Clean Air Status and Trends Network (CASTNET)
Quarterly Data Summary for First Quarter 2020 (January through March)

Prepared for: U.S. Environmental Protection Agency (EPA), Clean Air Markets Division
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Introduction

This quarterly report summarizes the Clean Air Status and Trends Network (CASTNET) data collected during first quarter 2020. Trends in pollutants measured at eastern and western reference sites are shown. Results from the quality assurance/quality control (QA/QC) program are presented for first quarter data and include completeness and precision of filter concentrations and hourly O_3 concentrations. This report also analyzes data for continuous, trace-level NO_y from eight sites and continuous SO_2 concentrations from three sites. Other QC statistics are given in the CASTNET First Quarter 2020 Quality Assurance Report (Wood, 2020).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O_3 Concentrations through First Quarter 2020 (ppb)

Figure 1 shows fourth highest daily maximum 8-hour average (DM8A) O_3 concentrations measured through first quarter 2020. No sites exceeded the 0.070 parts per million (ppm) National Ambient Air Quality Standard for O_3. The low concentrations were caused by winter weather conditions typical of the first quarter and also reduced NO_x emissions produced by a decline in industrial activities and traffic during the coronavirus pandemic (Bauwens *et al.*, 2020).

Trends

Trend analyses were performed based on filter pack pollutant concentrations measured in micrograms per cubic meter ($\mu g/m^3$) of air at the 34 eastern and 16 western reference sites during first quarter. Trends in quarterly mean filter pack and O_3 concentrations are shown using box plots in Figures 2 through 13.

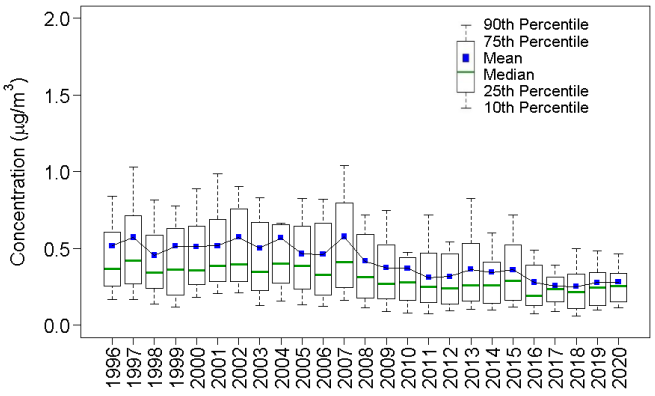
First Quarter Concentrations

Quarterly mean NO_3^-, NH_4^+, total NO_3^-, SO_2, SO_4^{2-}, Ca^{2+}, K^+, Mg^{2+}, and Na^+ concentrations decreased at eastern sites in 2020, and HNO_3 and Cl^- concentrations increased. Quarterly mean NO_3^-, NH_4^+, SO_2, Cl^-, Ca^{2+}, K^+, and Mg^{2+} concentrations decreased at western sites in 2020 while HNO_3, total NO_3^-, SO_4^{2-}, and Na^+ concentrations increased.

Quarterly O_3 concentrations were analyzed using box plots constructed by averaging all valid hourly O_3 concentrations within first quarter 2020 by site and then averaging those averages for all eastern and western reference sites (Figure 13). The figure shows an overall reduction in quarterly mean O_3 concentrations at eastern and western sites. Quarterly mean concentrations were higher at the western reference sites than at the eastern sites. Figures 14 through 16 compare time series of DM8A O_3 concentrations for the first quarter 2019 and 2020 for three sites with typically high concentrations – ABT147, CT; WSP144, NJ; and JOT403, CA. The O_3 concentrations measured during the last third of first quarter 2020 were lower than the respective 2019 levels.

Figure 2. Trends in First Quarter Mean HNO_3 Concentrations

Western Reference Sites



Eastern Reference Sites

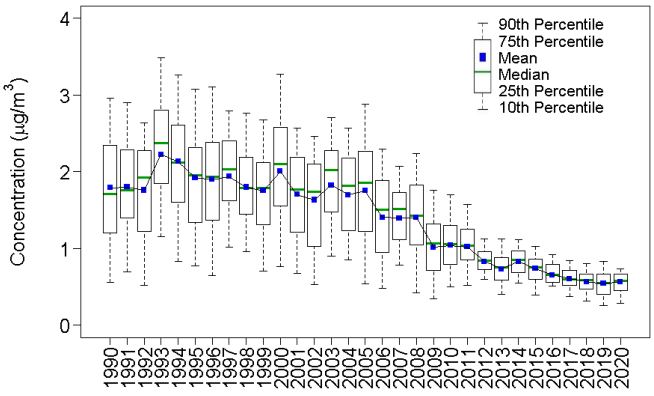
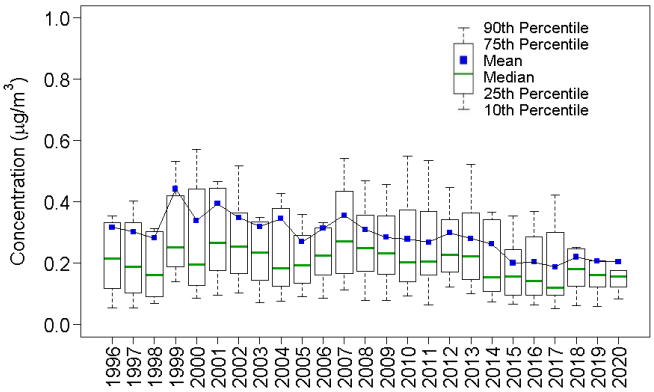


Figure 3. Trends in First Quarter Mean NO_3^- Concentrations

Western Reference Sites



Eastern Reference Sites

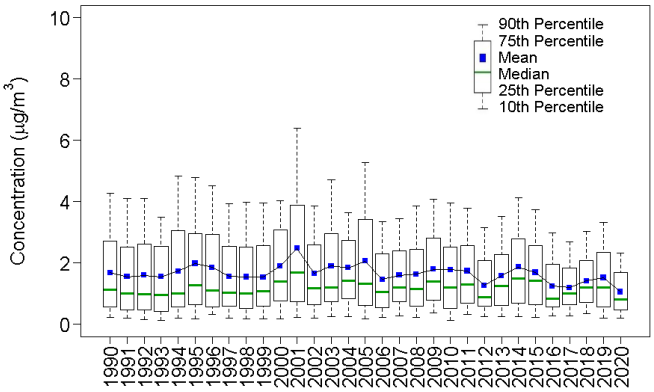
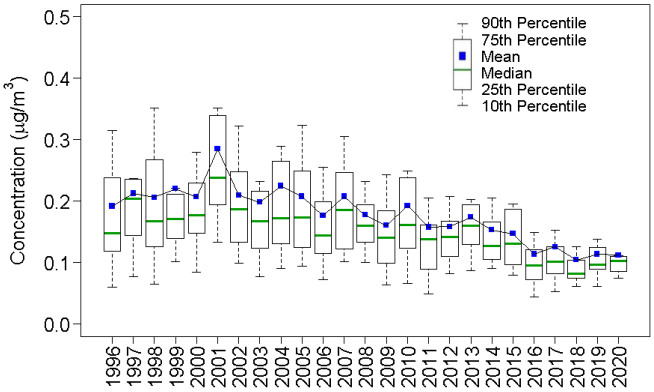


Figure 4. Trends in First Quarter Mean NH_4^+ Concentrations

Western Reference Sites



Eastern Reference Sites

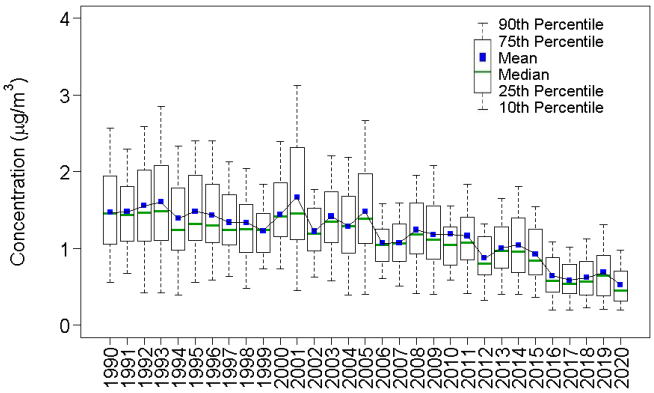
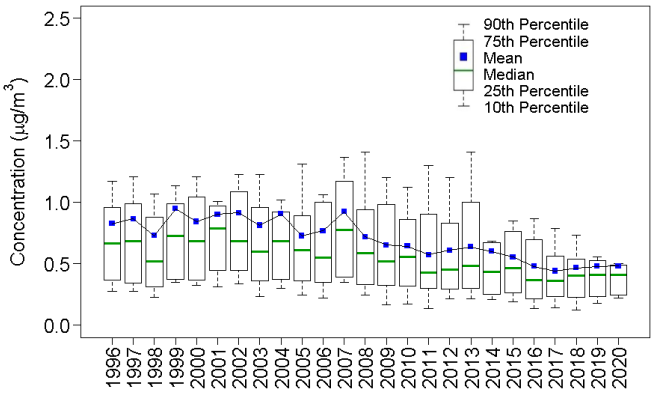


Figure 5. Trends in First Quarter Mean Total NO_3^- Concentrations

Western Reference Sites



Eastern Reference Sites

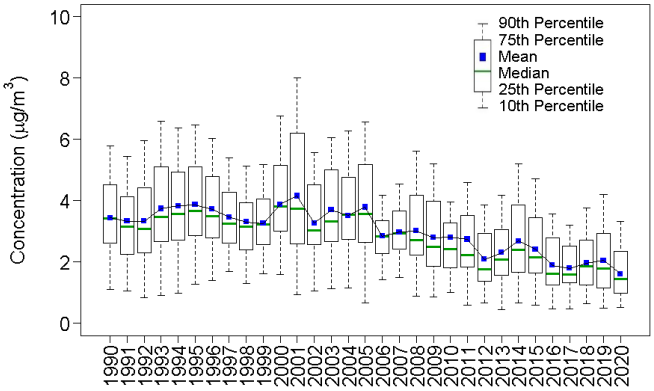
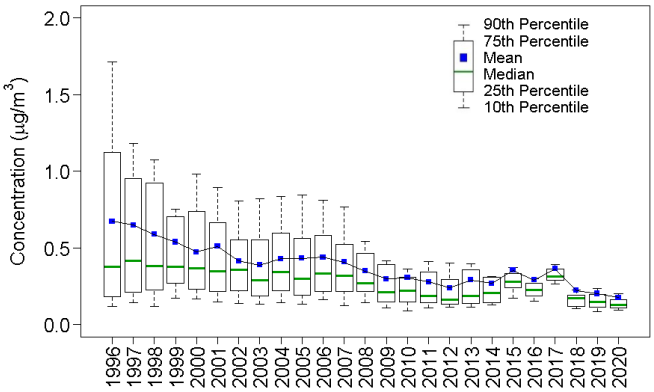


