

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

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 third quarter 2018. 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 third quarter data and include completeness and precision of filter concentrations and hourly O₃ concentrations. This report also analyzes data on continuous, trace-level NO_y from six sites and continuous SO₂ concentrations from one site. Other QC statistics are given in the CASTNET Third Quarter 2018 Quality Assurance Report (Wood, 2018).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O₃ Concentrations through Third Quarter 2018



Figure 1 shows fourth highest daily maximum 8-hour average O₃ concentrations measured through third quarter 2018. Eight western and seven eastern sites exceeded the 0.070 parts per million (ppm) National Ambient Air Quality Standard for O₃. No additional maps are shown in this report because the maps of other measured third quarter 2018 mean concentrations were consistent with third 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 (µg/m³) of air at the 34 eastern and 16 western reference sites during third quarter. Trends in quarterly mean filter pack and O₃ concentrations are shown using box plots in Figures 2 through 13.

Third Quarter Concentrations

Quarterly mean HNO₃, NH₄⁺, total NO₃⁻, SO₂, SO₄²⁻, Ca²⁺, Mg²⁺ concentrations decreased at eastern sites in 2018, and NO₃⁻, Cl⁻, K⁺, and Na⁺ concentrations increased. Quarterly mean SO₄²⁻ concentrations decreased at western sites in 2018 while HNO₃, NO₃⁻, NH₄⁺, total NO₃⁻, SO₂, Cl⁻, Ca²⁺, K⁺, Mg²⁺, and Na⁺ concentrations increased.

Quarterly O₃ concentrations were analyzed using box plots constructed by averaging all valid hourly O₃ concentrations within third quarter 2018 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 O₃ concentrations at eastern sites. Mean O₃ concentrations at western sites increased in third quarter 2018. Quarterly mean concentrations were higher at the western reference sites than at the eastern sites.

