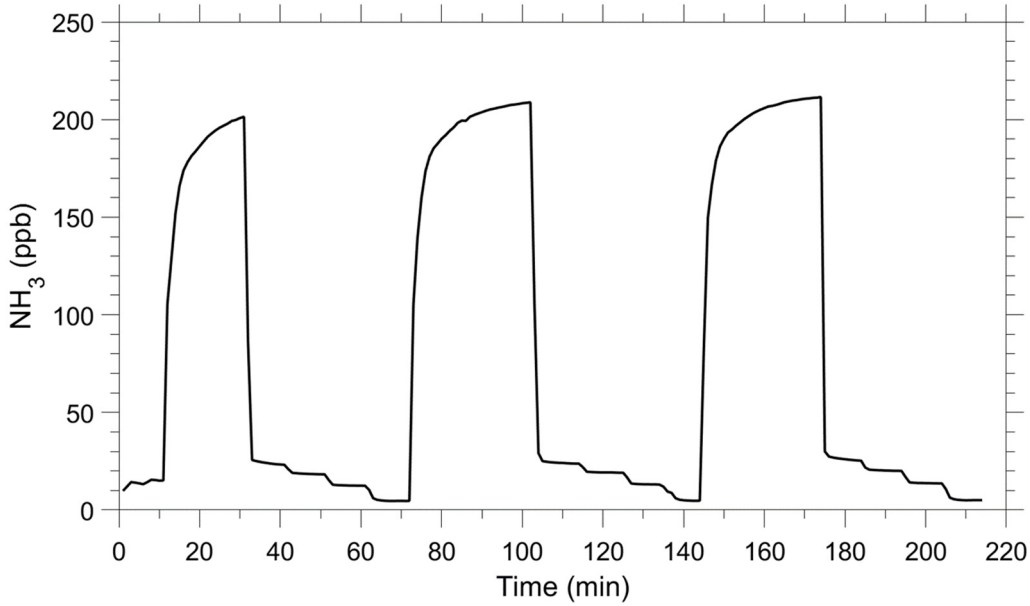

Figure S1. Calibration of the NH_3 analyzer using a diluted standard gas mixture of NH_3 and N_2.

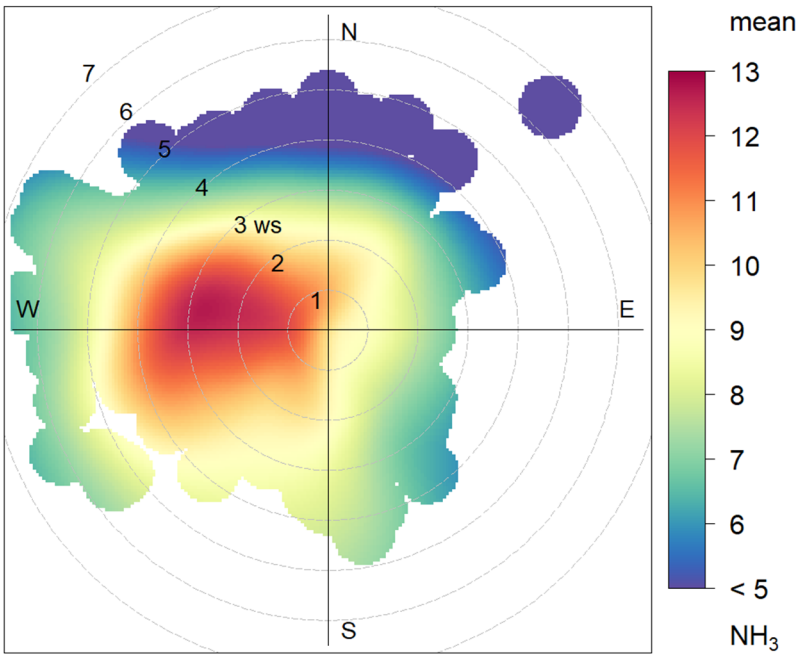

Figure S2. A result of polar plot during measuring period in Jeonju. Red color represents high NH_3 concentrations.