Figure 6. Trends in First Quarter Mean SO_2 Concentrations

Western Reference Sites



Eastern Reference Sites

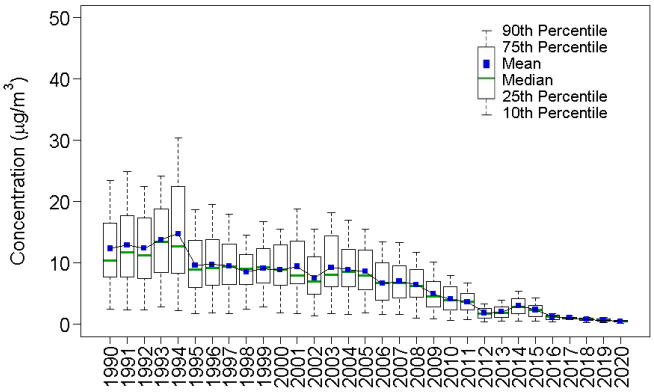
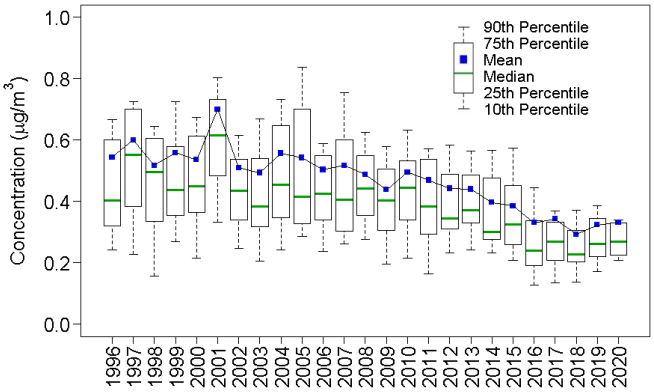


Figure 7. Trends in First Quarter Mean SO_4^{2-} Concentrations

Western Reference Sites



Eastern Reference Sites

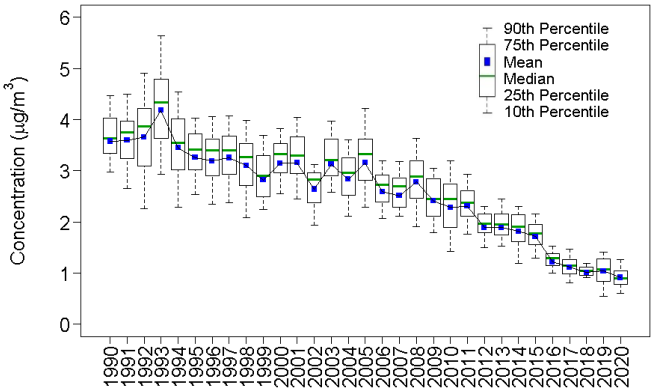
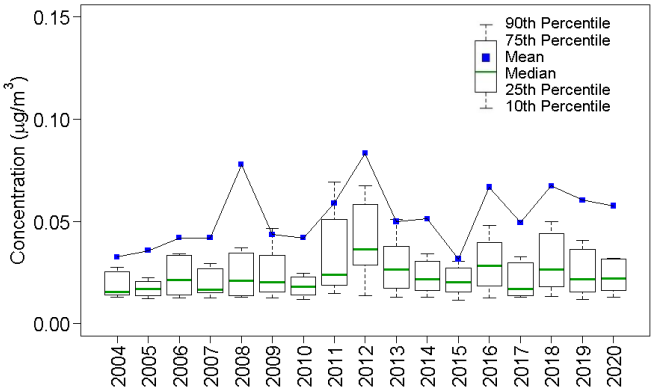


Figure 8. Trends in First Quarter Mean Cl^- Concentrations

Western Reference Sites



Eastern Reference Sites

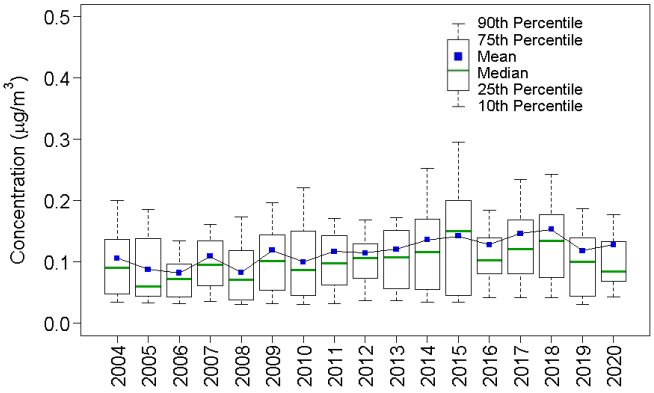
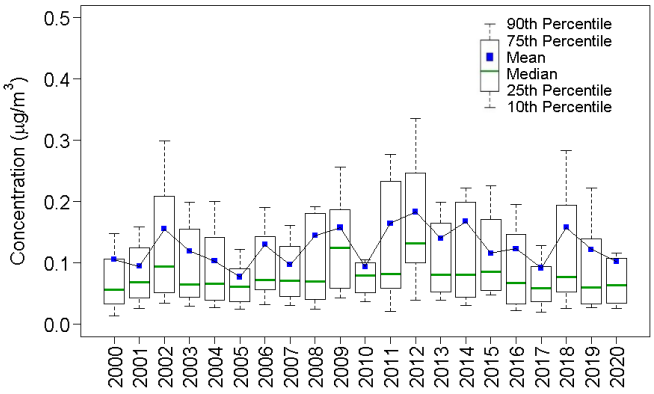


Figure 9. Trends in First Quarter Mean Ca^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

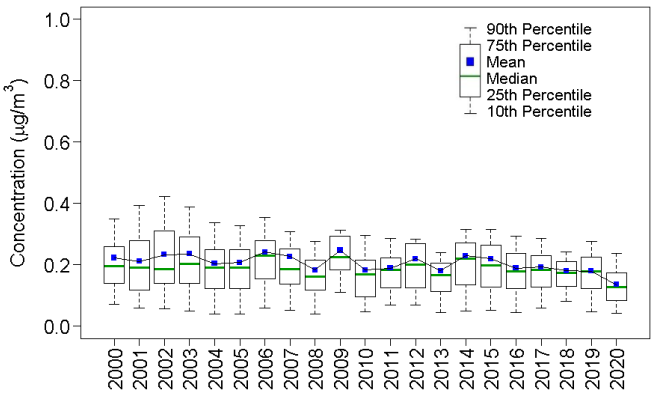
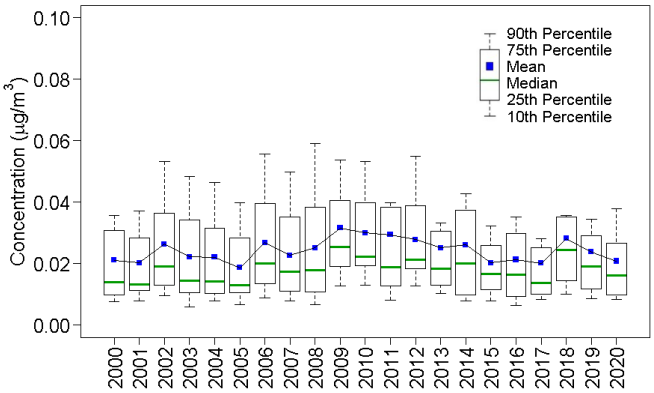


Figure 10. Trends in First Quarter Mean K^{+} Concentrations

Western Reference Sites



Eastern Reference Sites

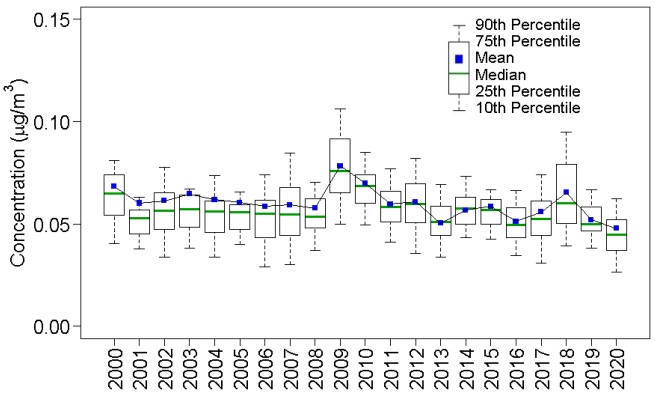
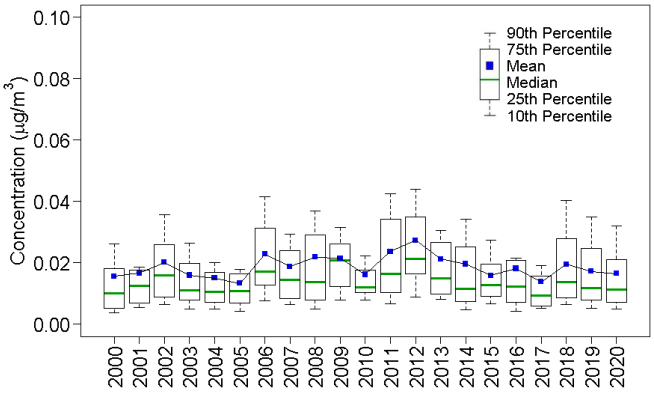


Figure 11. Trends in First Quarter Mean Mg^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