Figure 2. Trends in Third Quarter Mean HNO₃ Concentrations

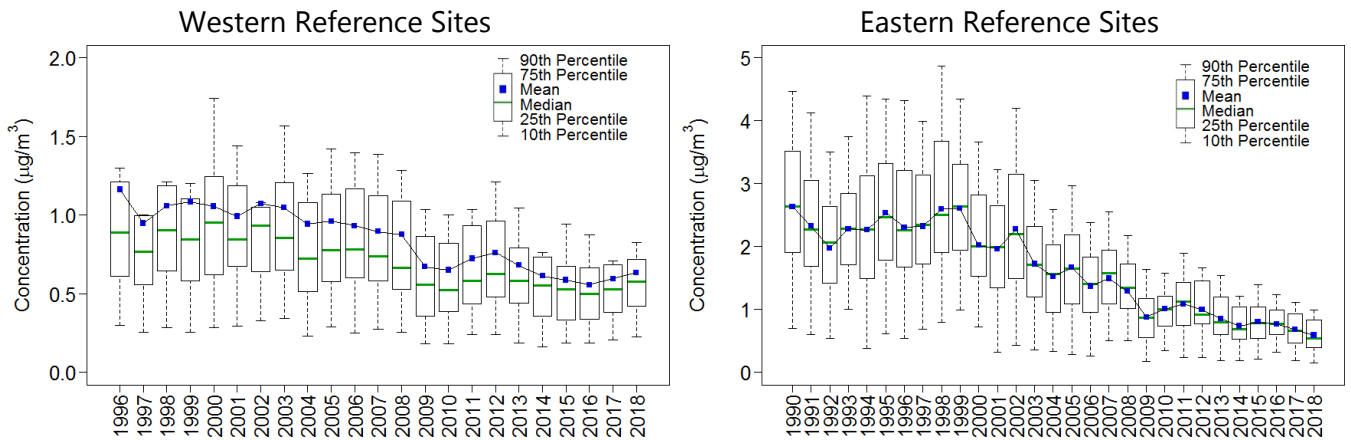


Figure 3. Trends in Third Quarter Mean NO₃ Concentrations

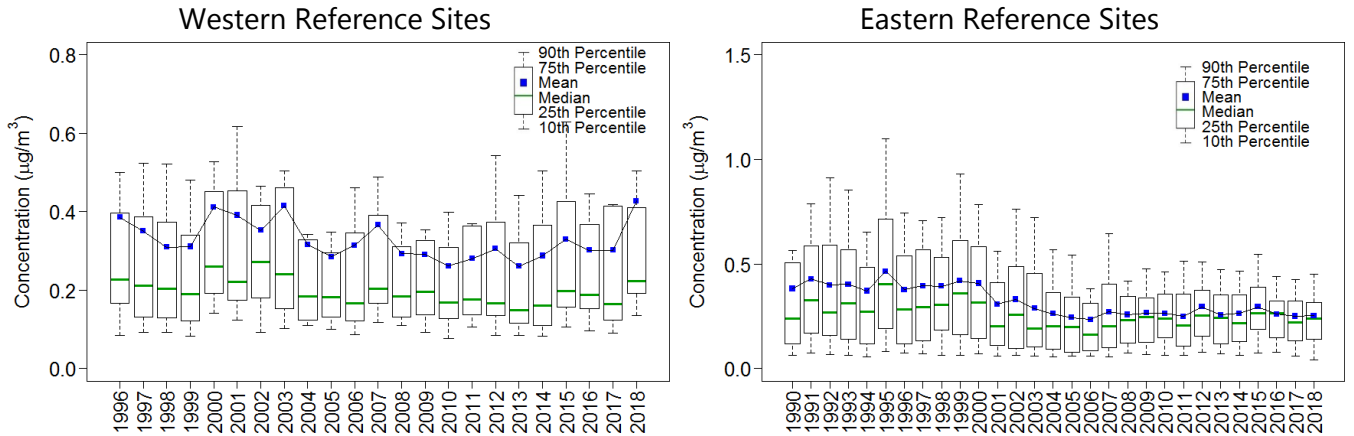


Figure 4. Trends in Third Quarter Mean NH₄⁺ Concentrations

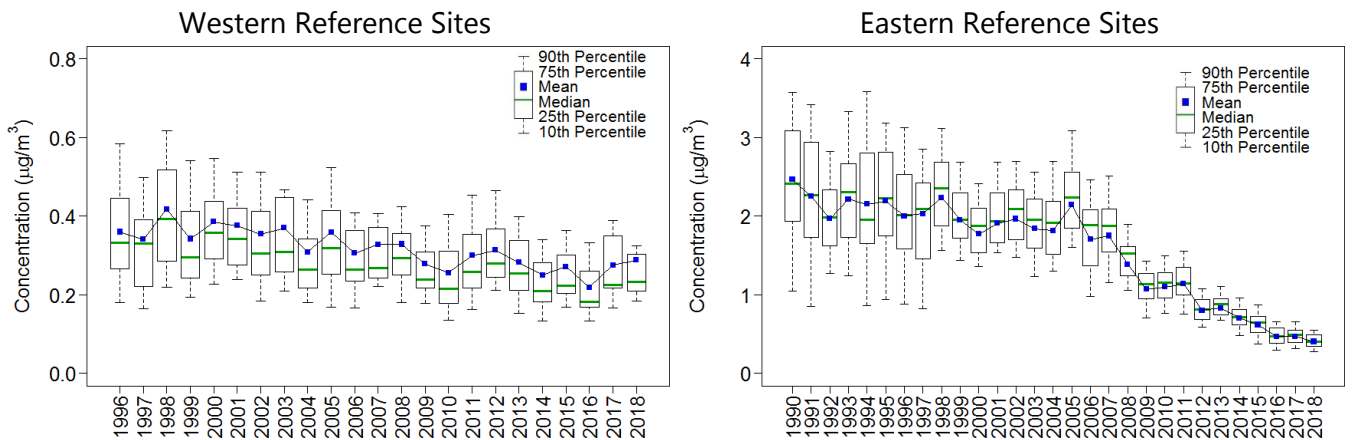


Figure 5. Trends in Third Quarter Mean Total NO₃ Concentrations

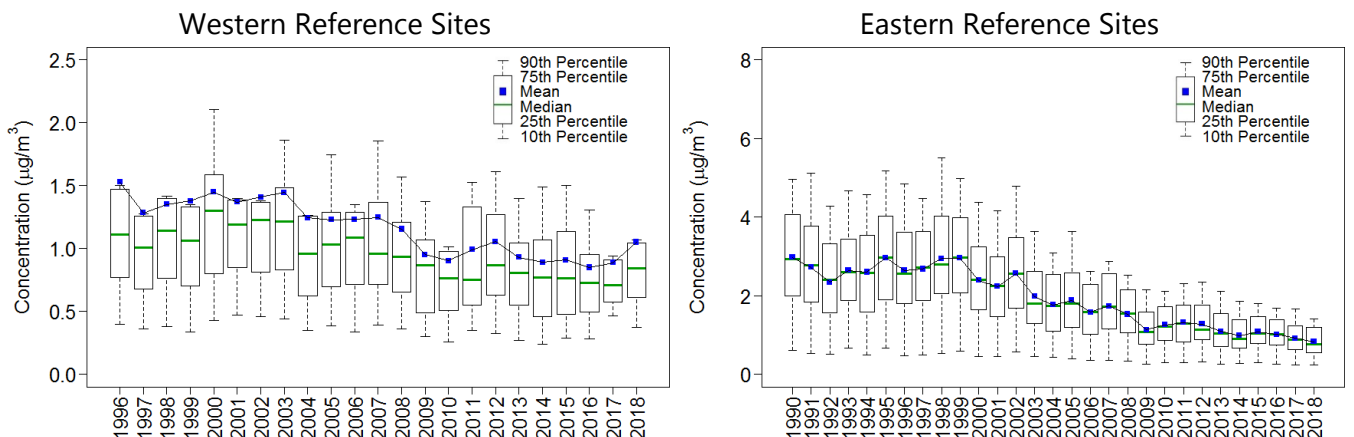


Figure 6. Trends in Third Quarter Mean SO₂ Concentrations

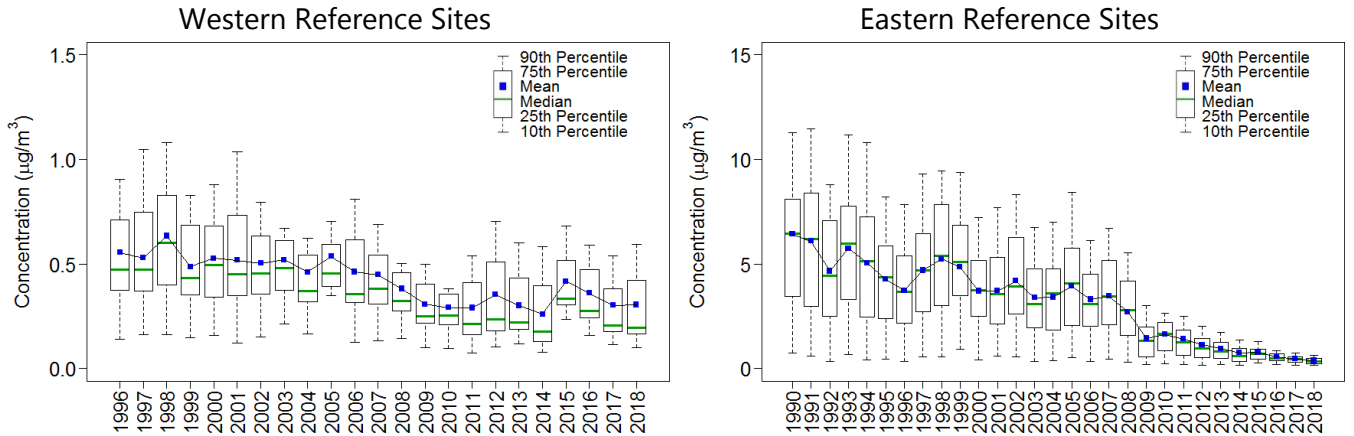


Figure 7. Trends in Third Quarter Mean SO₄²⁻ Concentrations

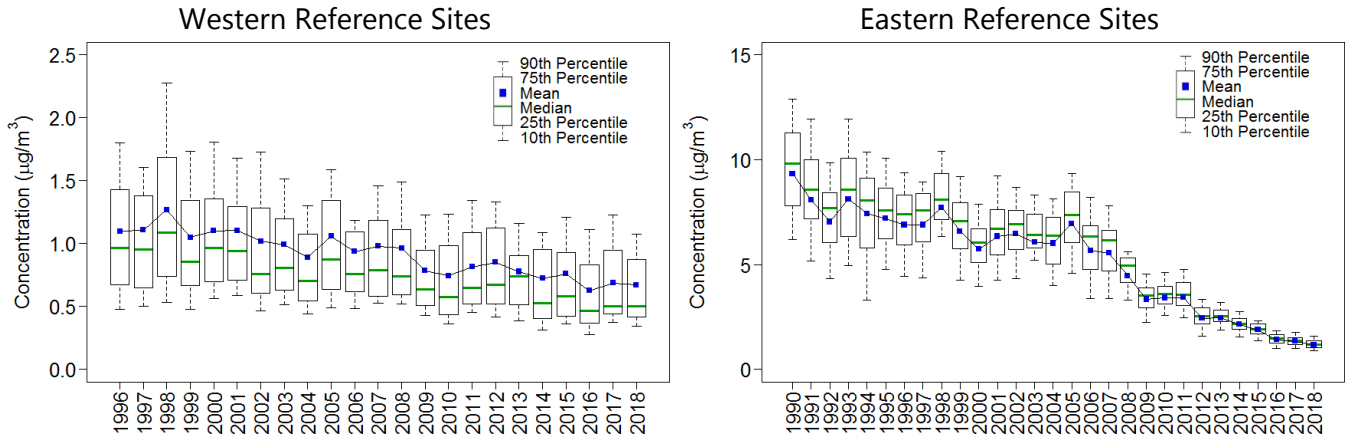


Figure 8. Trends in Third Quarter Mean Cl⁻ Concentrations

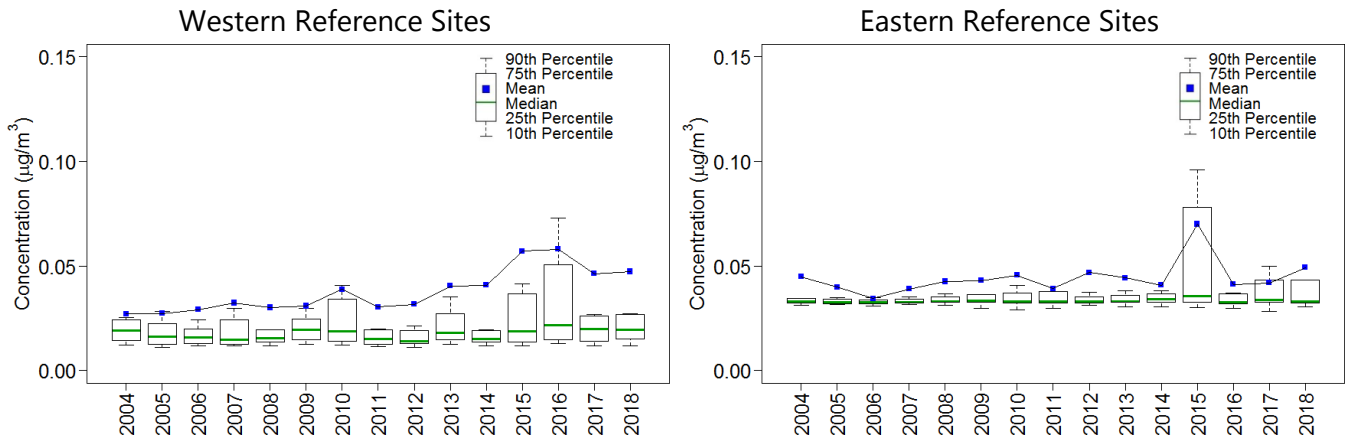


Figure 9. Trends in Third Quarter Mean Ca²⁺ Concentrations

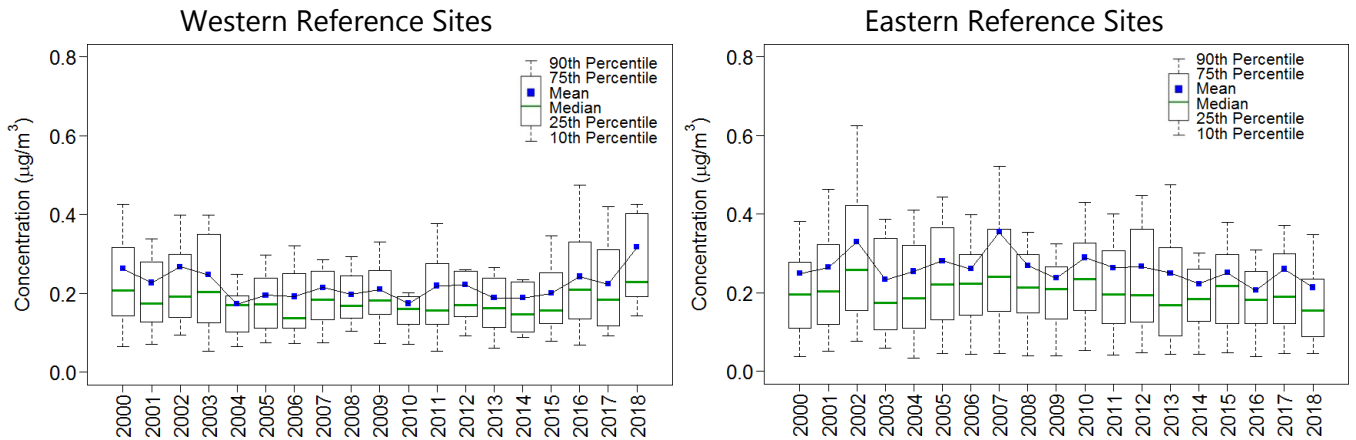


Figure 10. Trends in Third Quarter Mean K⁺ Concentrations

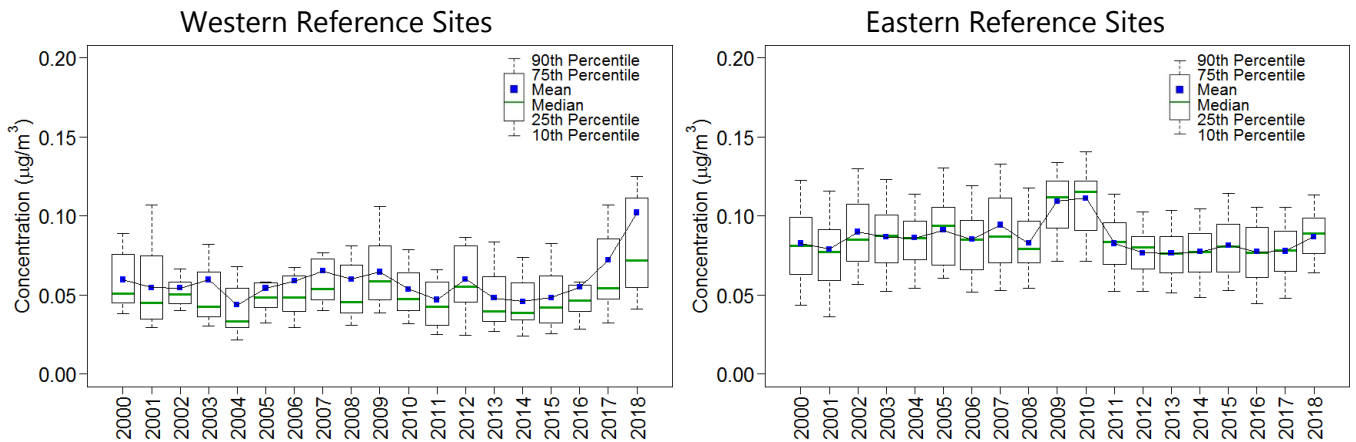


Figure 11. Trends in Third Quarter Mean Mg²⁺ Concentrations

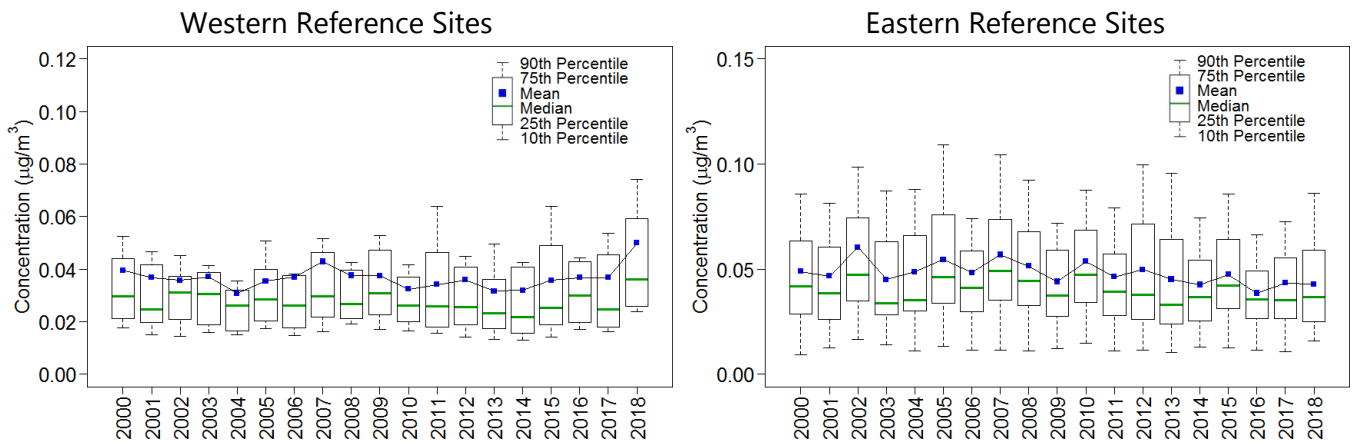


Figure 12. Trends in Third Quarter Mean Na⁺ Concentrations

