

Clean Air Status and Trends Network (CASTNET) Quarterly Data Summary for Third Quarter 2020 (July through September)

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 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 third quarter data and include completeness and precision of filter concentrations and hourly O₃ concentrations. This report also analyzes data for continuous, trace-level NO_y from eight sites and continuous SO₂ concentrations from three sites. Other QC statistics are given in the CASTNET Third Quarter 2020 Quality Assurance Report (Wood, 2020).

Figure 1. Fourth Highest Daily Maximum 8-hour Average O₃ Concentrations (ppb) through Third Quarter 2020



Figure 1 shows fourth highest daily maximum 8-hour average (DM8A) O₃ concentrations measured through third quarter 2020. Four sites in California and the monitor at Rocky Mountain National Park (ROM406) exceeded the 0.070 parts per million (ppm) National Ambient Air Quality Standard for O₃. No eastern sites exceeded the standard.

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, NO₃⁻, NH₄⁺, total NO₃⁻, SO₂, SO₄²⁻, Ca²⁺, and Na⁺ concentrations decreased at eastern sites in 2020, and Cl⁻, K⁺, and Mg²⁺ concentrations increased. Quarterly mean HNO₃, NO₃⁻, NH₄⁺, total NO₃⁻, SO₂, SO₄²⁻, Ca²⁺, K⁺, and Mg²⁺ concentrations increased at western sites in 2020 while Cl⁻ and Na⁺ concentrations decreased.

Quarterly O₃ concentrations were analyzed using box plots constructed by averaging all valid hourly O₃ concentrations within third 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 O₃ concentrations at eastern sites. Mean O₃ concentrations at western sites increased in third quarter 2020. Quarterly mean concentrations were higher at the western reference sites than at the eastern sites.

