Supplementary Materials

Long-Term Air Quality Study in Fairbanks, Alaska: Air Pollutant Temporal Variations, Correlations, and $PM_{2.5}$ Source Apportionment

Lexuan Ye [1] and Yungang Wang [2,*]

[1] Department of Applied Bioscience, Zhejiang University, Hangzhou 310058, China; 3170100179@zju.edu.cn
[2] Random Walk Inc, Alameda, CA 94501, USA; carlwyg@gmail.com
* Correspondence: carlwyg@gmail.com

Table S1. Anderson-Darling test results of meteorological parameters, criteria air pollutants and $PM_{2.5}$ speciation. (H—hypothesis test result; P—*p*-value; ADTEST—test statistics; CV—critical value). H = 1 indicates the rejection of the null hypothesis (data follows normal distribution) at the 0.05 significance level. When calculated P is less than the smallest tabulated value, 0.0005 is used for *p*-value.

Category		H	P	ADSTAT	CV
Meteorological parameters	RH	1	0.0005	21.975	0.75161
	T	1	0.0005	27.792	0.75161
	WS	1	0.0005	30.462	0.75161
Criteria air pollutant	SO_2	1	0.0005	66.648	0.75161
	NO_2	1	0.0005	27.115	0.75154
	O_3	1	0.0005	10.822	0.75158
	CO	1	0.0005	98.548	0.75159
	$PM_{2.5}$	1	0.0005	Inf	0.75135
	PM_{10}	1	0.0005	339.57	0.75161
$PM_{2.5}$ speciation	Al	1	0.0005	Inf	0.75104
	NH_4^+	1	0.0005	82.501	0.75104
	Br	1	0.0005	35.872	0.75104
	Ca	1	0.0005	44.572	0.75104
	Cl	1	0.0005	Inf	0.75104
	Cr	1	0.0005	Inf	0.75104
	Cu	1	0.0005	Inf	0.75104
	EC1	1	0.0005	88.351	0.75104
	EC2	1	0.0005	37.393	0.75104
	Fe	1	0.0005	Inf	0.75104
	Mg	1	0.0005	32.93	0.75104
	OC1	1	0.0005	131.63	0.75104
	OC2	1	0.0005	Inf	0.75104
	OC3	1	0.0005	54.075	0.75104
	OC4	1	0.0005	85.213	0.75104
	K	1	0.0005	Inf	0.75104
	Si	1	0.0005	Inf	0.75104
	Na	1	0.0005	Inf	0.75104
	S	1	0.0005	58.823	0.75104
	NO_3^-	1	0.0005	48.546	0.75104
	Zn	1	0.0005	54.141	0.75104

Table S2. Correlation significance test results (*p*-value) of $PM_{2.5}$ sources and meteorological parameters.

	Diesel	**Nitrate**	**Sulfate**	**Wood Smoke**	**Soil**	**Road Salt**	**Gasoline**
RH	0.0053	0.1615	0.1213	0.0027	0.0032	0.0324	0.0145
WS	0.0010	0.0280	0.0222	0.0002	0.0012	0.0082	0.0010
T	0.0000	0.0008	0.0002	0.0204	0.0666	0.0002	0.0159

Table S3. Correlation significance test results (*p*-value) of criteria air pollutants.