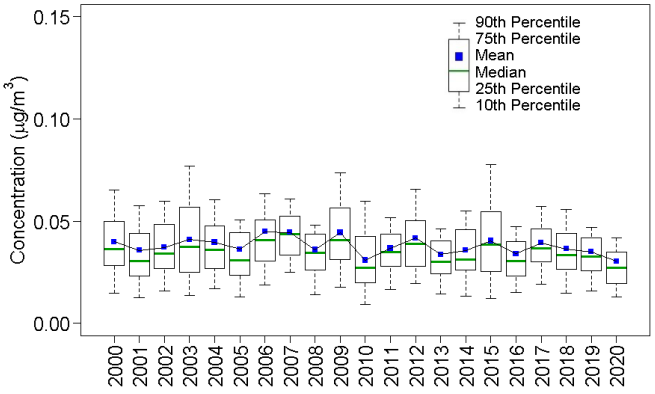


Figure 12. Trends in First Quarter Mean Na^+ Concentrations

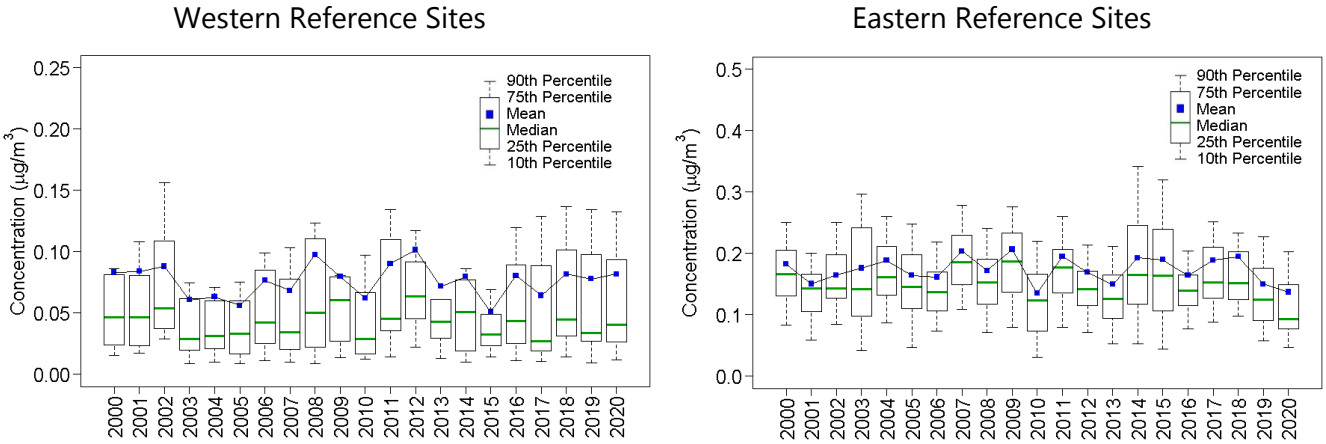


Figure 13. Trends in First Quarter Mean O_3 Concentrations

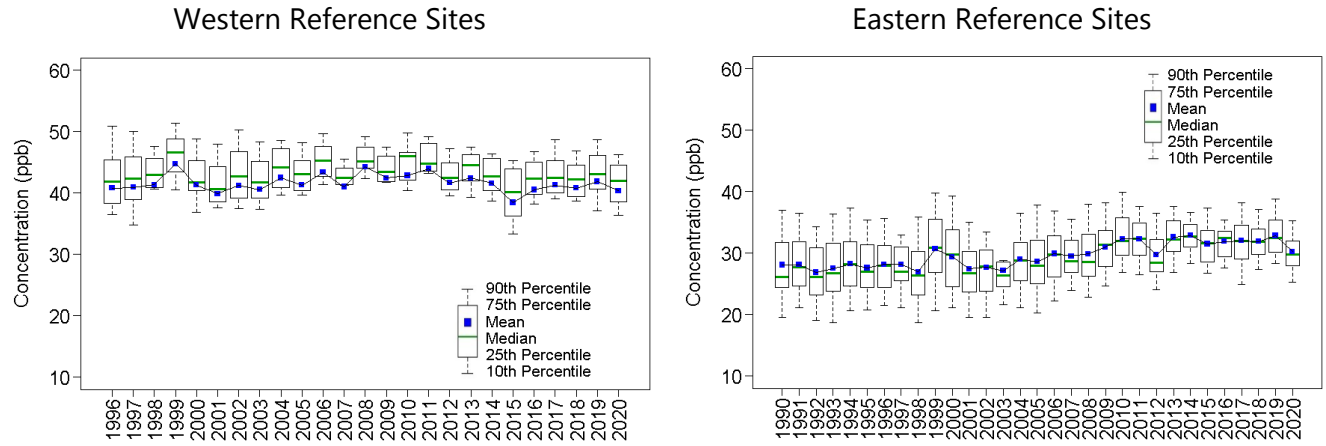


Figure 14. Trends in 2019 and 2020 First Quarter DM8A O_3 Concentrations for ABT147

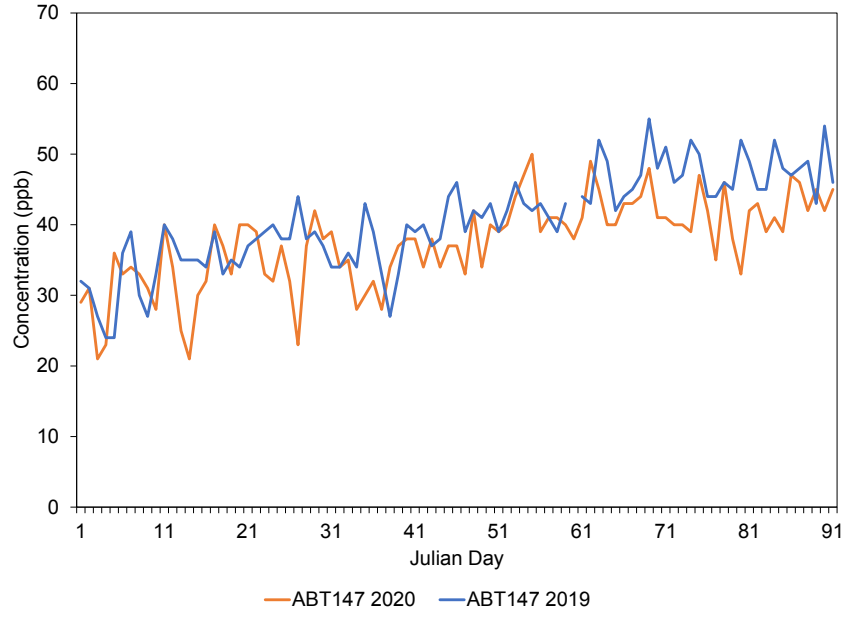


Figure 15. Trends in 2019 and 2020 First Quarter DM8A O_3 Concentrations for WSP144

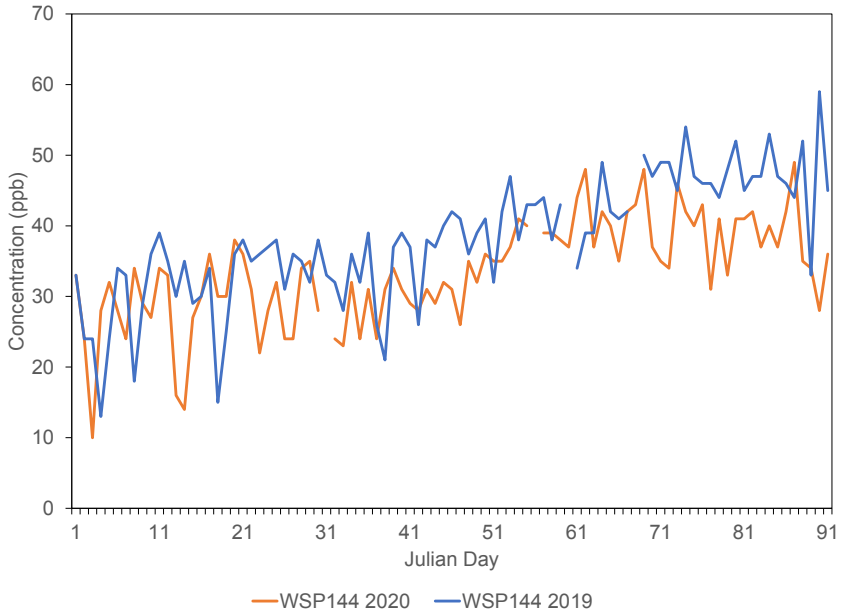
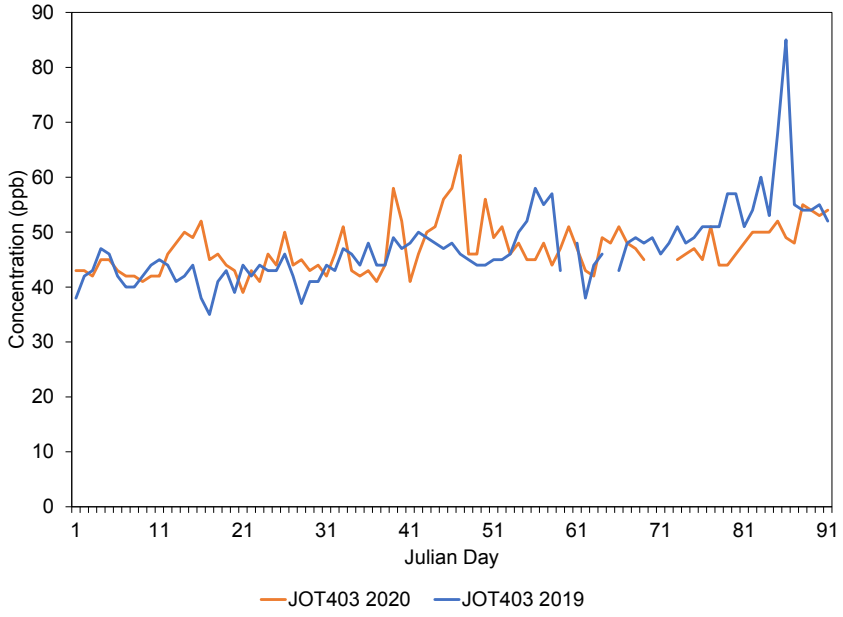


Figure 16. Trends in 2019 and 2020 First Quarter DM8A O_3 Concentrations for JOT403



Changes in 3-year Average First Quarter Concentrations

Three-year averages of quarterly mean concentrations of total NO_3^-, NH_4^+, SO_2, SO_4^{2-}, and O_3 were reduced over the period 1990–1992 through 2018–2020 for eastern reference sites and 1996–1998 through 2018–2020 for western reference sites. Tables 1 and 2 summarize changes in 3-year average first quarter concentrations. O_3 concentrations increased by 14 percent at eastern sites and showed no change at western sites.

Table 1. Eastern Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O_3 Pollutant Concentrations

	Total NO_3^- ($\mu g/m^3$)	NH_4^+ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	SO_4^{2-} ($\mu g/m^3$)	O_3 (ppb)
1990–1992	3.4	1.5	12.5	3.6	28
2018–2020	1.9	0.6	0.6	1.0	32
Percent Change	-44	-59	-95	-73	14

Table 2. Western Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O_3 Pollutant Concentrations

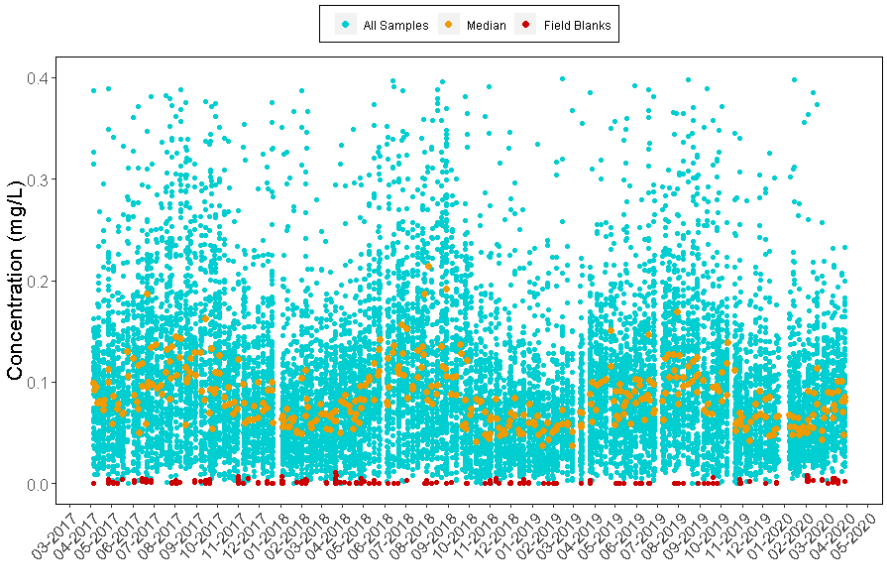
	Total NO_3^- ($\mu g/m^3$)	NH_4^+ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	SO_4^{2-} ($\mu g/m^3$)	O_3 (ppb)
1996–1998	0.8	0.2	0.6	0.6	41
2018–2020	0.5	0.1	0.2	0.3	41
Percent Change	-41	-46	-69	-43	0

Time Series of Laboratory Analysis Parameters for All Sites

Figures 17 through 27 give time series of laboratory-analyzed concentrations of field samples and field blanks in milligrams per liter (mg/L) of 11 parameters from second quarter 2017 through first quarter 2020. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

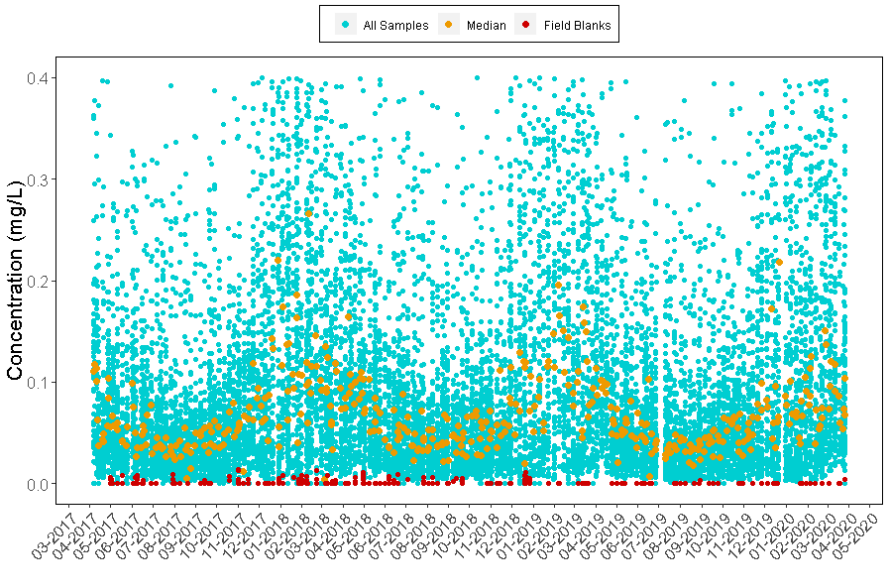
Previous review of filter pack analysis control charts indicated possible potassium contamination (Figure 25). Corrective actions were implemented, and subsequent testing indicated these actions have been effective.

