Clean Air Status and Trends Network (CASTNET)
Quarterly Data Summary for Fourth Quarter 2018 (October through December)

Prepared for: U.S. Environmental Protection Agency (EPA), Clean Air Markets Division
EPA Contract No.: EP-W-16-015, Task Order 2003 – CASTNET Base Program
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Submitted: April 1, 2019

Introduction

This quarterly report summarizes the Clean Air Status and Trends Network (CASTNET) data collected during fourth quarter 2018. Trends in pollutants measured at eastern and western reference sites are shown. This report also analyzes data on continuous, trace-level NO_y from six sites and continuous SO_2 concentrations from one site. Results from the quality assurance/quality control (QA/QC) program are presented for fourth quarter data and include completeness and precision of filter concentrations and hourly O_3 concentrations and completeness of trace-level gas measurements. Other QC statistics are given in the CASTNET Fourth Quarter 2018 Quality Assurance Report (Wood, 2019).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O_3 Concentrations through Fourth Quarter 2018

Figure 1 shows fourth highest daily maximum 8-hour average O_3 concentrations measured through fourth quarter 2018. Eight western and seven eastern sites exceeded the 0.070 parts per million (ppm) National Ambient Air Quality Standard for O_3. No additional maps are shown in this report because the maps of other measured fourth quarter 2018 mean concentrations were consistent with fourth quarter maps from previous years. No anomalies were identified on these maps.

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 fourth quarter. Trends in quarterly mean filter pack and O_3 concentrations are shown using box plots in Figures 2 through 13.

Fourth Quarter Concentrations

Quarterly mean NH_4^+ concentrations increased at eastern sites in 2018, and all other pollutant parameters decreased. Quarterly mean NO_3^-, NH_4^+, Cl^-, and Na^+ concentrations increased at western sites in 2018 while other concentrations decreased.

Quarterly O_3 concentrations were analyzed using box plots constructed by averaging all valid hourly O_3 concentrations within fourth quarter 2018 by site and then averaging those averages for all eastern and western reference sites (Figure 13). The figure shows quarterly mean O_3 concentrations at eastern sites and western sites decreased. Quarterly mean concentrations were higher at the western reference sites than at the eastern sites.