Figure 2. Trends in Third Quarter Mean HNO₃ Concentrations

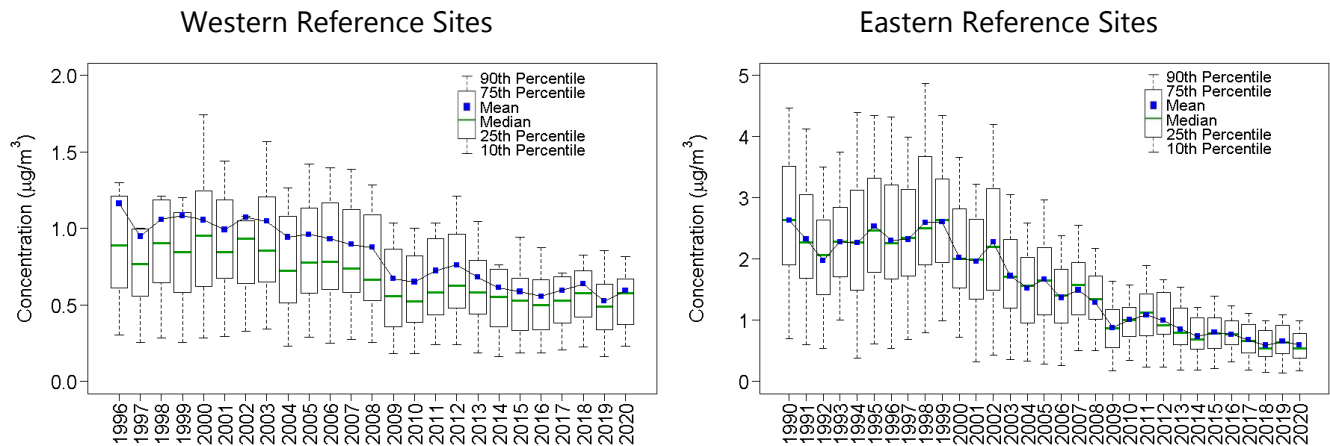


Figure 3. Trends in Third Quarter Mean NO₃ Concentrations

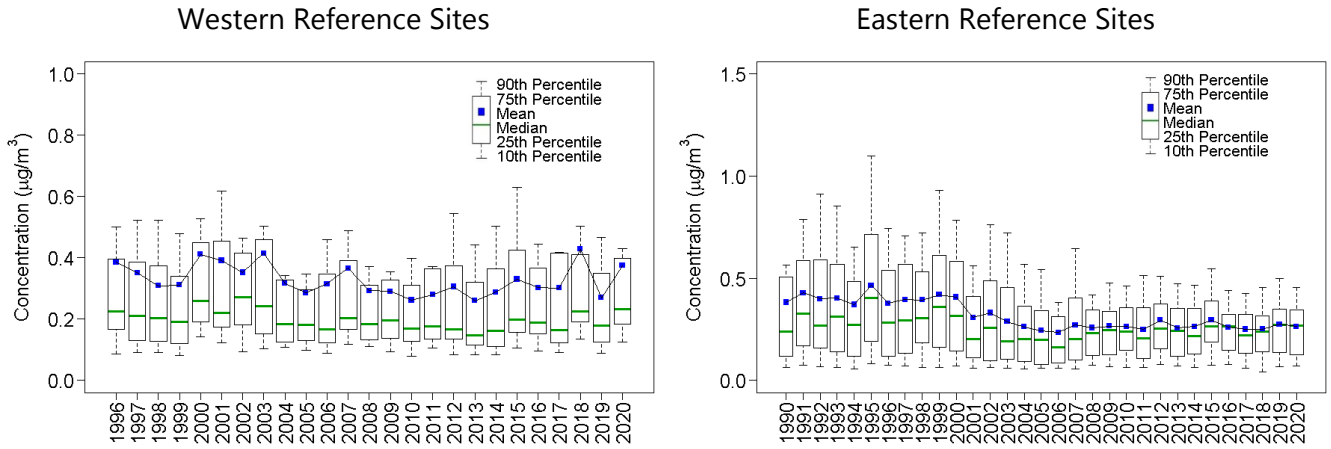


Figure 4. Trends in Third Quarter Mean NH₄ Concentrations

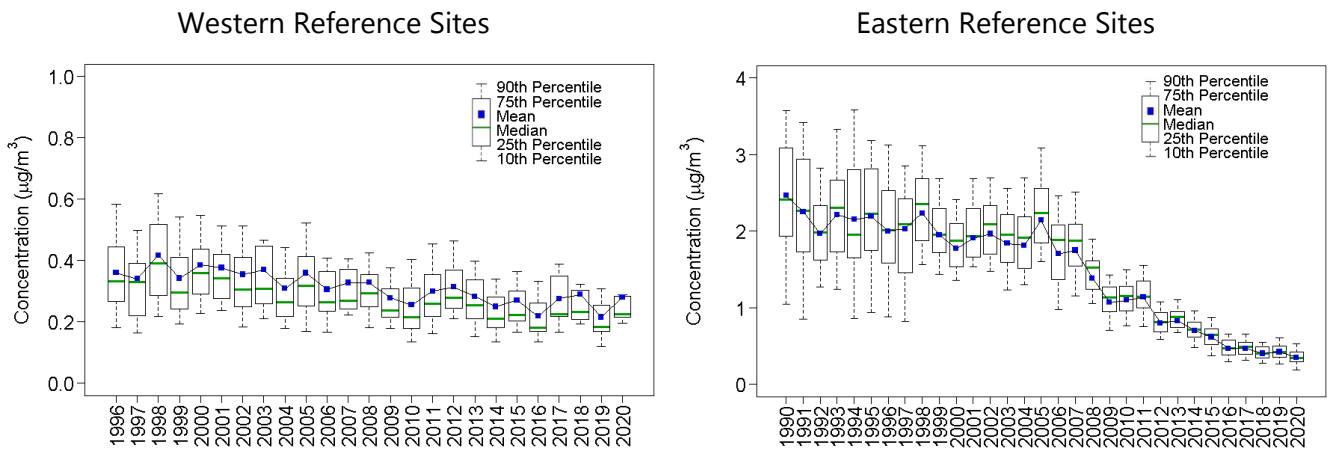


Figure 5. Trends in Third Quarter Mean Total NO₃ Concentrations

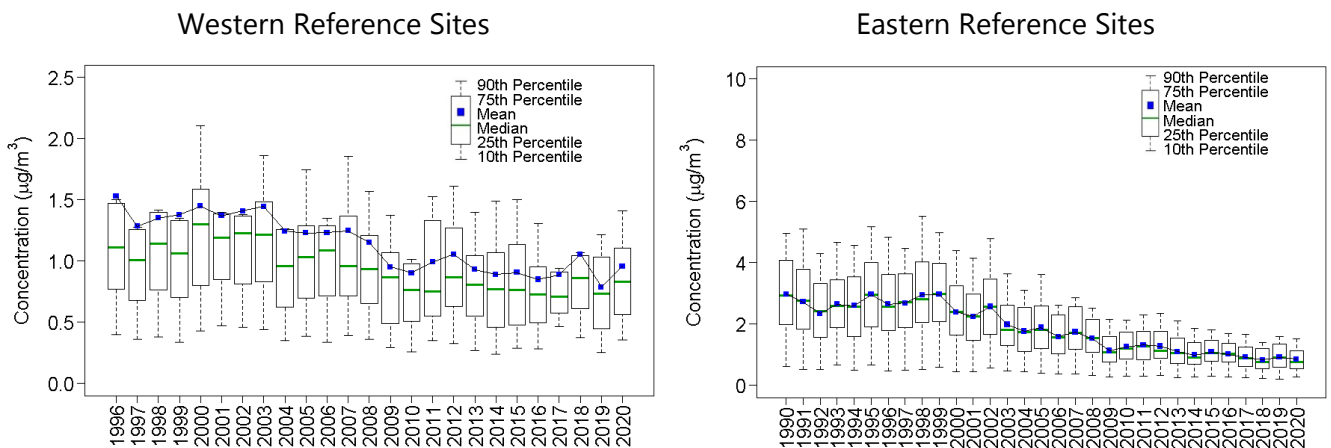


Figure 6. Trends in Third Quarter Mean SO₂ Concentrations

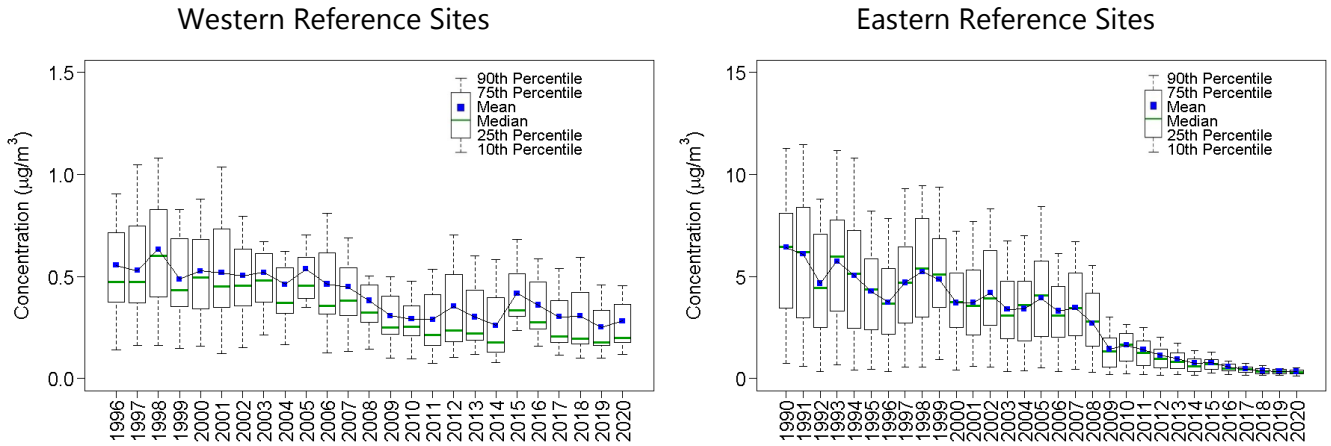


Figure 7. Trends in Third Quarter Mean SO₄²⁻ Concentrations

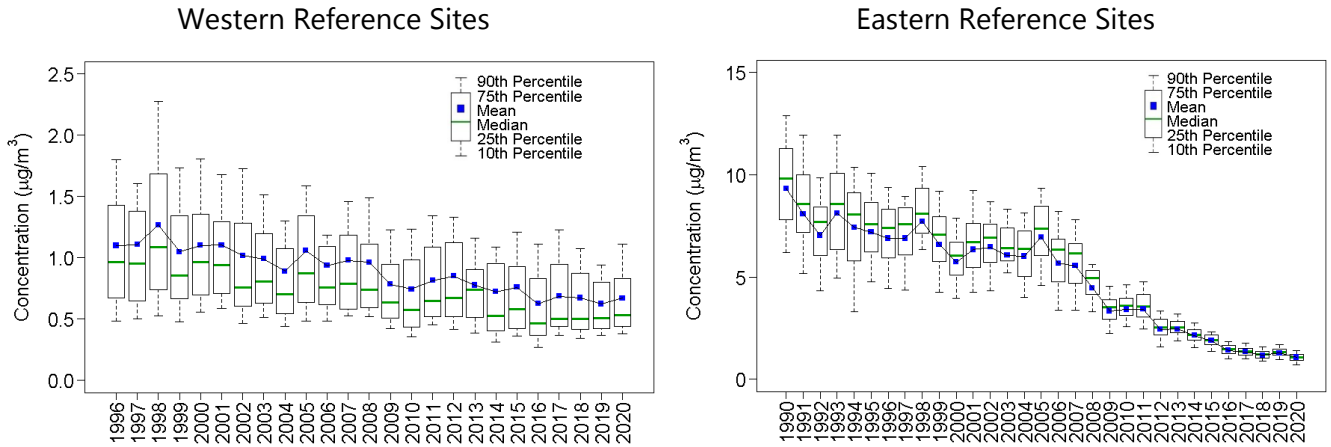


Figure 8. Trends in Third Quarter Mean Cl⁻ Concentrations

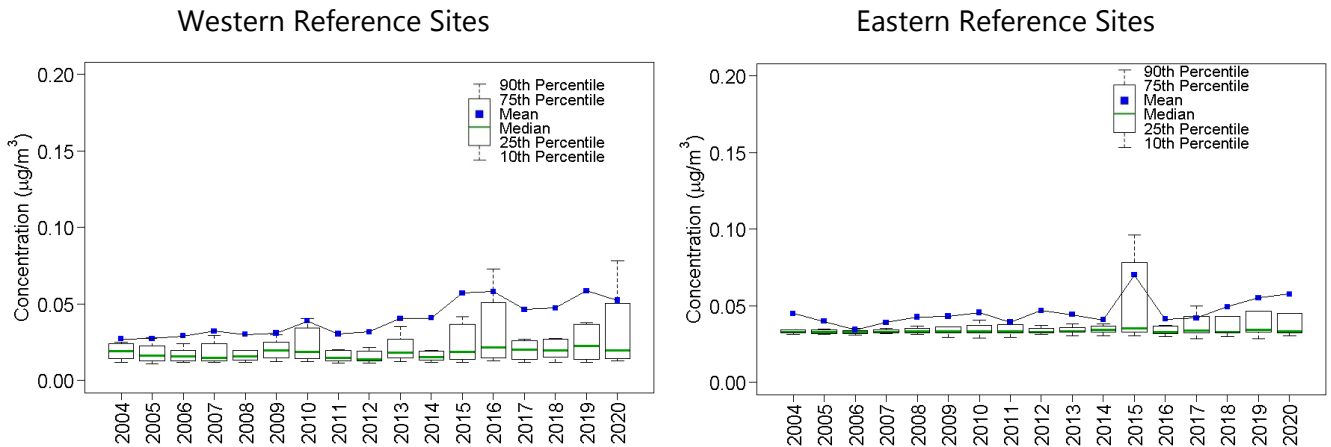


Figure 9. Trends in Third Quarter Mean Ca²⁺ Concentrations

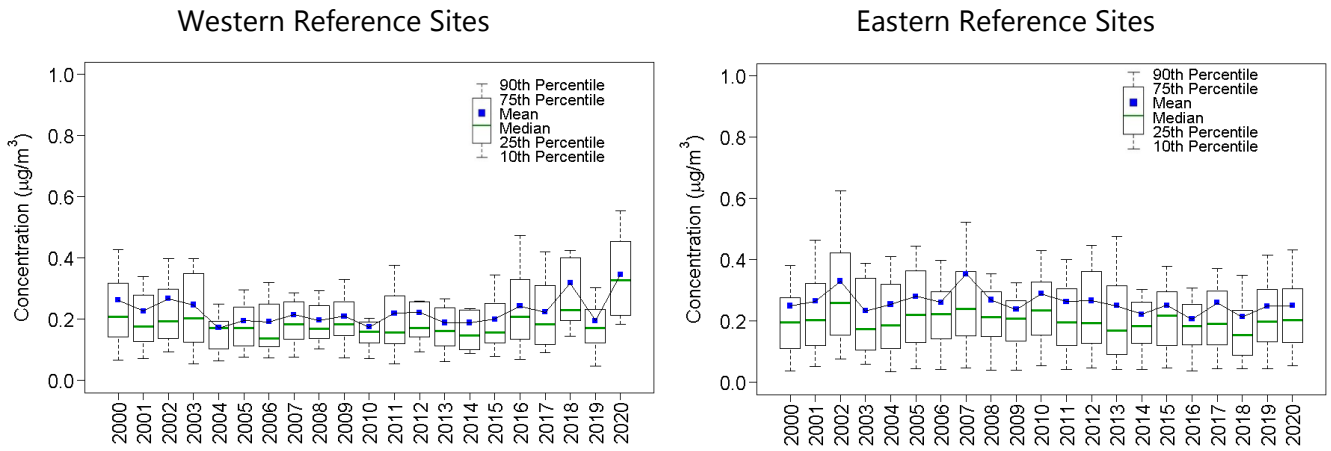


