Clean Air Status and Trends Network (CASTNET)
Quarterly Data Summary for Second Quarter 2018 (April through June)

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 second 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 second quarter data and include completeness and precision of filter concentrations and hourly O_3 concentrations. This report also analyzes data on continuous, trace-level NO_y from six sites and continuous SO_2 concentrations from one site. Other QC statistics are given in the CASTNET Second Quarter 2018 Quality Assurance Report (Wood, 2018).

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

Figure 1 shows fourth highest daily maximum 8-hour average O_3 concentrations measured through second quarter 2018. Seven 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 second quarter 2018 mean concentrations were consistent with second 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 second quarter. Trends in quarterly mean filter pack and O_3 concentrations are shown using box plots in Figures 2 through 13.

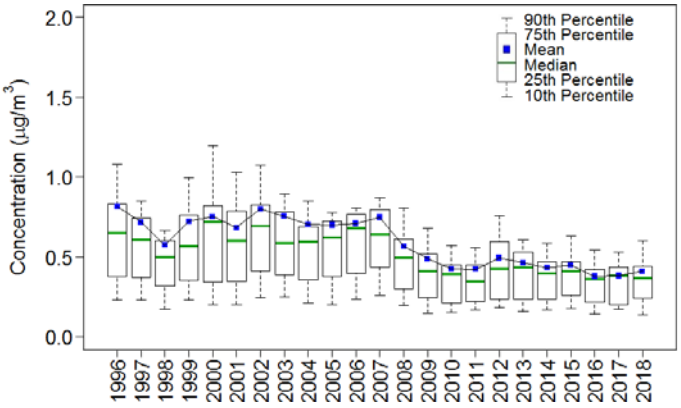
Second Quarter Concentrations

Quarterly mean SO_2, Cl^-, Ca^{2+}, and Na^+ concentrations decreased at eastern sites in 2018, and HNO_3, NO_3^-, NH_4^+, total NO_3^-, SO_4^{2-}, and K^+ concentrations increased relative to 2017. Mg^{2+} concentrations showed no change. Quarterly mean SO_2, SO_4^{2-}, and NH_4^+ concentrations decreased at western sites in 2018 while HNO_3, NO_3^-, total NO_3^-, Cl^-, Ca^{2+}, K^+ , Mg^{2+}, and Na^+ concentrations increased relative to 2017.

Quarterly O_3 concentrations were analyzed using box plots constructed by averaging all valid hourly O_3 concentrations within second quarter 2018 by site and then averaging those averages for all eastern and western reference sites (Figure 13). Quarterly mean O_3 concentrations at eastern and western sites increased relative to 2017. Quarterly mean concentrations were higher at the western reference sites than at the eastern sites.

Figure 2. Trends in Second Quarter Mean HNO_3 Concentrations

Western Reference Sites



Eastern Reference Sites

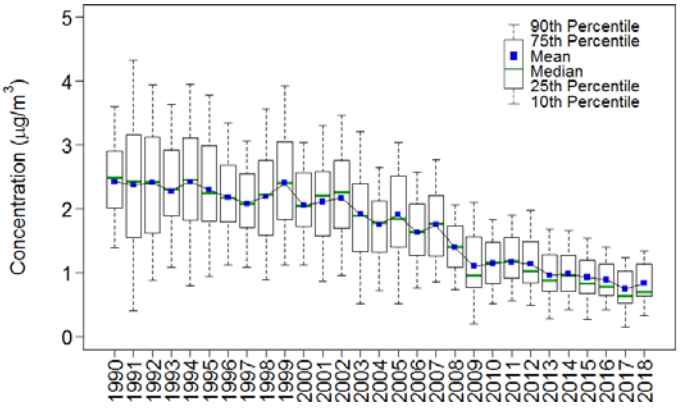
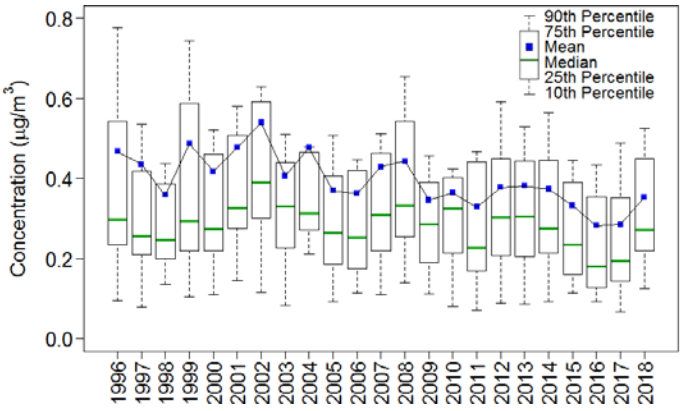


Figure 3. Trends in Second Quarter Mean NO_3^- Concentrations

Western Reference Sites



Eastern Reference Sites

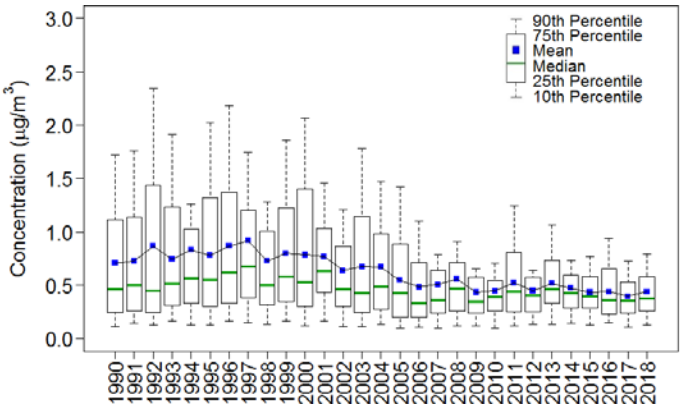
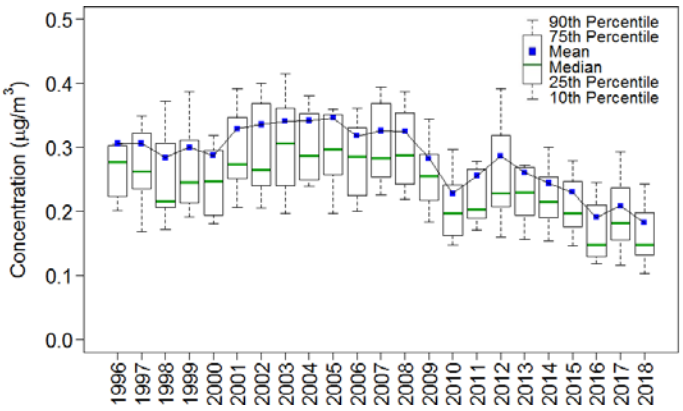


Figure 4. Trends in Second Quarter Mean NH_4^+ Concentrations

Western Reference Sites



Eastern Reference Sites

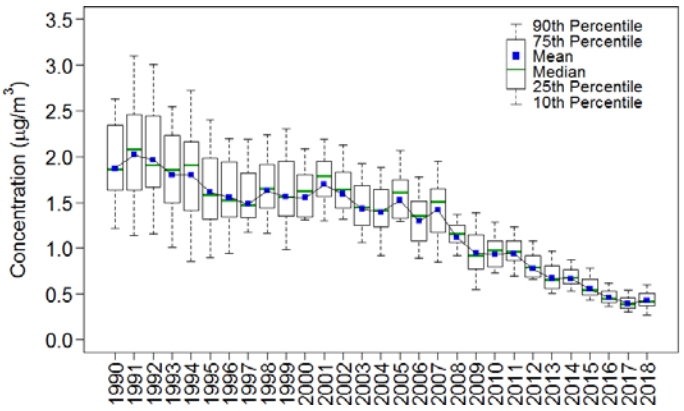
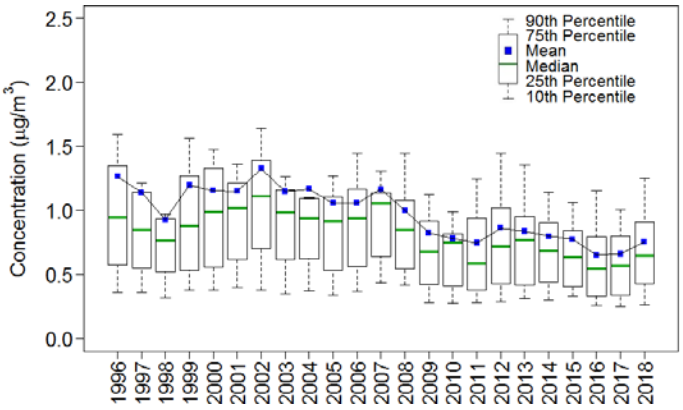