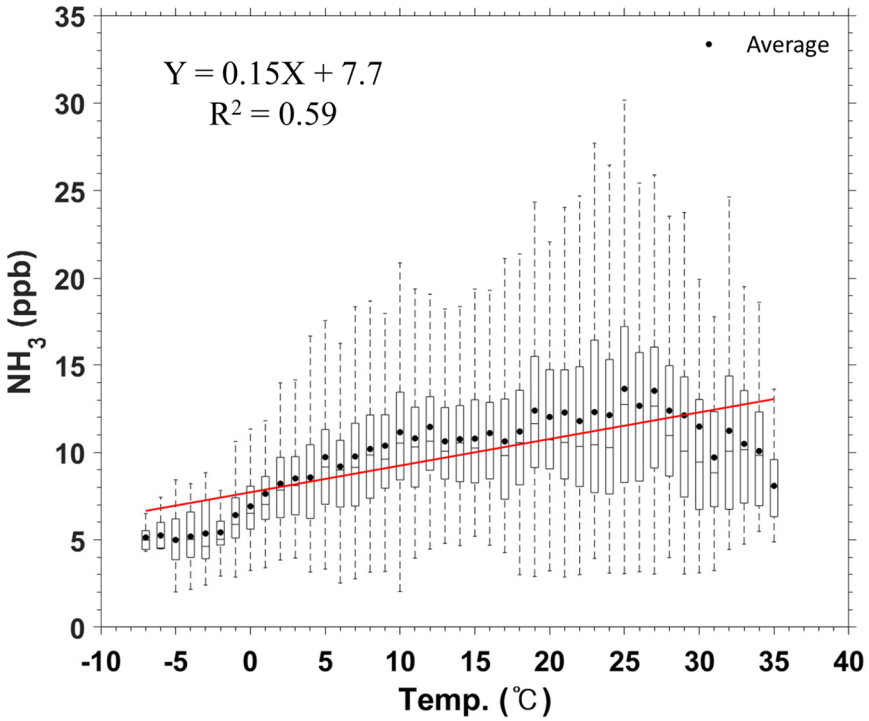

Figure S3. Relationship between hourly NH_3 concentrations and ambient temperature at the Samcheon-dong monitoring station during May 2019 to April 2020.

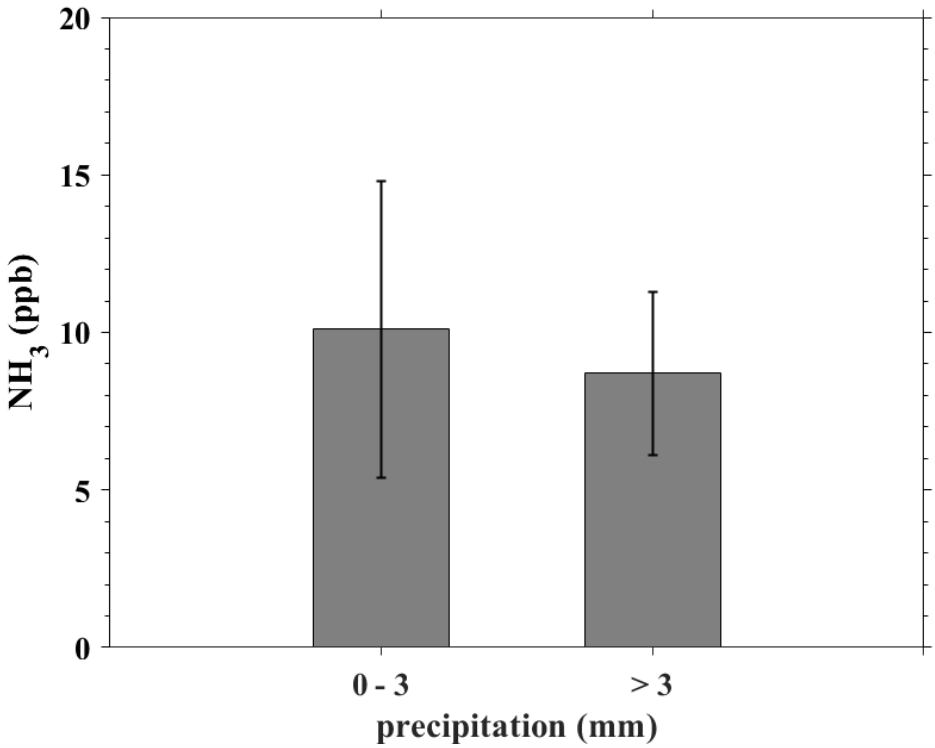

Figure S4. Hourly averaged concentration of NH_3 versus the precipitation per hour during the measuring period (temperature > 30 ˚C).