Figure 10. Trends in Third Quarter Mean K⁺ Concentrations

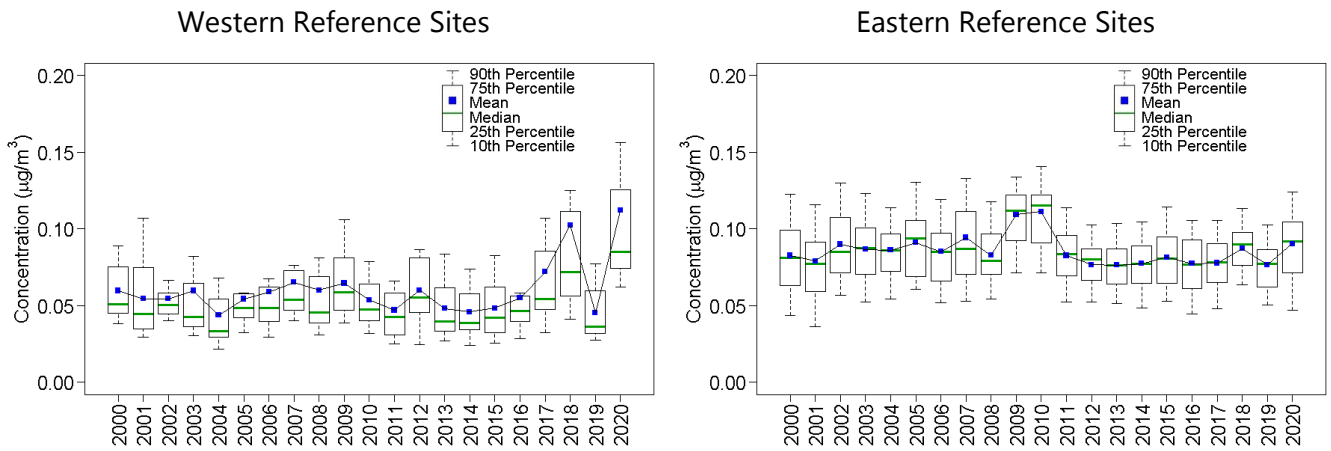


Figure 11. Trends in Third Quarter Mean Mg²⁺ Concentrations

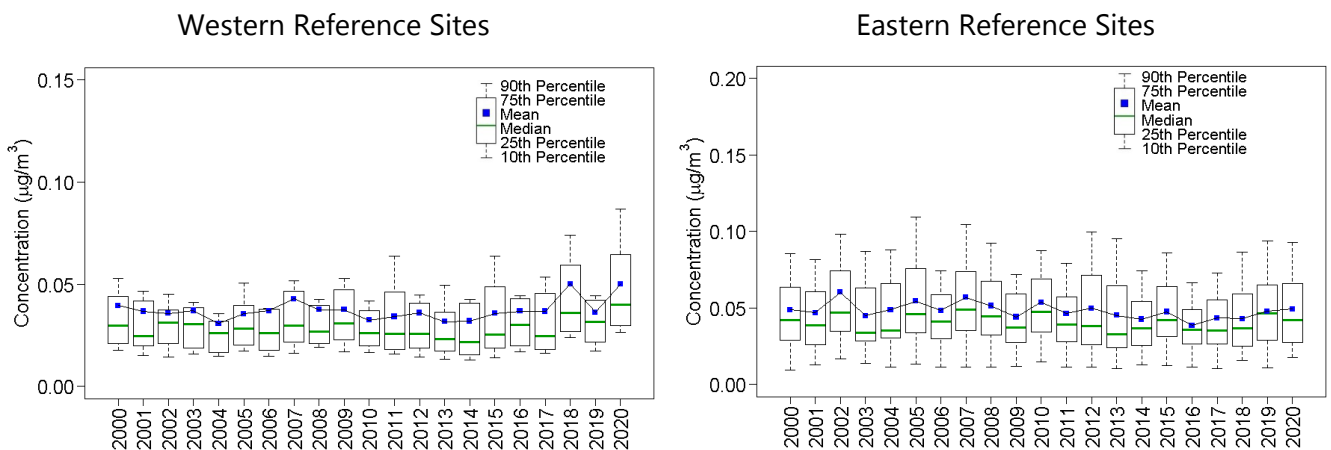


Figure 12. Trends in Third Quarter Mean Na⁺ Concentrations

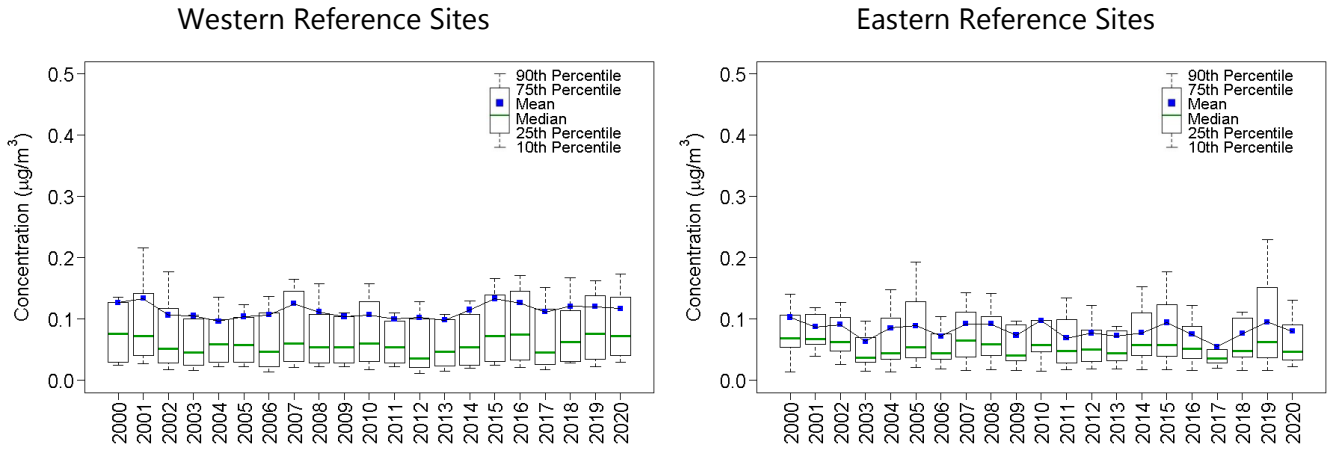
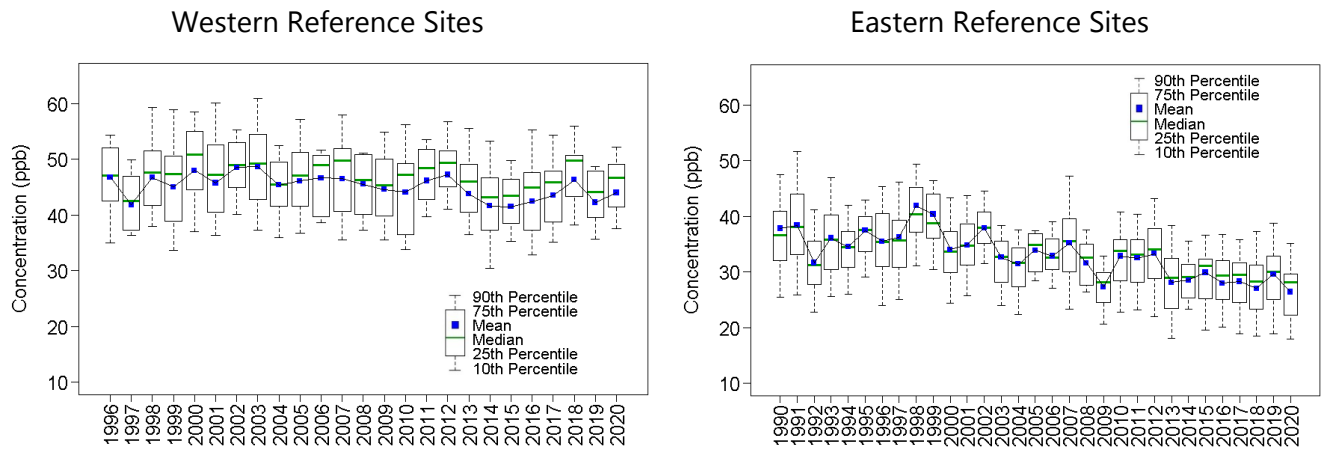


Figure 13. Trends in Third Quarter Mean O₃ Concentrations



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 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 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
2018–2020	0.9	0.4	0.4	1.2	28
Percent Change	-68	-82	-94	-86	-23

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

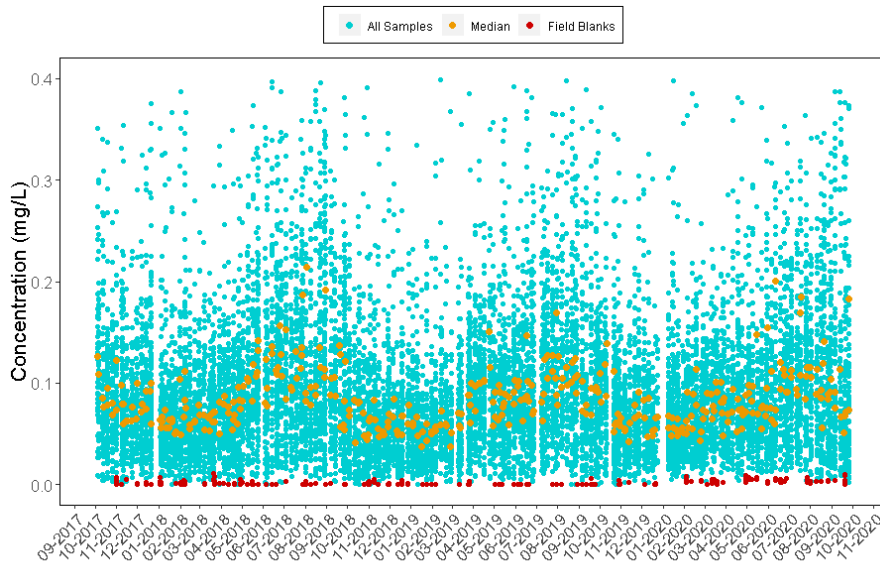
	Total NO ₃ ⁻ (µg/m ³)	NH ₄ ⁺ (µg/m ³)	SO ₂ (µg/m ³)	SO ₄ ²⁻ (µg/m ³)	O ₃ (ppb)