Figure 5. Trends in Second Quarter Mean Total NO_3^- Concentrations

Western Reference Sites



Eastern Reference Sites

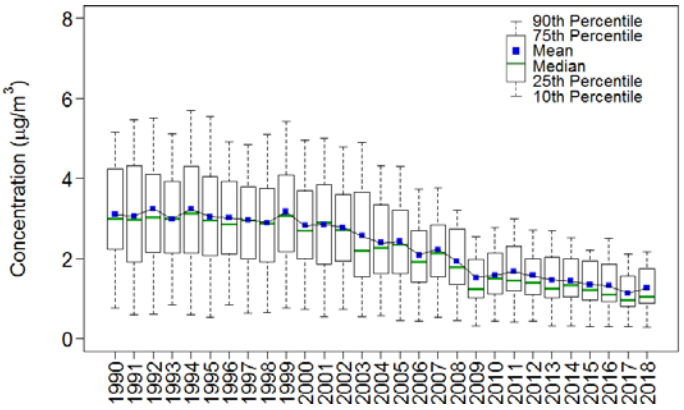
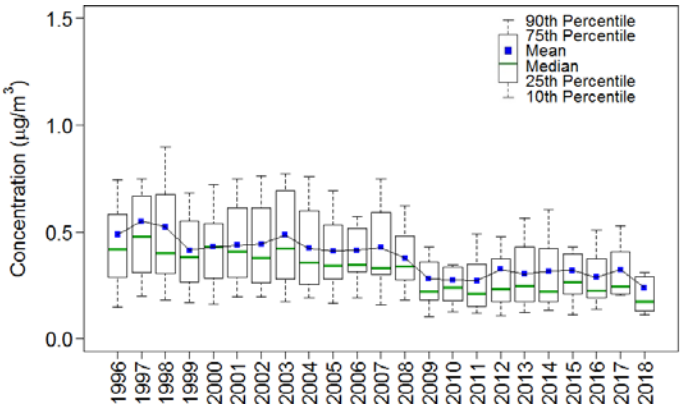


Figure 6. Trends in Second Quarter Mean SO_2 Concentrations

Western Reference Sites



Eastern Reference Sites

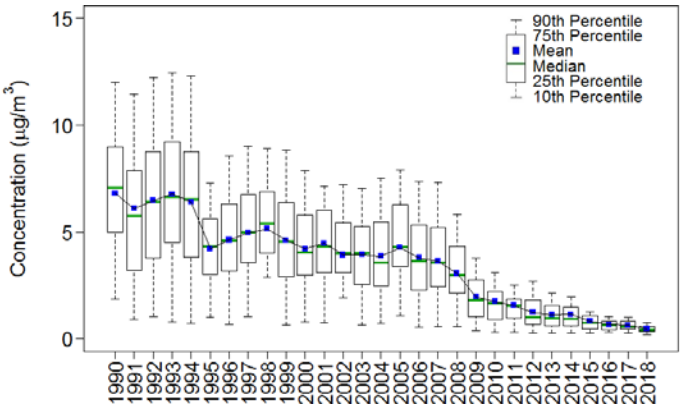
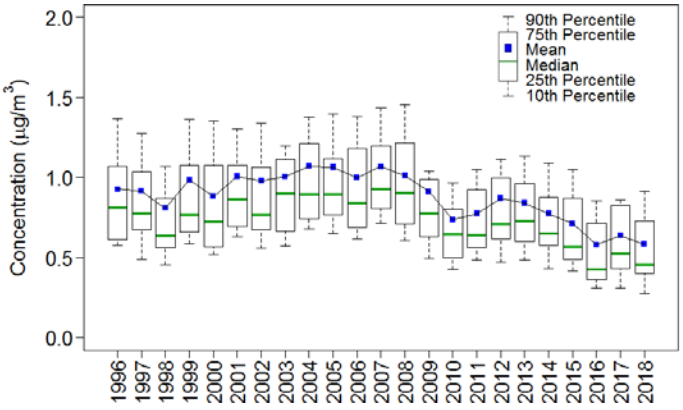


Figure 7. Trends in Second Quarter Mean SO_4^{2-} Concentrations

Western Reference Sites



Eastern Reference Sites

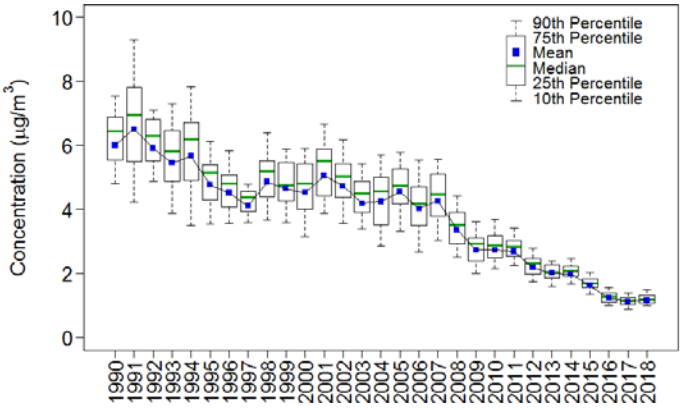
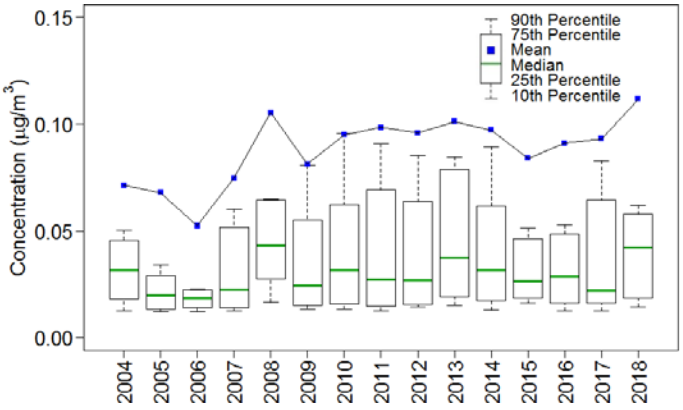


Figure 8. Trends in Second Quarter Mean Cl^- Concentrations

Western Reference Sites



Eastern Reference Sites

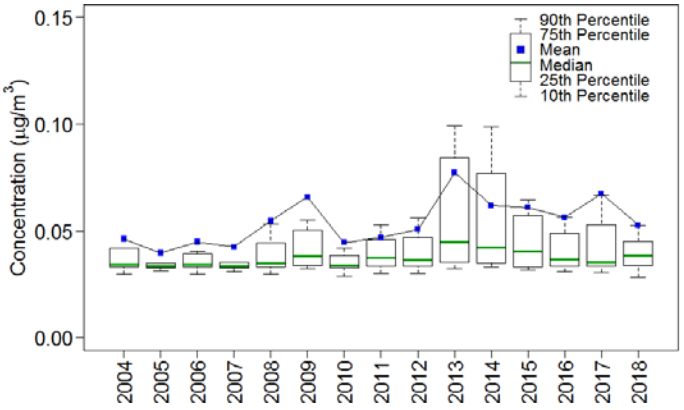
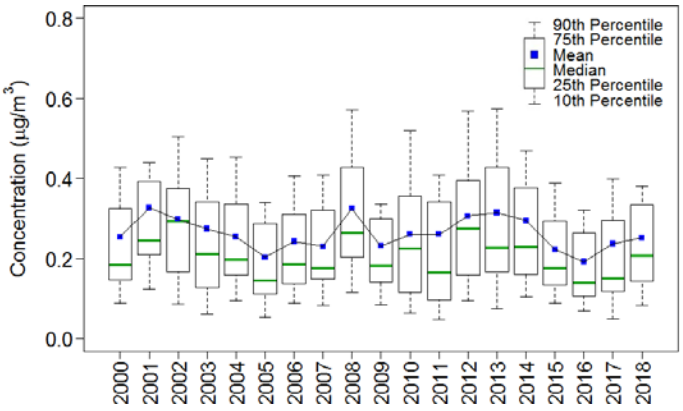


Figure 9. Trends in Second Quarter Mean Ca^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

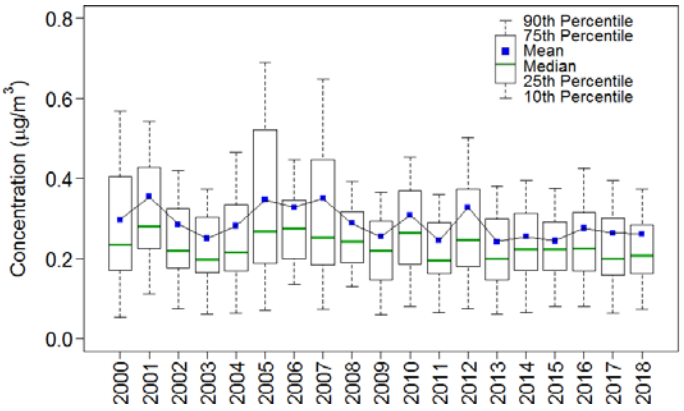
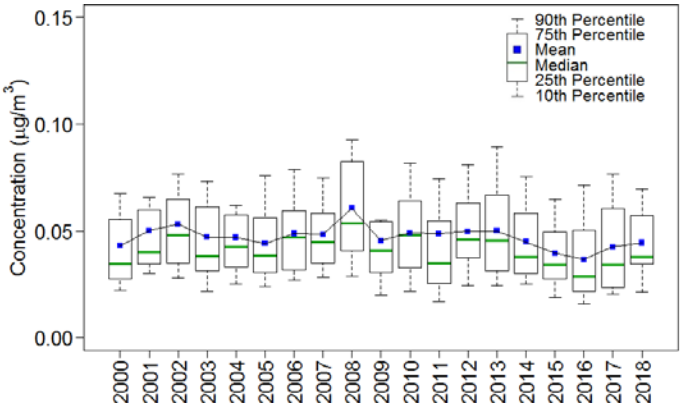