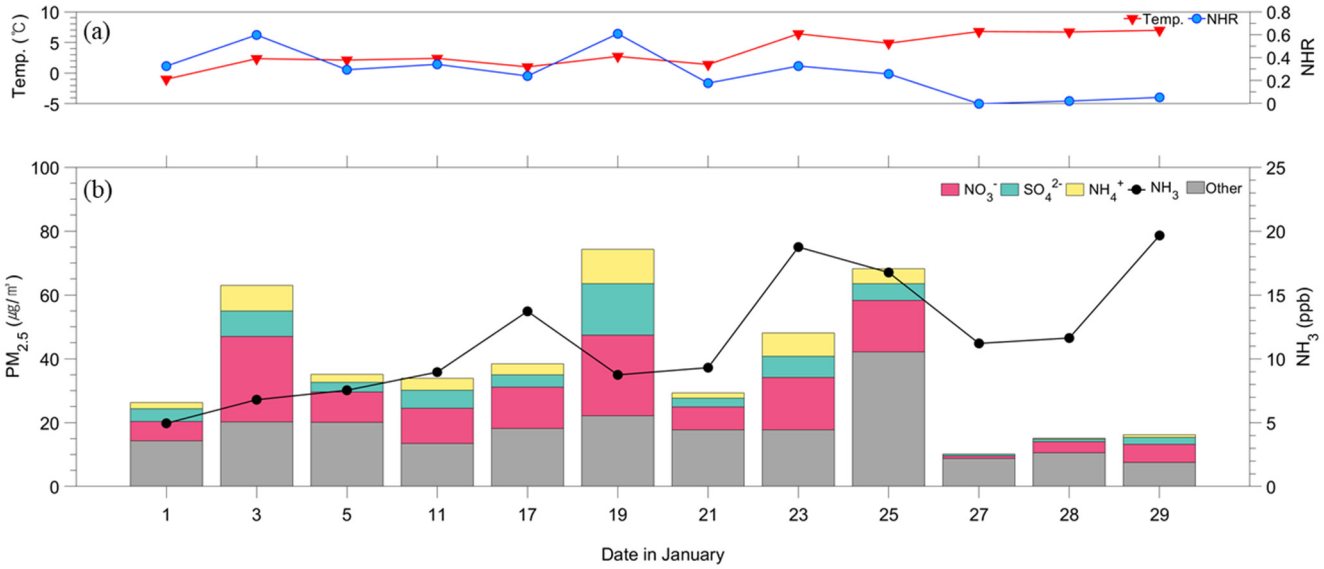

Figure S5. Monthly variation in (a) temperature and the ratio of NH_4^+ to total NH_3 (NHR) and (b) concentrations of NH_3, SNA, and $PM_{2.5}$ at the monitoring site in January 2020.

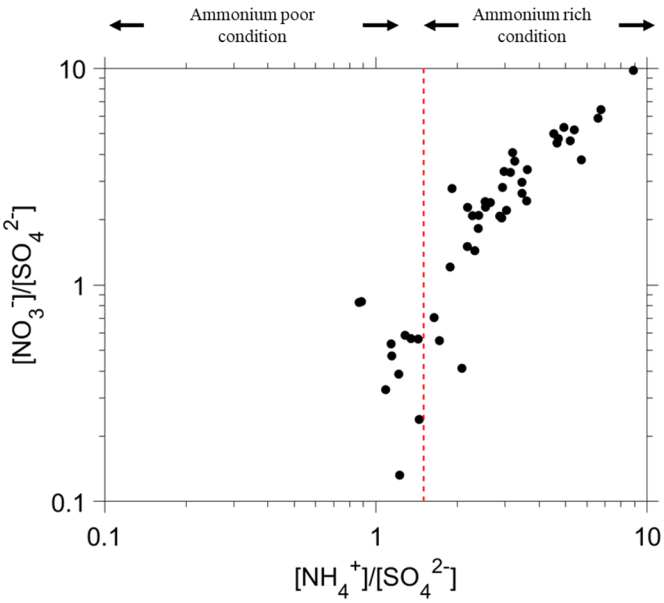

Figure S6. A result of ammonium-poor and ammonium-rich conditions during polluted periods.