1996–1998	1.4	0.4	0.6	1.2	45
2018–2020	0.9	0.3	0.3	0.7	44
Percent Change	-33	-30	-51	-43	-2

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 in milligrams per liter (mg/L) of 11 parameters from fourth quarter 2017 through third quarter 2020. These figures provide indications of potential issues with concentration measurements relative to detection and reporting limits.

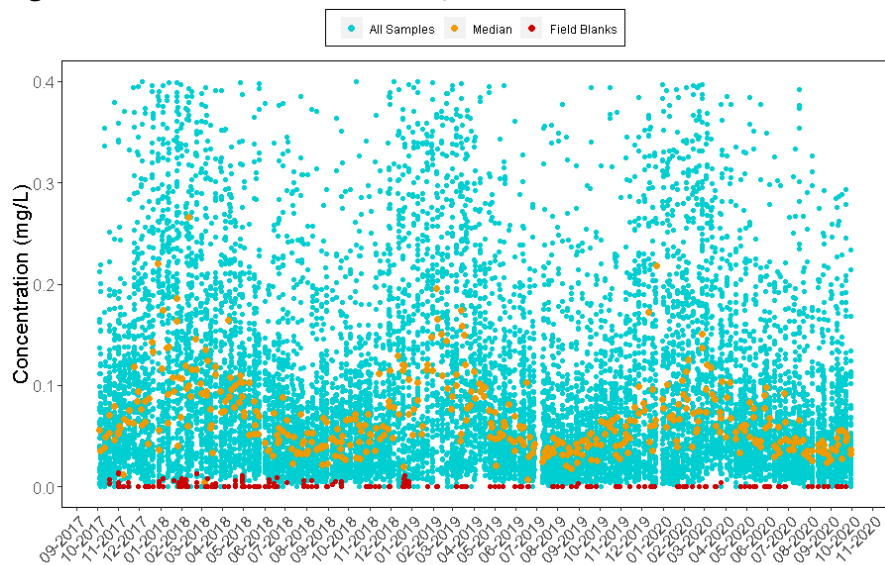
Previous review of filter pack analysis control charts indicated possible potassium contamination (Figure 22). Corrective actions were implemented, and subsequent testing indicated these actions have been effective.

Figure 14. Concentrations of NO₃⁻ (as N) from Nylon Filters



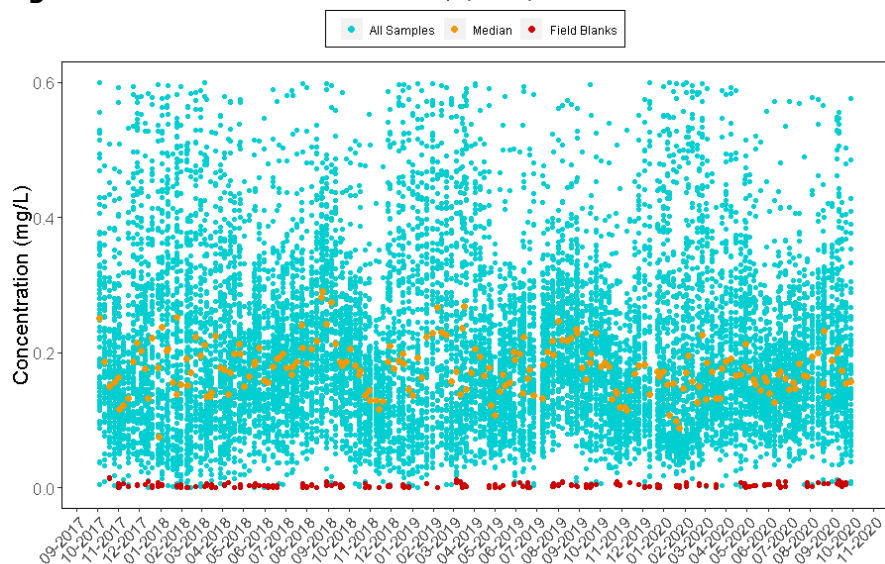
Note: Nominal reporting limit is 0.008 mg/L.