Yearly	**NO_2**	**O_3**	**CO**	**$PM_{2.5}$**	**PM_{10}**
SO_2	4.72×10^{-76}	1.26×10^{-16}	3.19×10^{-63}	4.28×10^{-62}	2.20×10^{-27}
NO_2	—	6.75×10^{-13}	1.46×10^{-71}	2.96×10^{-54}	2.43×10^{-25}
O_3		—	1.45×10^{-35}	7.69×10^{-26}	1.85×10^{-7}
CO			—	1.93×10^{-81}	1.31×10^{-26}
$PM_{2.5}$				—	1.76×10^{-55}
Spring	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
SO_2	1.78×10^{-14}	0.042409	1.49×10^{-10}	1.28×10^{-11}	0.011073
NO_2	—	0.001101	4.65×10^{-16}	5.66×10^{-13}	0.052803
O_3		—	0.002609	0.03395	0.97901
CO			—	1.03×10^{-10}	0.058666
$PM_{2.5}$				—	1.06×10^{-6}
Summer	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
SO_2	0.000313	0.58835	0.084332	0.000478	5.54×10^{-3}
NO_2	—	7.14×10^{-5}	0.10436	0.001588	8.82×10^{-6}
O_3		—	0.84244	0.078213	0.011449
CO			—	3.31×10^{-7}	0.000178
$PM_{2.5}$				—	6.39×10^{-16}
Fall	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
SO_2	9.65×10^{-21}	1.41×10^{-5}	7.06×10^{-26}	8.82×10^{-26}	1.77×10^{-9}
NO_2	—	0.016514	6.58×10^{-20}	1.29×10^{-18}	6.28×10^{-12}
O_3		—	2.39×10^{-6}	1.69×10^{-9}	8.36×10^{-5}
CO			—	7.72×10^{-26}	1.17×10^{-9}
$PM_{2.5}$				—	1.13×10^{-15}
Winter	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
SO_2	0.000405	6.12×10^{-7}	3.16×10^{-9}	7.41×10^{-18}	4.11×10^{-15}
NO_2	—	0.034838	1.36×10^{-7}	3.07×10^{-5}	4.8×10^{-6}
O_3		—	4.7×10^{-6}	3.84×10^{-9}	7.68×10^{-10}
CO			—	1.77×10^{-13}	1.45×10^{-13}
$PM_{2.5}$				—	2.66×10^{-37}

Table S4. Correlation significance test results (*p*-value) of criteria air pollutants and meteorological parameters.

	SO_2	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
T	6.11×10^{-50}	1.38×10^{-64}	1.53×10^{-22}	9.06×10^{-54}	2.33×10^{-36}	1.67×10^{-9}
WS	3.07×10^{-22}	1.34×10^{-16}	1.91×10^{-28}	1.58×10^{-28}	1.44×10^{-29}	2.81×10^{-10}
RH	1.63×10^{-4}	2.51×10^{-4}	4.42×10^{-48}	1.54×10^{-15}	3.72×10^{-6}	1.43×10^{-2}

Table S5. Quantities of pollutants emitted by wildfires in Alaska, 2015 (adapted from [16]).

Pollutant	Abbreviation	Quantities (ton)
carbon monoxide	CO	37,739,788
coarse particulate matter	PM_{10}	3,669,509
fine particulate matter	$PM_{2.5}$	3,147,159
methane	CH_4	1,775,990
volatile organic compounds	VOC	1,775,990
organic carbon	OC	1,514,815
oxides of nitrogen	NO_x	809,643
sulfur dioxide	SO_2	221,999
elemental carbon	EC	195,881
ammonia	NH_3	169,764

Table S6. Correlations between $PM_{2.5}$ sources and meteorological parameters (T-temperature; WS-wind speed; RH-relative humidity) in spearman correlation coefficient. Daily data were grouped by month, and monthly averages were used for calculation. Strong correlation: $|\varrho| > 0.5$; Moderate correlation, $0.3 < |\varrho| < 0.5$; Weak correlation, $|\varrho| \leq 0.3$. Number of stars represent significant levels. (***—p-value < 0.001; **—p-value < 0.05; *—p-value < 0.1).

	Diesel	**Nitrate**	**Sulfate**	**Wood Smoke**	**Soil**	**Road Salt**	**Gasoline**
RH	0.77**	0.43	0.48	0.80**	−0.80**	0.63**	0.70**
WS	−0.85***	−0.64**	−0.66**	−0.88***	0.84**	−0.74**	−0.85***
Temp	−0.99***	−0.85***	−0.88**	−0.67**	0.55*	−0.88***	−0.69**

Table S7. Annual and seasonal (two-season division) correlations of six criteria air pollutants in spearman correlation coefficient. Daily measurements were used for calculation. Strong correlation: $|\varrho| > 0.5$; Moderate correlation, $0.3 < |\varrho| < 0.5$; Weak correlation, $|\varrho| \leq 0.3$. Number of stars represent significant levels. (***—p-value < 0.001; **—p-value < 0.05; *—p-value < 0.1).