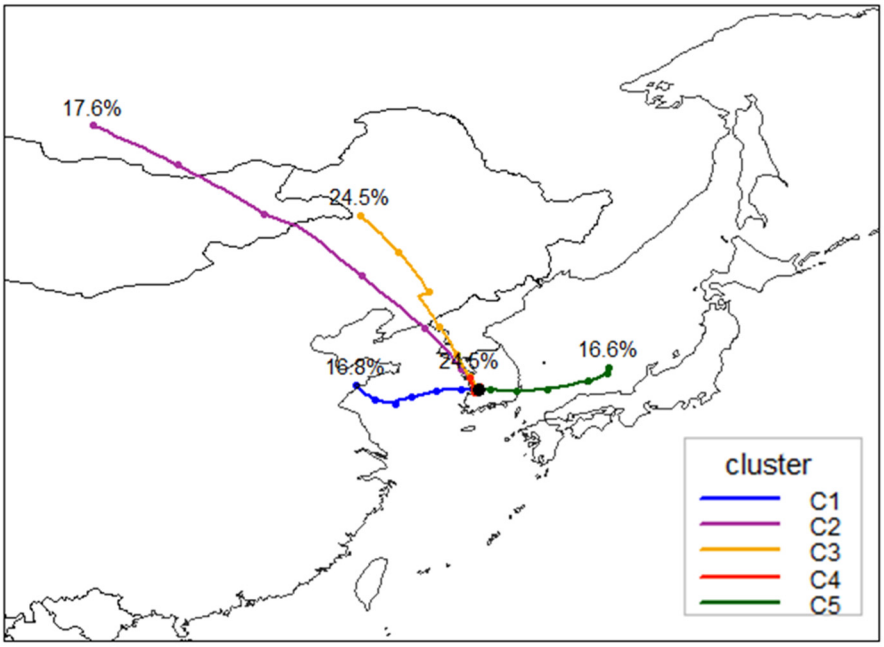

Figure S7. Cluster analysis for 72 h backward trajectories at the monitoring site from May 2019 to April 2020.

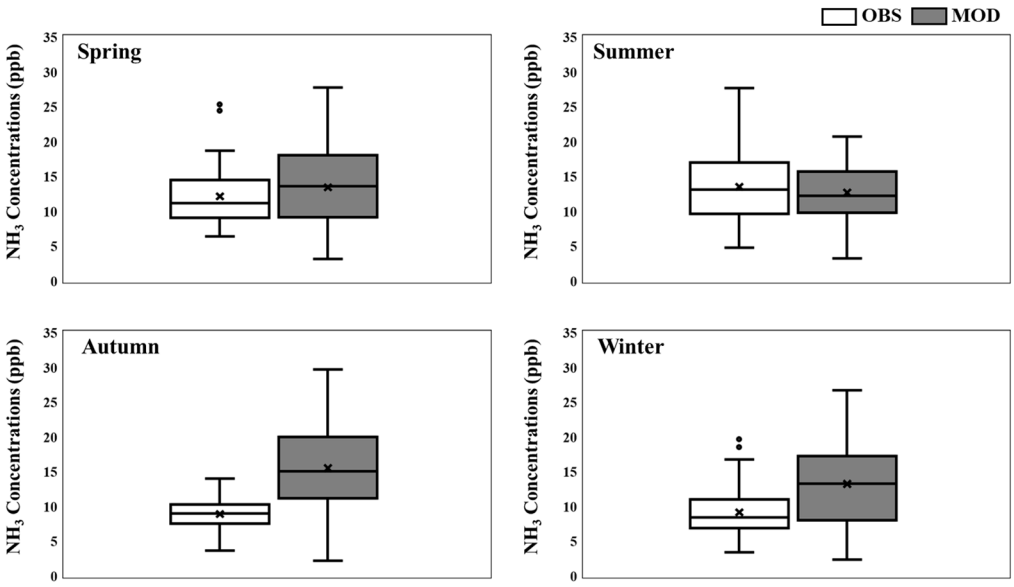

Figure S8. Seasonally observed (left) and simulated (right) ammonia (NH_3) concentrations in Samcheon-dong. The lines represent the maximum, 75th quartile, median, 25th quartile and the minimum values of the data. The crosses indicate the average of the data and the circles indicate outliers.