Figure 17. Concentrations of NO_3^- (as N) from Nylon Filters



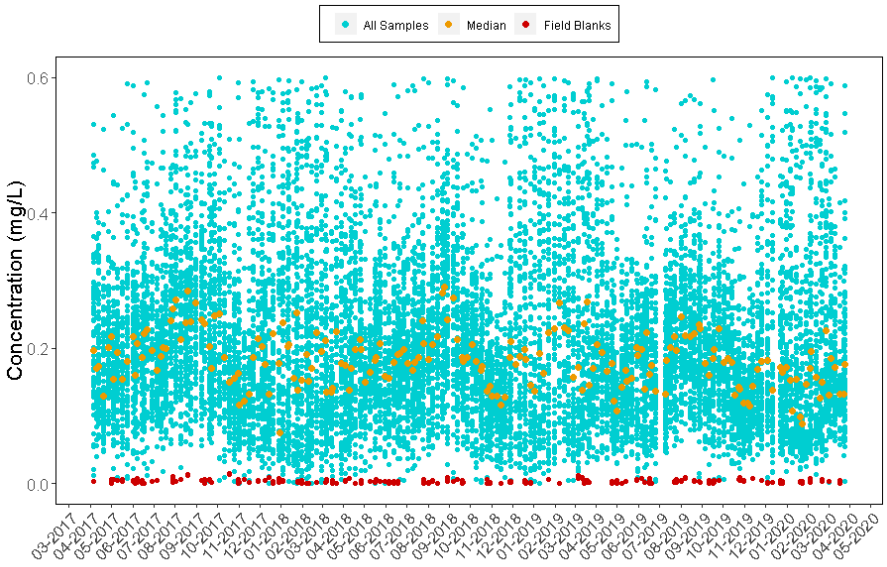
Note: Nominal reporting limit is 0.008 mg/L.

Figure 18. Concentrations of NO_3^- (as N) from Teflon Filters



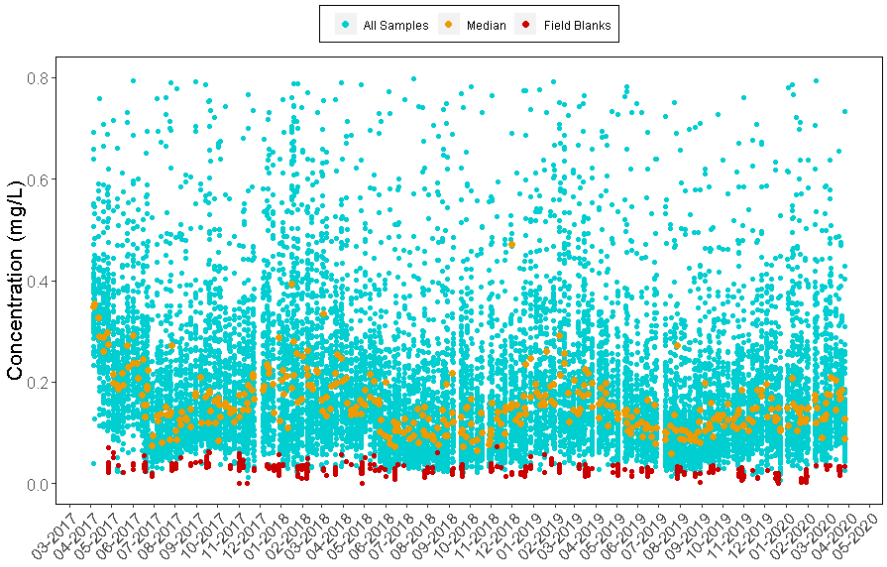
Note: Nominal reporting limit is 0.008 mg/L.

Figure 19. Concentrations of NH_4^+ (as N) from Teflon Filters



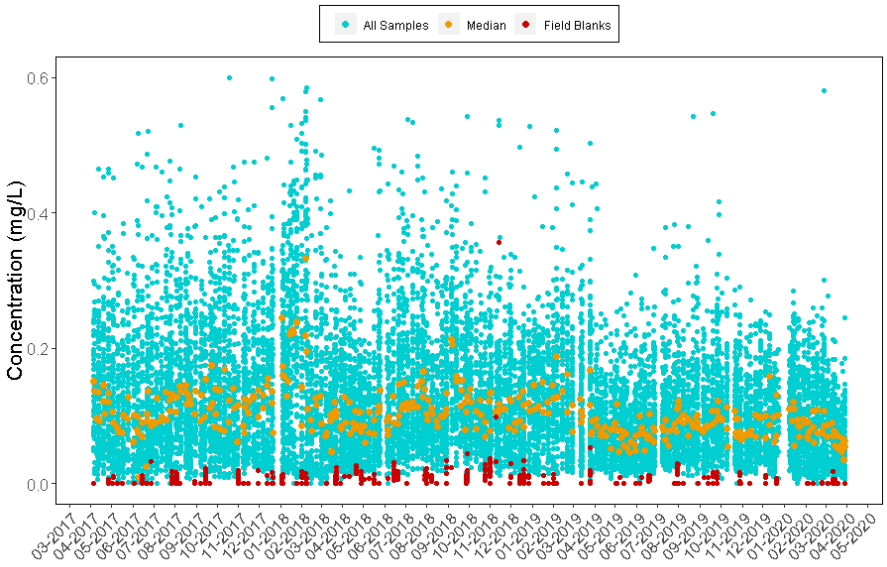
Note: Nominal reporting limit is 0.020 mg/L.

Figure 20. Concentrations of SO_2 from K_2CO_3-impregnated Cellulose Filters



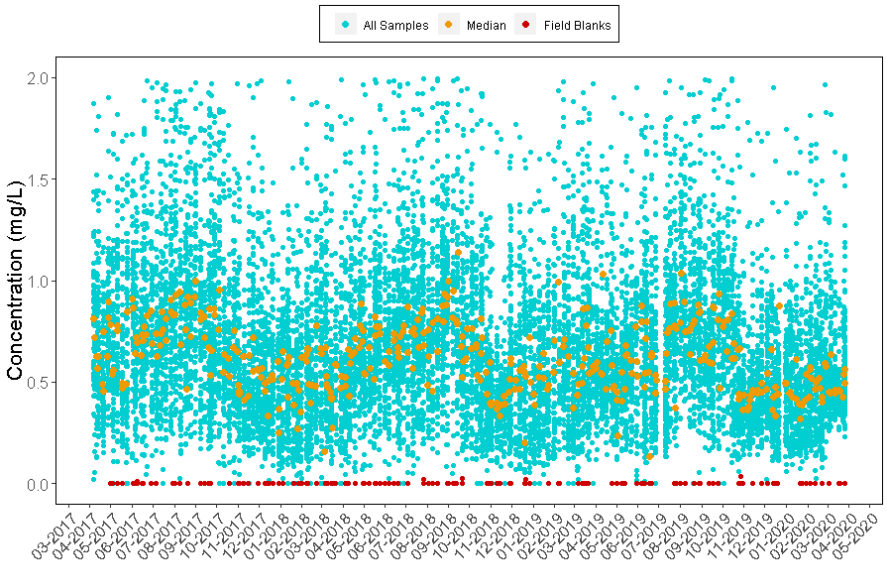
Note: Nominal reporting limit is 0.040 mg/L.

Figure 21. Concentrations of SO_4^{2-} from Nylon Filters



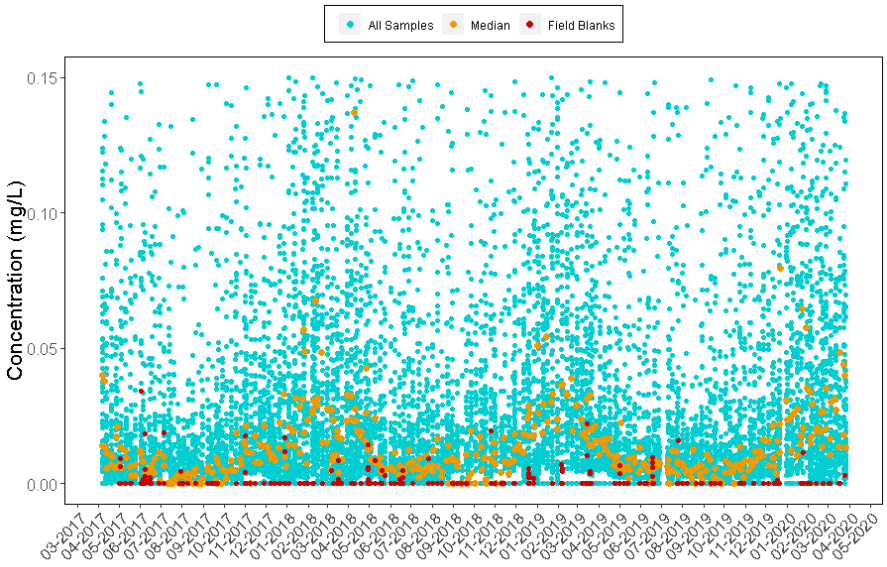
Note: Nominal reporting limit is 0.040 mg/L.

Figure 22. Concentrations of SO_4^{2-} from Teflon Filters



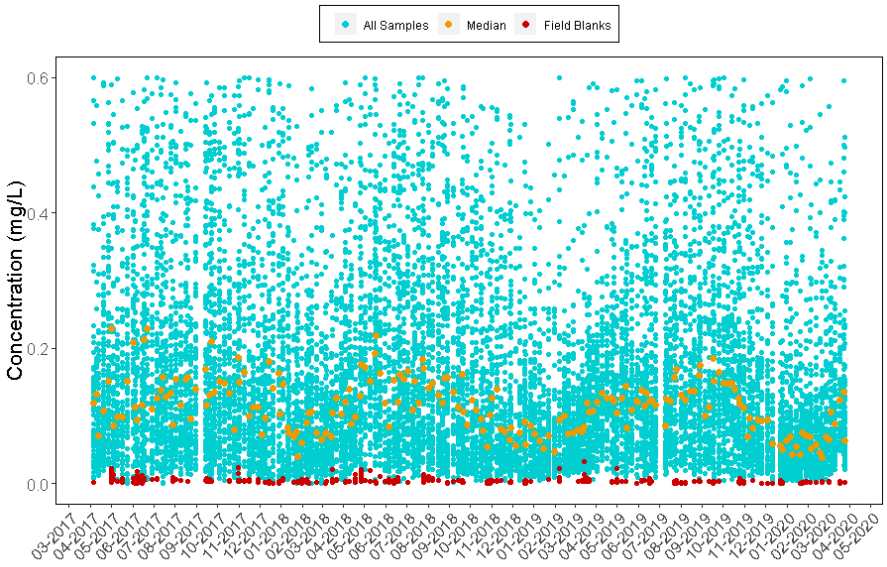
Note: Nominal reporting limit is 0.040 mg/L.