Figure 2. Trends in Fourth Quarter Mean HNO_3 Concentrations

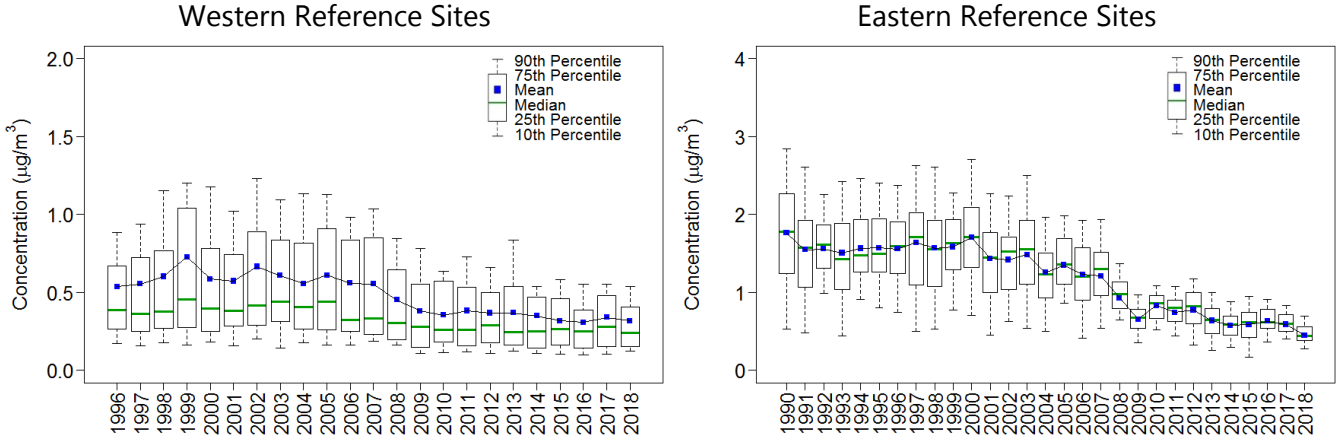


Figure 3. Trends in Fourth Quarter Mean NO_3^- Concentrations

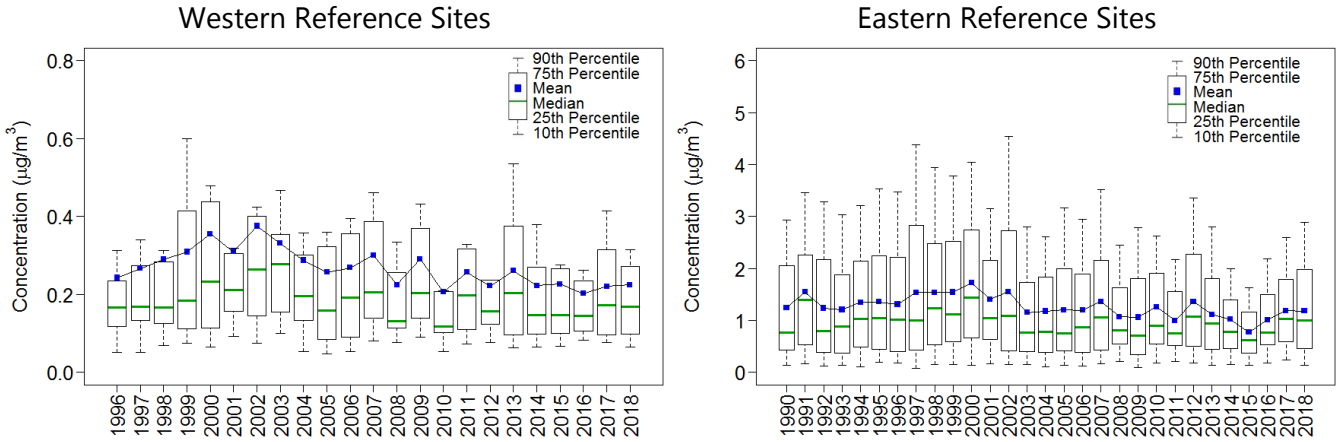


Figure 4. Trends in Fourth Quarter Mean NH_4^+ Concentrations

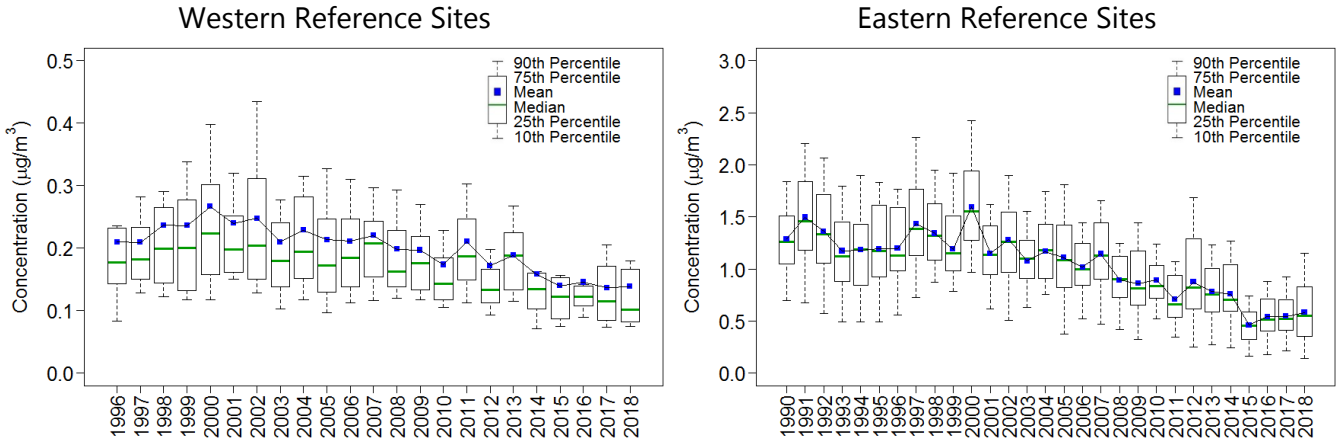


Figure 5. Trends in Fourth Quarter Mean Total NO_3^- Concentrations

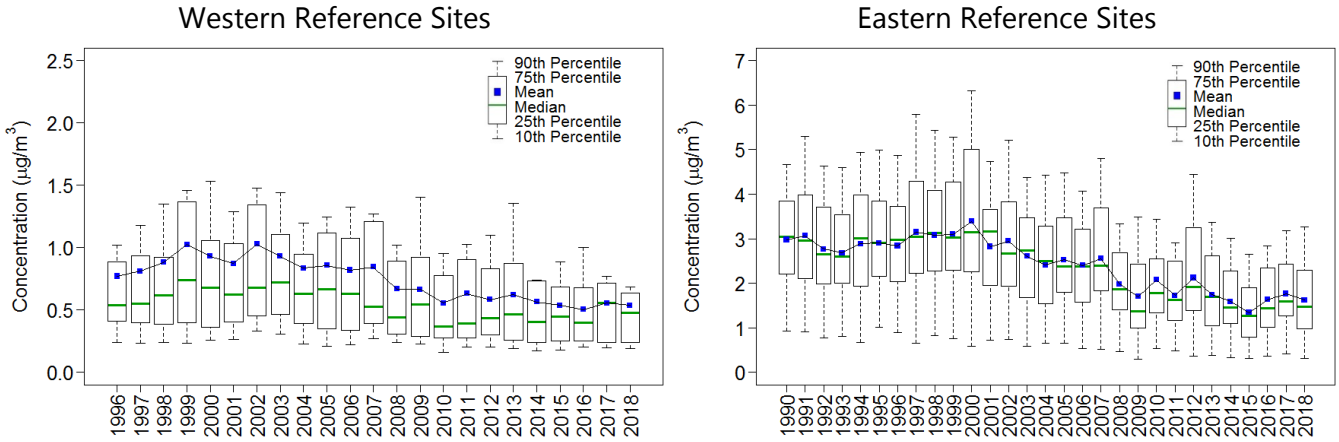


Figure 6. Trends in Fourth Quarter Mean SO_2 Concentrations

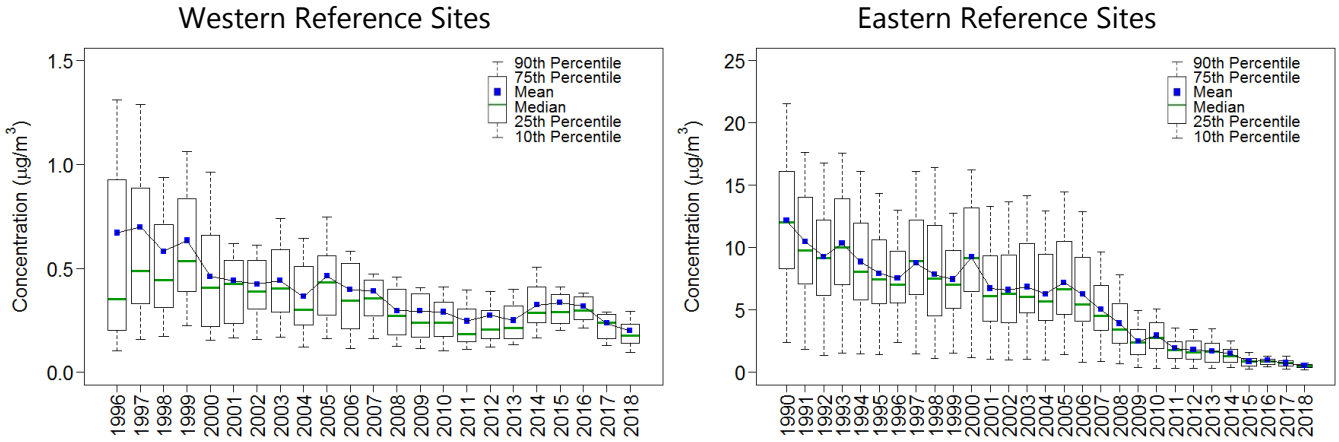


Figure 7. Trends in Fourth Quarter Mean SO_4^{2-} Concentrations

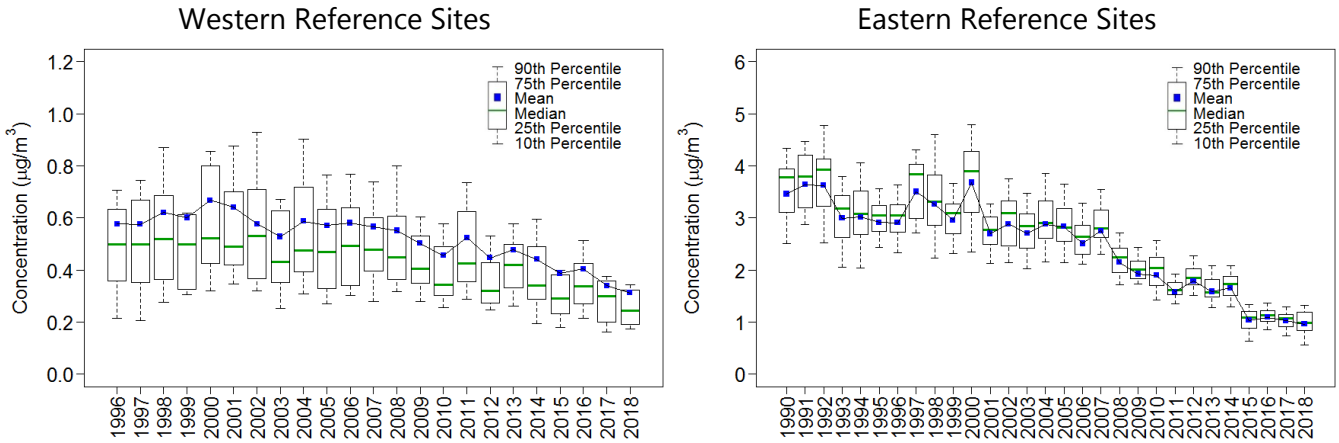


Figure 8. Trends in Fourth Quarter Mean Cl^- Concentrations

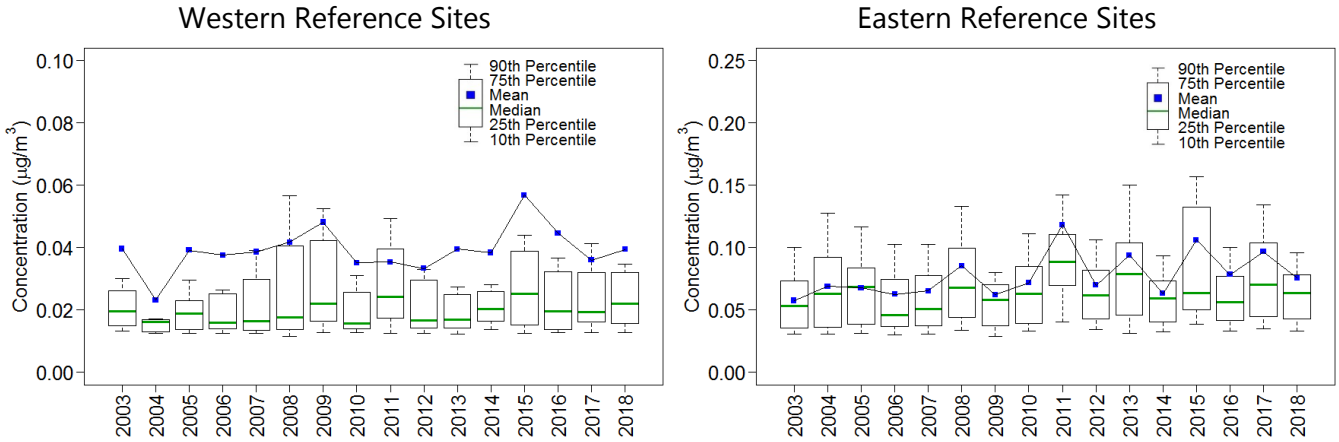


Figure 9. Trends in Fourth Quarter Mean Ca^{2+} Concentrations

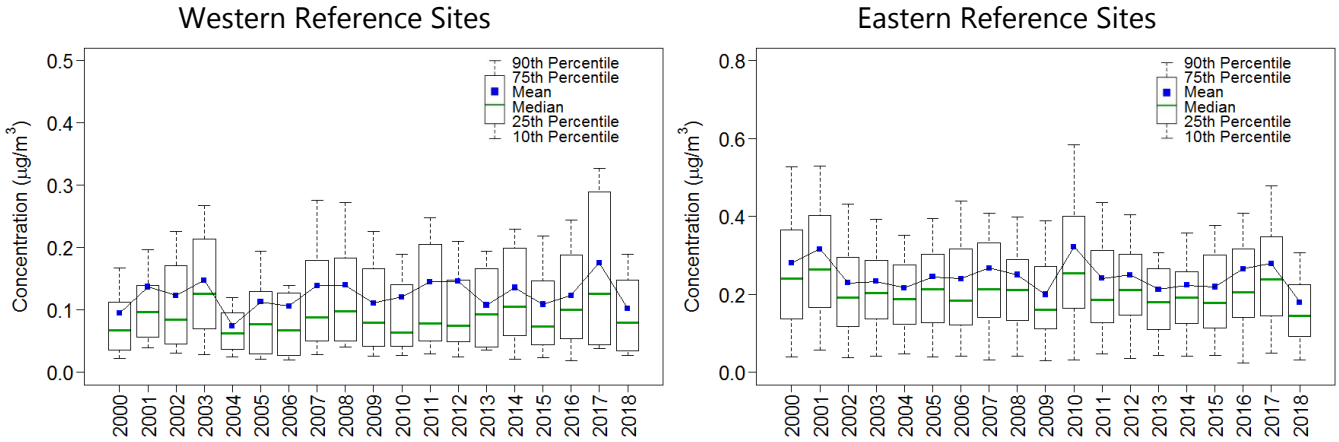


Figure 10. Trends in Fourth Quarter Mean K^{+} Concentrations

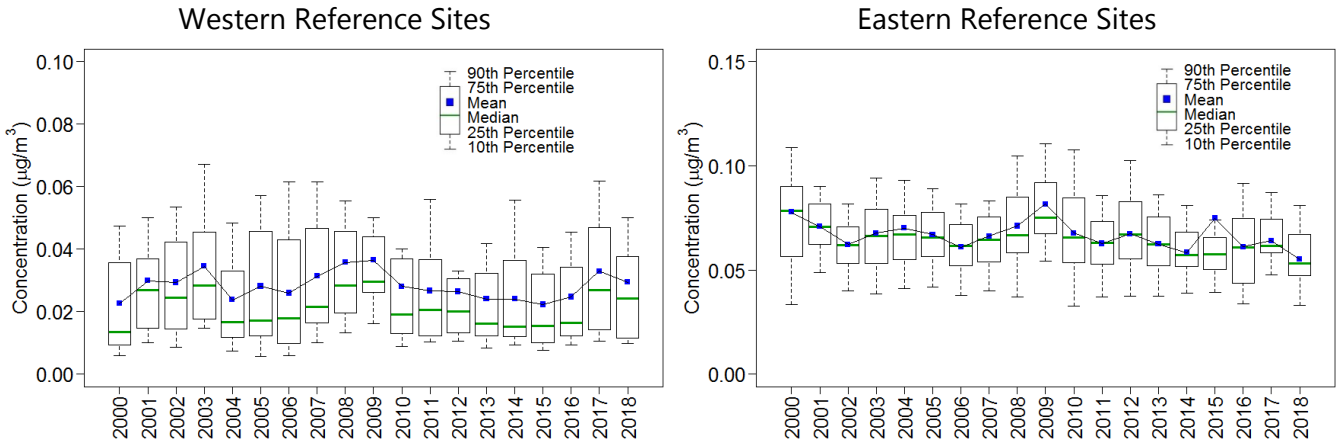


Figure 11. Trends in Fourth Quarter Mean Mg^{2+} Concentrations

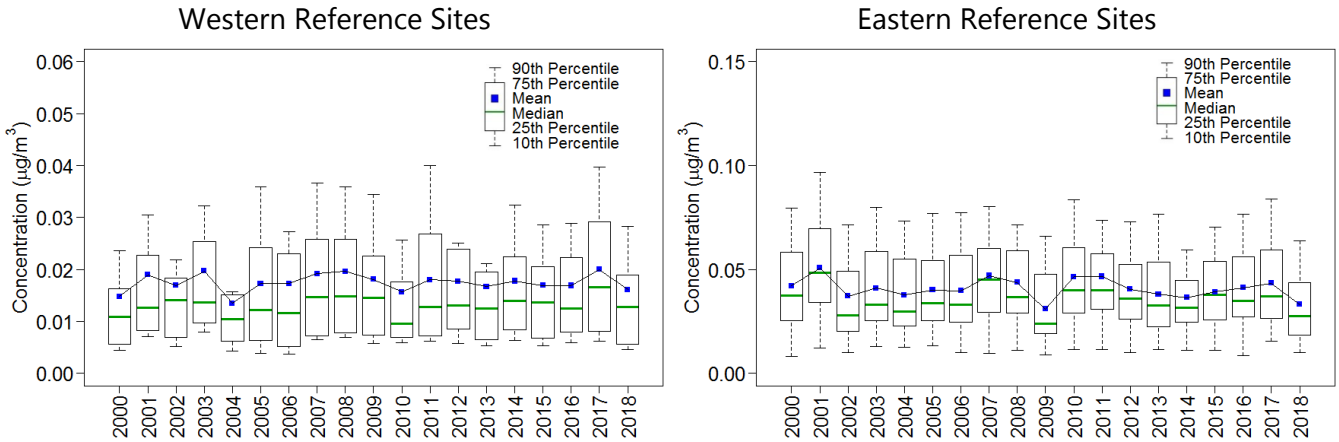


Figure 12. Trends in Fourth Quarter Mean Na^+ Concentrations

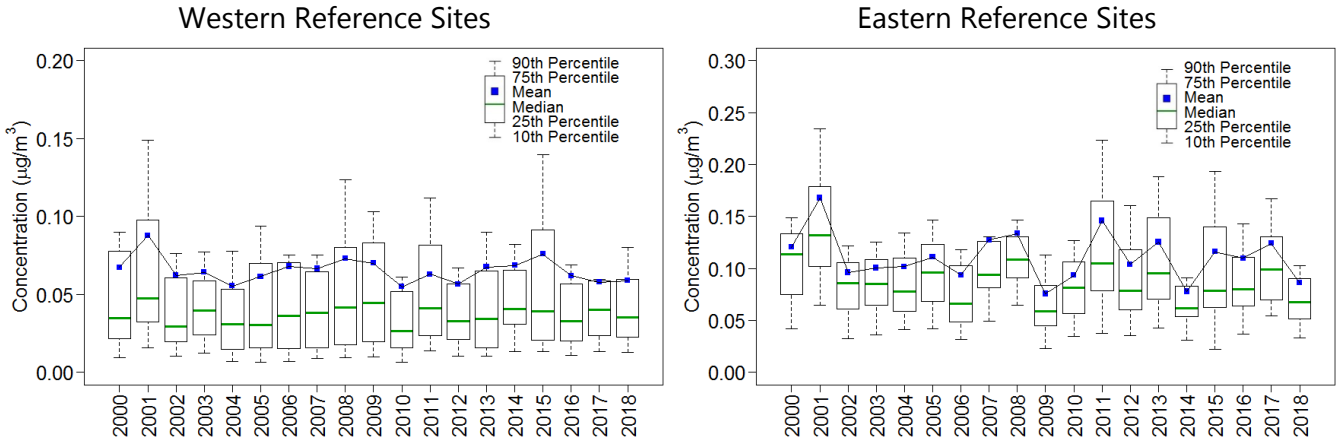
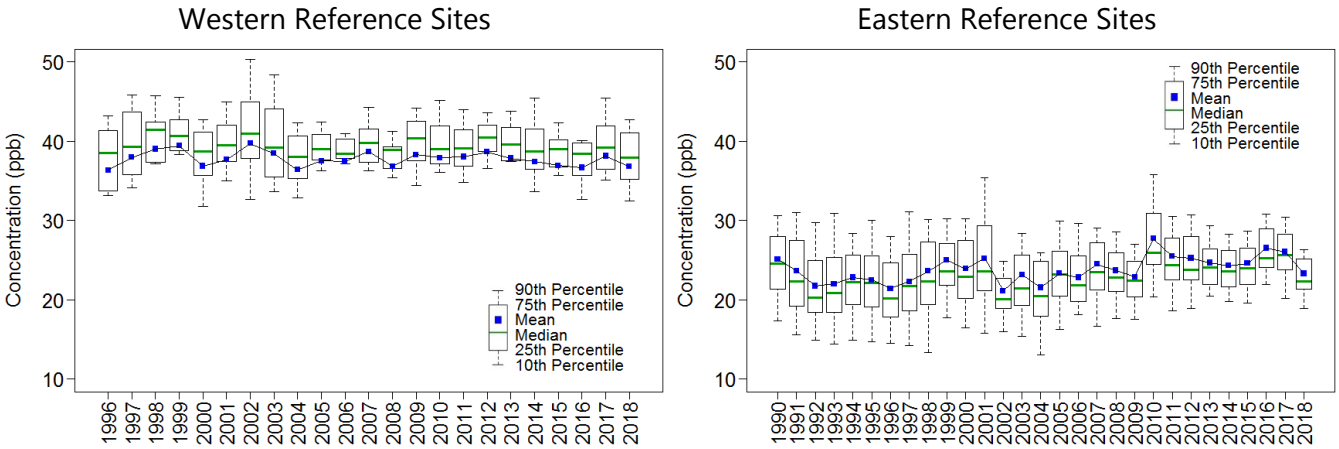


Figure 13. Trends in Fourth Quarter Mean O_3 Concentrations