Figure 10. Trends in Second Quarter Mean K^{+} Concentrations

Western Reference Sites



Eastern Reference Sites

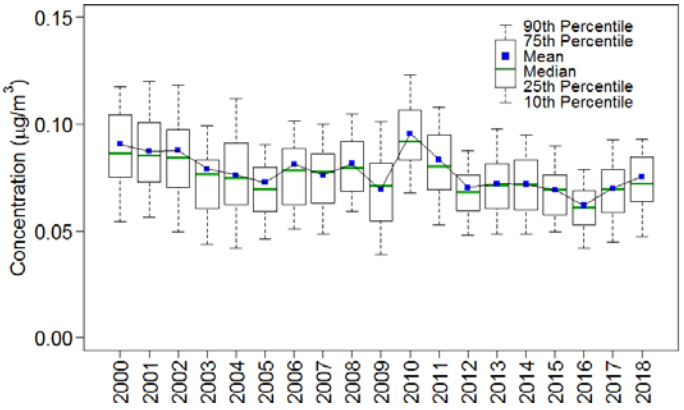
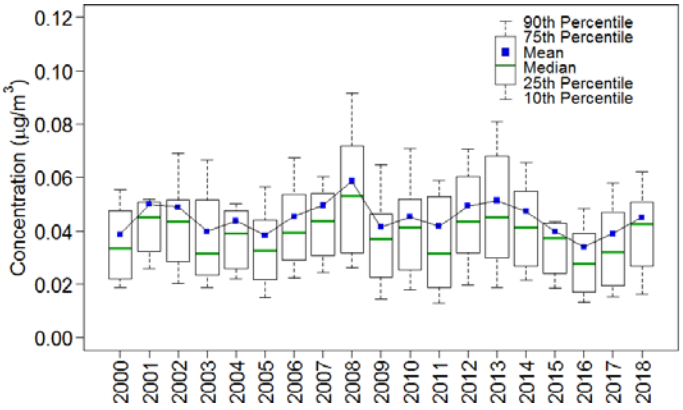


Figure 11. Trends in Second Quarter Mean Mg^{2+} Concentrations

Western Reference Sites



Eastern Reference Sites

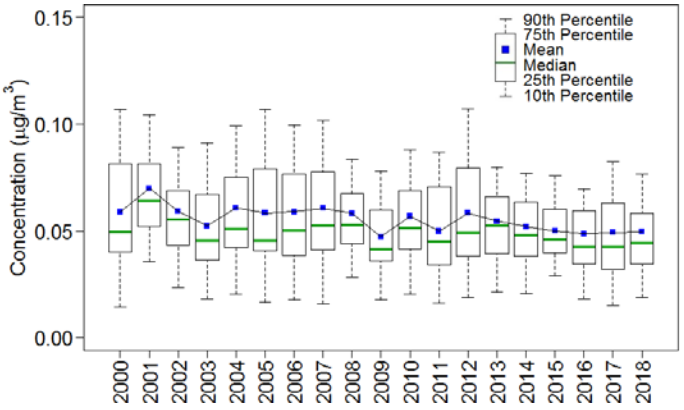
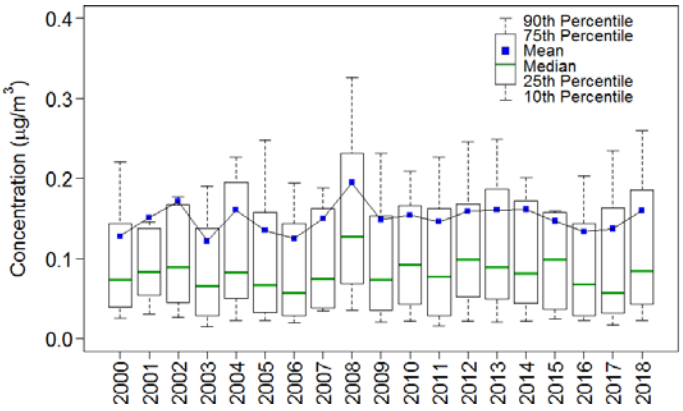


Figure 12. Trends in Second Quarter Mean Na^+ Concentrations

Western Reference Sites



Eastern Reference Sites

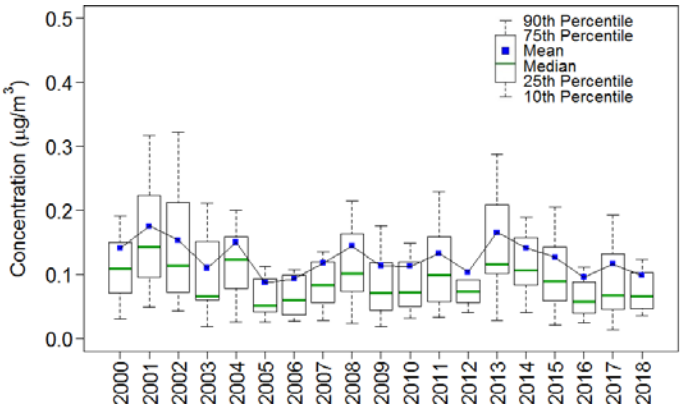
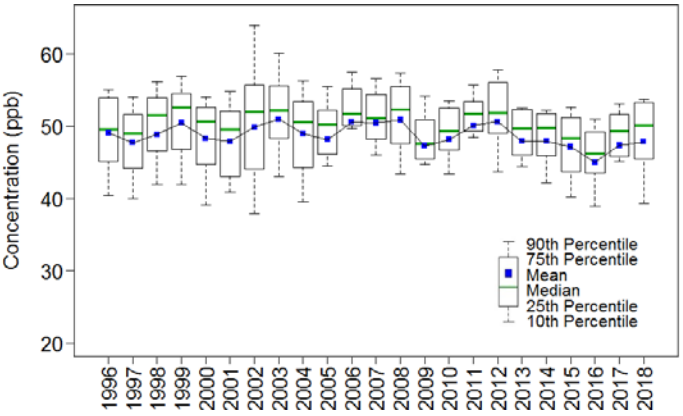
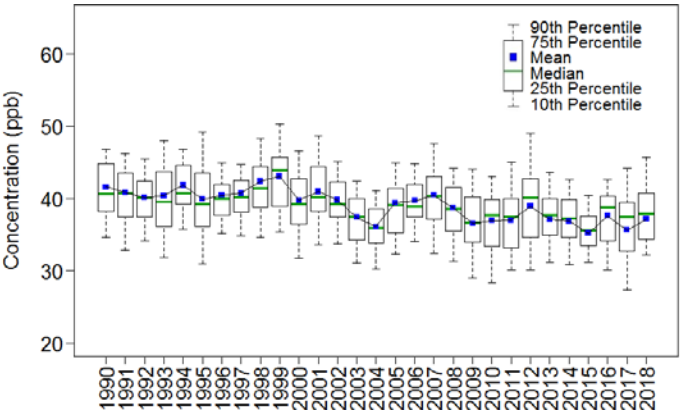


Figure 13. Trends in Second Quarter Mean O_3 Concentrations

Western Reference Sites



Eastern Reference Sites



Changes in 3-year Average Second 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 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 second 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	3.1	2.0	6.5	6.1	41
2016–2018	1.2	0.4	0.6	1.2	37
Percent Change	-61	-78	-91	-81	-10

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

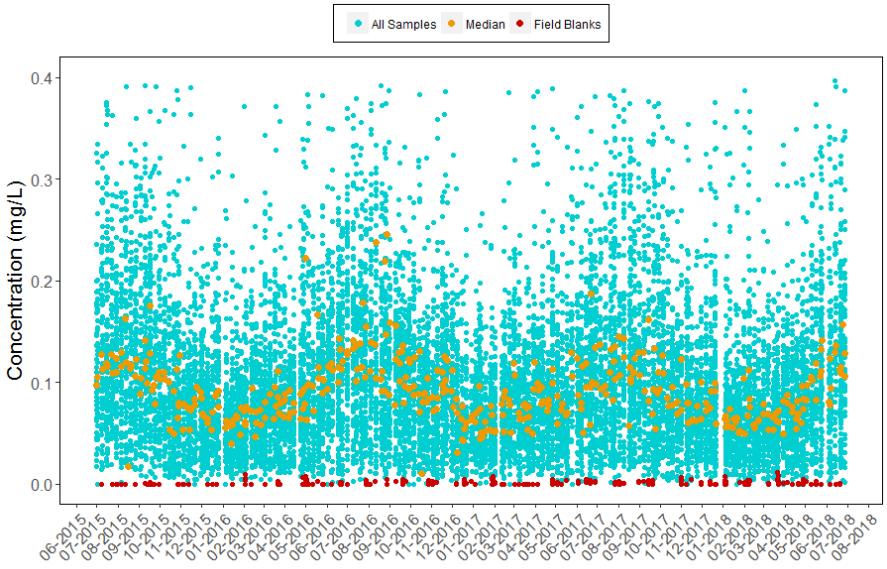
	Total NO_3^- ($\mu g/m^3$)	NH_4^+ ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	SO_4^{2-} ($\mu g/m^3$)	O_3 (ppb)
1996–1998	1.1	0.3	0.5	0.9	49
2016–2018	0.7	0.2	0.3	0.6	47
Percent Change	-38	-35	-46	-32	-4