Yearly	**NO_2**	**O_3**	**CO**	**$PM_{2.5}$**	**PM_{10}**
SO_2	0.80***	−0.43***	0.76***	0.75***	0.55***
NO_2	—	−0.38***	0.79***	0.72***	0.53***
O_3		—	−0.61***	−0.53***	−0.28***
CO			—	0.82***	0.54***
$PM_{2.5}$				—	0.72***
Warm Season	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
SO_2	0.44***	0.06	0.23**	0.37***	0.31***
NO_2	—	0.23**	0.36***	0.35***	0.41***
O_3		—	−0.20**	0.11	0.30***
CO			—	0.44***	0.29***
$PM_{2.5}$				—	0.67***
Cold Season	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
SO_2	0.73***	−0.54***	0.80***	0.83***	0.52***
NO_2	—	−0.40***	0.71***	0.69***	0.42***
O_3		—	−0.72***	−0.75***	−0.45***
CO			—	0.90***	0.51***
$PM_{2.5}$				—	0.66***

Table S8. Correlation significance test results (*p*-value) of criteria air pollutants (two-season division).

Yearly	**NO_2**	**O_3**	**CO**	**$PM_{2.5}$**	**PM_{10}**
SO_2	4.72×10^{-76}	1.26×10^{-16}	3.19×10^{-63}	4.28×10^{-62}	2.20×10^{-27}
NO_2	—	6.75×10^{-13}	1.46×10^{-71}	2.96×10^{-54}	2.43×10^{-25}
O_3		—	1.45×10^{-35}	7.69×10^{-26}	1.85×10^{-7}
CO			—	1.93×10^{-81}	1.31×10^{-26}
$PM_{2.5}$				—	1.76×10^{-55}
Warm Season	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
SO_2	1.29×10^{-8}	0.48727	0.003872	2.57×10^{-6}	9.92×10^{-5}
NO_2	—	0.004837	4.51×10^{-6}	9.38×10^{-6}	1.38×10^{-7}
O_3		—	0.012436	0.19827	0.000222
CO			—	1.16×10^{-8}	0.000391
$PM_{2.5}$				—	1.28×10^{-20}
Cold Season	NO_2	O_3	CO	$PM_{2.5}$	PM_{10}
SO_2	9.81×10^{-32}	3.33×10^{-15}	6.54×10^{-43}	4.51×10^{-48}	6.02×10^{-14}
NO_2	—	1.62×10^{-8}	6.16×10^{-30}	4.76×10^{-27}	3.75×10^{-9}
O_3		—	2.13×10^{-30}	2.76×10^{-35}	1.73×10^{-10}
CO			—	3.67×10^{-67}	2.11×10^{-13}
$PM_{2.5}$				—	9.01×10^{-25}

Table S9. Annual and seasonal average source contributions using newly-defined seasons. (SE-standard error).

Source	Warm Season (May–Sept)		Cold Season (Oct–Apr)		Average	
	Mean ± SE (μg/m³)	%	Mean ± SE (μg/m³)	%	Mean ± SE (μg/m³)	%
Diesel	−0.018 ± 0.015	−0.5	1.381 ± 0.062	10.7	0.858 ± 0.047	9.2
Nitrate	0.406 ± 0.074	10.6	2.139 ± 0.096	16.6	1.455 ± 0.070	15.7
Sulfate	0.051 ± 0.065	1.3	4.900 ± 0.340	38.0	3.038 ± 0.229	32.7
Wood Smoke	1.440 ± 0.204	37.6	2.254 ± 0.142	17.5	1.787 ± 0.102	19.3
Soil	0.334 ± 0.030	8.7	0.294 ± 0.020	2.3	0.355 ± 0.022	3.8
Gasoline	1.599 ± 0.062	41.8	1.782 ± 0.081	13.8	1.694 ± 0.053	18.2
Road Salt	0.013 ± 0.006	0.3	0.144 ± 0.016	1.1	0.095 ± 0.011	1.0
Sum	3.825 ± 0.302	100.0	12.894 ± 0.499	100.0	9.282 ± 0.363	100.0