Changes in 3-year Average Fourth Quarter Concentrations

Three-year averages of quarterly mean concentrations of total NO_3^-, NH_4^+, SO_2, and SO_4^{2-} were reduced over the period 1990–1992 through 2016–2018 for eastern reference sites and 1996–1998 through 2016–2018 for western reference sites. Ozone concentrations increased at the eastern reference sites by 8 percent while concentrations at the western sites decreased by 2 percent. Tables 1 and 2 summarize changes in 3-year average fourth quarter concentrations.

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	2.9	1.4	10.6	3.6	24
2016–2018	1.7	0.6	0.7	1.0	25
Percent Change	-43	-60	-93	-71	8

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

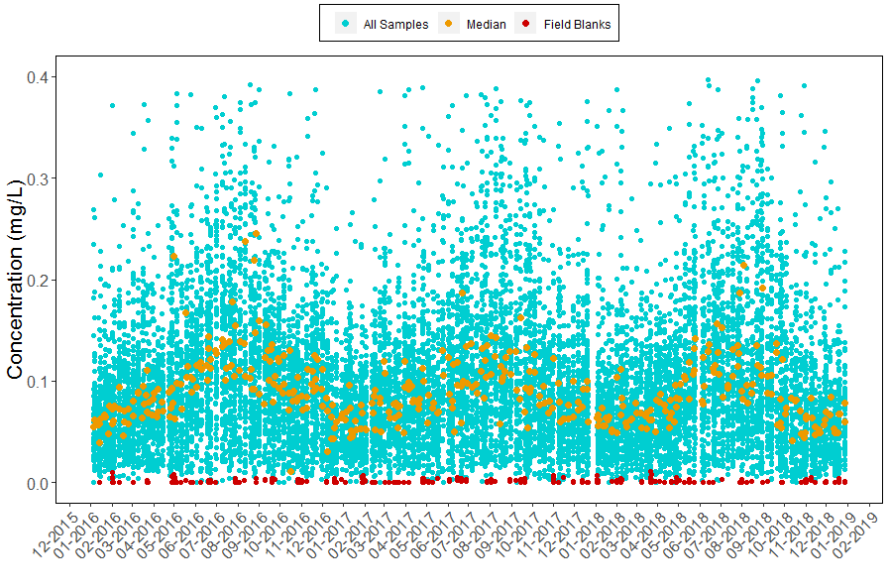
	Total NO_3^- ($\mu g/m^3$)	NH_4^+ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	SO_4^{2-} ($\mu g/m^3$)	O_3 (ppb)
1996–1998	0.8	0.2	0.7	0.6	38
2016–2018	0.5	0.1	0.3	0.4	37
Percent Change	-35	-36	-61	-40	-2

Time Series of Laboratory Analysis Parameters for All Sites

Figures 14 through 24 give time series of laboratory-analyzed concentrations of field samples and field blanks (FB) in milligrams per liter (mg/L) of 11 parameters from fourth quarter 2015 through fourth quarter 2018. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