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 third quarter 2015 through second quarter 2018. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

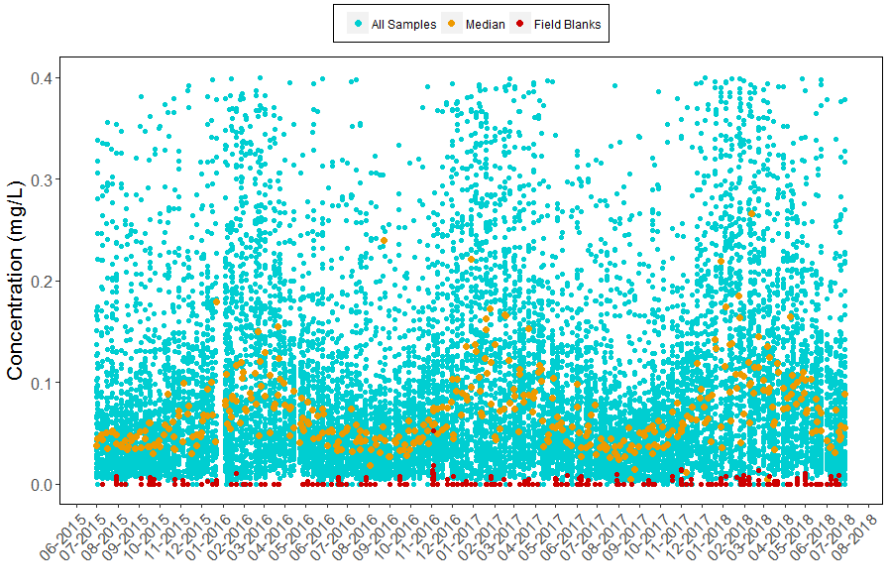
Review of filter pack analysis control charts during preparation of the First Quarter 2018 QA Report indicated possible potassium contamination (Figure 22). Note the field blank results at the end of the quarter. A corrective action was initiated. During the investigation, non-conformance to the established 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 washing and 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. Results from laboratory and field blanks will continue to be tested, and results will be included in the third quarter report.

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



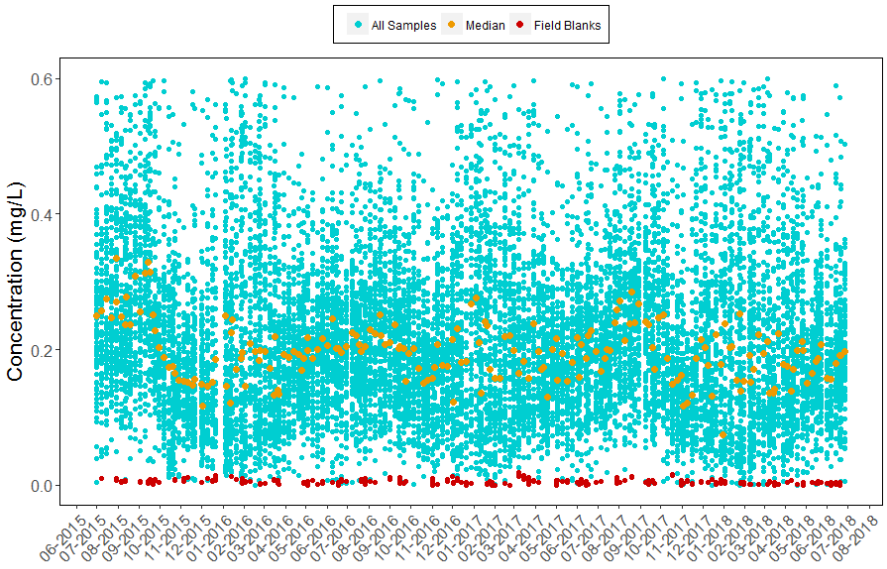
Note: Nominal reporting limit is 0.008 mg/L.

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



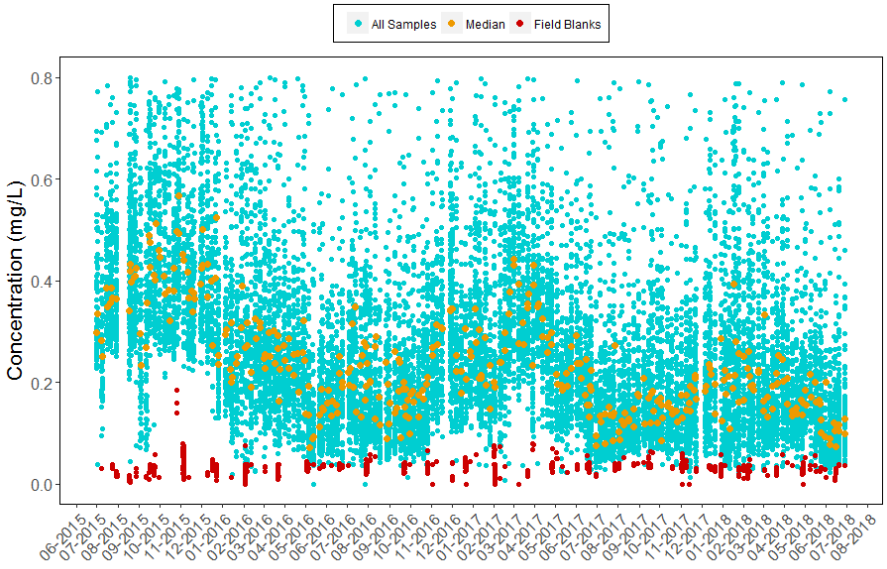
Note: Nominal reporting limit is 0.008 mg/L.

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



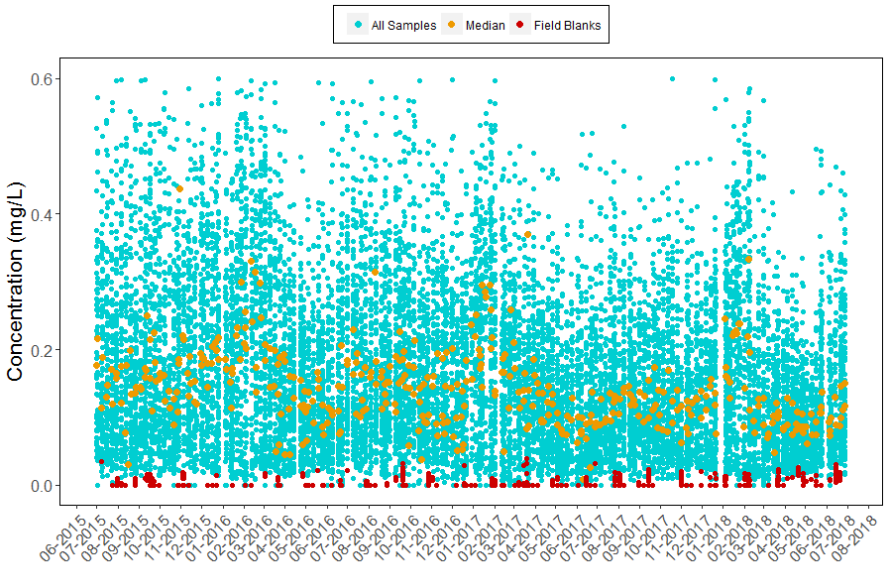
Note: Nominal reporting limit is 0.020 mg/L.