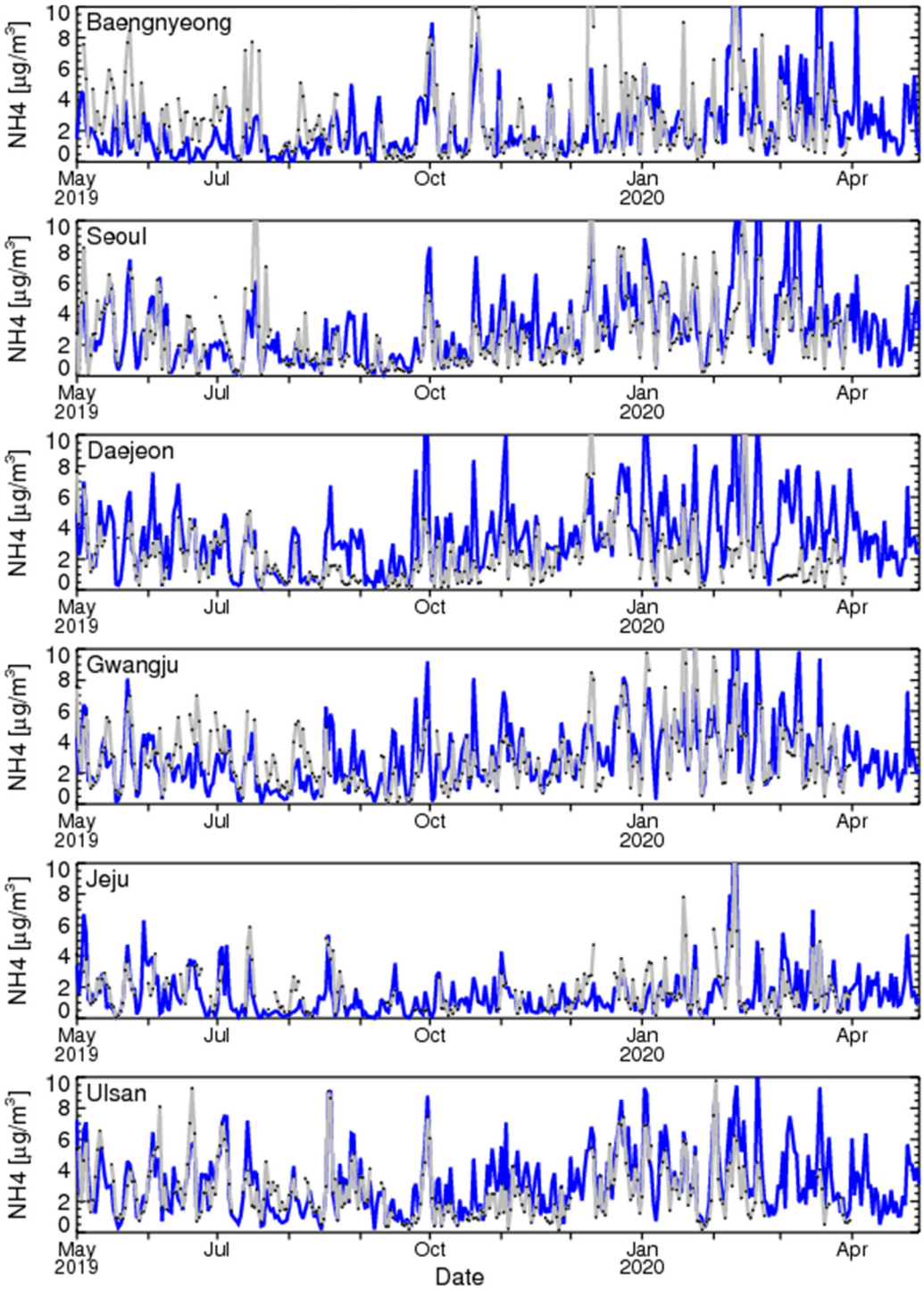

Figure S9. Time series for the observed and simulated NH_4^+ concentrations in the six supersites (Baengnyeong, Seoul, Daejeon, Gwangju, Jeju, and Ulsan) in South Korea from May 2019 to April 2020.

Table S1. Monthly average concentrations of $PM_{2.5}$ and its ionic species, and NH_3, and meteorological conditions in Jeonju from May 2019 to April 2020.