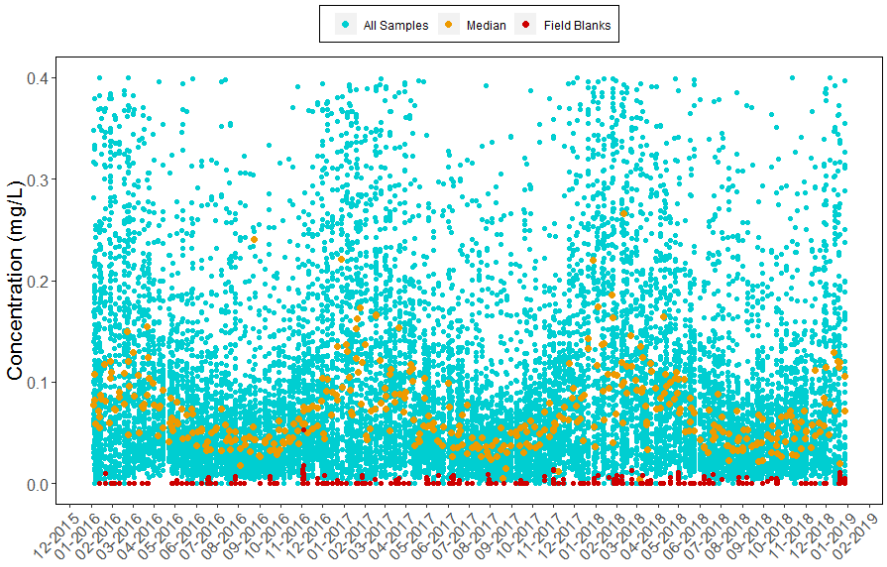
Previous review of filter pack analysis control charts indicated possible potassium contamination (Figure 22). Note the field blank results at the end of second quarter. A corrective action was initiated. During the investigation, non-conformance to the established washing procedures for filter pack housings was observed. The technician was retrained and subsequent conformance to documented procedures was verified. Continued intermittent contamination was traced to the foil used to line the bins for the drying of filter pack parts. Use of foil was discontinued during late July 2018. A set of filter packs was prepared each week during July and August for testing as process blanks to verify the effectiveness of the corrective actions taken. The corrective actions have been effective as shown in Figure 22.

Figure 14. Concentrations of NO_3^- (as N) from Nylon Filters



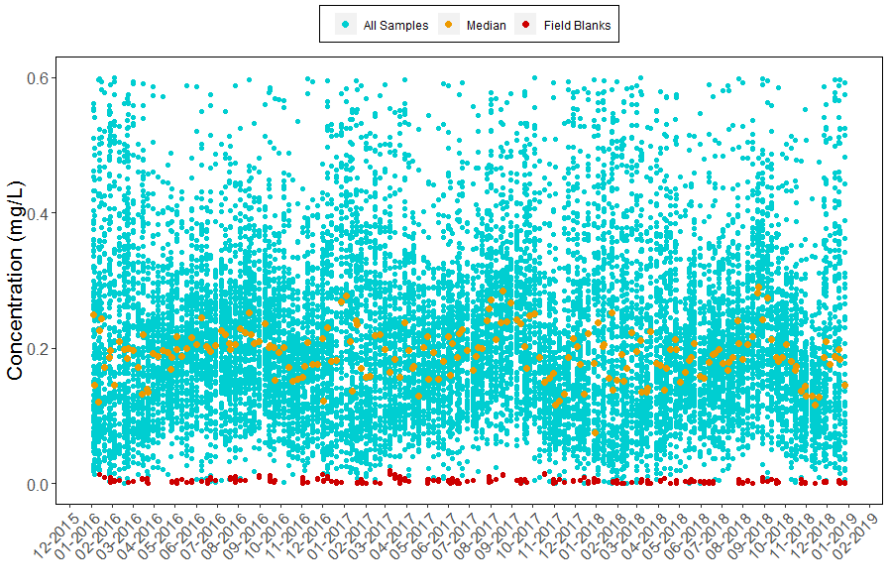
Note: Nominal reporting limit is 0.008 mg/L.

Figure 15. Concentrations of NO_3^- (as N) from Teflon Filters



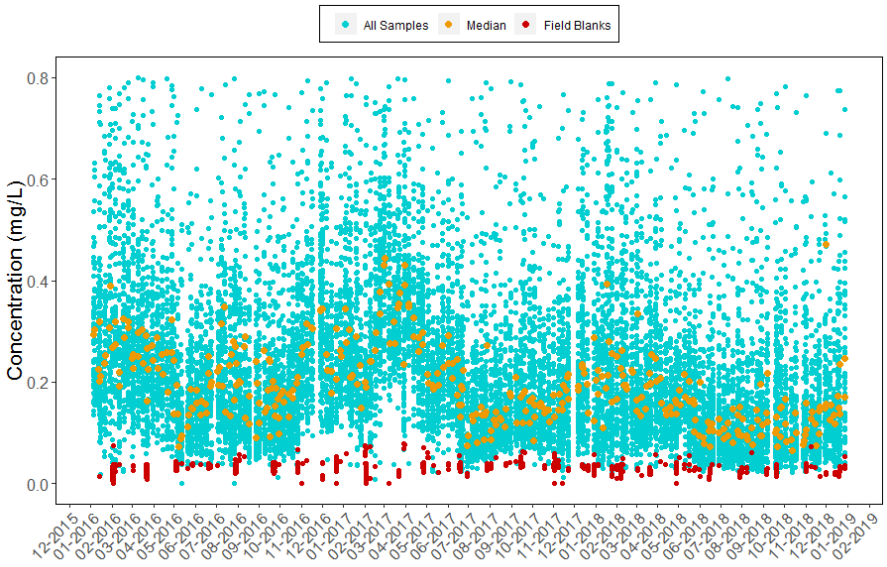
Note: Nominal reporting limit is 0.008 mg/L.

Figure 16. Concentrations of NH_4^+ (as N) from Teflon Filters



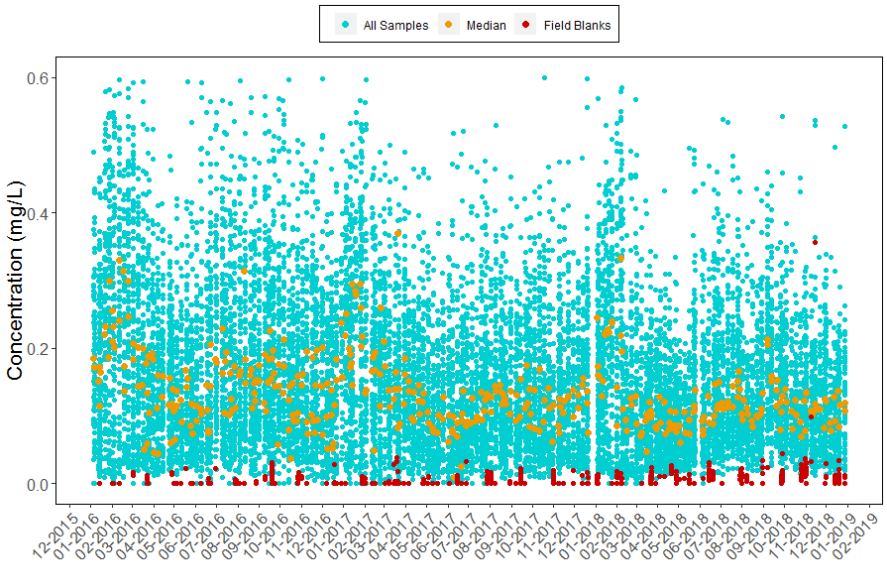
Note: Nominal reporting limit is 0.020 mg/L.

Figure 17. Concentrations of SO_2 from K_2CO_3 Impregnated Cellulose Filters



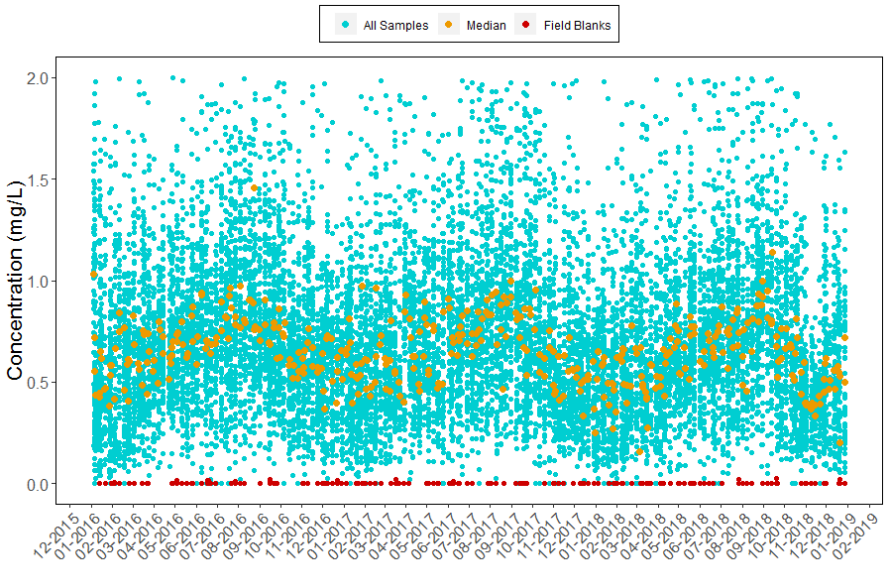
Note: Nominal reporting limit is 0.040 mg/L.