Figure 17. Concentrations of SO_2 from K_2CO_3 Impregnated Cellulose Filters



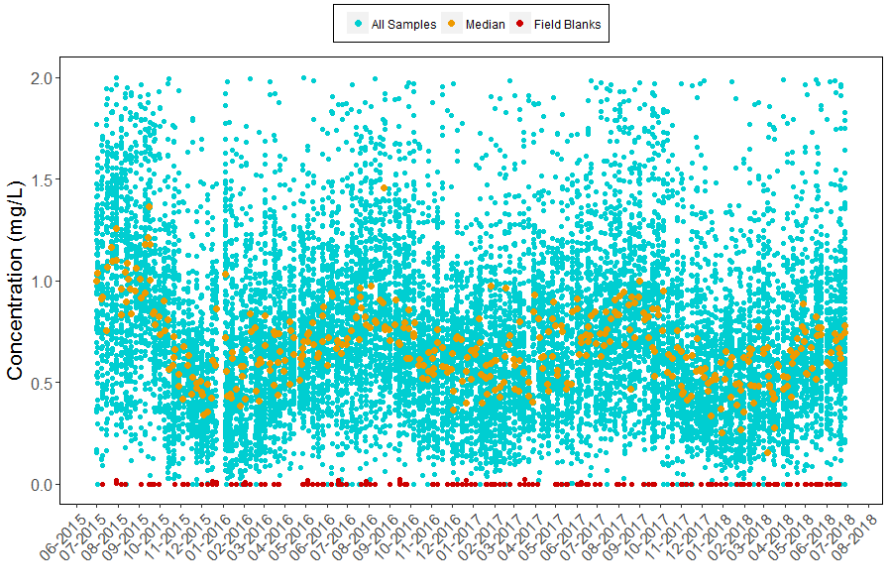
Note: Nominal reporting limit is 0.040 mg/L.

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



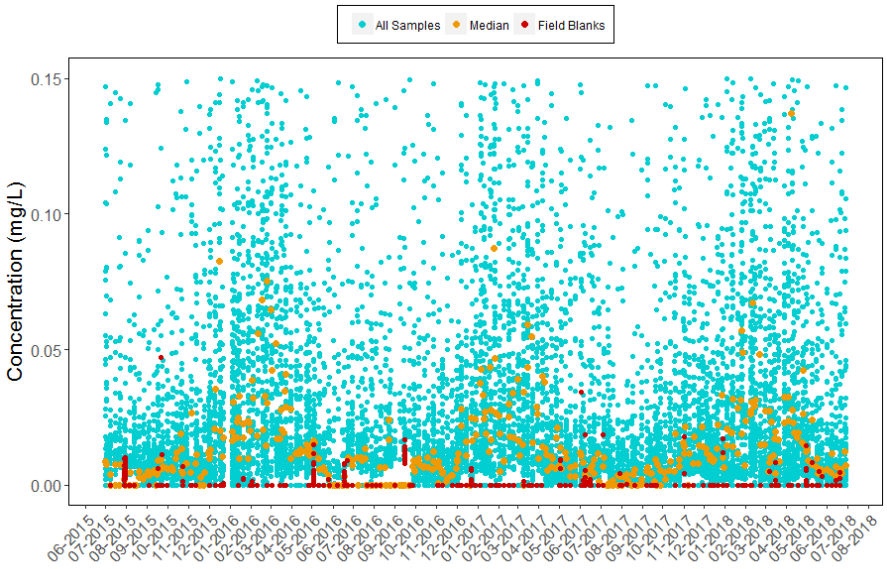
Note: Nominal reporting limit is 0.040 mg/L.

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



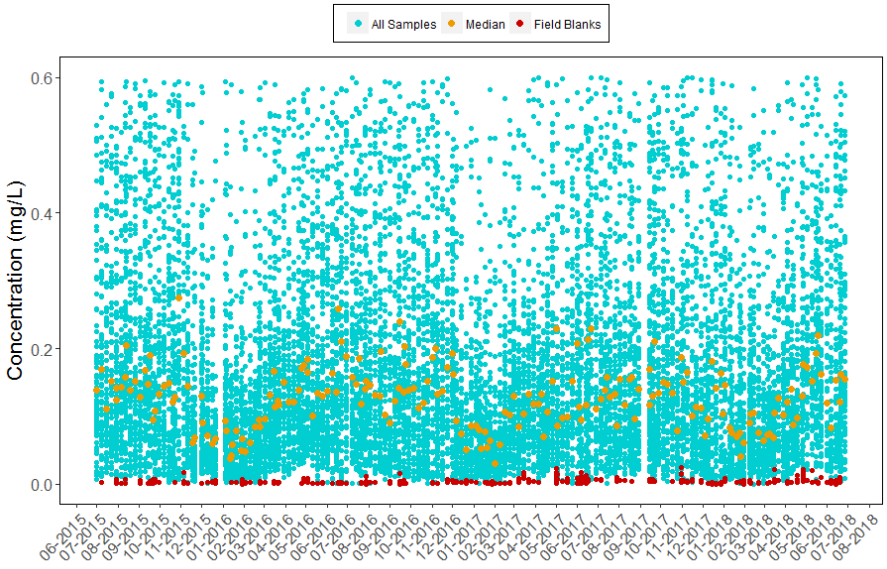
Note: Nominal reporting limit is 0.040 mg/L.

Figure 20. Concentrations of Cl^- from Teflon Filters



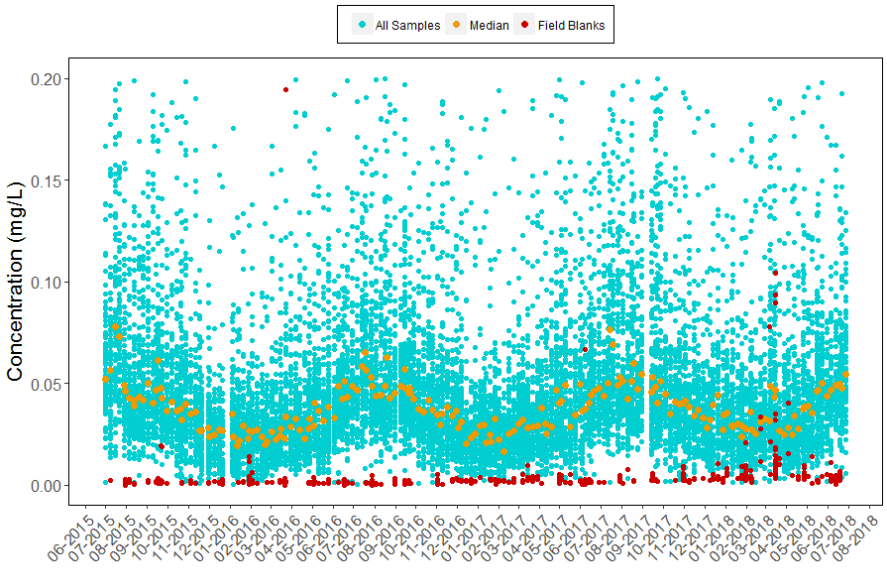
Note: Nominal reporting limit is 0.020 mg/L.

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



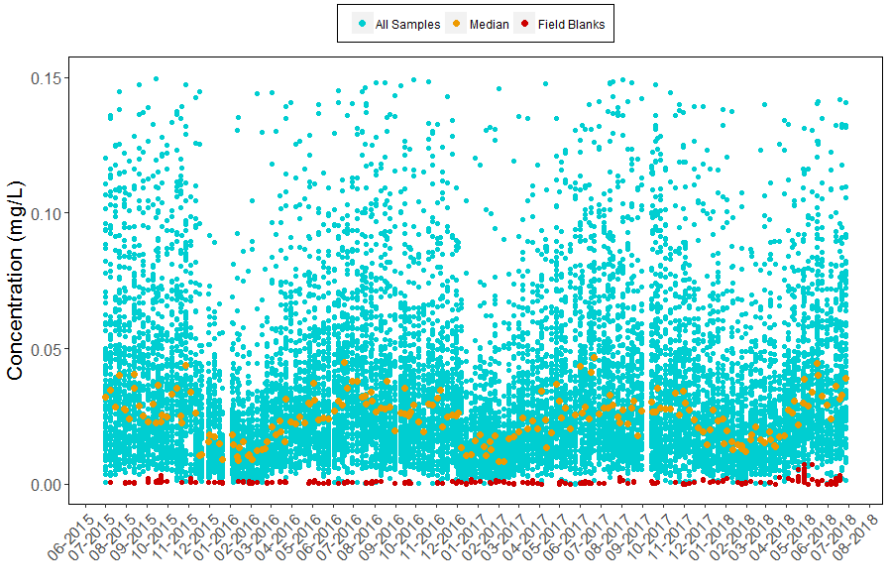
Note: Nominal reporting limit is 0.006 mg/L.

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



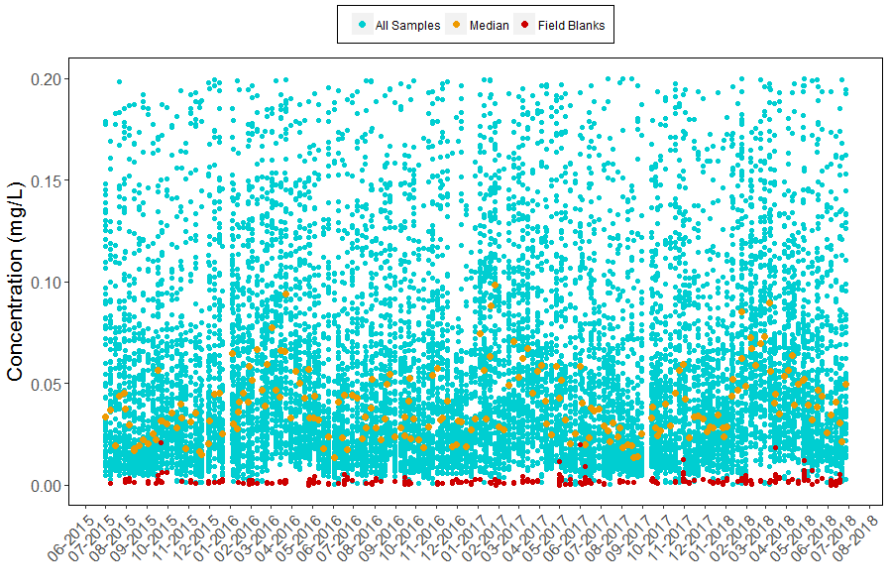
Note: Nominal reporting limit is 0.006 mg/L.