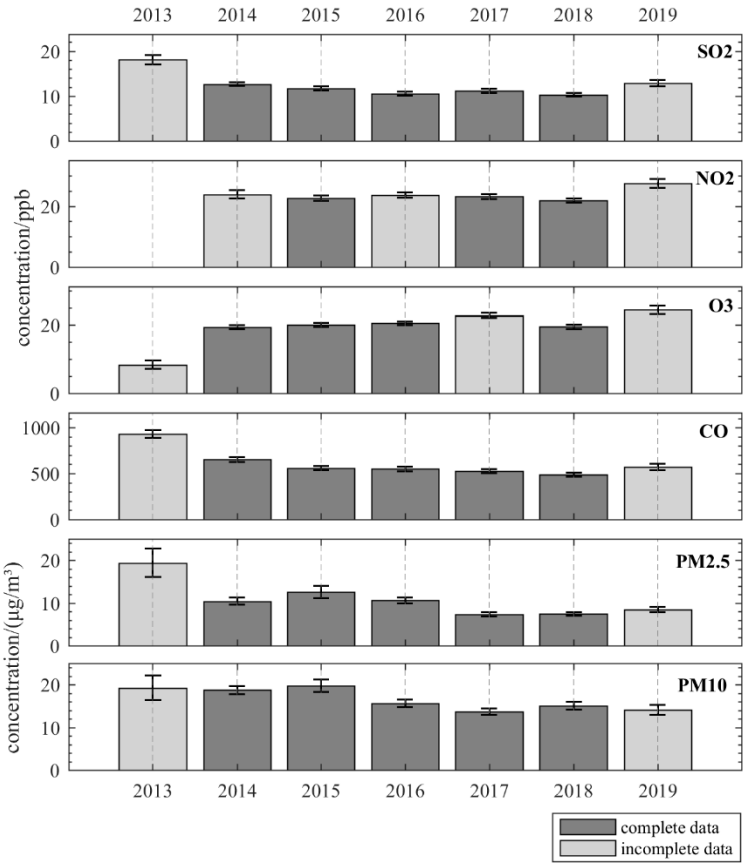

Figure S1. Interannual variations of six criteria air pollutants (μg/m³ for $PM_{2.5}$ and PM_{10}, ppb for SO_2, NO_2, O_3 and CO) in Fairbanks from 2013 to 2019. Dark grey bars represent years with observations from every month. Light grey bars represent years with at least one month of missing observations. Error bars represent one standard error.