Figure 18. Concentrations of SO_4^{2-} from Nylon Filters



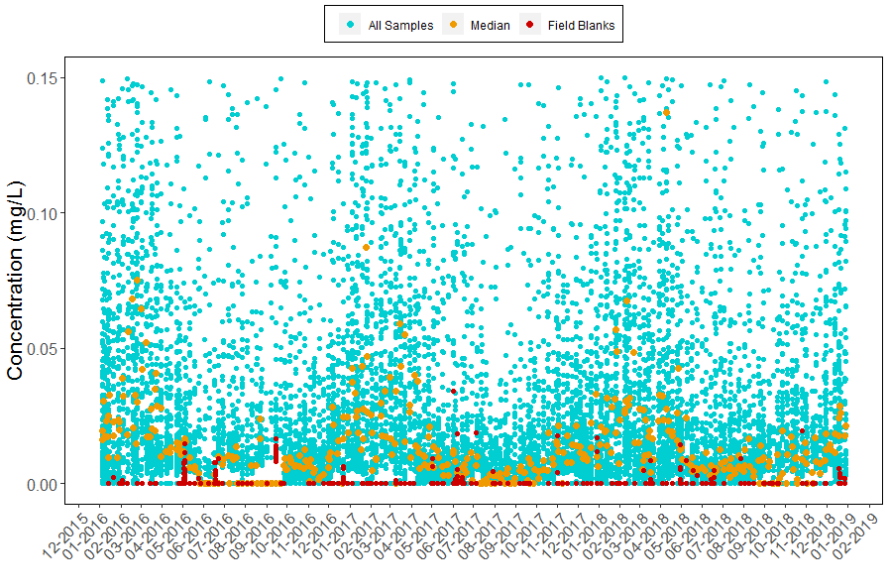
Note: Nominal reporting limit is 0.040 mg/L.

Figure 19. Concentrations of SO_4^{2-} from Teflon Filters



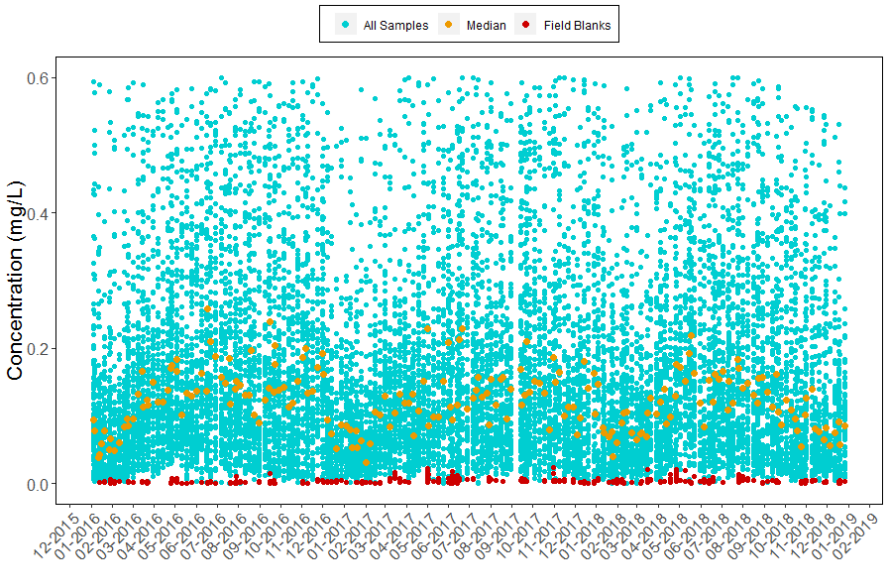
Note: Nominal reporting limit is 0.040 mg/L.

Figure 20. Concentrations of Cl^- from Teflon Filters



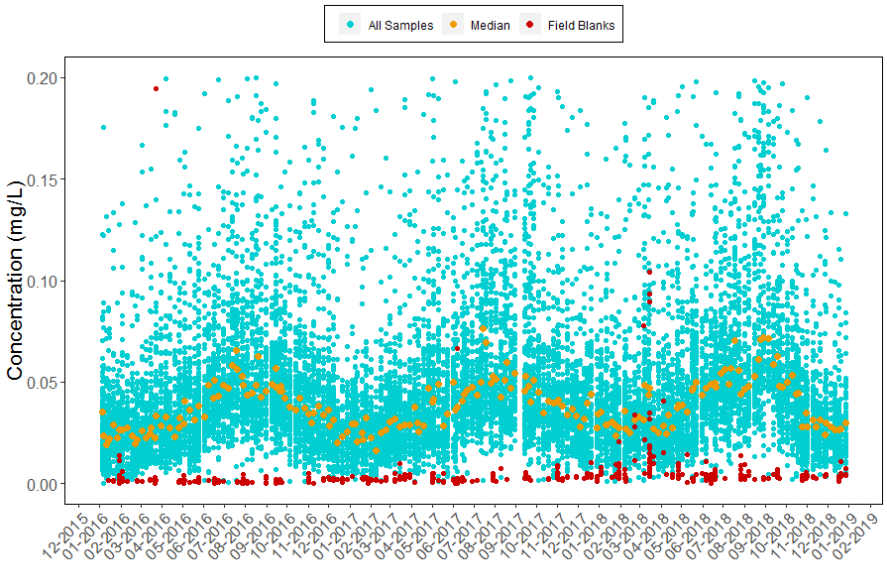
Note: Nominal reporting limit is 0.020 mg/L.

Figure 21. Concentrations of Ca^{2+} from Teflon Filters



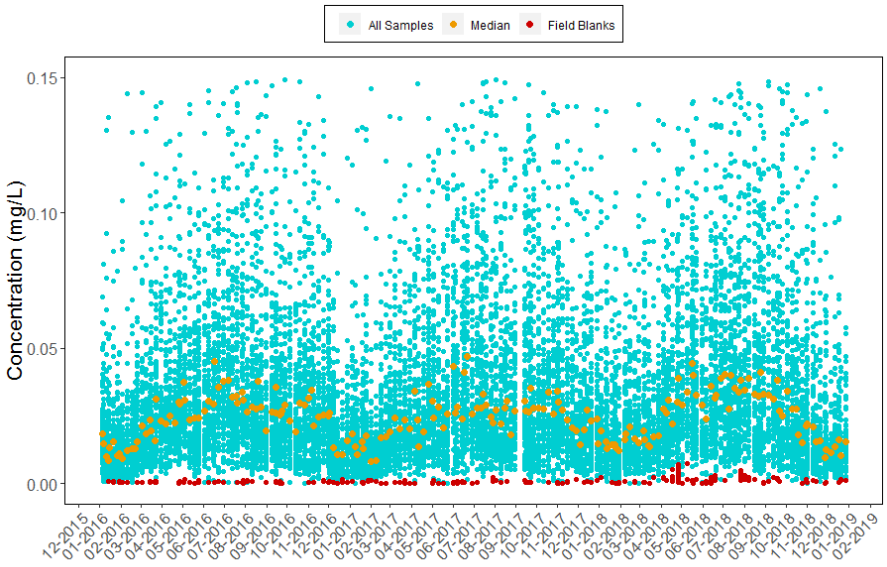
Note: Nominal reporting limit is 0.006 mg/L.

Figure 22. Concentrations of K^{+} from Teflon Filters



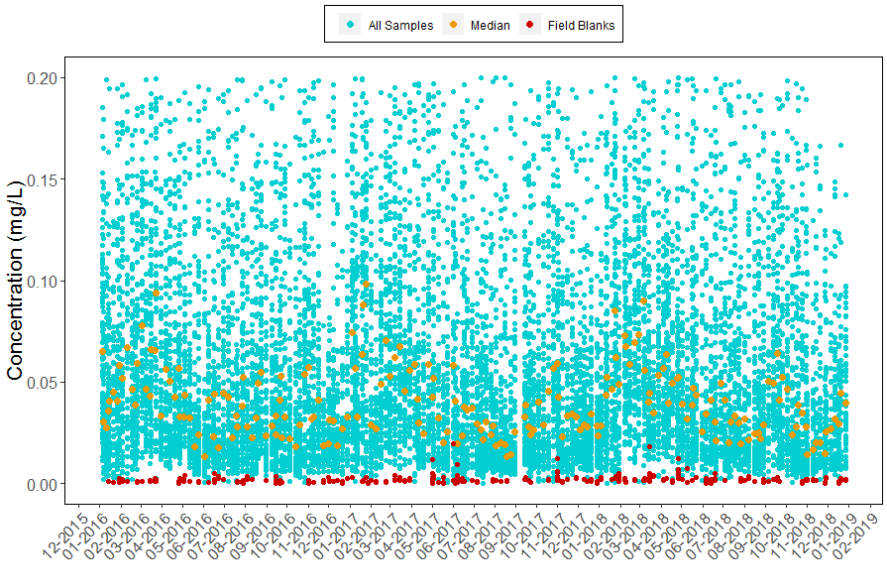
Note: Nominal reporting limit is 0.006 mg/L.

Figure 23. Concentrations of Mg^{2+} from Teflon Filters



Note: Nominal reporting limit is 0.003 mg/L.

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



Note: Nominal reporting limit is 0.005 mg/L.