Figure 23. Concentrations of Cl^- from Teflon Filters



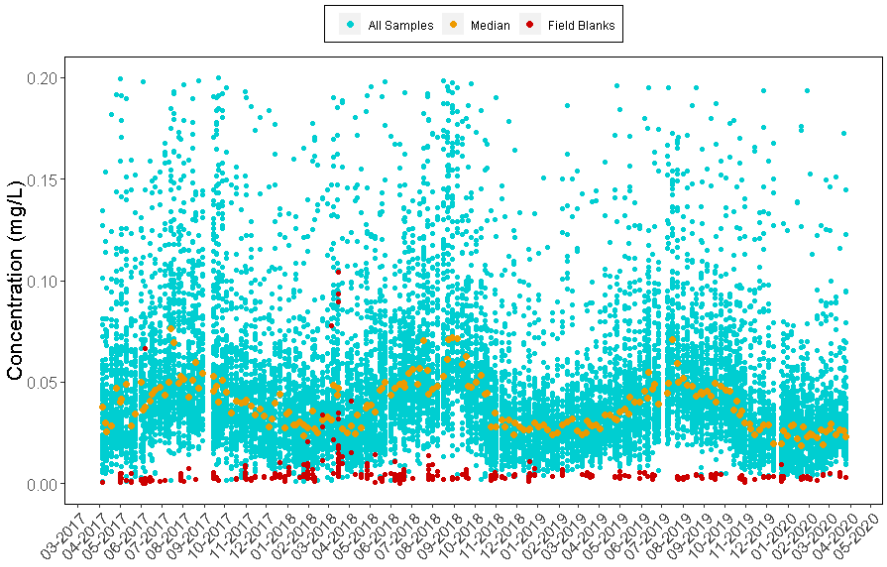
Note: Nominal reporting limit is 0.020 mg/L.

Figure 24. Concentrations of Ca^{2+} from Teflon Filters



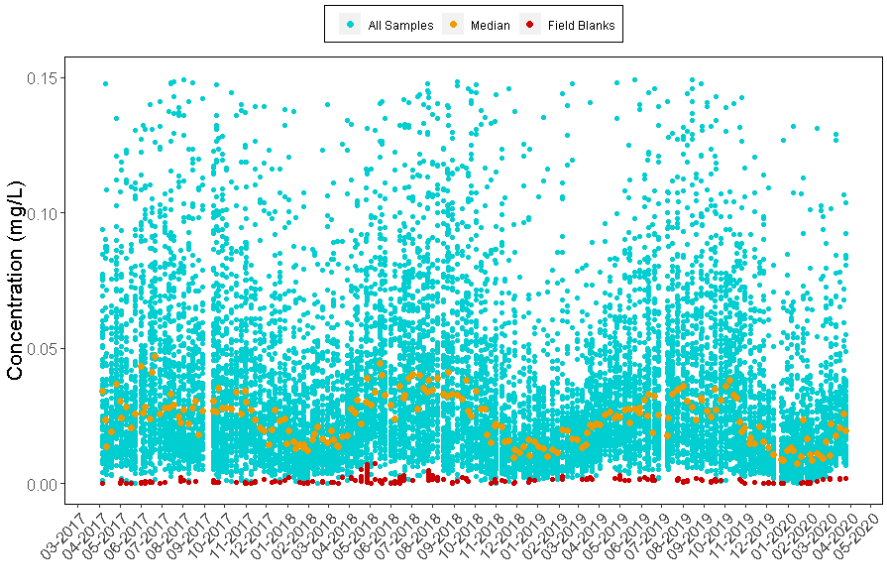
Note: Nominal reporting limit is 0.006 mg/L.

Figure 25. Concentrations of K^{+} from Teflon Filters



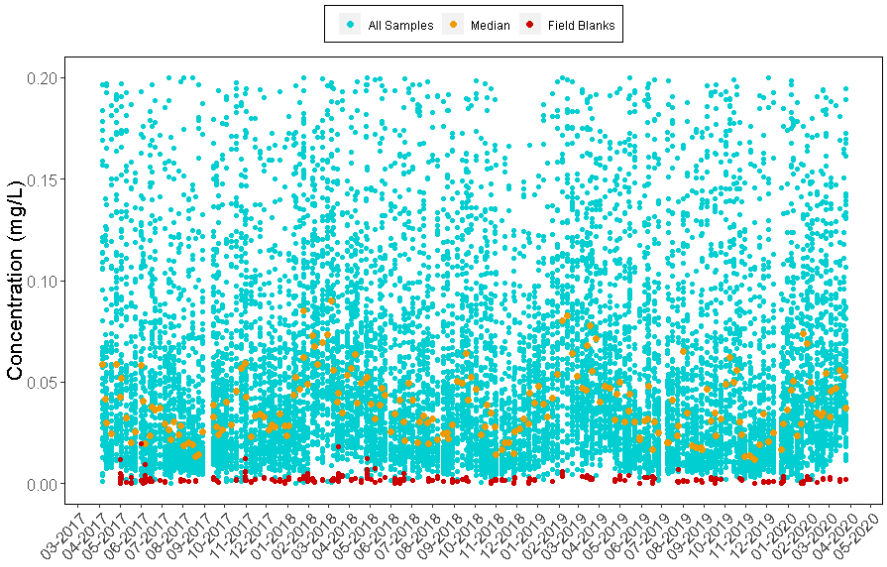
Note: Nominal reporting limit is 0.006 mg/L.

Figure 26. Concentrations of Mg^{2+} from Teflon Filters



Note: Nominal reporting limit is 0.003 mg/L.

Figure 27. Concentrations of Na^{+} from Teflon Filters



Note: Nominal reporting limit is 0.005 mg/L.

Time Series of Concentration Differences from Co-located Sites

Figures 28 and 29 show times series of concentration differences between the two sets of co-located sites.

Figure 28. Time Series of Filter Concentration Differences between MCK131 and MCK231, KY

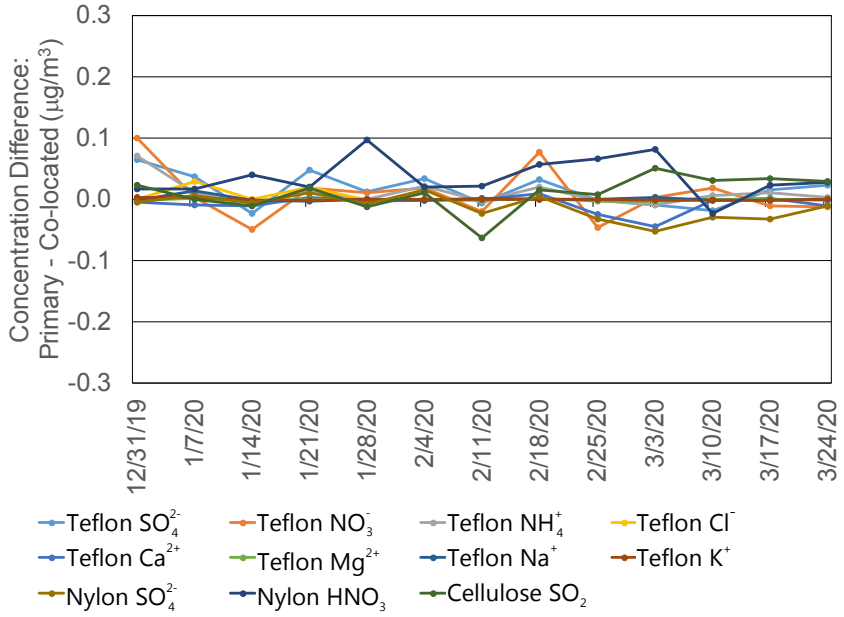
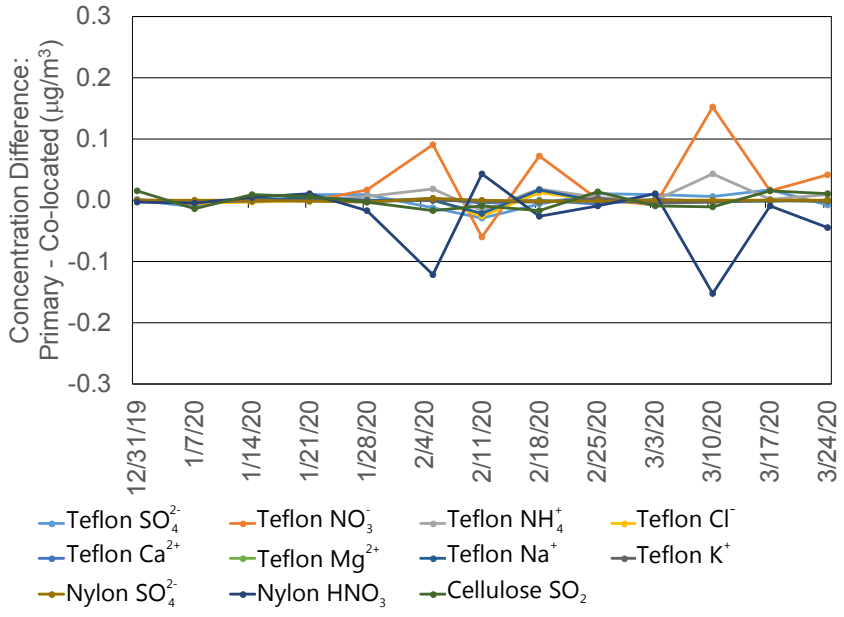


Figure 29. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



Precision of Filter Pack Concentrations

Table 3 shows mean absolute relative percent differences (MARPD) for concentrations measured at MCK131/231 and ROM406/206 during first quarter 2020. The MARPD values met the 20 percent criterion.

Table 3. Precision (MARPD) for Co-located Filter Pack Data during First Quarter 2020

	SO_4^{2-}	NO_3^-	NH_4^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HNO_3	SO_2	Total NO_3^-
MCK131/231, KY											
$\overline{X}$ (µg/m^3)	1.07	0.99	0.59	0.13	0.02	0.08	0.05	0.07	0.83	0.48	1.81
$\overline{Y}$ (µg/m^3)	1.05	0.98	0.58	0.14	0.02	0.08	0.05	0.06	0.80	0.47	1.77
MAD	0.02	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.02	0.04
MARPD	2.90	3.53	3.24	4.98	6.11	2.61	2.87	4.30	4.44	4.82	2.70
ROM406/206, CO											
$\overline{X}$ (µg/m^3)	0.30	0.21	0.14	0.05	0.01	0.03	0.01	0.02	0.29	0.13	0.49
$\overline{Y}$ (µg/m^3)	0.30	0.18	0.13	0.05	0.01	0.03	0.01	0.03	0.32	0.13	0.49
MAD	0.01	0.05	0.01	0.00	0.00	0.01	0.00	0.00	0.04	0.01	0.01
MARPD	4.66	17.60	7.51	6.27	11.62	15.96	12.11	16.85	12.53	11.35	3.12

Completeness for Filter Pack Concentrations

Table 4 shows CASTNET sites with less than 90 percent completeness for weekly filter pack concentrations. Comments are included to provide information on why these sites experienced low data completeness.