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



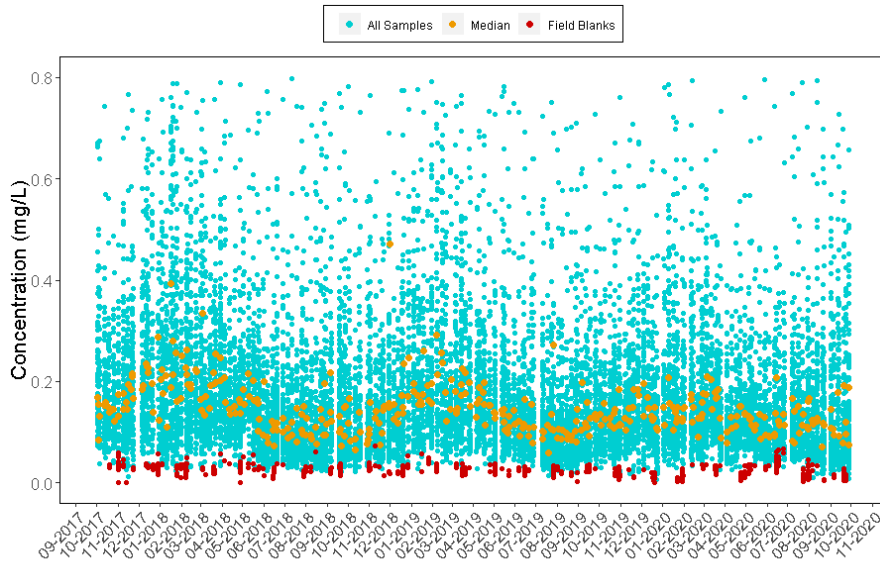
Note: Nominal reporting limit is 0.008 mg/L.

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



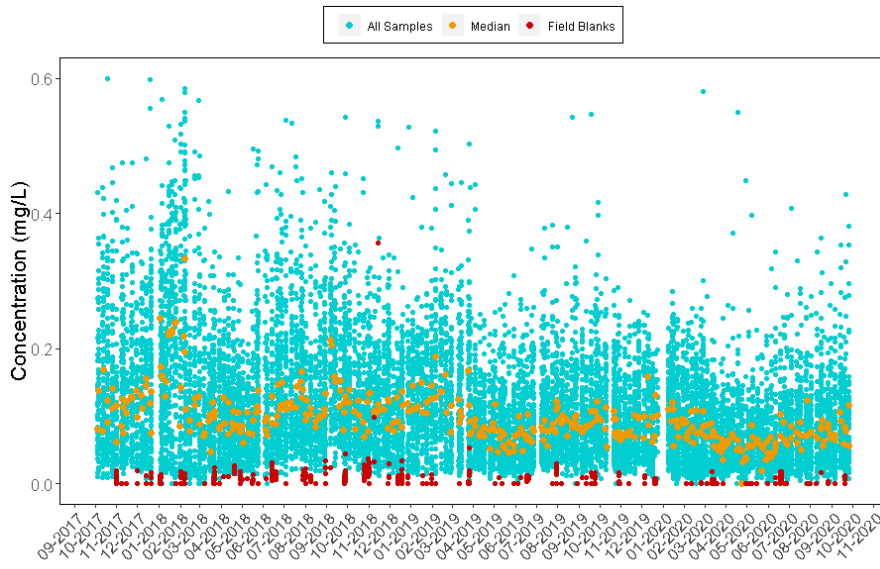
Note: Nominal reporting limit is 0.020 mg/L.

Figure 17. Concentrations of SO₂ from K₂CO₃-impregnated Cellulose Filters



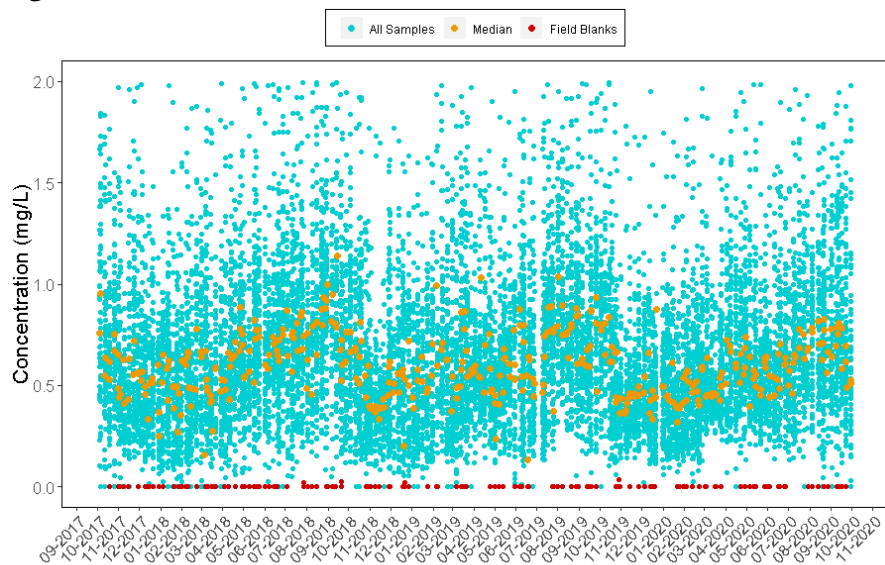
Note: Nominal reporting limit is 0.040 mg/L.

Figure 18. Concentrations of SO₄²⁻ from Nylon Filters



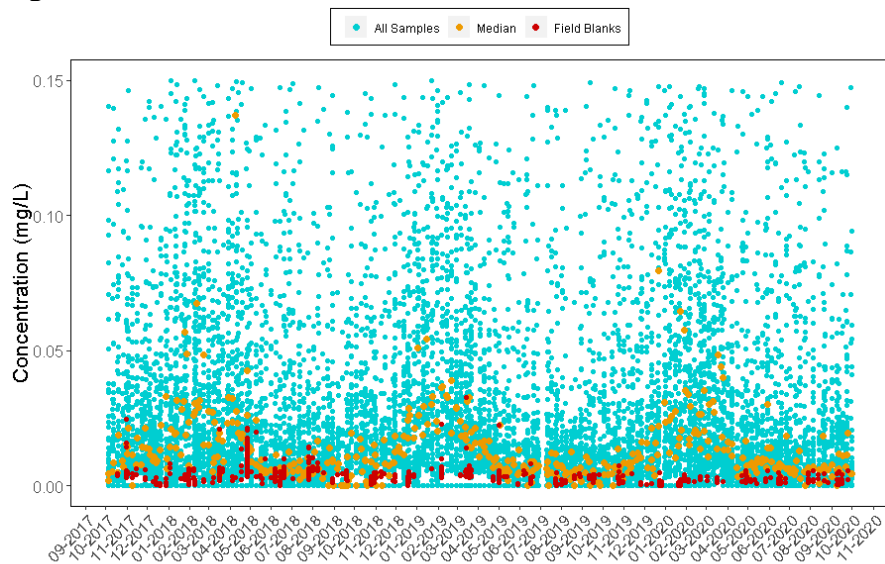
Note: Nominal reporting limit is 0.040 mg/L.