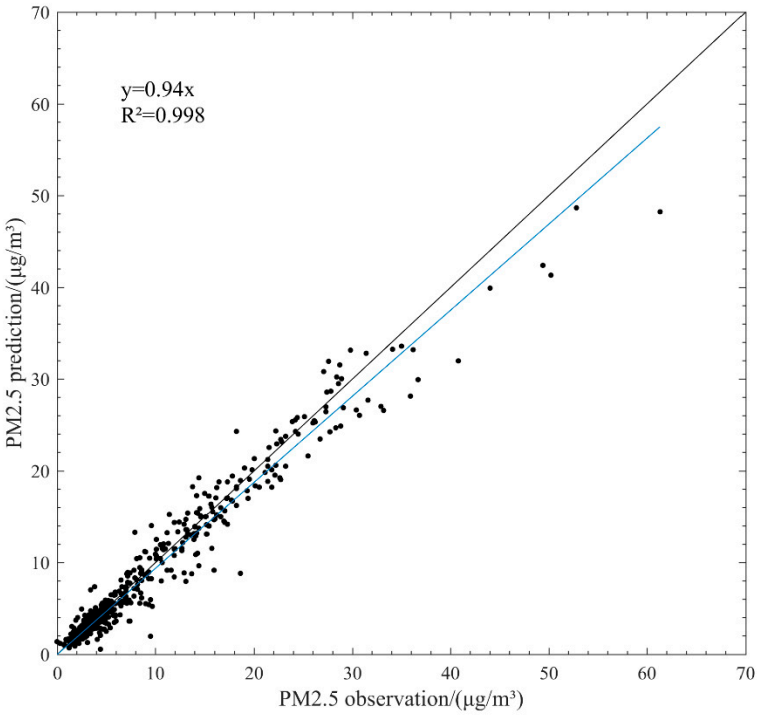

Figure S2. Predicted VS observed $PM_{2.5}$ concentrations. Data points with missing $PM_{2.5}$ observations and data points on June 23rd, June 26th, July 2nd and July 8th, 2015 were removed. Black line represents the one-to-one line. Blue line represents the fitting straight line.

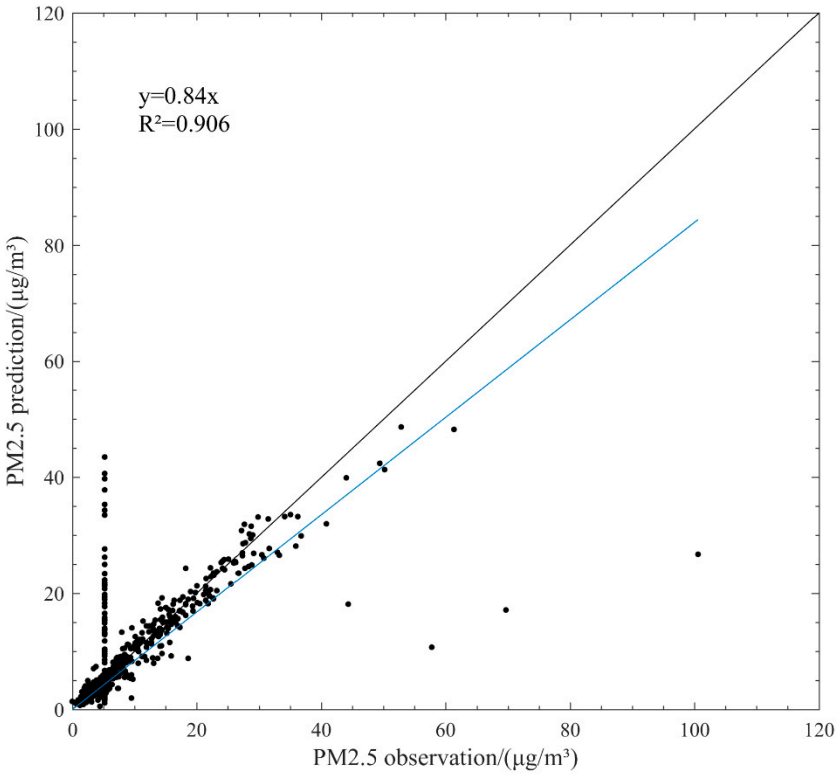

Figure S3. Predicted VS observed $PM_{2.5}$ concentrations (complete data). Black line represents the one-to-one line. Blue line represents the fitting straight line.