Table 4. Sites with less than 90 Percent Data Completeness for Filter Concentrations for First Quarter 2020

Site ID	Teflon SO_4^{2-}	Teflon NO_3^-	Teflon NH_4^+	Teflon Minor Cations	Teflon Cl^-	Nylon HNO_3	Nylon SO_4^{2-}	Cellulose SO_2	Comment
BAS601, WY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	One sample was installed for three weeks.
BVL130, IL	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The mass flow controller malfunctioned affecting two samples.
CDZ171, KY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The mass flow controller malfunctioned affecting two samples.
CND125, NC	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The flow pump was not turned on during one sampling week. Another sampling week was a 2-week sample.
PED108, VA	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The mass flow controller malfunctioned affecting two samples.
SPD111, TN	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	A power failure and subsequent issues with the data logger affected two samples.

Precision of Ozone Concentrations

Time series of co-located hourly O_3 concentration differences for first quarter 2020 are provided in Figures 30 and 31 for MCK131/231 and ROM406/206, respectively. The figures indicate no consistent bias between the co-located analyzers at these site locations.

Figure 30. Time Series of the Differences in Co-located O_3 Concentrations for MCK131/231, KY

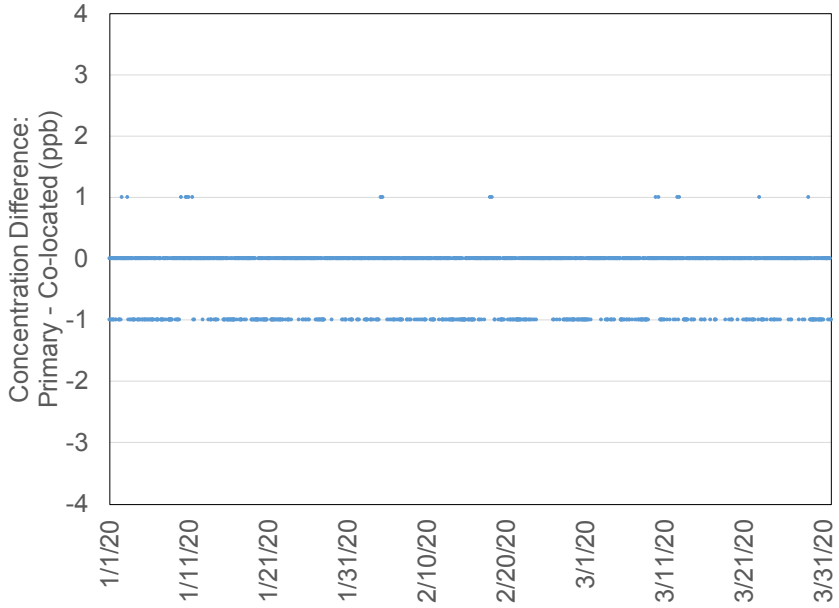


Figure 31. Time Series of the Differences in Co-located O_3 Concentrations for ROM406/206, CO

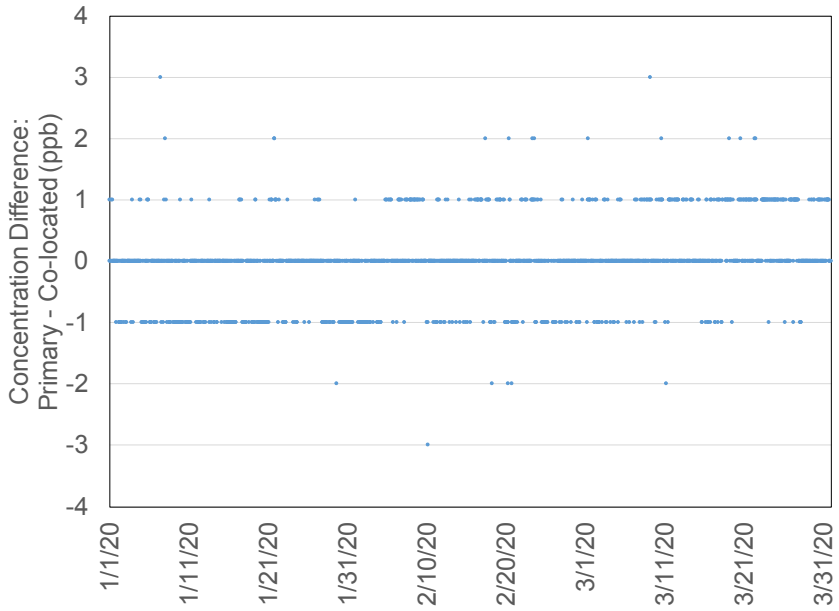


Table 5 gives MARPD data for O_3 data measured at the two co-located sites.

Table 5. Quarterly Precision (MARPD) for Co-located O_3 Concentrations

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	2	4/1/19	1.5	2064
	3	7/1/19	0.8	2085
	4	10/1/19	1.1	2003
	1	1/1/20	1.0	2063
ROM406/206, CO				
	2	4/1/19	1.3	1949
	3	7/1/19	1.4	2030
	4	10/1/19	1.1	1989
	1	1/1/20	0.8	2004

Completeness for O_3 Concentrations

Calculation of an annual O_3 value requires 75 percent completeness. However, calculation of the 3-year design value used for regulatory purposes requires 90 percent completeness. Table 6 shows CASTNET sites with less than 90 percent completeness for DM8A O_3 concentrations. Comments are provided for these sites.

Table 6. Sites with less than 90 Percent Data Completeness for DM8A Concentrations during First Quarter 2020

Site ID	Percent Completeness	Comments
SPD111, TN	85.7	A power failure and subsequent issues with the data logger affected two weeks.
DEV412, CA	89.0	The analyzer pump failed, affecting one week.

Table 7 shows CASTNET sites with less than 90 percent completeness for hourly O_3 concentrations. Comments are provided for these sites. The annual average for each of these sites is included for reference.

Table 7. Sites with less than 90 Percent Data Completeness for O_3 Concentrations

Site ID	Q1 2020	Q2 2019–Q1 2020	Comments
WSP144, NJ	88.0	95.0	Intermittent solenoid malfunctions occurred during February. The site analyzer was replaced 2/26/20.
SPD111, TN	88.7	92.5	A power failure and subsequent issues with the data logger affected two weeks.
DEV412, CA	89.3	93.3	The analyzer pump failed affecting one week.

Filter Pack Total Nitrate and Continuous Trace-level NO_y Concentrations at Eight CASTNET Sites

Figures 32 through 39 show a comparison of weekly average continuous NO_y measurements with weekly filter pack total NO_3^- concentrations collected at the eight sites with NO_y measurements. The NO_y concentrations were consistently higher than the total NO_3^- levels at all sites. The average weekly NO_y levels, the weekly total NO_3^- concentrations, and their ratios for the eight sites with available data are shown in Table 8. Ratios of NO_y to total NO_3^- varied from 2.88 at PNF126 to 10.99 at DUK008.

Table 8. Summary of Total NO_3^- and NO_y Measurements for First Quarter 2020

Site ID	Elevation	Total NO_3^- (ppb)	NO_y (ppb)	Ratio
DUK008, NC	164	0.52	2.78	10.99
BVL130, IL	213	1.09	3.92	3.85
MAC426, KY	243	0.74	2.45	3.45
HWF187, NY	497	0.23	1.29	6.23
GRS420, TN	793	0.35	1.91	5.62
PNF126, NC	1216	0.30	0.84	2.88
PND165, WY	2386	0.12	0.58	4.90
ROM206, CO	2742	0.15	1.00	6.58