Date	NH_3 (ppb)	$PM_{2.5}$ (μg/m³)	SO_4^{2-} (μg/m³)	NO_3^- (μg/m³)	NH_4^+ (μg/m³)	NHR (%)	Temperature (℃)	RH (%)	Wind speed (m/s)	Wind direction (°)	Total Precipitation (mm)	Collected $PM_{2.5}$ filters (#)
2019-May	14.1 ± 6.4	19.7 ± 8.4	5.0 ± 3.3	1.3 ± 0.9	1.1 ± 0.9	8.1	19.5	54.1	1.7	220	45.6	20
Jun	17.1 ± 5.4	28.1 ± 13.8	8.0 ± 4.8	3.5 ± 4.4	1.9 ± 1.9	11.4	22.1	71.8	1.6	220	89.1	10
Aug	9.8 ± 3.6	16.5 ± 3.2	4.4 ± 0.2	0.5 ± 0.1	0.6 ± 0.1	7.7	27.3	75.4	1.5	210	117.7	3
Sep	8.9 ± 3.2	14.1 ± 8.7	3.7 ± 2.9	0.6 ± 0.5	0.5 ± 1.0	5.2	23.0	77.3	1.3	220	194.8	5
Oct	8.8 ± 2.6	18.1 ± 8.4	3.2 ± 1.8	2.4 ± 2.7	0.7 ± 1.0	7.2	16.6	73.7	1.3	220	73.0	23
Nov	9.0 ± 3.4	24.8 ± 9.9	3.7 ± 1.5	3.9 ± 2.3	1.2 ± 0.9	11.4	9.8	67.3	1.5	210	57.0	10
Dec	8.1 ± 2.9	23.6 ± 9.0	3.2 ± 1.0	6.3 ± 3.5	1.8 ± 1.3	20.1	4.2	63.0	1.5	210	30.6	7
2020-Jan	9.9 ± 5.2	38.1 ± 20.3	4.9 ± 4.0	11.8 ± 7.8	3.8 ± 3.2	27.2	3.5	70.5	1.3	210	76.8	12
Feb	9.7 ± 4.3	30.1 ± 10.0	4.9 ± 2.3	7.7 ± 3.7	2.5 ± 1.5	23.6	4.2	68.3	1.5	210	65.9	9
Mar	11.4 ± 3.9	29.0 ± 10.5	3.9 ± 1.8	6.6 ± 4.3	2.1 ± 1.3	18.5	8.2	59.9	1.8	220	25.4	12
Apr	9.5 ± 2.5	18.4 ± 4.3	2.2 ± 0.8	3.6 ± 1.8	0.7 ± 0.6	10.7	9.1	54.6	1.7	220	0	7
Whole period	10.5 ± 4.8	24.0 ± 12.9	4.3 ± 3.1	4.4 ± 4.9	1.6 ± 1.8	13.3	13.6	67.6	1.5	220	775.9	118

Table S2. Model performance evaluation for NH_4^+ concentrations in the six supersites (Baengnyeong, Seoul, Daejeon, Gwangju, Jeju, and Ulsan) in South Korea from May 2019 to April 2020.

SITE	NDATA	MEAN1 (OBS)	MEAN2 (MOD)	MB	RMSE	IOA	NME	NMB	FB	FE	R
Baengnyeong	272	2.75	2.2	-0.55	2.24	0.77	52.00	-19.93	-18.02	58.6	0.62
Seoul	299	2.73	3.06	0.32	1.64	0.87	41.19	11.88	13.33	42.73	0.77
Daejeon	274	2.11	3.51	1.4	2.46	0.65	84.31	66.48	50.07	65.09	0.56
Gwangju	293	3.1	3.23	0.12	1.76	0.82	41.94	3.99	1.53	46.15	0.68
Ulsan	275	2.73	3.31	0.58	1.49	0.86	41.25	21.26	18.49	42.27	0.79
Jeju	215	1.85	1.71	-0.14	1.21	0.84	46.33	-7.47	-13.6	51.9	0.73

MEAN1 (OBS), the mean of the observed values; MEAN2 (MOD), the mean of the simulated values; Mean Bias (MB); Normalized Mean Error (NME); Normalized Mean Bias (NMB); Fractional Bias (FB); Fractional Error (FE); Pearson Correlation coefficient