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



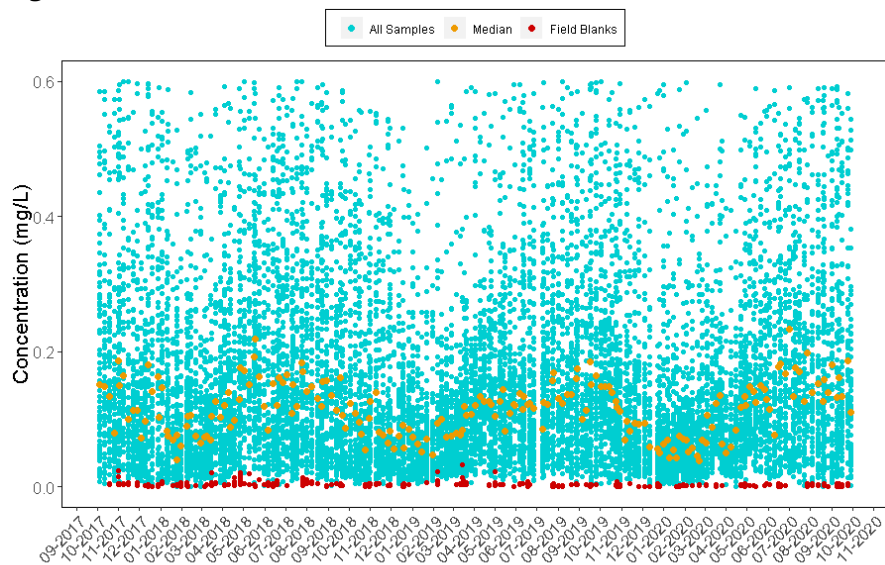
Note: Nominal reporting limit is 0.040 mg/L.

Figure 20. Concentrations of Cl^- from Teflon Filters



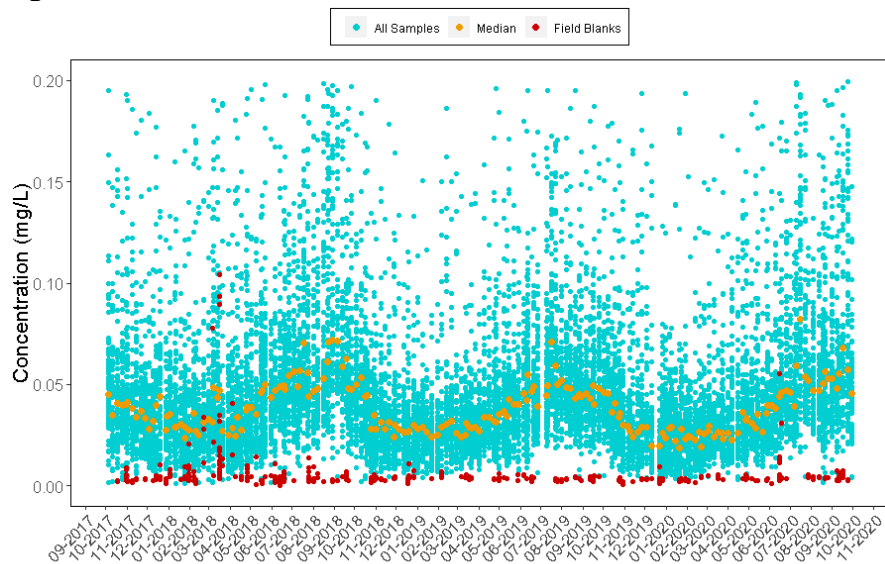
Note: Nominal reporting limit is 0.020 mg/L.

Figure 21. Concentrations of Ca²⁺ from Teflon Filters



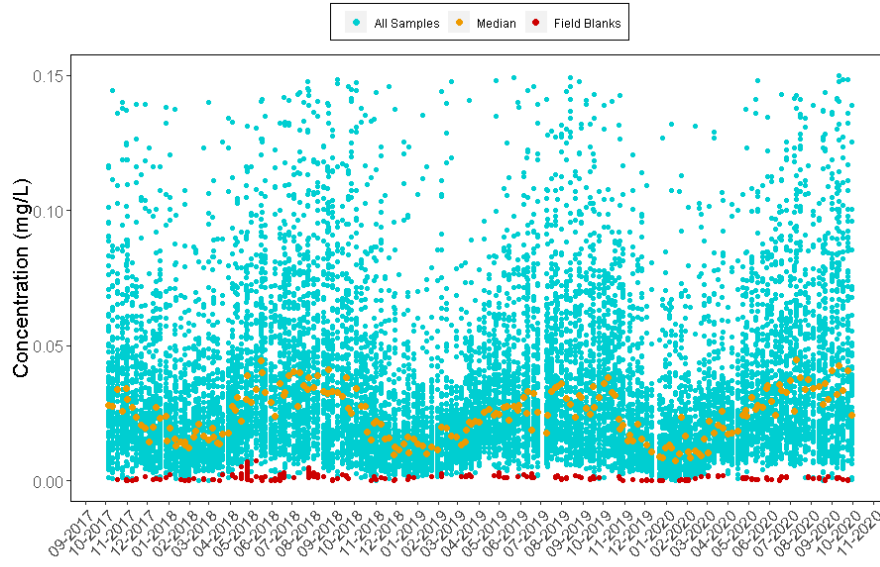
Note: Nominal reporting limit is 0.006 mg/L.

Figure 22. Concentrations of K⁺ from Teflon Filters



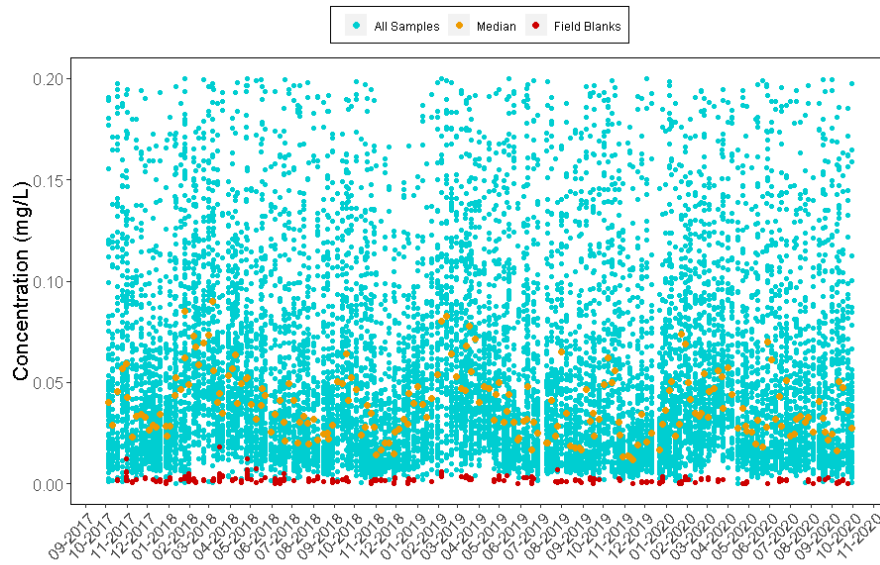
Note: Nominal reporting limit is 0.006 mg/L.

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

Figures 25 and 26 show time series of concentration differences between the two sets of co-located sites.