Time Series of Concentration Differences from Co-located Sites

Figure 25. Time Series of Filter Concentration Differences between MCK131 and MCK231, KY

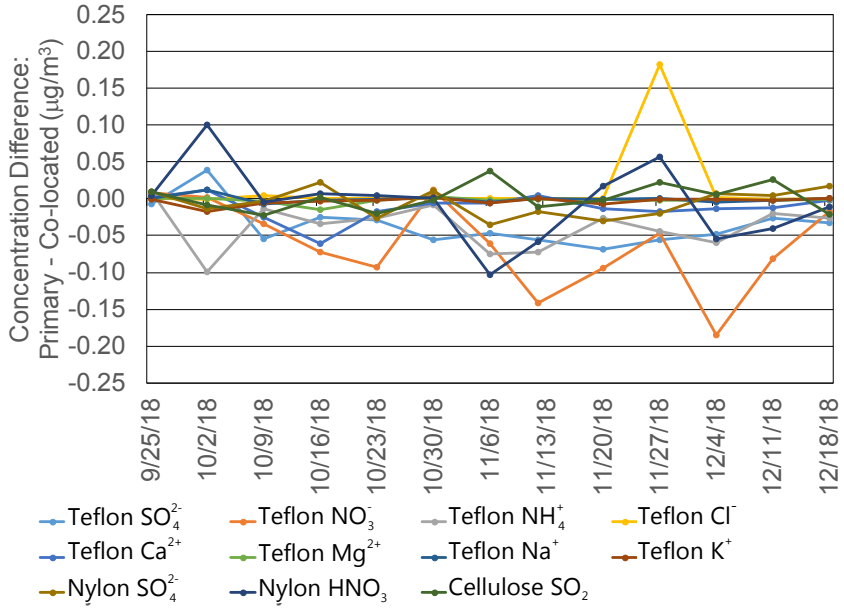
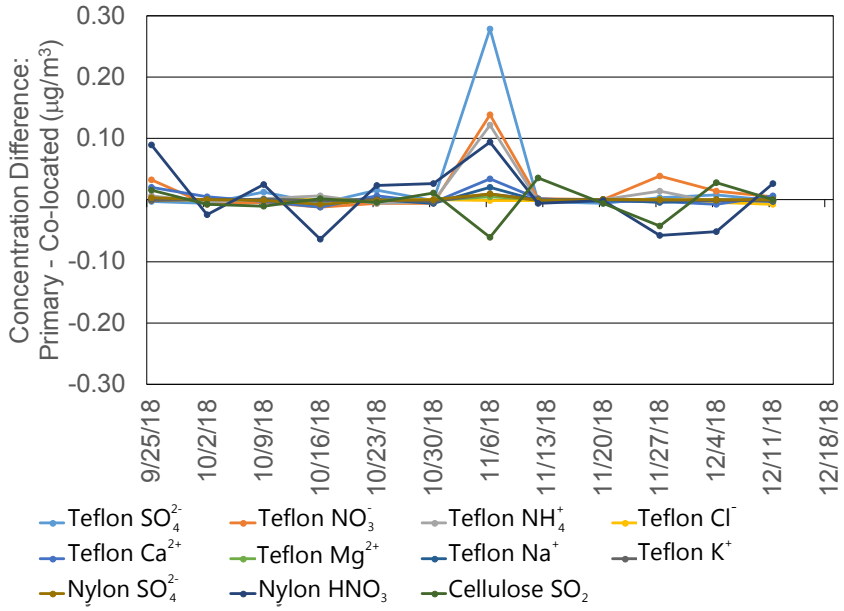


Figure 26. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



Precision of Filter Pack Concentrations

Table 3 shows mean absolute relative percent differences (MARPD) for concentrations measured at MCK131/231 and ROM406/206 during fourth quarter 2018. The MARPD values exceeded the 20 percent criterion at ROM406/206 for Ca^{2+}, Mg^{2+} and Na^{+}. Cation measurements taken during week 45 (11/6/18) at ROM406 were significantly higher than concentrations measured at ROM206. These resulted in an increased quarterly MARPD. Excluding week 45 from the data would have resulted in MARPD values less than 20 percent. The receiving technician for the analytical laboratory noted that the ROM406 filter was extremely dirty for that week. Additionally, filters were not collected during weeks 52 and 53 because of the government shutdown.

Table 3. Precision (MARPD) for Co-located Filter Pack Data during Fourth Quarter 2018

	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)	1.11	1.46	0.72	0.21	0.03	0.07	0.06	0.06	0.71	0.61	2.13
$\overline{Y}$ (µg/m^3)	1.14	1.53	0.76	0.22	0.03	0.07	0.06	0.04	0.72	0.61	2.23
MAD	0.04	0.07	0.04	0.02	0.00	0.00	0.00	0.02	0.04	0.02	0.10
MARPD	4.30	5.76	6.92	7.70	8.03	6.58	6.65	14.30	5.46	3.97	4.71
ROM406/206, CO											
$\overline{X}$ (µg/m^3)	0.23	0.18	0.12	0.05	0.01	0.03	0.01	0.03	0.29	0.15	0.46
$\overline{Y}$ (µg/m^3)	0.20	0.16	0.11	0.04	0.01	0.03	0.01	0.03	0.29	0.16	0.48
MAD	0.04	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.05	0.02	0.06
MARPD	13.83	18.67	14.13	24.16	21.04	20.85	16.05	3.36	17.46	14.72	15.25

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 Fourth Quarter 2018 (1 of 2)

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
ANA115, MI	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two 2-week samples occurred during the quarter.
BFT142, NC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	The site was inoperable due to damage from Hurricane Florence.
BWR139, MD	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two 2-week samples occurred during the quarter.
CAT175, NY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Power was out for two consecutive sampling weeks (late November/early December).
CNT169, WY	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	A polling issue affected one sampling week in October, and a data logger failure affected two sampling weeks in late November.
FOR605, WY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Intermittent power failures in December were caused by a loose wire in the circuit breaker. The government shutdown affected sampling the last two weeks of the quarter.
HOW191, ME	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	Filter pack operations were halted during icy winter conditions that affected the walk-up tower.
JOT403, CA	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	Power was out for one sampling week in October. The government shutdown affected sampling the last two weeks of the quarter.
KIC003, KS	30.8	30.8	30.8	30.8	30.8	30.8	30.8	30.8	No tribal site operator was available during November and December.
NEC602, WY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	A polling issue affected one week of sampling. The government shutdown affected sampling the last two weeks of the quarter.
NIC001, NY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Site was down for park infrastructure work.

Table 4. Sites with less than 90 Percent Data Completeness for Filter Concentrations for Fourth Quarter 2018 (2 of 2)

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
PED108, VA	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Power was out for two consecutive sampling weeks in October.
SAN189, NE	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	A polling issue affected two sampling weeks.
SUM156, FL	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	The site was inoperable due to damage from Hurricane Michael.
UND002, VT	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	Intermittent power failures affected five sampling weeks.
VOY413, MN	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	Flow values were low for three weeks due to debris in the Balston filter.

Precision of Ozone Concentrations

Time series of co-located hourly O_3 concentration differences for fourth quarter 2018 are provided in Figures 27 and 28 for MCK131/231 and ROM406/206, respectively. The figures indicate no consistent bias between the co-located analyzers at these site locations.

Figure 27. Time Series of the Differences in Co-located O_3 Concentrations for MCK131/231, KY

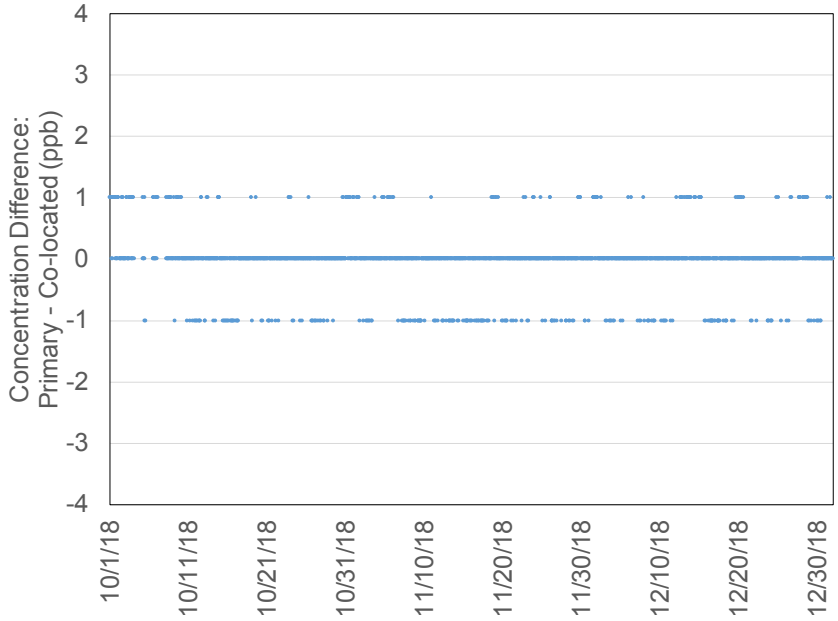


Figure 28. Time Series of the Differences in Co-located O_3 Concentrations for ROM406/206, CO

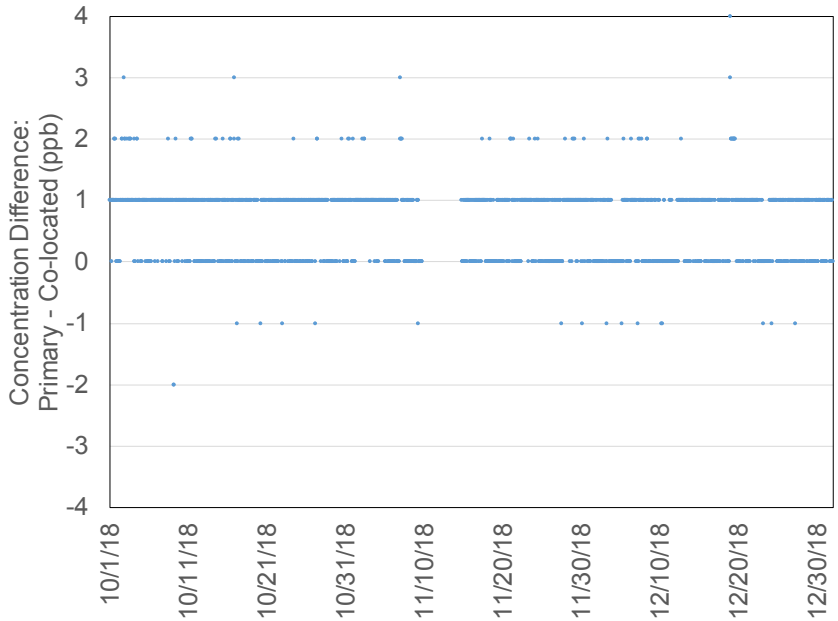


Table 5 gives MARPD data for O_3 data measured at the two co-located sites.