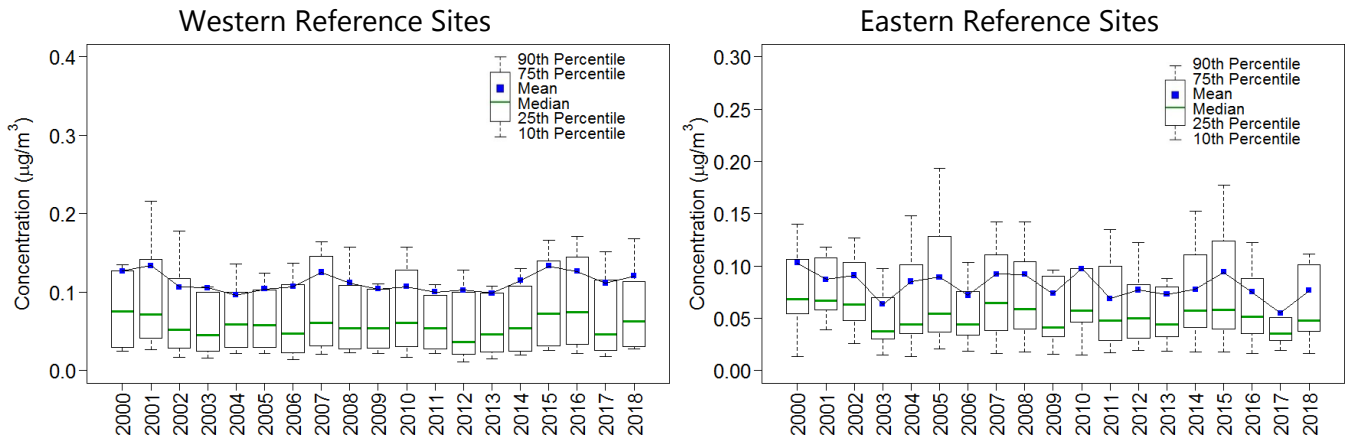
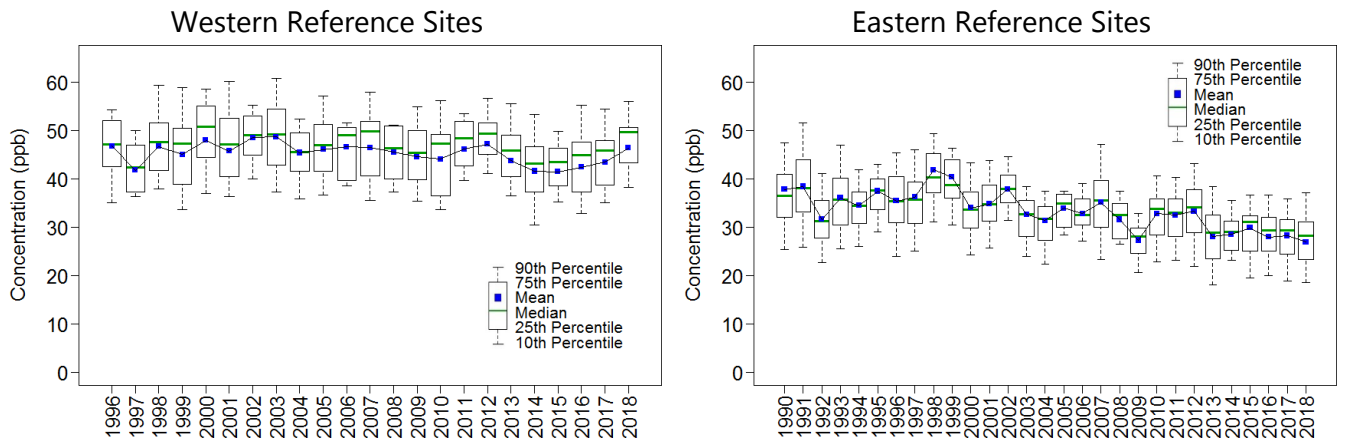


Figure 13. Trends in Third Quarter Mean O₃ Concentrations



Changes in 3-year Average Third Quarter Concentrations

Three-year averages of quarterly mean concentrations of total NO₃⁻, NH₄⁺, SO₂, SO₄²⁻, and O₃ were reduced over the period 1990–1992 through 2016–2018 for eastern reference sites and 1996–1998 through 2016–2018 for western reference sites. Tables 1 and 2 summarize changes in 3-year average third quarter concentrations.

Table 1. Eastern Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O₃ Pollutant Concentrations

	Total NO ₃ ⁻ (µg/m ³)	NH ₄ ⁺ (µg/m ³)	SO ₂ (µg/m ³)	SO ₄ ²⁻ (µg/m ³)	O ₃ (ppb)
1990–1992	2.7	2.2	5.7	8.1	36
2016–2018	0.9	0.4	0.5	1.3	28
Percent Change	-66	-80	-92	-84	-23

Table 2. Western Reference Sites: 3-Year Mean Nitrogen, Sulfur, and O₃ Pollutant Concentrations

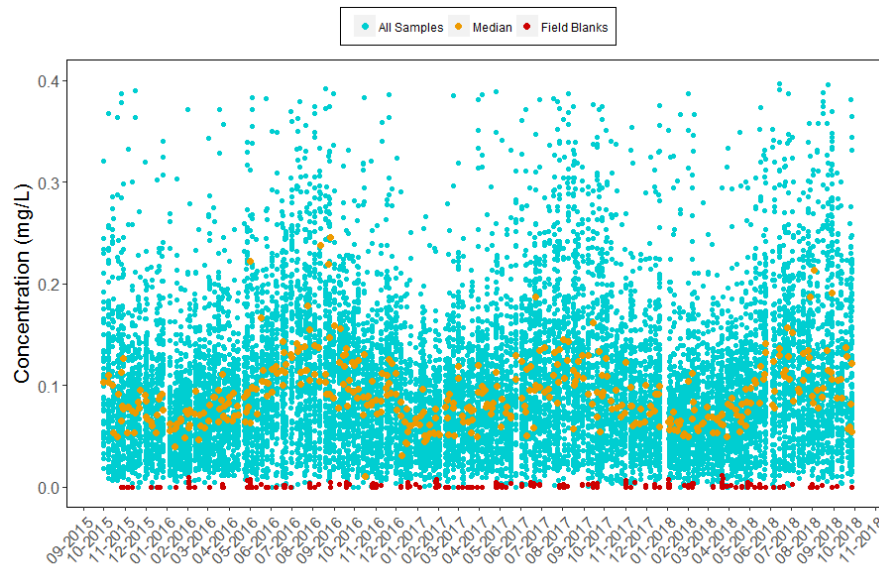
	Total NO ₃ ⁻ (µg/m ³)	NH ₄ ⁺ (µg/m ³)	SO ₂ (µg/m ³)	SO ₄ ²⁻ (µg/m ³)	O ₃ (ppb)
1996–1998	1.4	0.4	0.6	1.2	45
2016–2018	0.9	0.3	0.3	0.7	44
Percent Change	-33	-30	-44	-43	-2