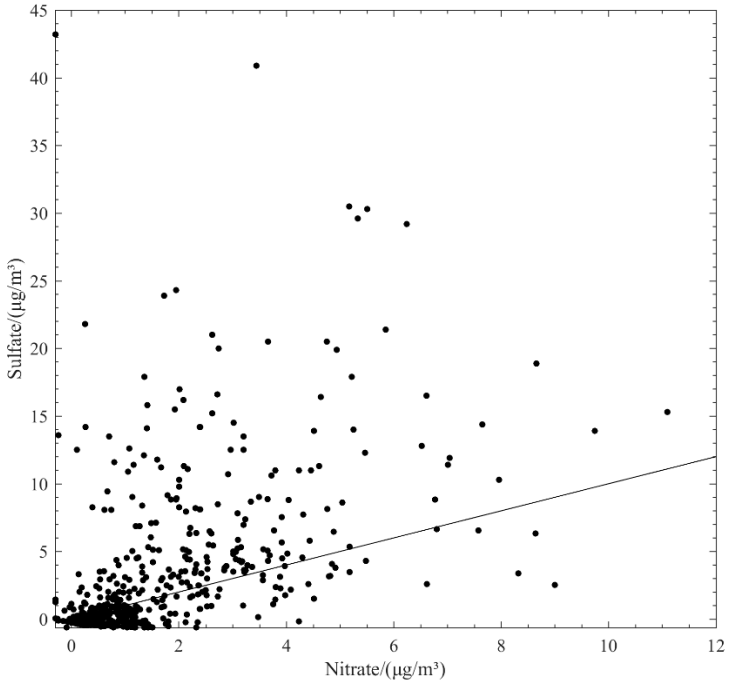

Figure S4. Nitrate VS Sulfate G-space scatter plot. Black line represents the one to one line.

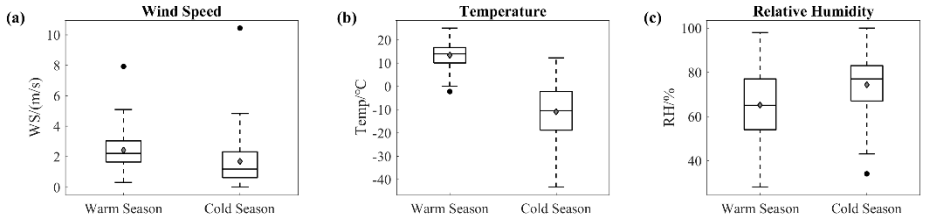

Figure S5. Comparison of (**a**) wind speed (**b**) temperature (**c**) relative humidity in warm and cold seasons. The central box represents values from lower to upper quartile (25th to 75th percentile). The vertical line extends from the 10th percentile to the 90th percentile. The middle solid line represents the median. The grey diamond represents the arithmetic average. Maximal and minimal outliers are plotted as black dots.

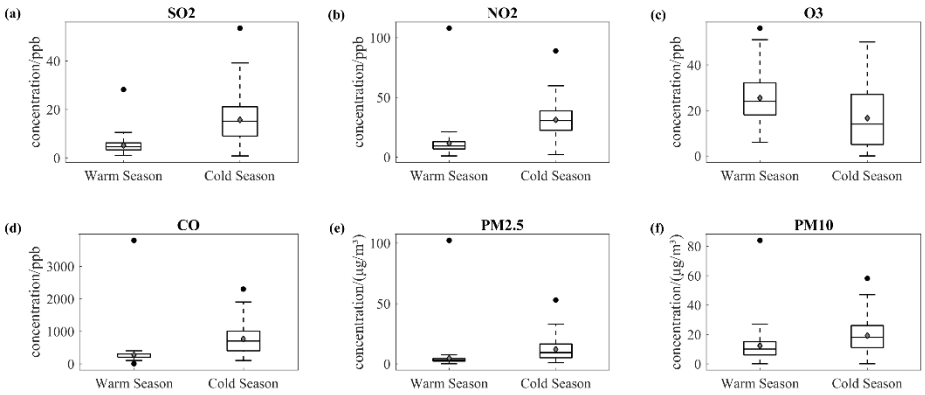

Figure S6. Comparison of (**a**) SO_2 (**b**) NO_2 (**c**) O_3 (**d**) CO (**e**) $PM_{2.5}$ (**f**) PM_{10} in warm and cold seasons. The central box represents values from lower to upper quartile (25^{th} to 75^{th} percentile). The vertical line extends from the 10^{th} percentile to the 90^{th} percentile. The middle solid line represents the median. The grey diamond represents the arithmetic average. Maximal and minimal outliers are plotted as black dots.