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

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	1	1/1/18	2.1	1979
	2	4/1/18	1.5	1786
	3	7/1/18	1.5	1921
	4	10/1/18	1.0	2025
ROM406/206, CO				
	1	1/1/18	0.6	2023
	2	4/1/18	1.3	2064
	3	7/1/18	1.1	2068
	4	10/1/18	1.9	1973

Completeness for O_3 Concentrations

Table 6 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 6. Sites with less than 90 Percent Data Completeness for O_3 Concentrations

Site ID	Percent Q4 2018	Percent Q1 2018–Q4 2018	Comments
BFT142, NC	0.0	61.0	Site was inoperable due to damage from Hurricane Florence.
BWR139, MD	84.6	96.0	A polling issue affected one sampling week in October and one in December.
CHA467, AZ	88.4	94.9	Ozone was invalid for one week due to a bad cable and one week because the cap was left on the inlet following a leak check.
CNT169, WY	81.0	92.6	A polling issue affected one sampling week in October and a data logger failure affected two sampling weeks in late November.
CVL151, MS	72.8	88.7	The site analyzer malfunctioned in late November and was replaced 12/5.
MEV405, CO	81.8	89.3	Ozone was invalid 11/13 through 11/29 due to a leak and restriction in the line.
PED108, VA	84.3	95.5	Power was out for two consecutive sampling weeks in October.
SUM156, FL	14.0	77.6	Site was inoperable due to damage from Hurricane Michael.

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

Figures 29 through 34 show a comparison of weekly average continuous NO_y measurements with weekly filter pack total NO_3^- concentrations collected at the six 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 six sites with available data are shown in Table 7. These were calculated as the average of all valid weekly filter pack concentrations, the average of mean NO_y values matching the run time of the weekly filter packs, and the average of the ratios calculated for each week. Ratios of NO_y to total NO_3^- varied from 4.40 at BVL130 to 7.63 at ROM206.

Table 7. Summary of Total NO_3^- and NO_y Measurements for Fourth Quarter 2018

Site ID	Elevation	Total NO_3^- (ppb)	NO_y (ppb)	Ratio
DUK008, NC	164	0.50	3.00	7.34
BVL130, IL	213	1.21	4.78	4.40
HWF187, NY	497	0.15	0.87	7.22
PNF126, NC	1216	0.24	1.19	4.92
PND165, WY	2386	0.10	0.58	5.63
ROM206, CO	2742	0.14	0.90	7.63