Figure 32. Comparison of DUK008 Weekly Mean NO_y and Total NO_3^- Concentrations

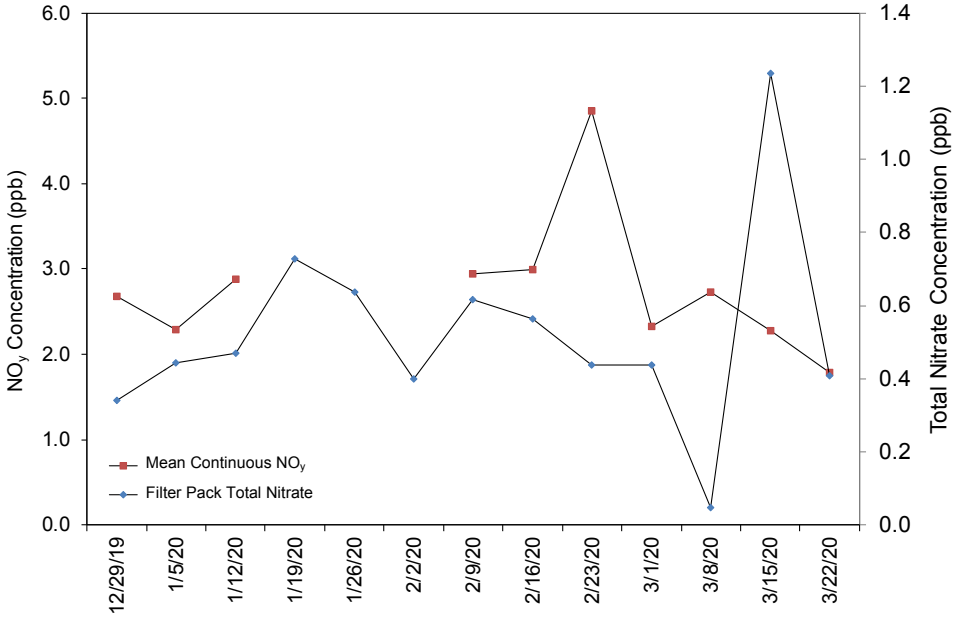


Figure 33. Comparison of BVL130 Weekly Mean NO_y and Total NO_3^- Concentrations

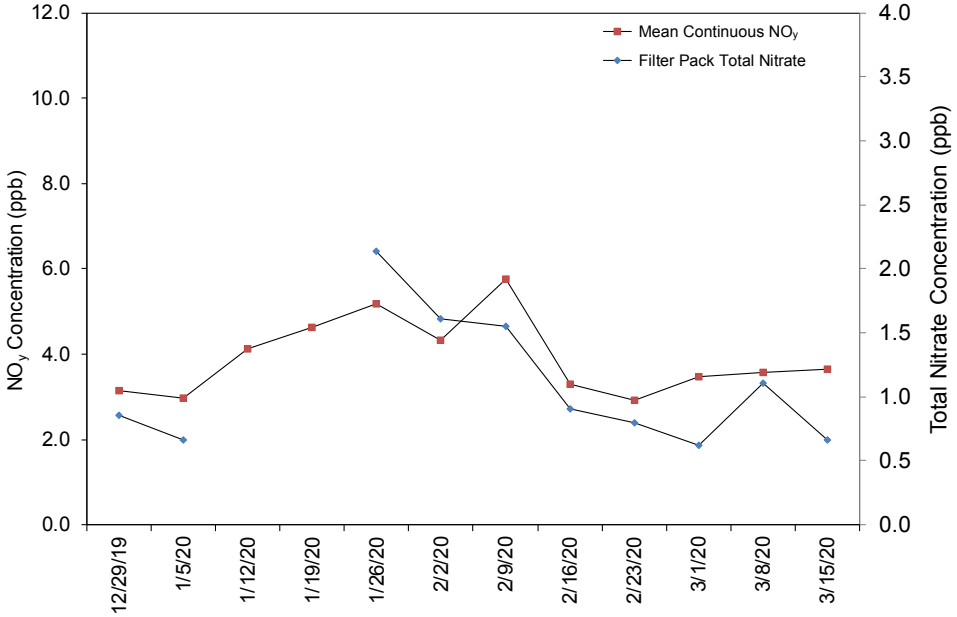


Figure 34. Comparison of MAC426 Weekly Mean NO_y and Total NO_3^- Concentrations

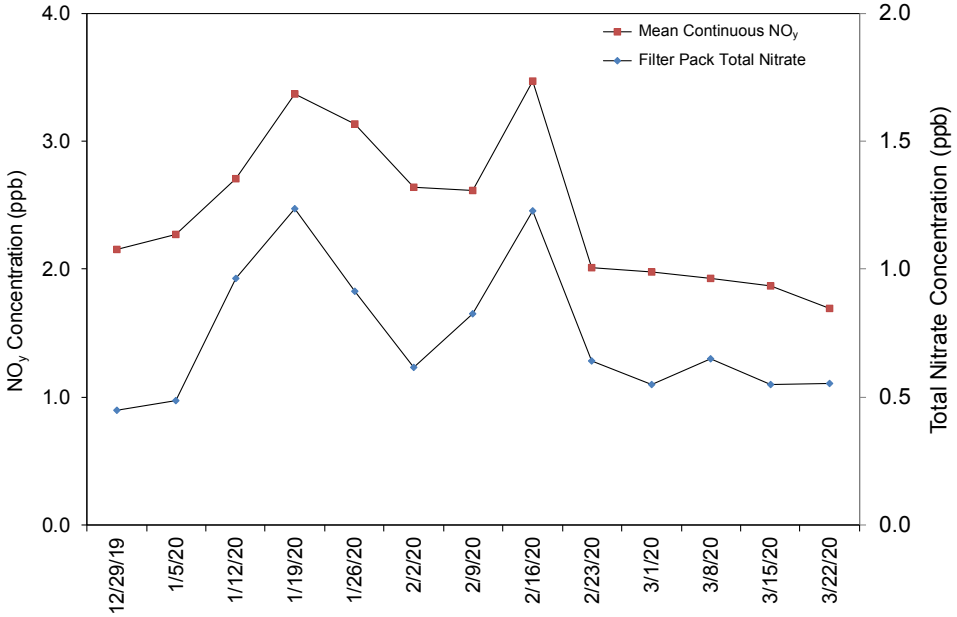


Figure 35. Comparison of HWF187 Weekly Mean NO_y and Total NO_3^- Concentrations

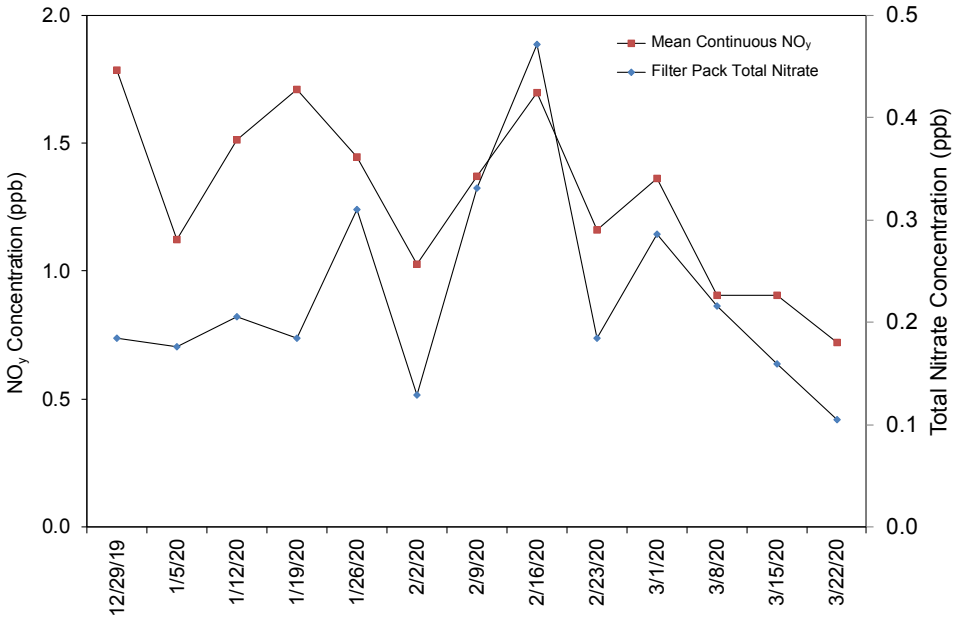


Figure 36. Comparison of GRS420 Weekly Mean NO_y and Total NO_3^- Concentrations

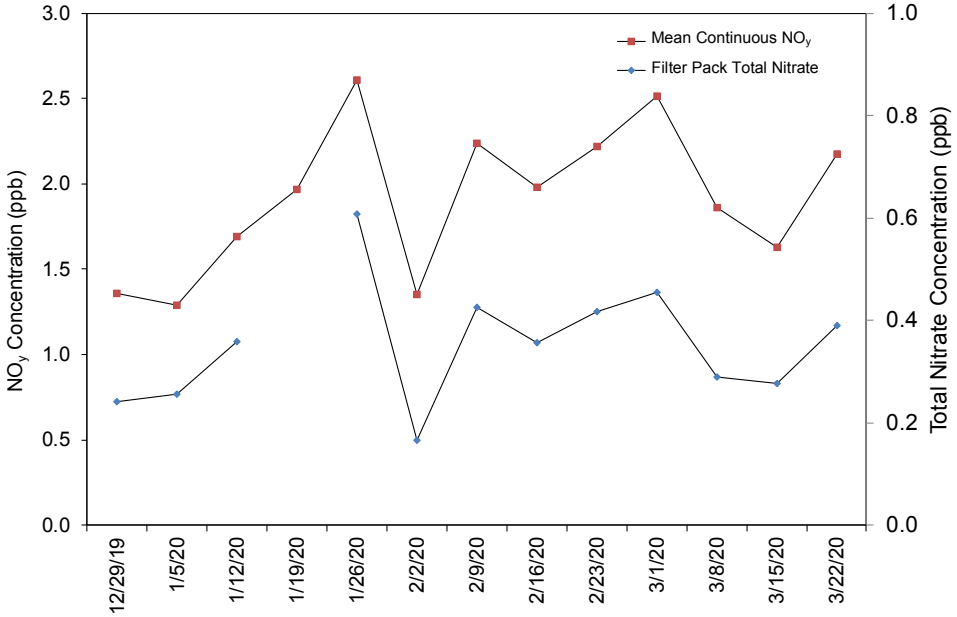


Figure 37. Comparison of PNF126 Weekly Mean NO_y and Total NO_3^- Concentrations

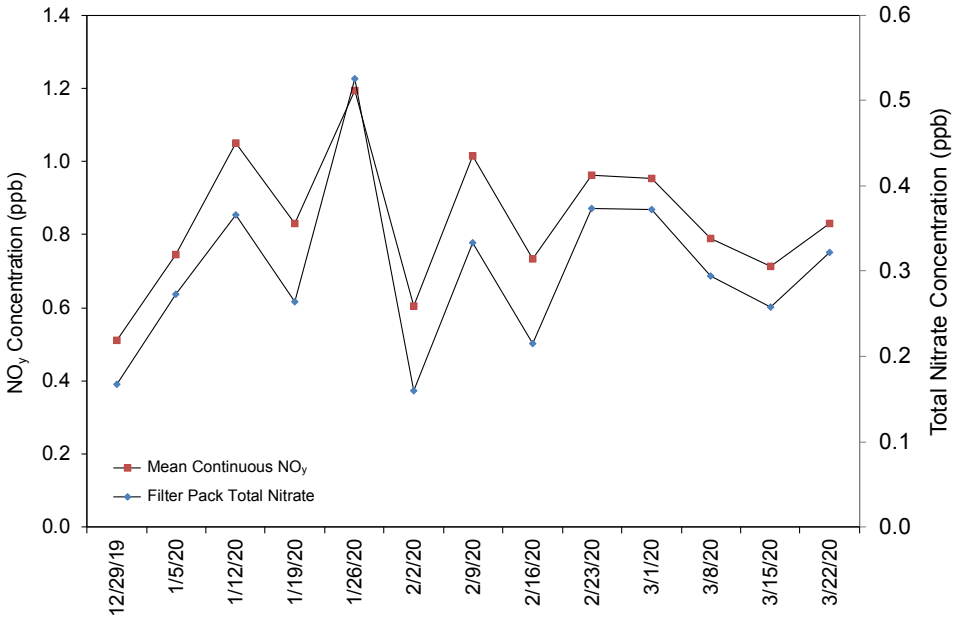


Figure 38. Comparison of PND165 Weekly Mean NO_y and Total NO_3^- Concentrations

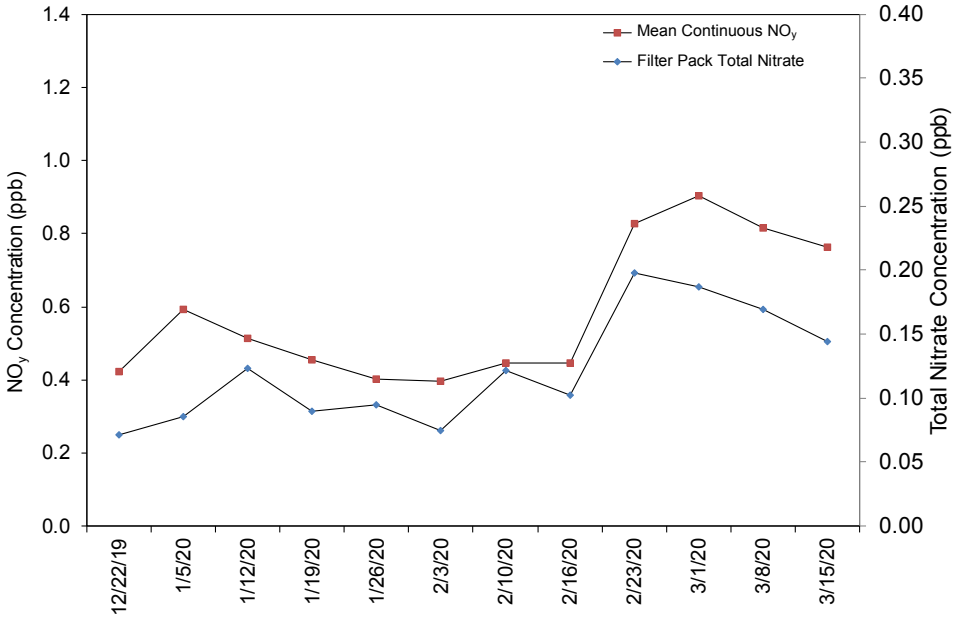
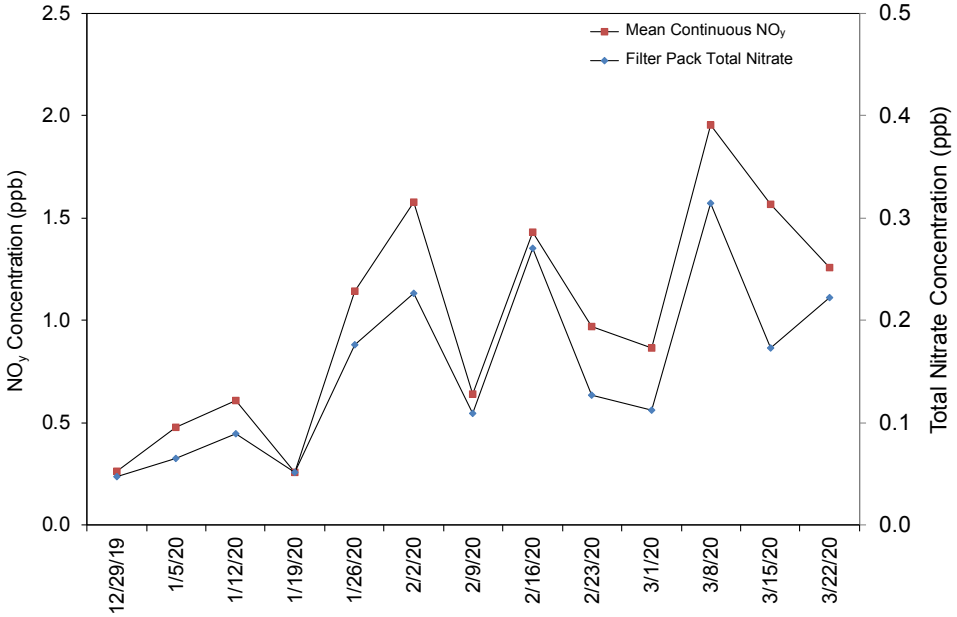


Figure 39. Comparison of ROM206 Weekly Mean NO_y and Total NO_3^- Concentrations



Filter Pack and Continuous Trace-level Gas Sulfur Dioxide Concentrations

Figures 40 through 42 provide diagrams that compare weekly filter pack SO_2 concentrations with continuous trace-level gas data measured at BVL130, MAC426, and GRS420. The continuously measured trace-level concentrations were higher than filter pack concentrations at BVL130 and were comparable at MAC426 and GRS420.