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 third quarter 2018. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

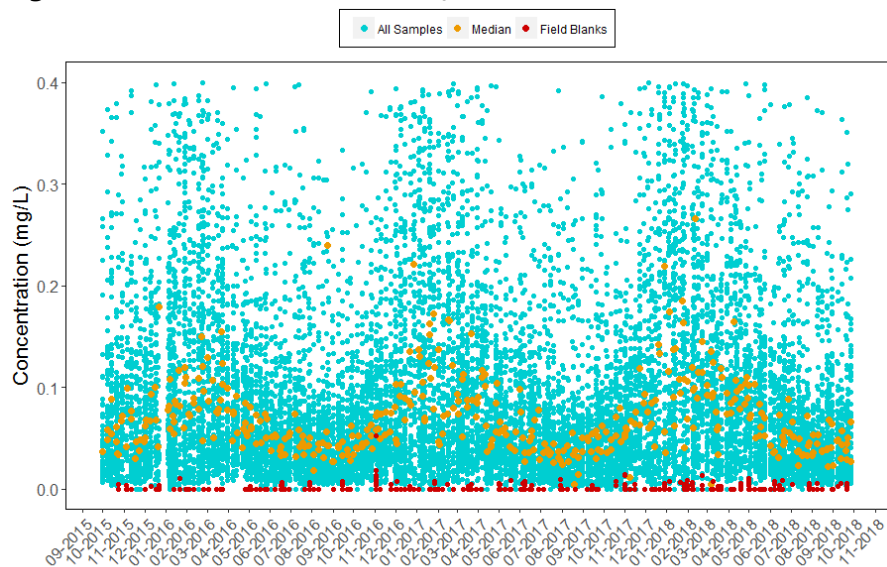
As discussed in the second quarter 2018 report, review of filter pack analysis control charts during preparation of the First Quarter 2018 QA Report indicated possible potassium contamination (Figure 22). Note the field blank results at the end of second quarter. A corrective action was initiated. During 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. As of late July 2018, use of foil was discontinued. 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 NO₃⁻ (as N) from Nylon Filters



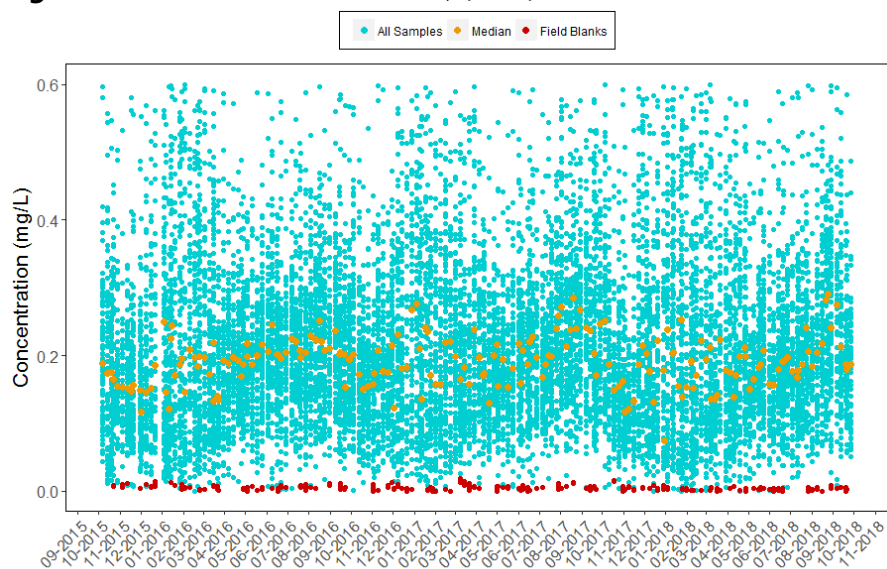
Note: Nominal reporting limit is 0.008 mg/L.

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



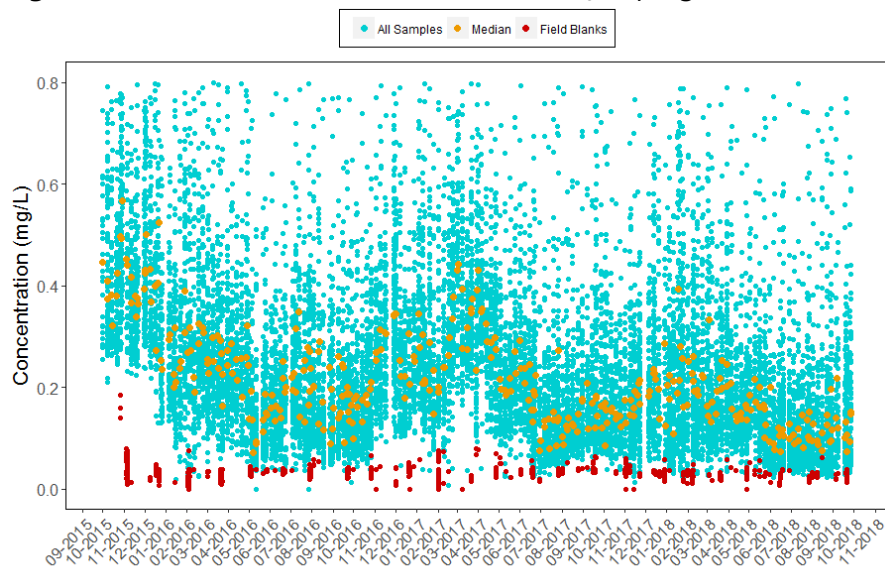
Note: Nominal reporting limit is 0.008 mg/L.

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



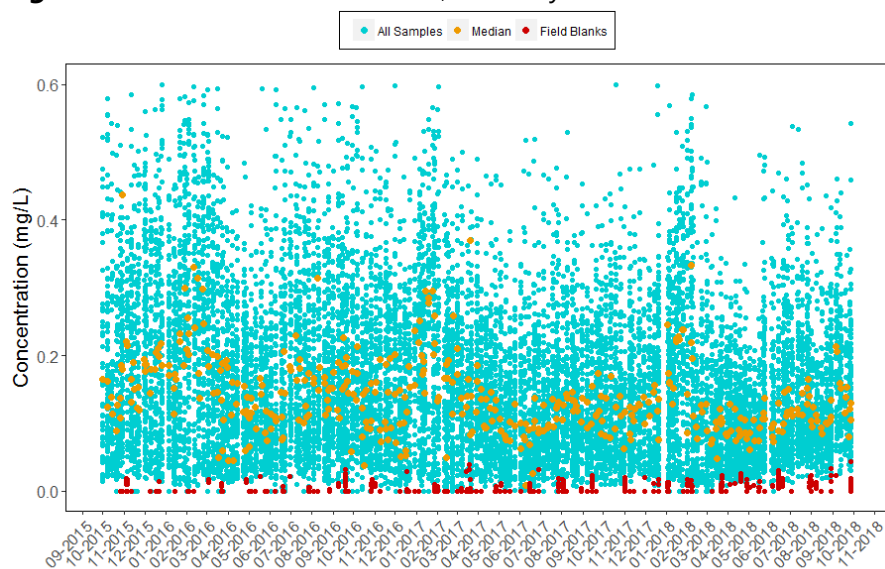
Note: Nominal reporting limit is 0.020 mg/L.

Figure 17. Concentrations of SO₂ from K₂CO₃ Impregnated Cellulose Filters



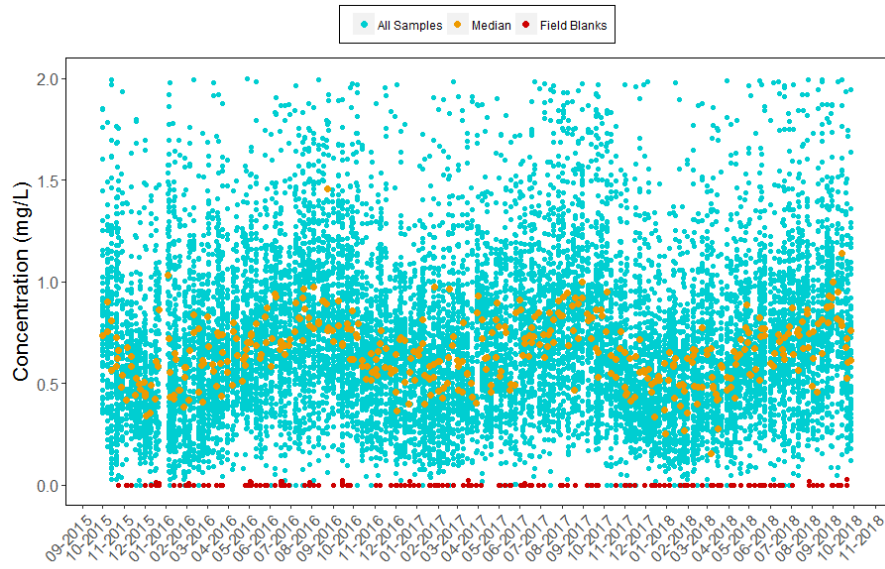
Note: Nominal reporting limit is 0.040 mg/L.