Figure 29. Comparison of DUK008 Weekly Mean NO_y and Total NO_3^- Concentrations

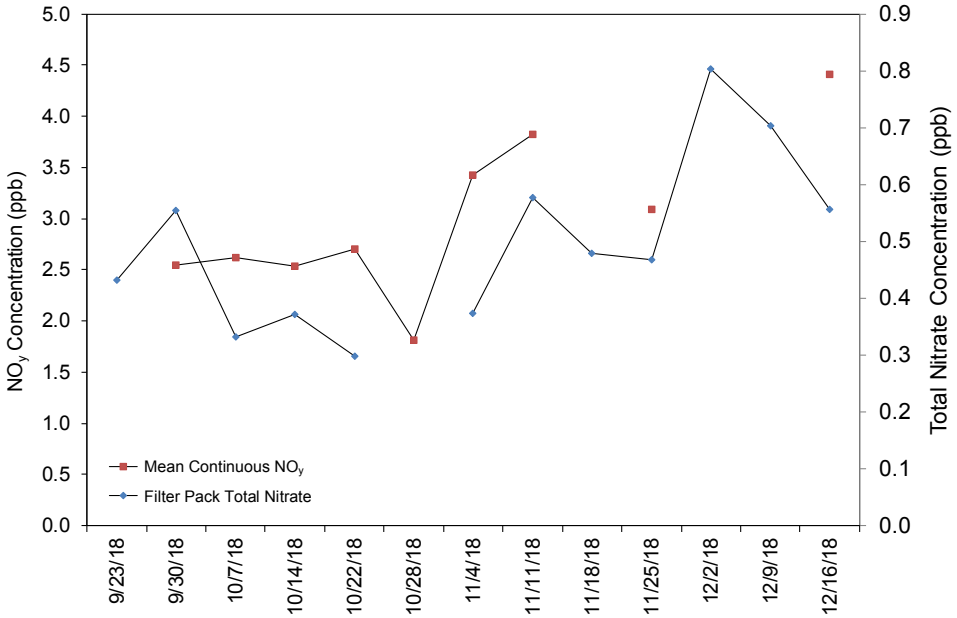


Figure 30. Comparison of BVL130 Weekly Mean NO_y and Total NO_3^- Concentrations

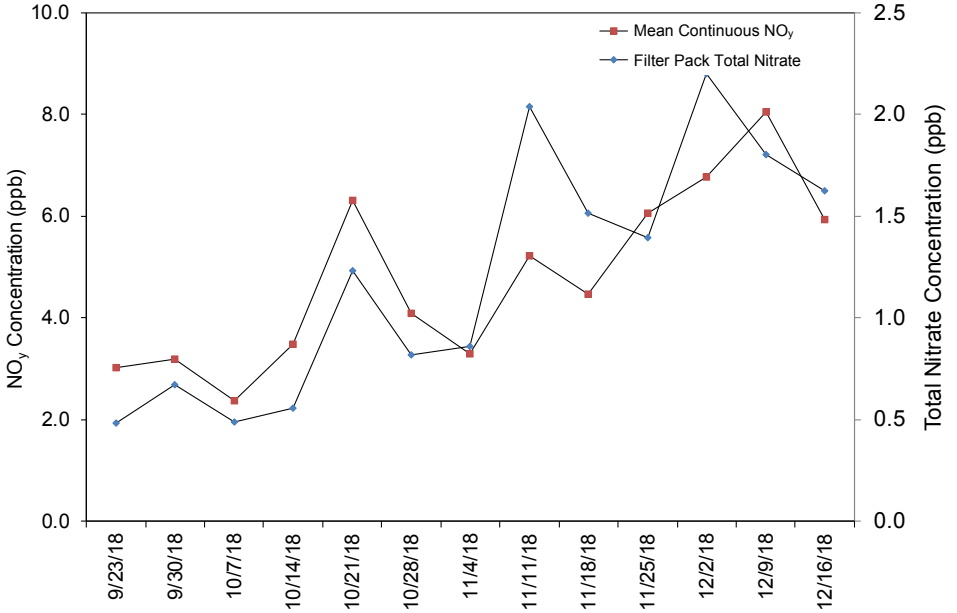


Figure 31. Comparison of HWF187 Weekly Mean NO_y and Total NO_3^- Concentrations

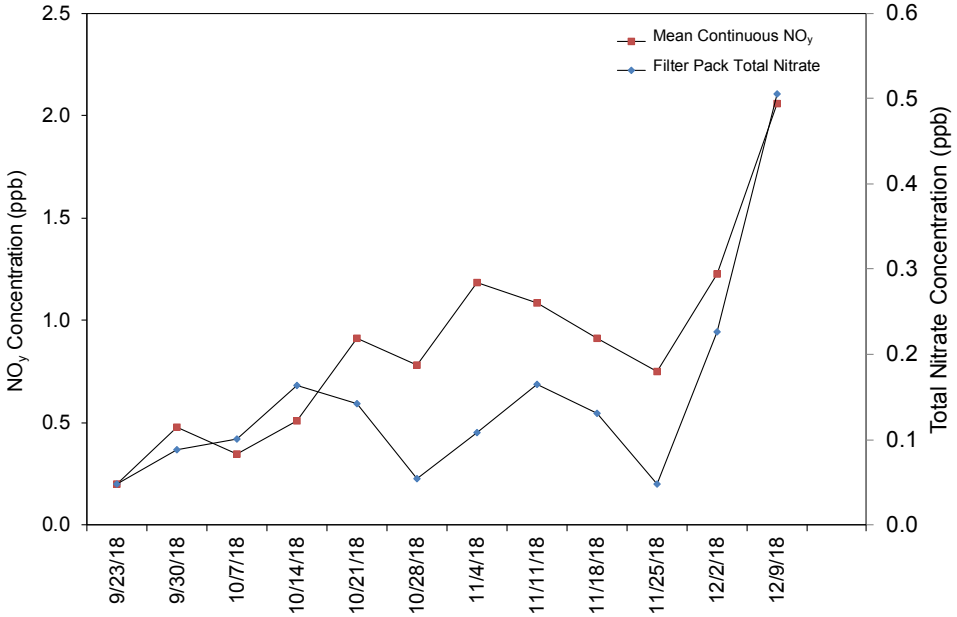


Figure 32. Comparison of PNF126 Weekly Mean NO_y and Total NO_3^- Concentrations

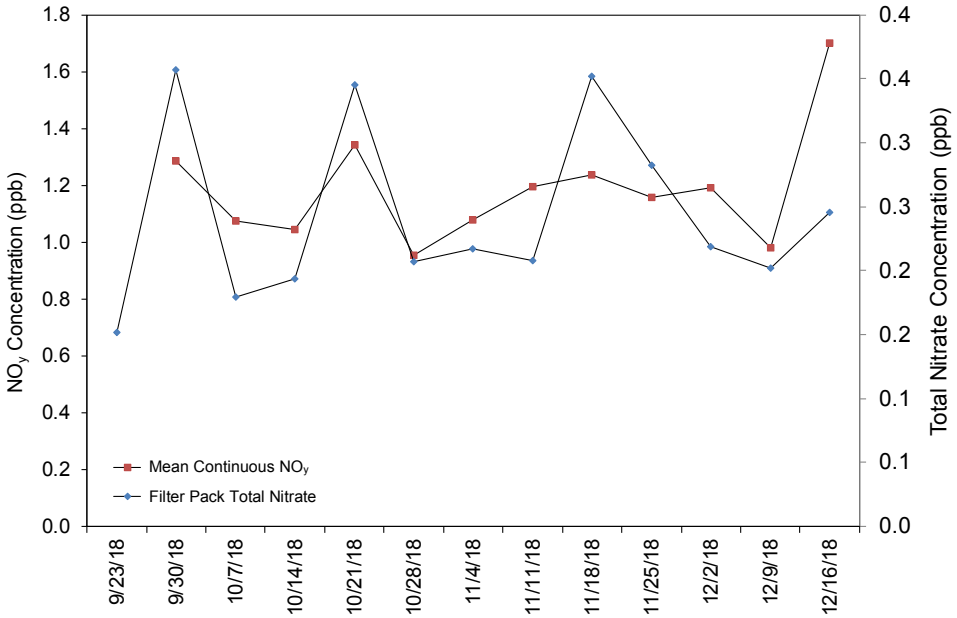


Figure 33. Comparison of PND165 Weekly Mean NO_y and Total NO_3^- Concentrations

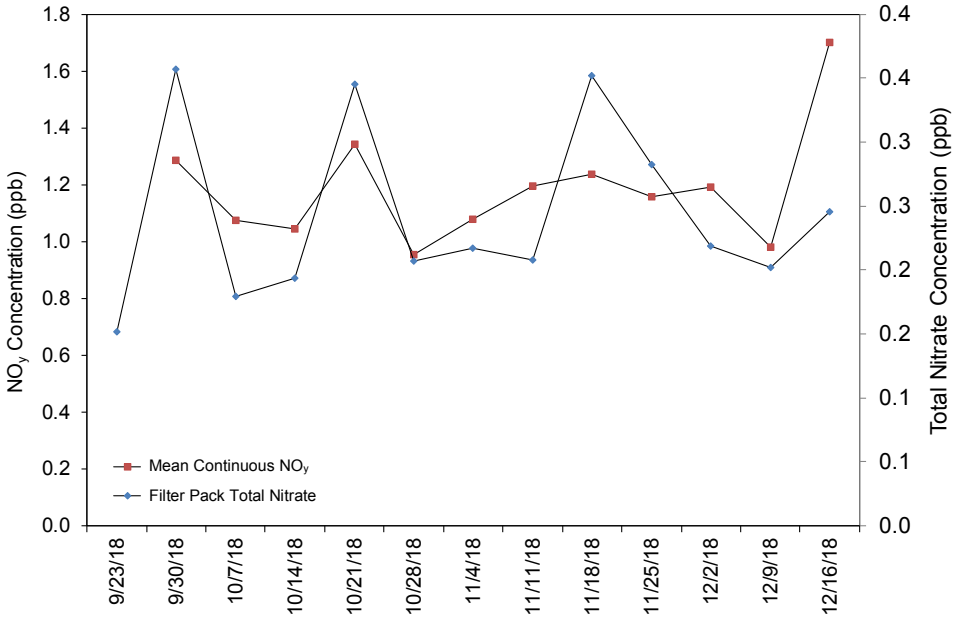
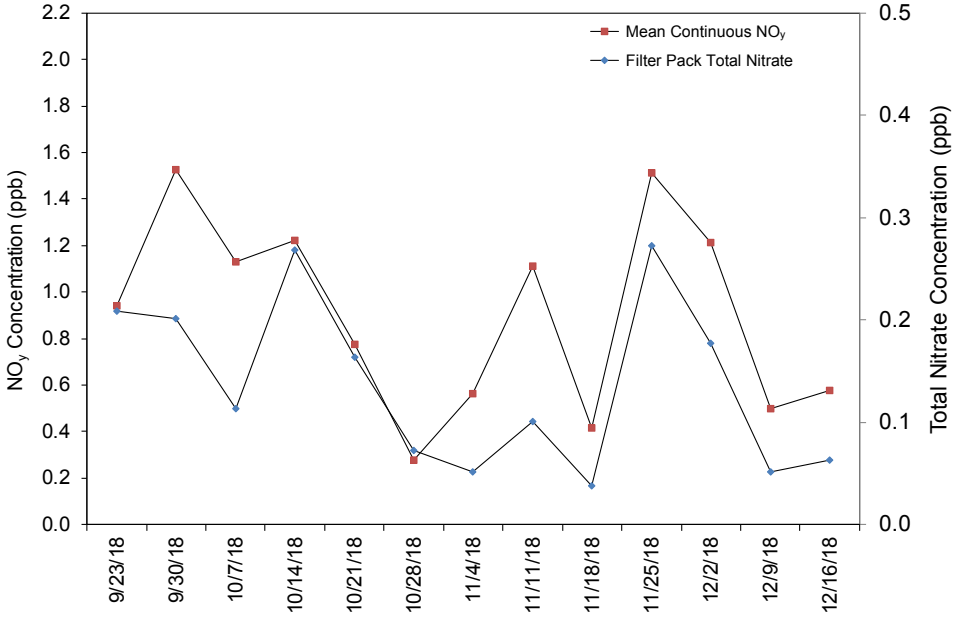


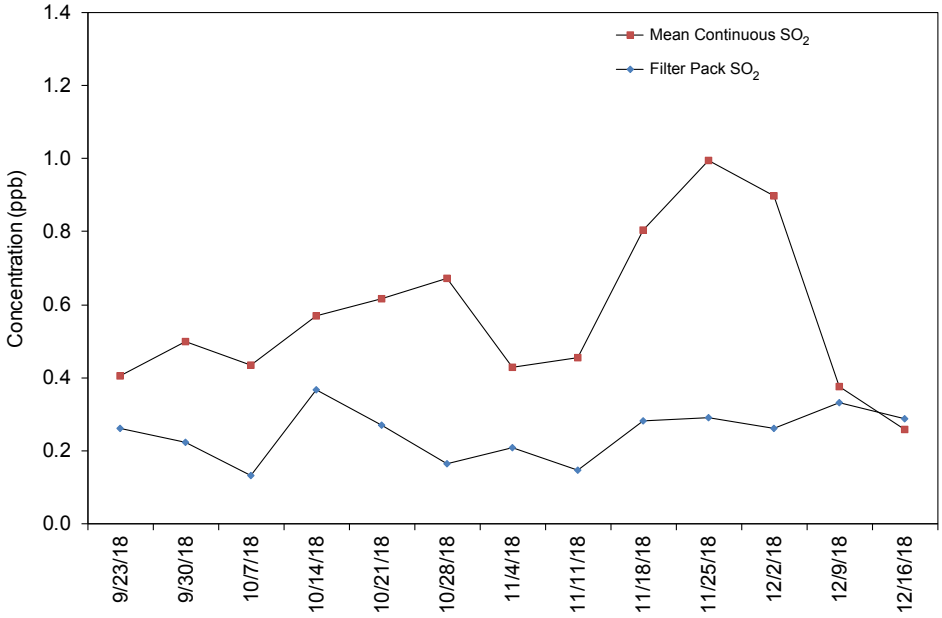
Figure 34. Comparison of ROM206 Weekly Mean NO_y and Total NO_3^- Concentrations



Filter Pack and Continuous Trace-level Gas Sulfur Dioxide Concentrations

Figure 35 provides a diagram that compares weekly filter pack SO_2 concentrations with continuous trace-level gas data measured at BVL130. The continuously measured trace-level concentrations were higher than filter pack concentrations.

Figure 35. Comparison of BVL130 Weekly Mean SO_2 Concentrations



Completeness for Continuous Trace-level Gas Measurements

Table 8 shows the percent completeness for CASTNET trace-level gas measurements. Sites with less than 80 percent completeness for hourly trace-level gas concentrations during fourth quarter 2018 are shaded. Comments on the low data completeness are provided. The annual hourly average for each of the sites is included for reference.

Table 8 Percent Data Completeness for Continuous Trace-level Gas Measurements

Site ID	Parameter*	Percent Q4 2018	Percent Q1 2018–Q4 2018	Comments
BVL130, IL	CO	35	67	There were auto-reference issues during November and December.
	NO	91	91	
	NOY	91	91	
	NOYDIF	91	91	
	SO2_GA	92	90	
DUK008, NC	HNO3	70	71	DUK008 had site communications issues that affected data collection during November and December. Additionally, shelter temperature was outside the criterion on several occasions.
	NH3	70	64	
	NO	70	74	
	NO2_TRUE	70	77	
	NOX_TRUE	70	74	
	NOY	70	71	
	NOY_MINUS	70	72	
	NOYDIF	70	71	
	TNX	70	66	
HWF187, NY	NO	90	93	
	NOY	90	93	
	NOYDIF	90	93	
PNF126, NC	NO	86	77	Data were invalidated 10/7-10/13 due to ZPS failures. The site analyzer was recalibrated.
	NOY	93	80	
	NOYDIF	86	77	
PND165, WY	NO	78	80	Data were invalidated due to zsp QC check failures. The site analyzer required recalibration several times during the quarter.
	NOY	77	84	
	NOYDIF	74	79	
ROM206, CO	NO	93	92	
	NOY	95	92	
	NOYDIF	93	92	

Note: * See Table 9

zsp = zero/span/precision

The parameters listed in Table 8 are both calculated and measured. Table 9 provides information on how the parameters listed in Table 8 are obtained.

Table 9. 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	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
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. 2019. *Clean Air Status and Trends Network (CASTNET) Fourth Quarter 2018 Quality Assurance Report with 2018 Annual Summary*. https://java.epa.gov/castnet/documents.do