Figure 40. Comparison of BVL130 Weekly Mean SO_2 Concentrations

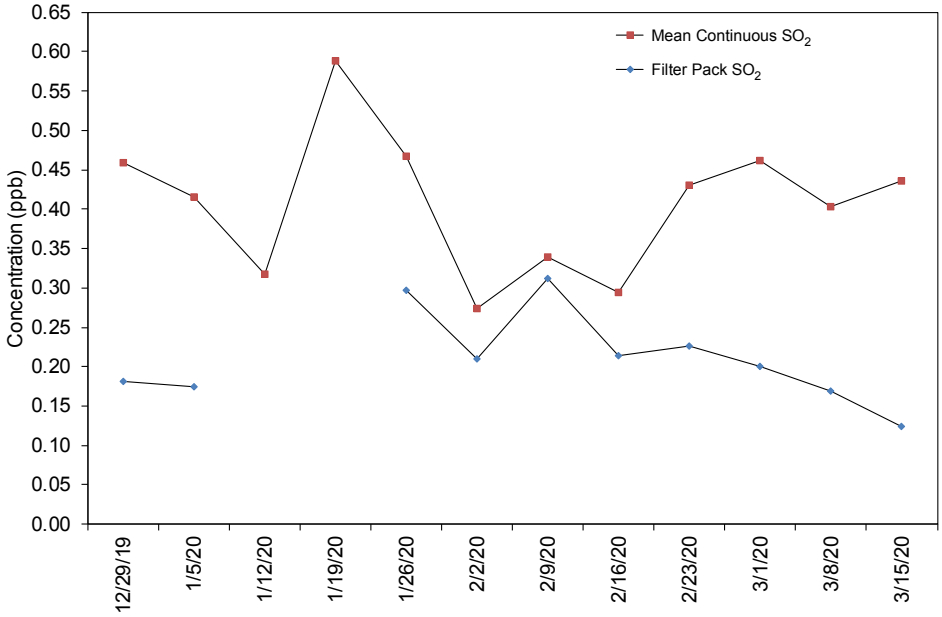


Figure 41. Comparison of MAC426 Weekly Mean SO_2 Concentrations

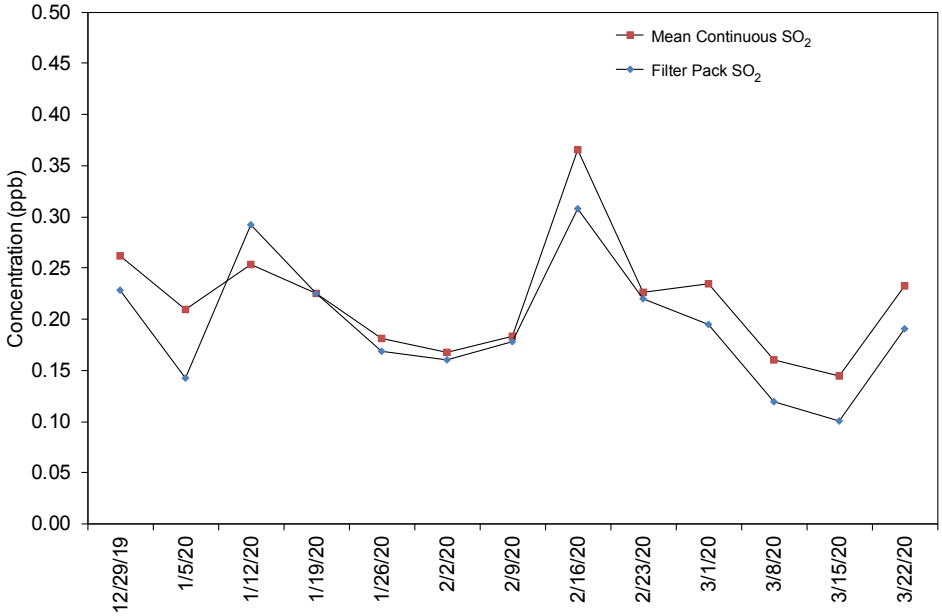
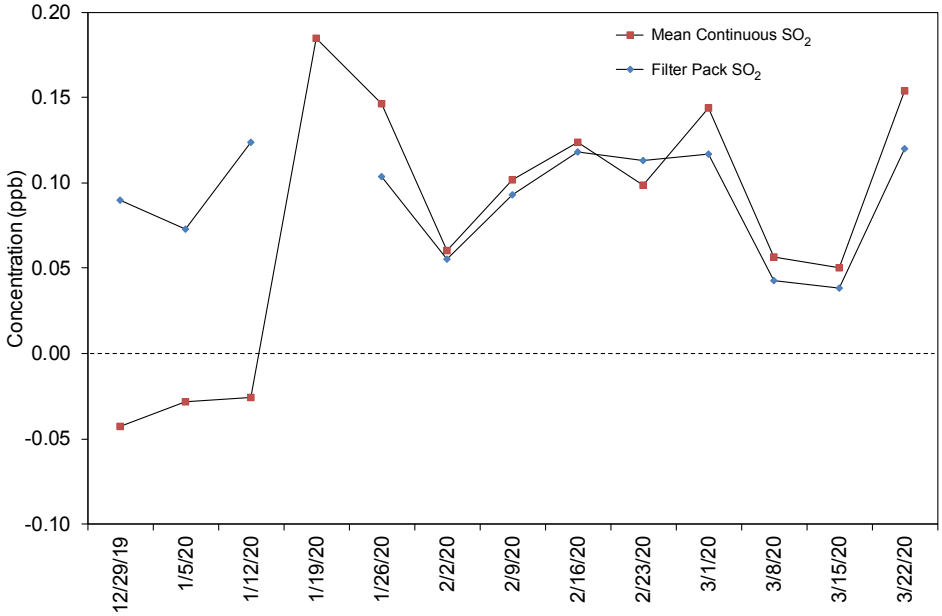


Figure 42. Comparison of GRS420 Weekly Mean SO_2 Concentrations



Completeness for Continuous Trace-level Gas Measurements

Table 9 shows the percent completeness for CASTNET trace-level gas measurements. Comments are provided for sites with less than 90 percent completeness for hourly trace-level gas concentrations during first quarter 2020. The annual hourly average for each of the sites is included for reference.

Table 9. Percent Data Completeness for Continuous Trace-level Gas Measurements (1 of 2)

Site ID	Parameter*	Q1 2020	Q2 2019 – Q1 2020	Comments
BVL130, IL	CO	53	20	Instrument stability issues continued through late January when the analyzer was serviced and recalibrated. In addition, there were two zsp failures in February.
	NO	92	88	
	NOY	92	90	
	NOYDIF	92	88	
	SO2_GA	89	89	Data were invalidated for several short periods in January during troubleshooting of the CO instrument and in January and March while performing trace instrument calibrations.
CHC432, NM	NO	98	95	
	NOX	98	95	
	NOXDIF	98	95	
DUK008, NC	HNO3	61	54	The analyzer had recurring problems with drift associated with ambient temperatures below 5° Celsius.
	NH3	56	56	
	NO	61	71	
	NO2_TRUE	62	71	
	NOX_TRUE	61	71	
	NOY	61	57	
	NOY_MINUS	61	66	
	NOYDIF	61	57	
	TNX	56	68	
GRS420, TN	CO	89	86	Data were invalidated when station temperatures were outside limits.
	NO	91	84	
	NOY	91	84	
	NOYDIF	92	87	
	SO2_GA	89	89	Data were invalidated when station temperatures were outside limits.
HWF187, NY	NO	93	83	
	NOY	93	77	
	NOYDIF	93	77	
MAC426, KY	CO	95	90	
	NO	97	93	
	NOY	97	87	
	NOYDIF	97	87	
	SO2_GA	97	93	
PND165, WY	NO	93	90	
	NOY	93	90	
	NOYDIF	93	90	

Table 9. Percent Data Completeness for Continuous Trace-level Gas Measurements (2 of 2)

Site ID	Parameter*	Q1 2020	Q2 2019 – Q1 2020	Comments
PNF126, NC	NO	93	93	
	NOY	93	93	
	NOYDIF	93	93	
ROM206, CO	NO	95	94	
	NOY	95	94	
	NOYDIF	95	94	

Note: * See Table 10

The parameters listed in Table 9 are both calculated and measured. Table 10 provides information on how the parameters listed in Table 9 are obtained.

Table 10. CASTNET Trace-level Gas Measurements

Parameter Name	How Obtained	Description of Process
CO	Measured	Gas filter correlation
HNO3	Calculated	NOY minus NOY_MINUS
NH3	Calculated	TNX minus NOY
NO	Measured	Chemiluminescence reaction/no converter used
NO2_TRUE	Calculated	NOX_TRUE minus NO
NOX_TRUE	Measured	Photolytic converter
NOY	Measured	Molybdenum converter at 315° Celsius
NOYDIF	Calculated	NOY minus NO
NOY_MINUS	Measured	Sodium carbonate denuder followed by molybdenum converter at 315° Celsius
NOX	Measured	Molybdenum converter at 325° Celsius
NOXDIF	Calculated	NOX minus NO
SO2_GA	Measured	Ultraviolet fluorescence
TNX	Measured	Platinum/stainless steel converter at 825° Celsius followed by molybdenum converter at 315° Celsius

References

Wood Environment & Infrastructure Solutions, Inc. 2020. *Clean Air Status and Trends Network (CASTNET) First Quarter 2020 Quality Assurance Report.* https://java.epa.gov/castnet/documents.do

M. Bauwens, S. Compernolle, T. Stavrakou, J.-F. Müller, J. Gent, H. Eskes, P. F. Levelt, R. A, J. P. Veefkind, J. Vlietinck, Huan Yu, C. Zehner. 2020. Impact of Coronavirus Outbreak on NO_2 Pollution Assessed Using TROPOMI and OMI Observations. *Geophysical Research Letters*, 2020; DOI: 10.1029/2020GL087978