Figure 18. Concentrations of SO₄²⁻ from Nylon Filters



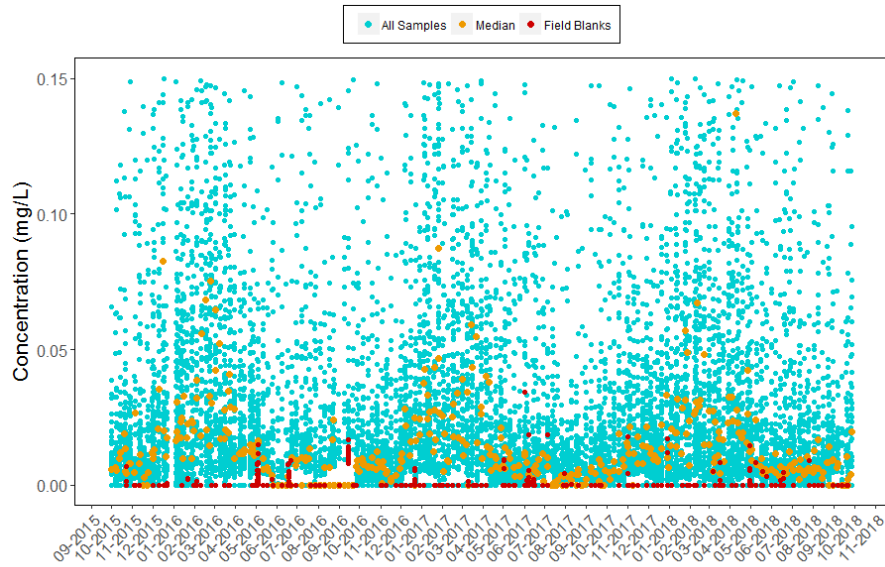
Note: Nominal reporting limit is 0.040 mg/L.

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



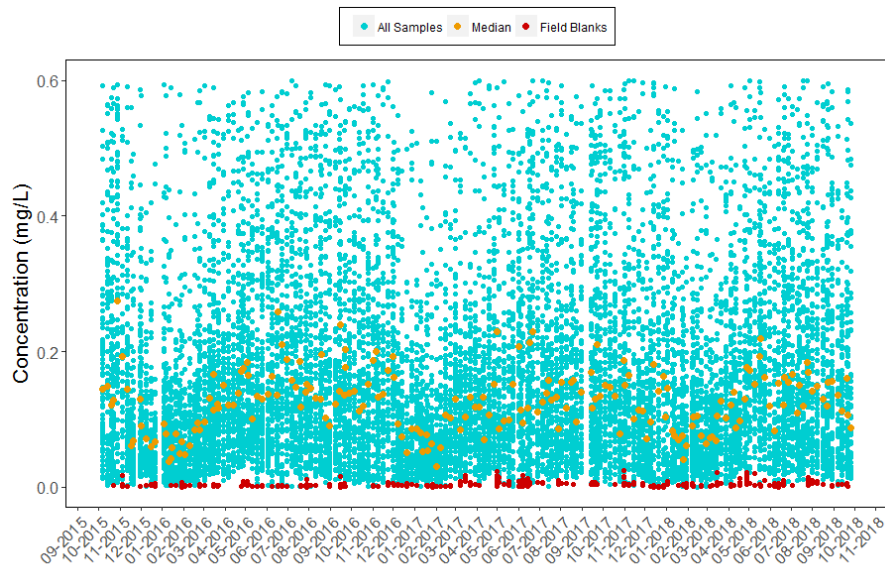
Note: Nominal reporting limit is 0.040 mg/L.

Figure 20. Concentrations of Cl^- from Teflon Filters



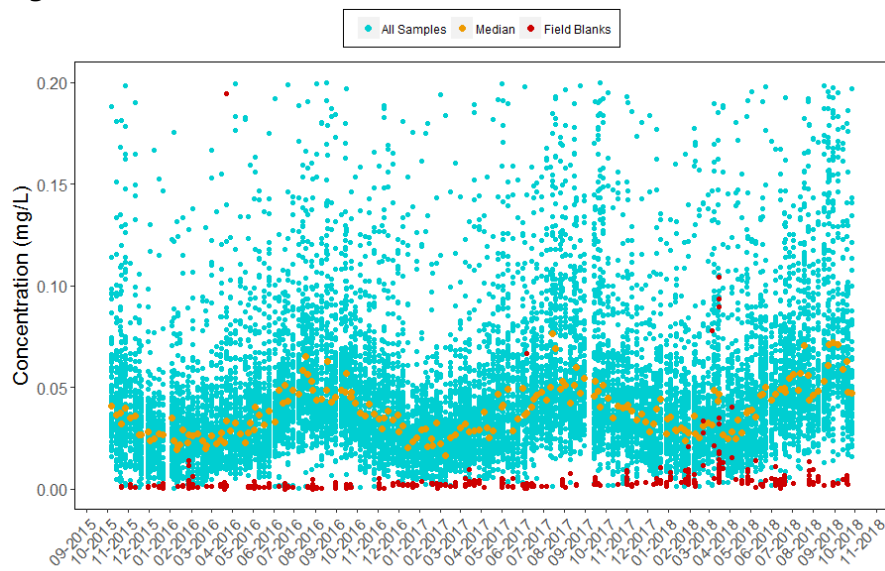
Note: Nominal reporting limit is 0.020 mg/L.

Figure 21. Concentrations of Ca²⁺ from Teflon Filters



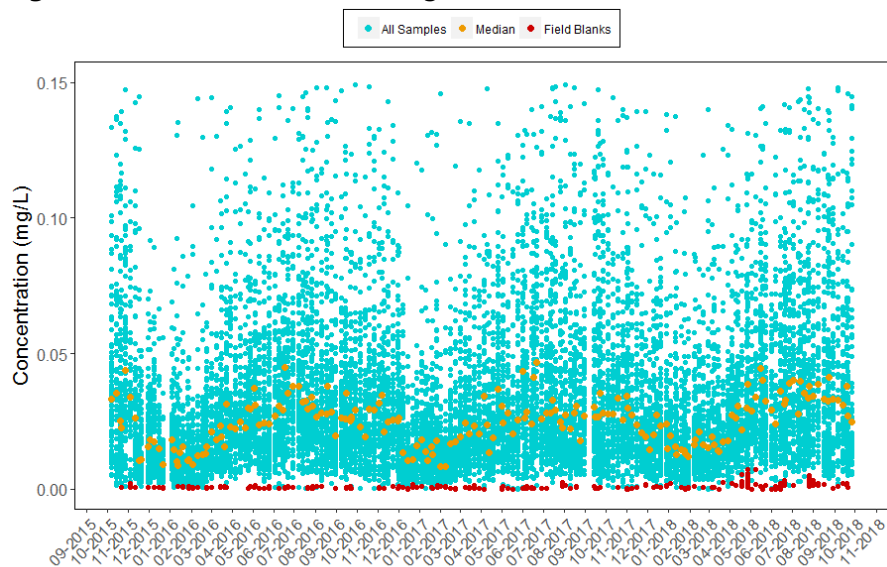
Note: Nominal reporting limit is 0.006 mg/L.

Figure 22. Concentrations of K⁺ from Teflon Filters



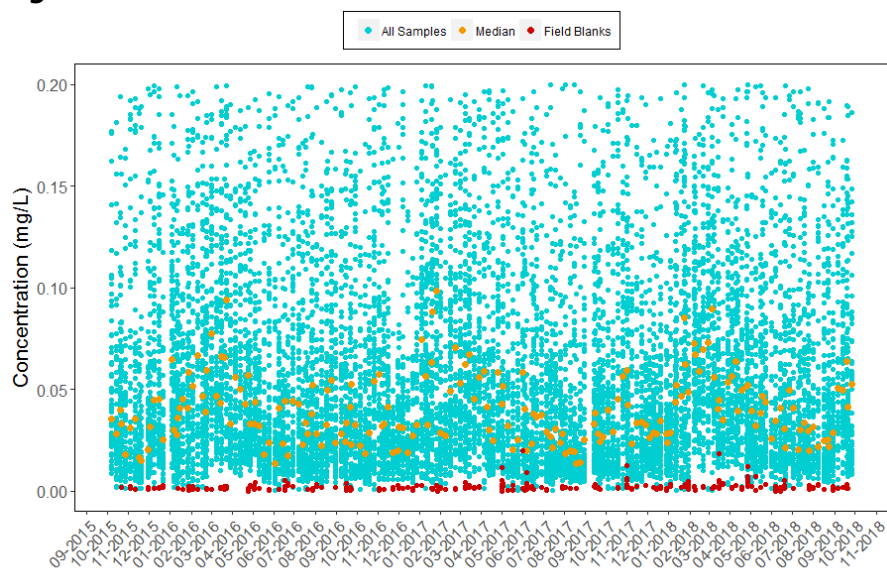
Note: Nominal reporting limit is 0.006 mg/L.