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

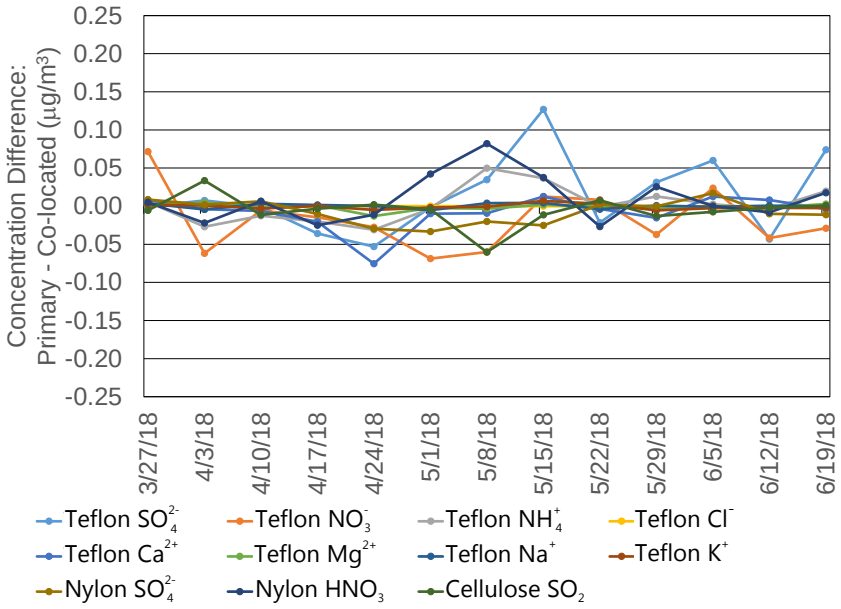
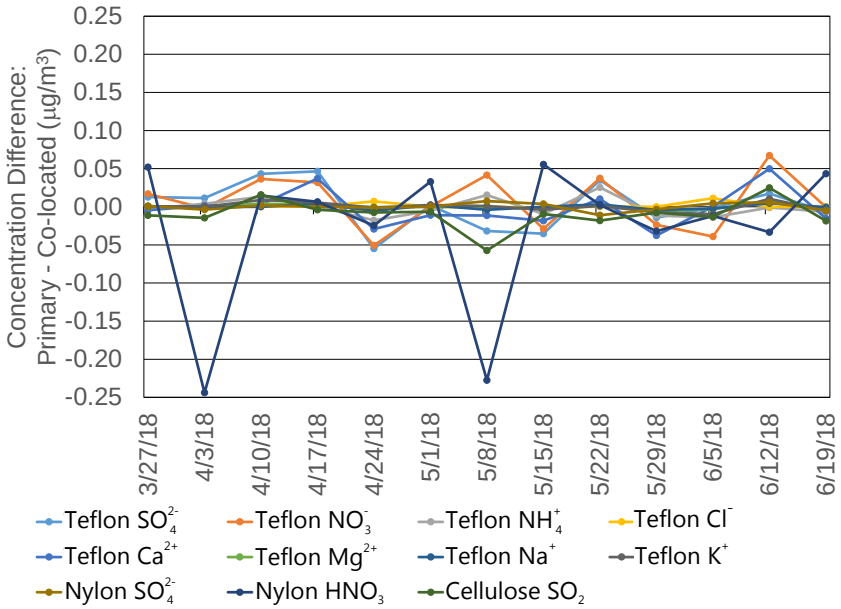


Figure 26. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



Precision of Filter Pack Concentrations

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

Table 3. Precision (MARPD) for Co-located Filter Pack Data during Second 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)	1.34	0.49	0.52	0.26	0.05	0.08	0.08	0.03	1.01	0.44	1.49
$\overline{Y}$ (µg/m^3)	1.32	0.51	0.52	0.27	0.05	0.08	0.08	0.03	1.00	0.46	1.49
MAD	0.04	0.03	0.02	0.02	0.00	0.00	0.00	0.00	0.03	0.02	0.03
MARPD	3.22	6.74	3.47	7.26	9.01	3.11	3.68	0.34	3.06	4.38	2.49
ROM406/206, CO											
$\overline{X}$ (µg/m^3)	0.54	0.36	0.19	0.26	0.04	0.05	0.05	0.02	0.50	0.17	0.86
$\overline{Y}$ (µg/m^3)	0.54	0.35	0.19	0.25	0.04	0.05	0.05	0.02	0.55	0.19	0.89
MAD	0.03	0.04	0.01	0.03	0.00	0.00	0.01	0.00	0.08	0.02	0.09
MARPD	5.65	9.86	6.62	11.33	8.71	6.90	13.26	7.29	16.75	13.23	11.28

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 Second 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
STK138, IL	46.2	46.2	46.2	46.2	46.2	46.2	46.2	46.2	The site operator passed away unexpectedly. A trained site operator was not available for six weeks. No filter packs were installed during this time.
GRS420, TN	61.5	61.5	61.5	61.5	61.5	61.5	61.5	61.5	Filter pack flow data were invalidated for five samples due to a system leak.
CKT136, KY	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	Four samples were invalidated for suspect values.
UND002, VT	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	Four samples were invalidated due to intermittent power failures.
WFM105, NY	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	One sample was invalidated due to a power failure. Three samples were invalidated due to a flow system leak.
LAV410, CA	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	Filter pack flow data were invalidated for three samples due to a system leak.
ANA115, MI	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The period includes a 3-week sample.
NEC602, WY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	One sample was invalidated for suspect values.

Precision of Ozone Concentrations

Time series of co-located hourly O_3 concentration differences for second 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

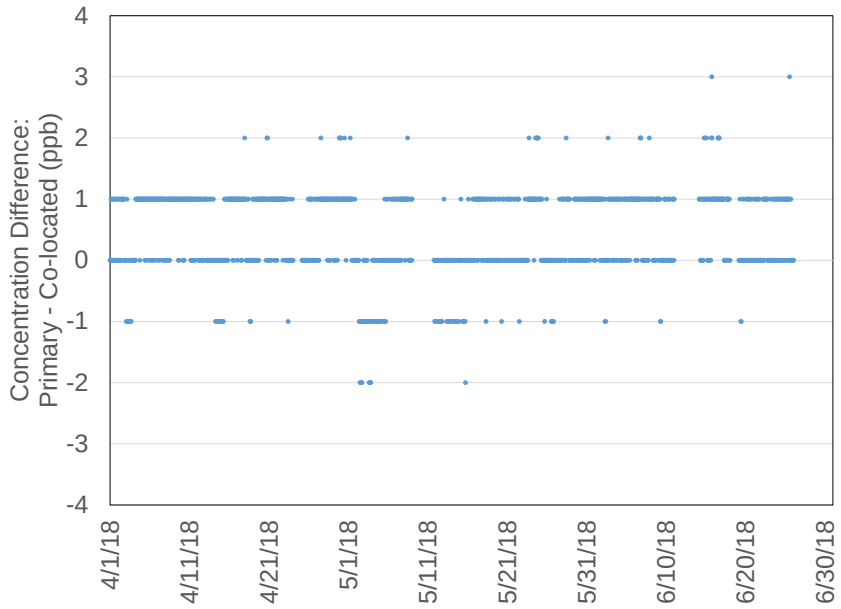


Figure 28. Time Series of the Differences in Co-located O_3 Concentrations for ROM406/206, CO

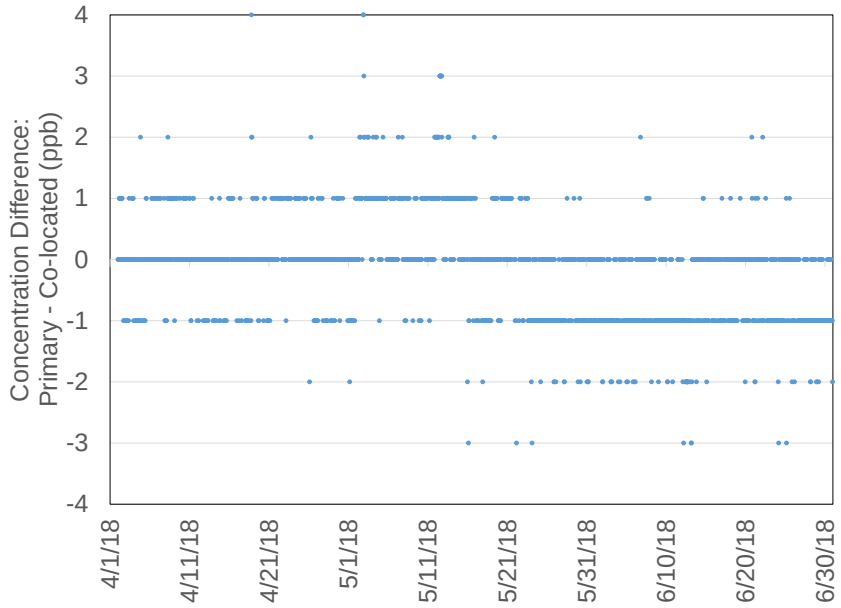


Table 5 gives MARPD data for O_3 data measured at the two co-located sites.