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

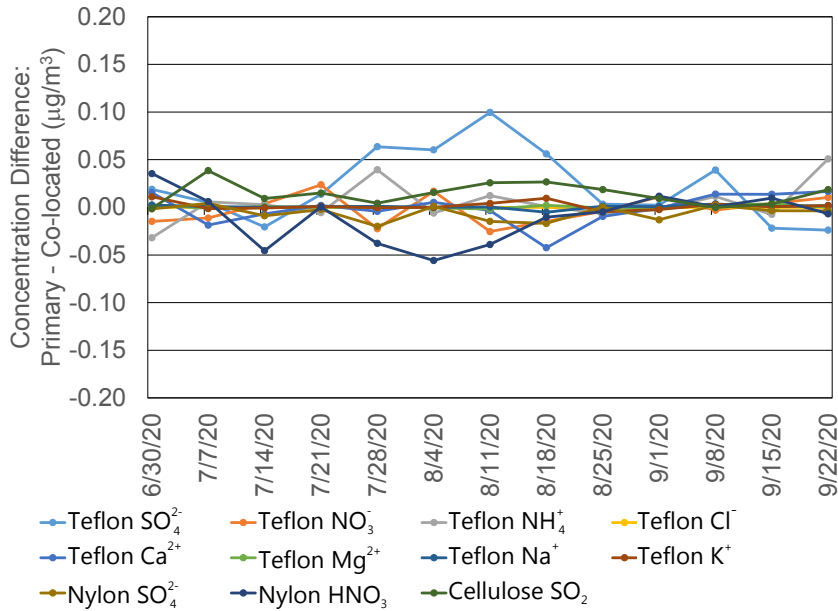
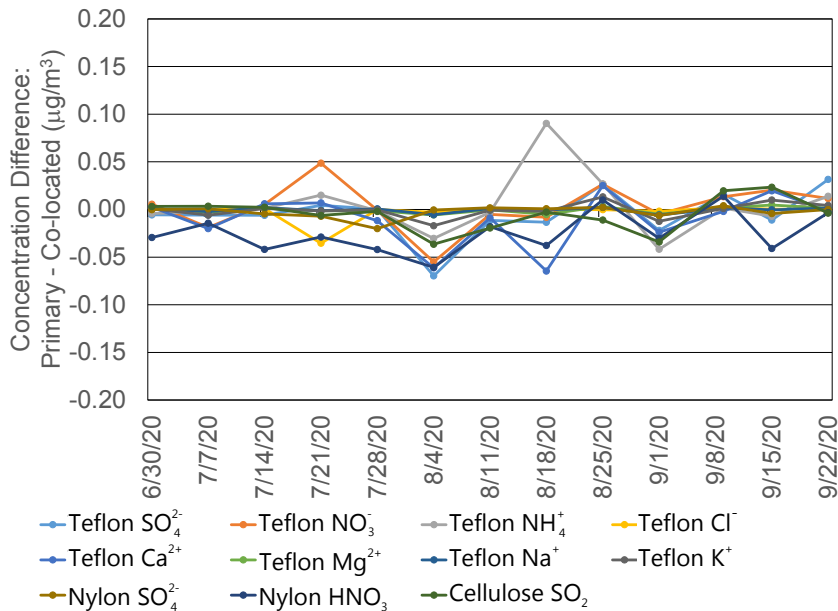


Figure 26. Time Series of Filter Concentration Differences between ROM406 and ROM206, CO



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 2020. The MARPD values met the 20 percent criterion.

Table 3. Precision (MARPD) for Co-located Filter Pack Data during Third 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											
\bar{X} (μg/m ³)	1.34	0.27	0.47	0.21	0.04	0.05	0.11	0.03	0.70	0.32	0.96
\bar{Y} (μg/m ³)	1.32	0.27	0.47	0.22	0.04	0.05	0.11	0.03	0.71	0.31	0.97
MAD	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.03
MARPD	2.46	6.01	3.73	5.74	3.79	4.65	2.81	0.21	2.77	4.49	2.74
ROM406/206, CO											
\bar{X} (μg/m ³)	0.68	0.31	0.33	0.31	0.04	0.05	0.12	0.02	0.62	0.25	0.92
\bar{Y} (μg/m ³)	0.69	0.30	0.32	0.33	0.04	0.05	0.12	0.02	0.66	0.26	0.95
MAD	0.02	0.02	0.03	0.03	0.00	0.00	0.01	0.00	0.04	0.02	0.05
MARPD	4.15	8.86	8.20	8.31	10.16	5.61	6.88	14.35	6.23	7.73	5.53

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 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
CHE185, OK	53.8	53.8	53.8	53.8	53.8	53.8	53.8	53.8	The mass flow controller (MFC) was replaced after calibration drift was found. Six samples were affected.
ALC188, TX	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	The MFC malfunctioned and was replaced. Three samples were affected.
BWR139, MD	76.9	76.9	76.9	76.9	76.9	76.9	76.9	76.9	Two separate filter packs were installed for two weeks, and another was invalidated because the Teflon filter was perforated.
CAT175, NY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The MFC malfunctioned and was replaced. Two samples were affected.
CTH110, NY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	The flow channel was left down following a calibration visit, and one sample was invalidated. Another sample was invalidated for suspect data.
FOR605, WY	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	A system leak resulted in invalid flow data that affected two samples.
UND002, VT	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two samples were lost because of an extended power outage.
VOY413, MN	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Two samples were invalidated because of a malfunctioning MFC.
VPI120, VA	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	Three samples were not collected during the time the site was being moved to a new location.

Precision of Ozone Concentrations

Time series of co-located hourly O₃ concentration differences for third quarter 2020 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

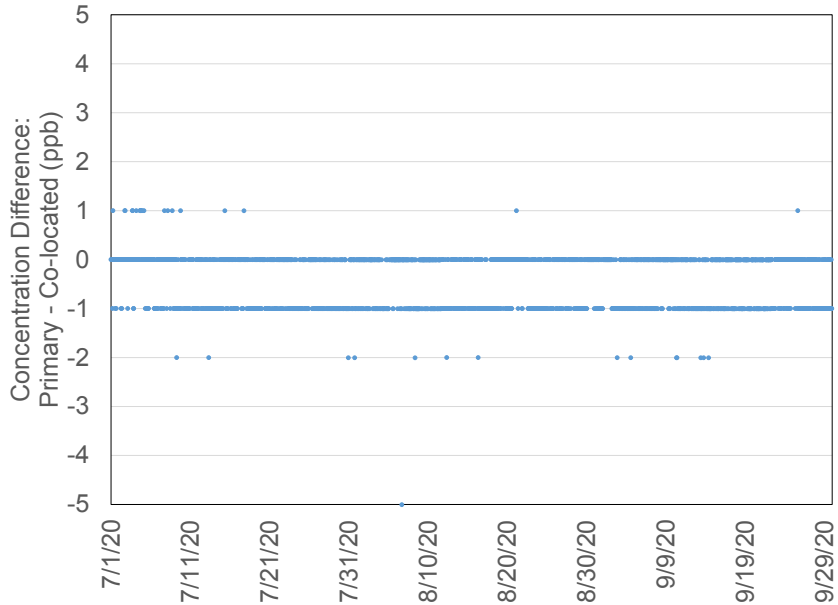


Figure 28. Time Series of the Differences in Co-located O₃ Concentrations for ROM406/206, CO

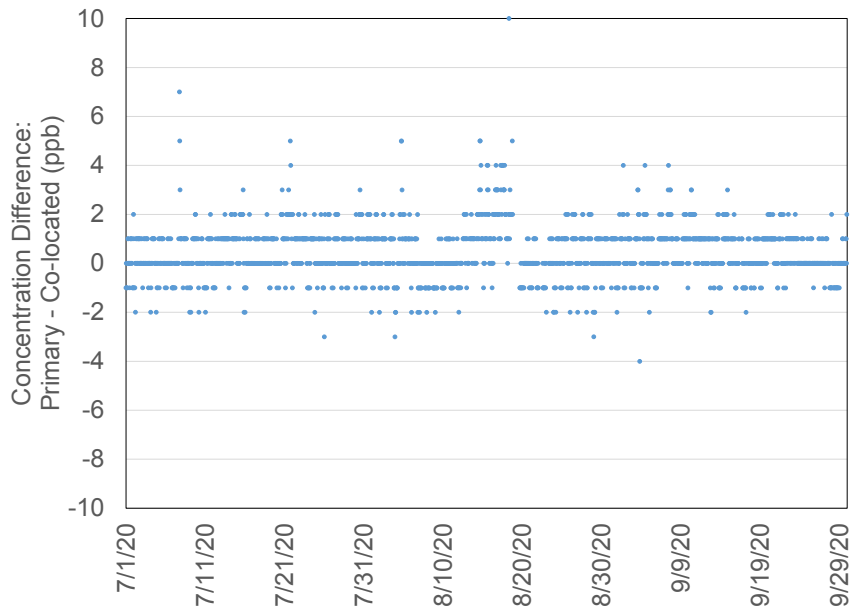


Table 5 gives MARPD data for O₃ data measured at the two co-located sites.