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

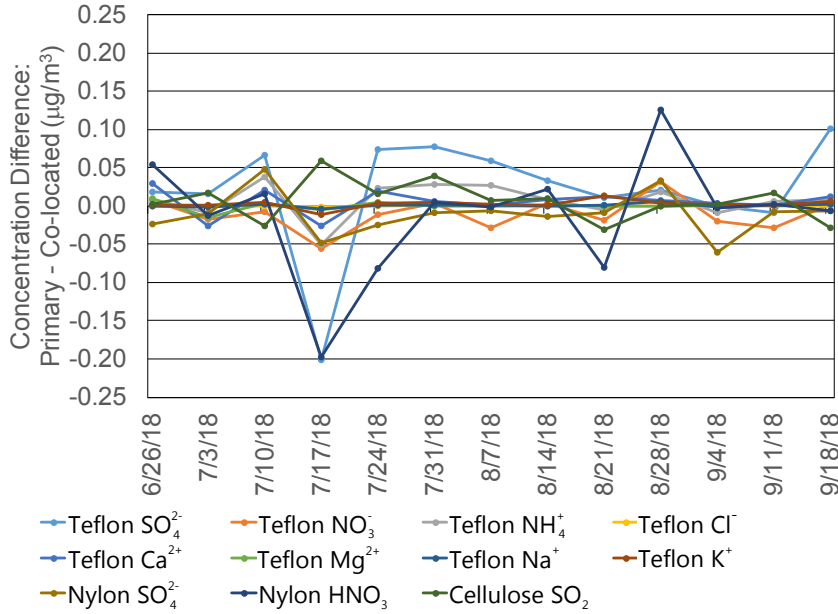
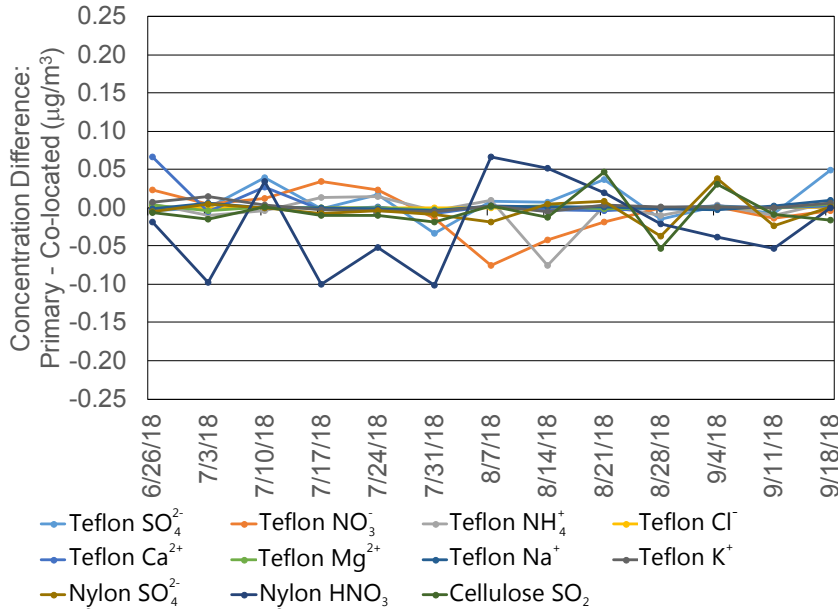


Figure 26. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



Precision of Filter Pack Concentrations

Table 3 shows mean absolute relative percent differences (MARPD) for concentrations measured at MCK131/231 and ROM406/206 during third quarter 2018. The MARPD values met the 20 percent criterion.

Table 3. Precision (MARPD) for Co-located Filter Pack Data during Third 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											
\bar{X} (μg/m ³)	1.47	0.27	0.55	0.21	0.04	0.05	0.11	0.03	0.75	0.35	1.01
\bar{Y} (μg/m ³)	1.45	0.29	0.54	0.21	0.04	0.04	0.11	0.03	0.77	0.35	1.04
MAD	0.05	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.04	0.02	0.06
MARPD	3.42	8.30	3.45	5.40	5.81	5.20	4.63	0.70	5.77	6.52	5.95
ROM406/206, CO											
\bar{X} (μg/m ³)	0.62	0.28	0.31	0.23	0.03	0.04	0.09	0.02	0.72	0.22	0.98
\bar{Y} (μg/m ³)	0.61	0.29	0.32	0.23	0.03	0.04	0.09	0.02	0.74	0.23	1.01
MAD	0.02	0.03	0.02	0.01	0.00	0.00	0.01	0.00	0.08	0.03	0.06
MARPD	3.77	10.18	5.24	3.72	5.79	7.76	5.51	4.11	10.42	14.96	6.89

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 Third Quarter 2018

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 filter packs were left installed for two weeks during the quarter.
BFT142, NC	53.8	53.8	53.8	53.8	53.8	53.8	53.8	53.8	The site had polling issues in late August and then was out of service due to hurricane damage.
BWR139, MD	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two filter packs were left installed for two weeks during the quarter.
ESP127, TN	46.2	46.2	46.2	46.2	46.2	46.2	46.2	46.2	Due to the limited availability of the site operator, four filter packs were left installed for two weeks and one filter pack was left installed for four weeks during the quarter.
MEV405, CO	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	One filter pack was left installed for two weeks. One filter pack was invalidated due to flow issues. Flow data were flagged as invalid for another filter pack.
NIC001, NY	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	The site was taken offline in mid-September due to infrastructure work (burying power lines).
UND002, VT	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	Intermittent power outages occurred in July and August. Four filter packs were invalidated for insufficient flow volume.
WST109, NH	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	One filter pack was left installed for two weeks. One filter pack was received late and will be reported later.

Precision of Ozone Concentrations

Time series of co-located hourly O₃ concentration differences for third 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 O₃ Concentrations for MCK131/231, KY

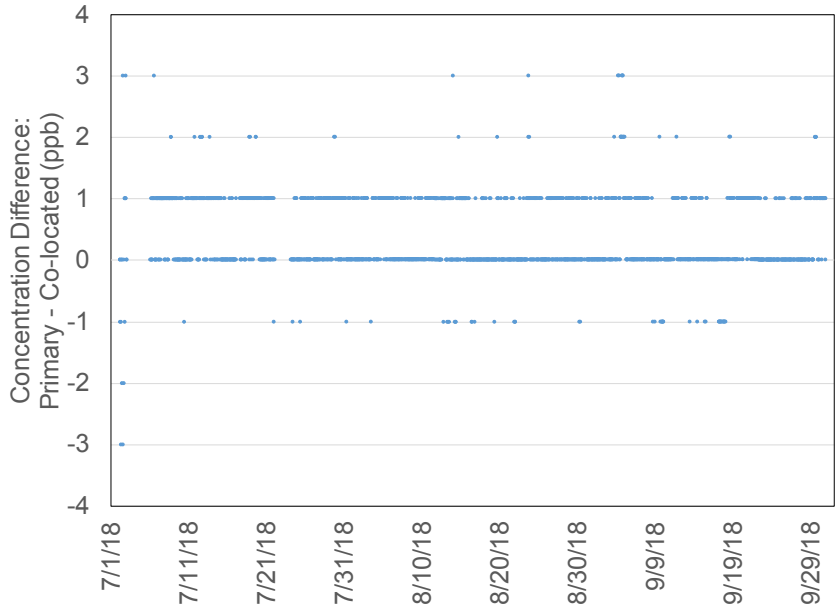


Figure 28. Time Series of the Differences in Co-located O₃ Concentrations for ROM406/206, CO

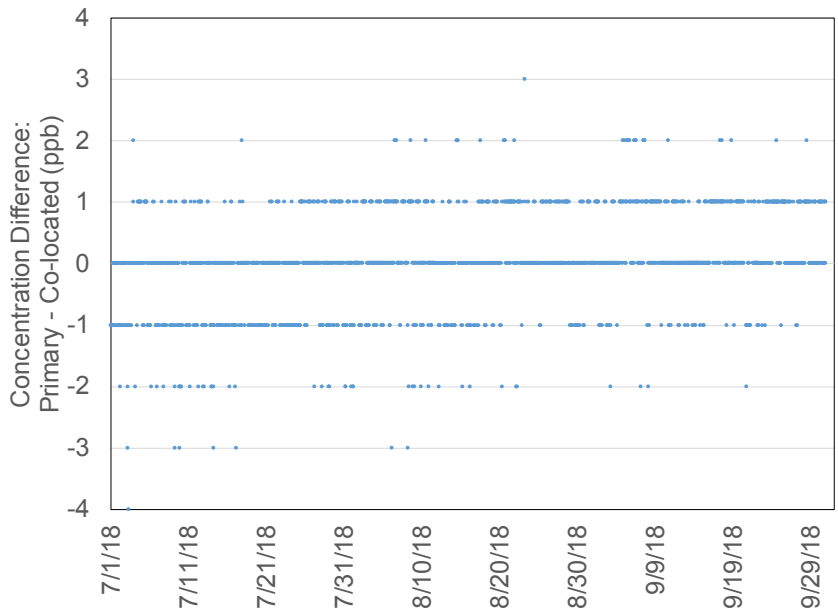


Table 5 gives MARPD data for O₃ data measured at the two co-located sites.