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

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	3	7/1/17	0.9	1932
	4	10/1/17	1.8	2041
	1	1/1/18	2.1	1979
	2	4/1/18	1.5	1786
ROM406/206, CO				
	3	7/1/17	1.3	1716
	4	10/1/17	0.8	2074
	1	1/1/18	0.6	2023
	2	4/1/18	1.3	2064

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	Q2 2018	Q3 2016–Q2 2018	Comments
GAS153, GA	47.1	84.7	The analyzer malfunctioned and was replaced 5/11/2018.
SND152, AL	84.6	93.7	The analyzer malfunctioned and was replaced 6/13/2018.
CDZ171, KY	85.2	89.8	A router malfunction resulted in missing data from 5/30/2018 through 6/7/2018. Analyzer bench temperatures were outside of criteria from 6/7/2018 through 6/12/2018.
CHC432, NM	85.7	92.8	Station temperature was either too high or too low intermittently from late April through May.
QAK172, OH	85.8	91.9	The analyzer malfunctioned and was replaced 5/4/2018.
CAN407, UT	86.0	95.5	The ozone analyzer pump failed from 4/13/2018 through 4/24/2018.
ESP127, TN	87.5	96.4	The analyzer malfunctioned and was replaced 4/13/2018. There were polling issues 6/28/2018 through 6/30/2018.
MCK131, KY	88.7	94.2	System moisture issues resulted in QC check failures and subsequent invalidation of associated ambient 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 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. Ratios of NO_y to total NO_3^- varied from 3.16 at PNF126 to 4.73 at BVL130.

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

Site ID	Elevation	Total NO_3^- (ppb)	NO_y (ppb)	Ratio
DUK008, NC	164	0.50	2.27	4.64
BVL130, IL	213	1.09	5.08	4.73
HWF187, NY	497	0.15	0.56	3.83
PNF126, NC	1216	0.32	0.90	3.16
PND165, WY	2386	0.16	0.52	3.34
ROM206, CO	2742	0.26	1.16	4.37