Table 5. Quarterly Precision (MARPD) for Co-located O₃ Concentrations

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	4	10/1/17	1.8	2041
	1	1/1/18	2.1	1979
	2	4/1/18	1.5	1786
	3	7/2/18	1.5	1921
ROM406/206, CO				
	4	10/1/17	0.8	2074
	1	1/1/18	0.6	2023
	2	4/1/18	1.3	2064
	3	7/1/18	1.1	2068

Completeness for O₃ Concentrations

Table 6 shows CASTNET sites with less than 90 percent completeness for hourly O₃ 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 O₃ Concentrations

Site ID	Q3 2018	Q4 2017– Q3 2018	Comments
BBE401, TX	78.9	93.2	Ozone data were invalid from 7-3-2018 through 7-17-2018 because the site operator accidentally left the cap on the ozone inlet, which eventually caused the pump to fail. Data were invalid again from 9-26-2018 through 9-30-2018 because the pump failed again.
BFT142, NC	54.7	85.8	The site had polling issues in late August and has subsequently been out of service due to hurricane damage.
GAS153, GA	72.0	78.9	Intermittent QC failures occurred during July due to system moisture, resulting in 82 percent of data flagged as invalid for the month.
GLR468, MT	73.8	88.3	Ozone data were invalid intermittently due to numerous shelter temperature issues caused by a relay problem.
MAC426, KY	86.8	96.0	Ozone data were invalid from 9-19-2018 through 9-30-2018 because the analyzer was removed for repair due to failing valves.
MEV405, CO	89.1	93.6	Ozone data were invalid from 7-22-2018 through 7-31-2018 due to failing 1-point QC checks.
NEC602, WY	78.7	88.0	Ozone data were invalid from 9-14-2018 through 9-25-2018 due to a bad pump.
PNF126, NC	81.4	85.9	The sample pump failed 8-10-2018 and was replaced 8-16-2018. The analyzer subsequently malfunctioned, and the replacement analyzer was damaged after installation. Both periods accounted for 52 percent of data flagged as invalid for August.
SEK430, CA	83.7	94.8	Ozone data were invalid from 8-3-2018 through 8-14-2018 due to a bad pump and again from 8-17-2018 through 8-20-2018 due to failing QC checks and noisy 1-minute data.

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 NO₃ concentrations collected at the six sites with NO_y measurements. The NO_y concentrations were consistently higher than the total NO₃ levels at all sites. The average weekly NO_y levels, the weekly total NO₃ concentrations, and their ratios for the six sites with available data are shown in Table 7. Ratios of NO_y to total NO₃ varied from 3.17 at HWF187 to 5.54 at BVL130.

Table 7. Summary of Total NO₃⁻ and NO_y Measurements for Third Quarter 2018

Site ID	Elevation	Total NO ₃ ⁻ (ppb)	NO _y (ppb)	Ratio
DUK008, NC	164	0.38	2.03	5.27
BVL130, IL	213	0.56	3.06	5.54
HWF187, NY	497	0.12	0.38	3.17
PNF126, NC	1216	0.22	0.89	4.37
PND165, WY	2386	0.23	0.89	4.03
ROM206, CO	2742	0.30	1.31	4.48

Figure 29. Comparison of DUK008 Weekly Mean NO_y and Total NO₃⁻ Concentrations

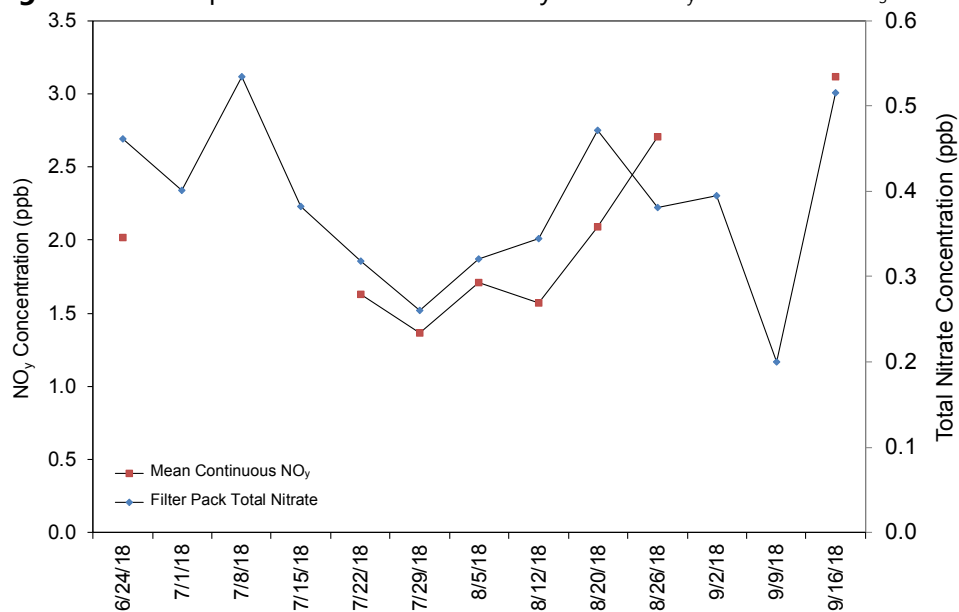


Figure 30. Comparison of BVL130 Weekly Mean NO_y and Total NO₃ Concentrations

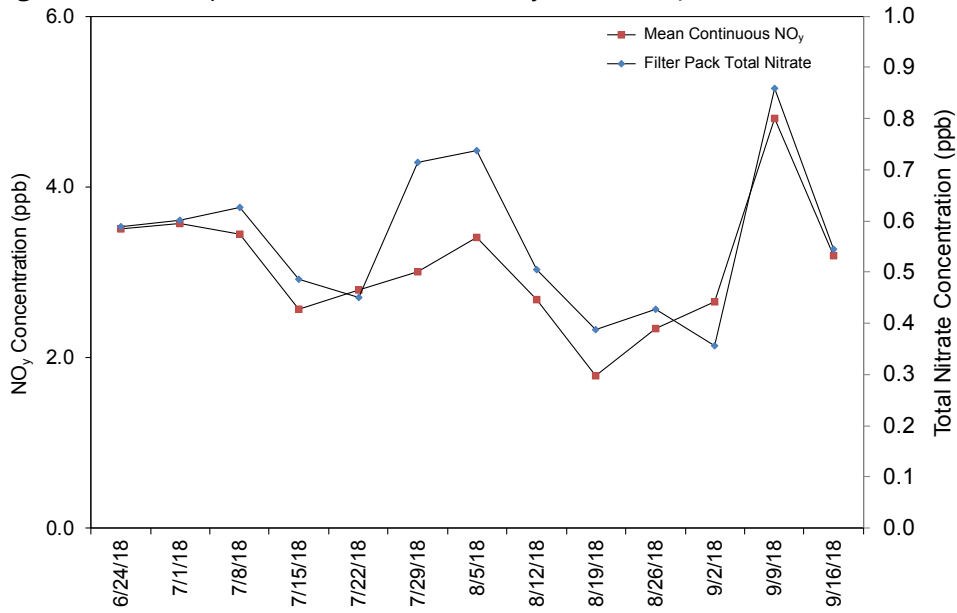


Figure 31. Comparison of HWF187 Weekly Mean NO_y and Total NO₃ Concentrations

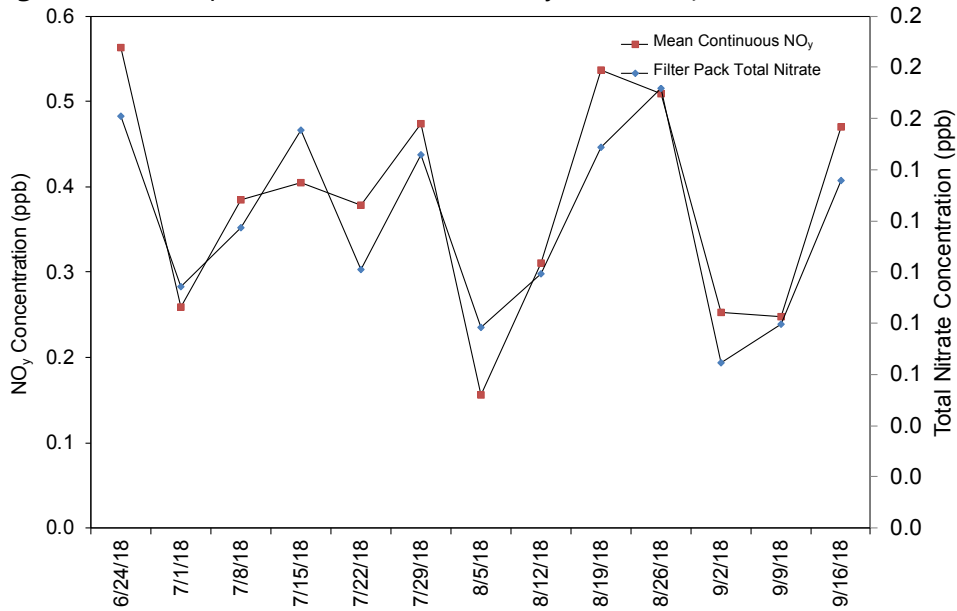


Figure 32. Comparison of PNF126 Weekly Mean NO_y and Total NO_3^- Concentrations

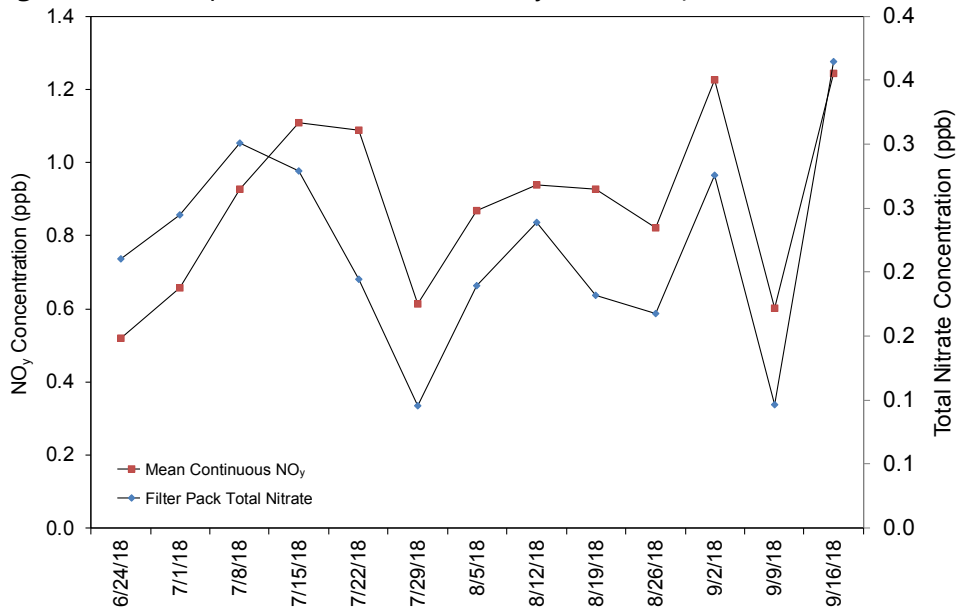


Figure 33. Comparison of PND165 Weekly Mean NO_y and Total NO_3^- Concentrations

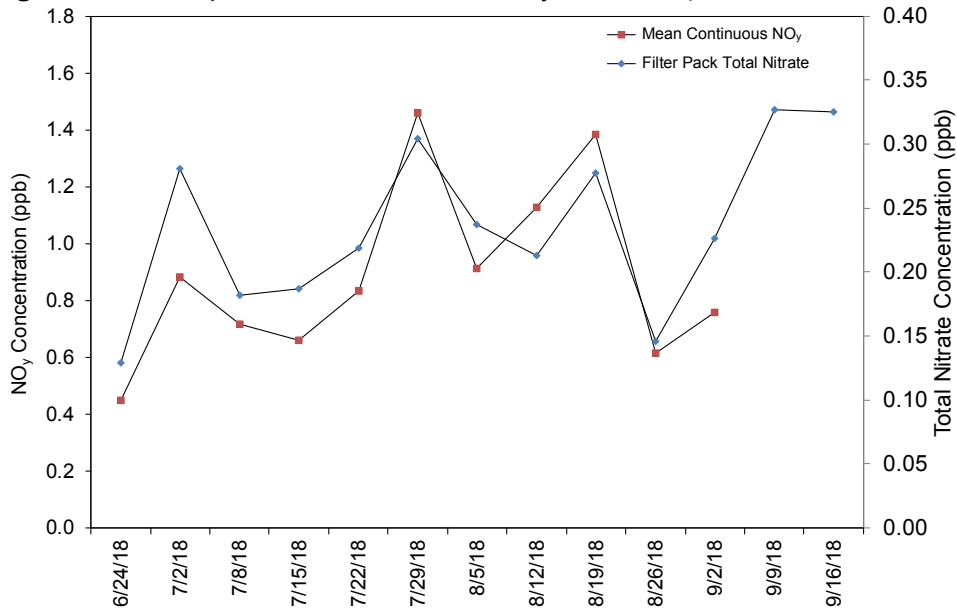
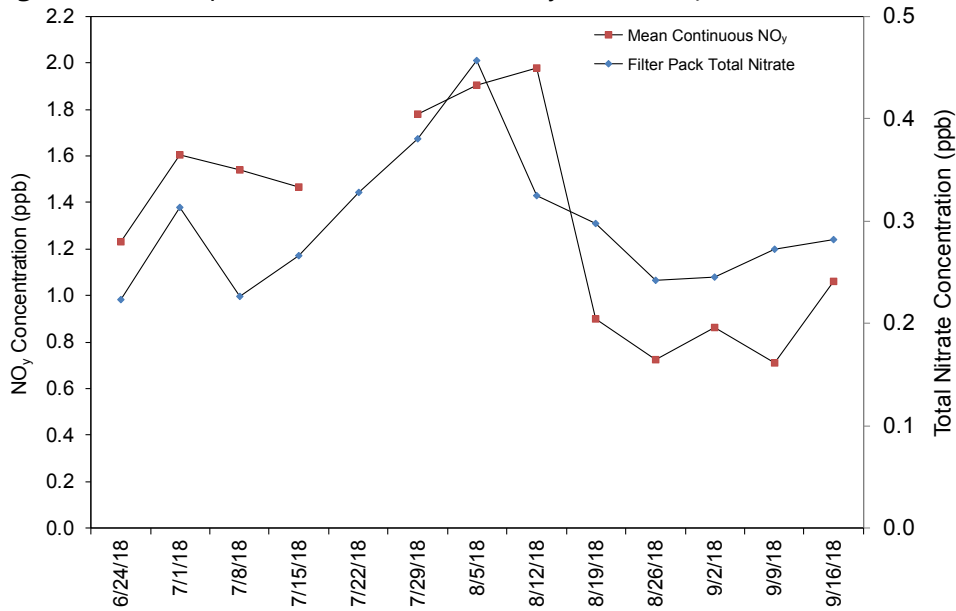


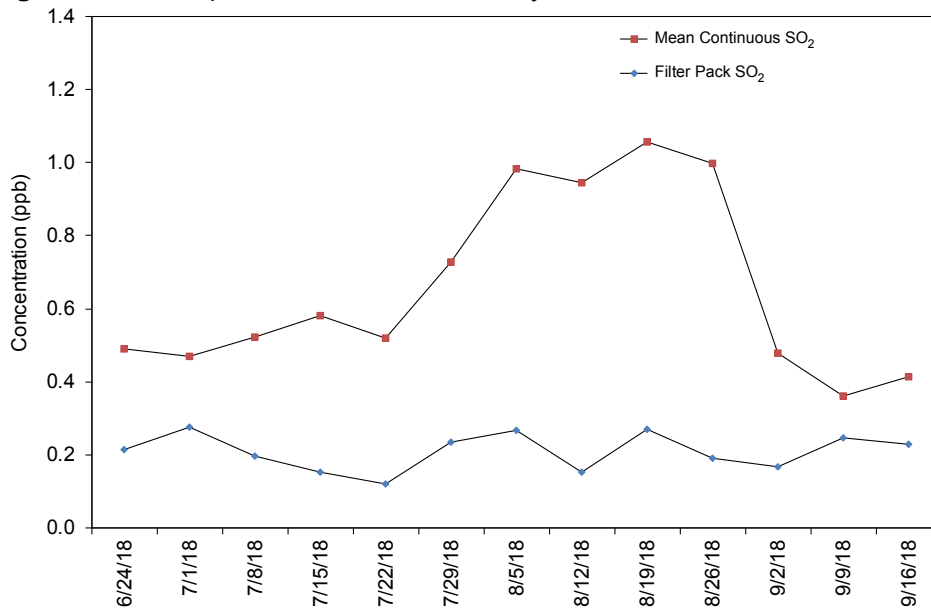
Figure 34. Comparison of ROM206 Weekly Mean NO_y and Total NO₃ Concentrations



Filter Pack and Continuous Trace-level Gas Sulfur Dioxide Concentrations

Figure 35 provides a diagram that compares weekly filter pack SO₂ 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 SO₂ 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 third quarter 2018 are shaded. Comments on the low data completeness values 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*	Q3 2018	Q4 2017 – Q3 2018	Comments
BVL130, IL	CO	76	82	QC failures during September were caused by analyzer drift. Analyzers were recalibrated during the month.
	NO	89	91	
	NOY	89	91	
	NOYDIF	89	91	
	SO2_GA	90	90	
DUK008, NC	HNO3	52	70	QC failures during July and September were caused by analyzer drift. Analyzers were recalibrated more than once during the two-month period.
	NH3	52	55	
	NO	52	76	
	NO2_TRUE	66	79	
	NOX_TRUE	53	76	
	NOY	52	70	
	NOY_MINUS	52	76	
	NOYDIF	52	70	
TNX	52	59		
HWF187, NY	NO	94	93	
	NOY	94	93	
	NOYDIF	94	93	
PNF126, NC	NO	85	77	
	NOY	89	78	
	NOYDIF	85	81	
PND165, WY	NO	68	82	QC failures late July and mid to late September were caused by analyzer drift. Analyzers were recalibrated more than once during the two-month period.
	NOY	79	85	
	NOYDIF	68	77	
ROM206, CO	NO	85	92	
	NOY	85	92	
	NOYDIF	85	92	

Note: * See Table 9

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. 2018. *Clean Air Status and Trends Network (CASTNET) Third Quarter 2018 Quality Assurance Report*.
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