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

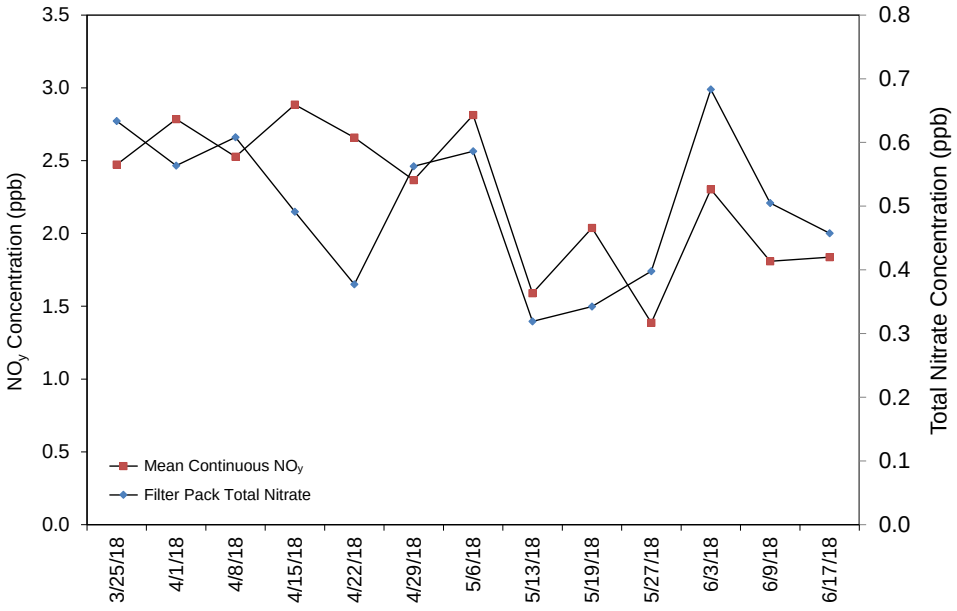


Figure 30. Comparison of BVL130 Weekly Mean NO_y and Total NO_3^- Concentrations

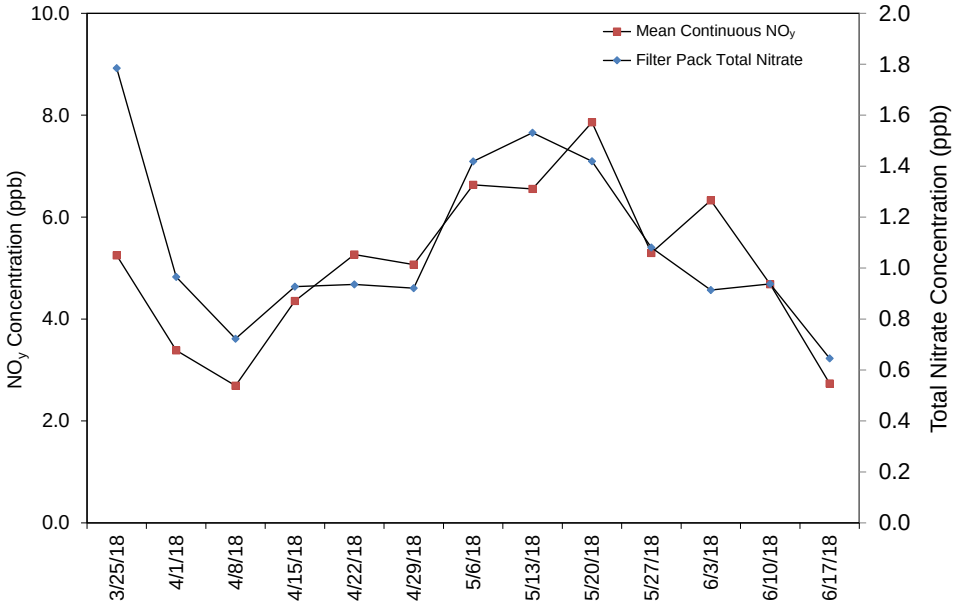


Figure 31. Comparison of HWF187 Weekly Mean NO_y and Total NO_3^- Concentrations

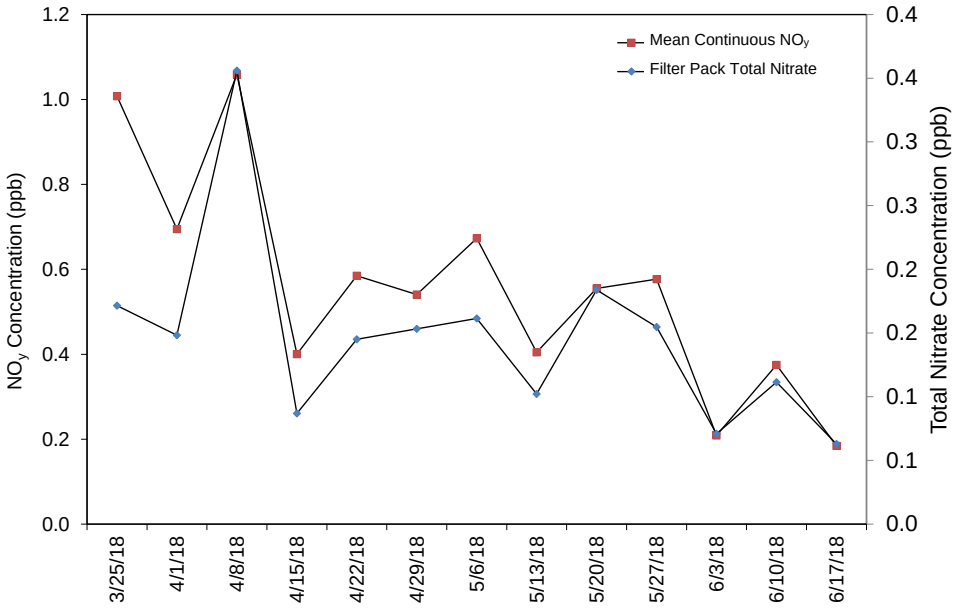


Figure 32. Comparison of PNF126 Weekly Mean NO_y and Total NO_3^- Concentrations

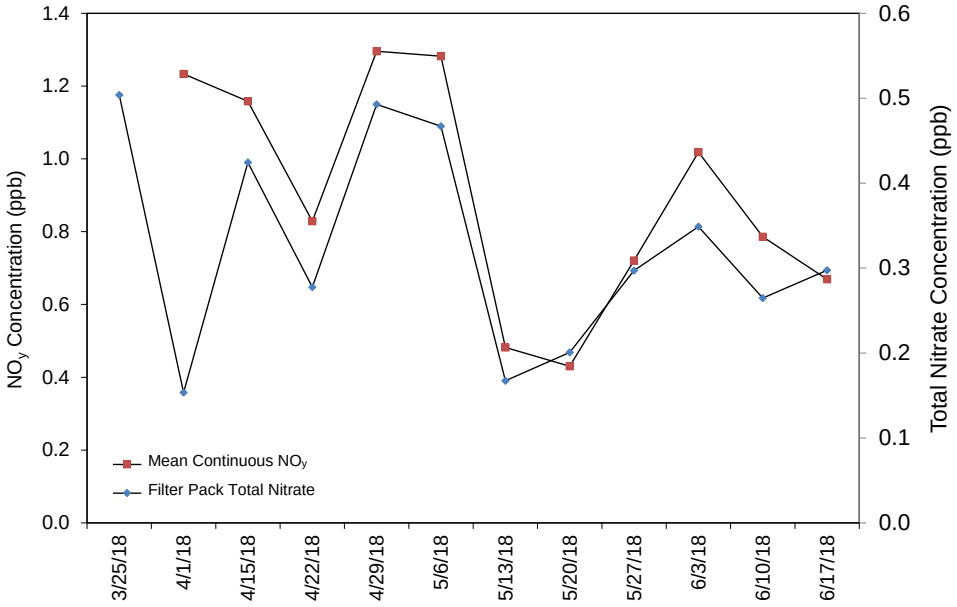


Figure 33. Comparison of PND165 Weekly Mean NO_y and Total NO_3^- Concentrations

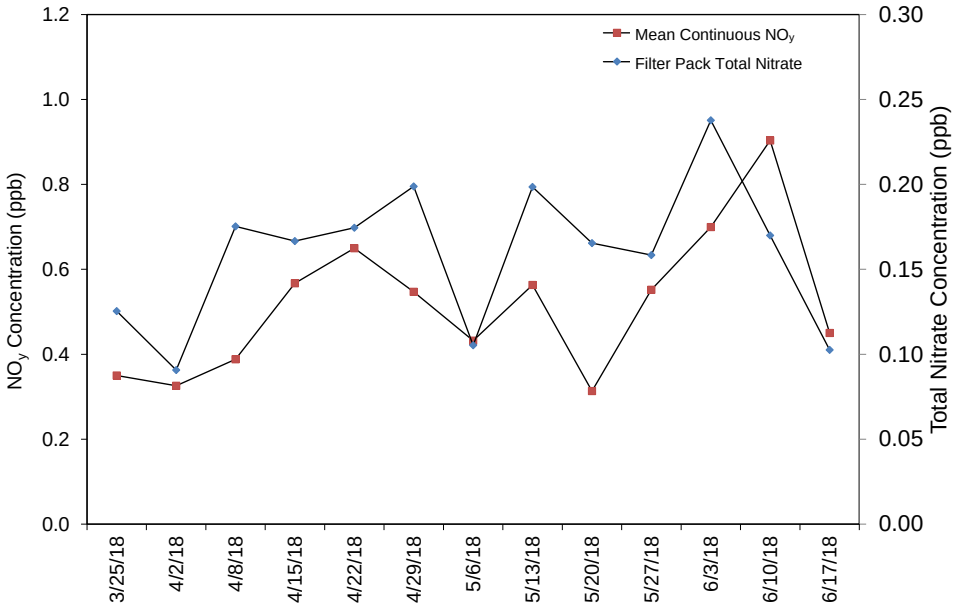
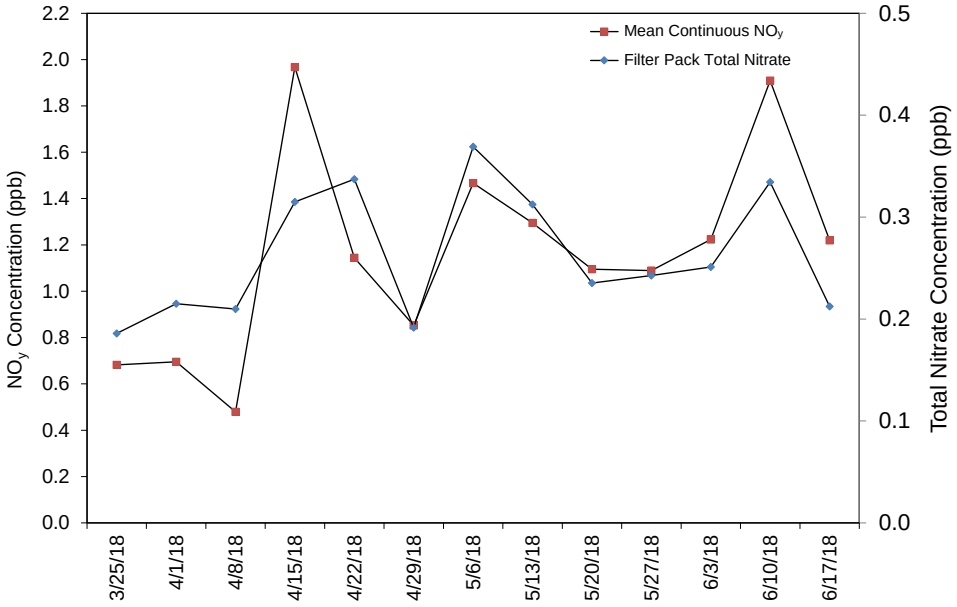


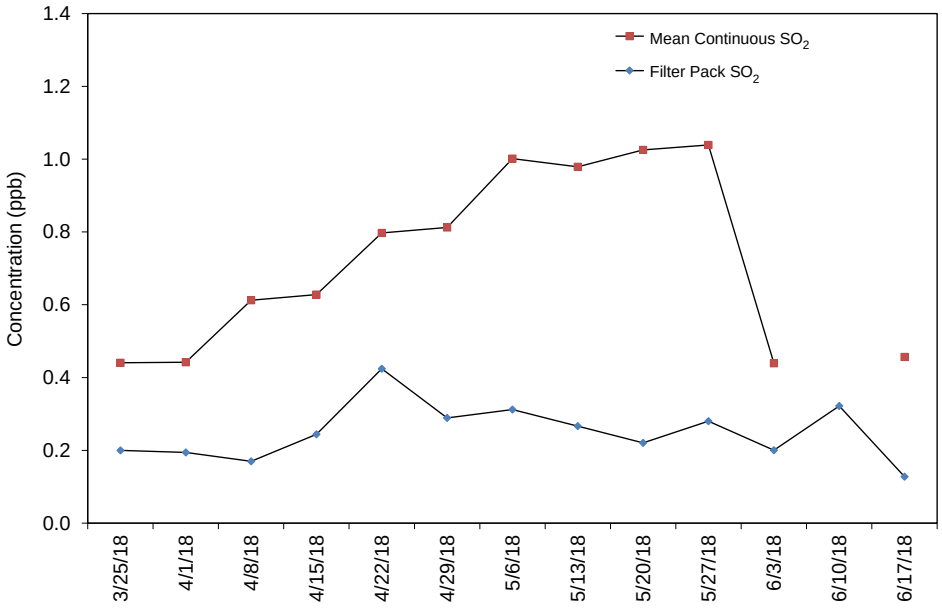
Figure 34. Comparison of ROM206 Weekly Mean NO_y and Total NO_3^- Concentrations



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 second quarter 2018 are shaded. During second quarter, only one parameter at one site had less than 80 percent completeness. A comment on the low data completeness is 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	Q2 2018	Q3 2017 – Q2 2018	Comment
BVL130, IL	CO	76	83	The site had several zsp QC failures in April.
	NO	92	92	
	NOY	92	92	
	NOYDIF	92	92	
	SO2_GA	88	88	
DUK008, NC	HNO3	87	72	
	NH3	87	57	
	NO	87	83	
	NO2_TRUE	87	83	
	NOX_TRUE	87	83	
	NOY	87	72	
	NOY_MINUS	87	83	
	NOYDIF	87	72	
	TNX	87	66	
HWF187, NY	NO	94	94	
	NOY	94	94	
	NOYDIF	94	94	
PND165, WY	NO	92	87	
	NOY	92	87	
	NOYDIF	92	86	
	NO	92	79	
	NOY	92	79	
	NOYDIF	92	79	
ROM206, CO	NO	95	94	
	NOY	95	94	
	NOYDIF	95	94	

Note: zsp = zero/span/precision

References

Wood Environment & Infrastructure Solutions, Inc. (formerly known as Amec Foster Wheeler Environment & Infrastructure, Inc.) 2018. *Clean Air Status and Trends Network (CASTNET) Second Quarter 2018 Quality Assurance Report.* https://java.epa.gov/castnet/documents.do