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

Site Pair	Quarter	Start Date	MARPD	Records
MCK131/231, KY				
	4	10/1/19	1.1	2003
	1	1/1/20	1.0	2063
	2	4/1/20	0.8	1986
	3	7/1/20	1.8	2086
ROM406/206, CO				
	4	10/1/19	1.1	1983
	1	1/1/20	0.8	2004
	2	4/1/20	1.3	2028
	3	7/1/20	1.7	2023

Completeness for O₃ Concentrations

Calculation of an annual O₃ 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 O₃ concentrations. Comments are provided for these sites.

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

Site ID	Percent Completeness	Comments
NPT006, ID	75.0	Analyzer bench temperature exceeded the criterion during July due to a malfunctioning air conditioning unit. The unit was replaced 7/20/20.
VPI120, VA	78.3	The site was moved to a new location. Equipment was removed 7/23/20. Ozone data collection was restored 8/8/20.
IRL141, FL	79.3	Analyzer bench temperature exceeded the criterion during September.
UVL124, MI	82.6	Analyzer bench temperature exceeded the criterion during July due to a malfunctioning air conditioning unit. The unit was replaced 7/21/20.
DUK008, NC	84.8	Several ZPS QC checks failed due to system moisture during August and several periods were invalidated in September due to elevated bench temperature.
DEN417, AK	85.9	The analyzer pump failed in late August and was replaced in early September.
ALH157, IL	87.0	Several ZPS QC check failures were caused by system moisture during July.
CAN407, UT	87.0	The analyzer pump failed in early August and was replaced.
HWF187NY	88.0	Several periods were invalidated in July due to elevated bench temperature, and several periods were invalidated in September due to an intermittent analyzer malfunction.
CHE185, OK	89.1	Site data were missing between 8/19/20 and 8/23/20.
STK138, IL	89.1	ZPS QC check failures were due to a pneumatic leak.

Table 7 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 7. Sites with less than 90 Percent Data Completeness for O₃ Concentrations

Site ID	Q3 2020	Q4 2019– Q2 2020	Comments
NPT006, ID	78.6	87.0	Analyzer bench temperature exceeded the criterion during July due to a malfunctioning air conditioning unit. The unit was replaced 7/20/20.
VPI120, VA	81.3	93.6	The site was moved to a new location. Equipment was removed 7/23/20. Ozone data collection was restored 8/8/20.
IRL141, FL	83.9	93.3	Analyzer bench temperature exceeded the criterion during September.
UVL124, MI	87.2	94.7	Analyzer bench temperature exceeded the criterion during July due to a malfunctioning air conditioning unit. The unit was replaced 7/21/20.
DEN417, AK	87.4	96.3	The analyzer pump failed in late August and was replaced early September.
STK138, IL	88.8	96.4	ZPS QC check failures were caused by a pneumatic leak.

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

Figures 29 through 36 show a comparison of weekly average continuous NO_y measurements with weekly filter pack total NO₃⁻ concentrations collected at the eight 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 eight sites with available data are shown in Table 8. Ratios of NO_y to total NO₃⁻ varied from 0.63 at PNF126 to 5.51 at DUK008.

Figure 34 shows a somewhat unusual pattern for weekly NO_y concentrations measured at PNF126. However, the trace gas validation criteria do not require any adjustments.

Table 8. Summary of Total NO₃⁻ and NO_y Measurements for Third Quarter 2020

Site ID	Elevation	Total NO ₃ ⁻ (ppb)	NO _y (ppb)	Ratio
DUK008, NC	164	0.32	1.77	5.51
BVL130, IL	213	0.69	3.78	5.13
MAC426, KY	243	0.33	1.24	3.80
HWF187, NY	497	0.11	0.49	4.46
GRS420, TN	793	0.28	0.89	3.30
PNF126, NC	1216	0.18	0.12	0.63
PND165, WY	2386	0.22	0.73	3.22
ROM206, CO	2742	0.28	1.45	5.42

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

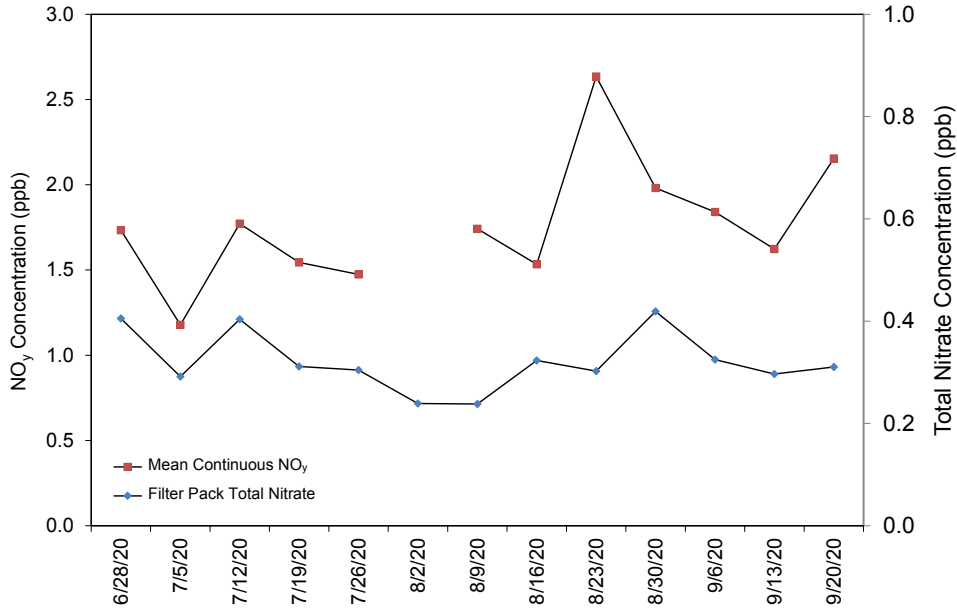


Figure 30. Comparison of BVL130 Weekly Mean NO_y and Total NO₃⁻ Concentrations

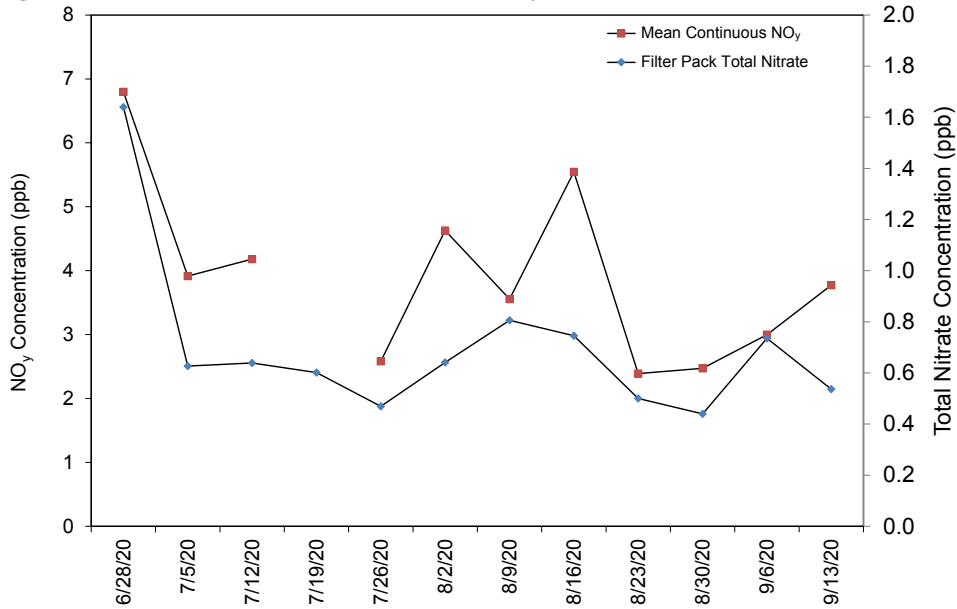


Figure 31. Comparison of MAC426 Weekly Mean NO_y and Total NO_3^- Concentrations

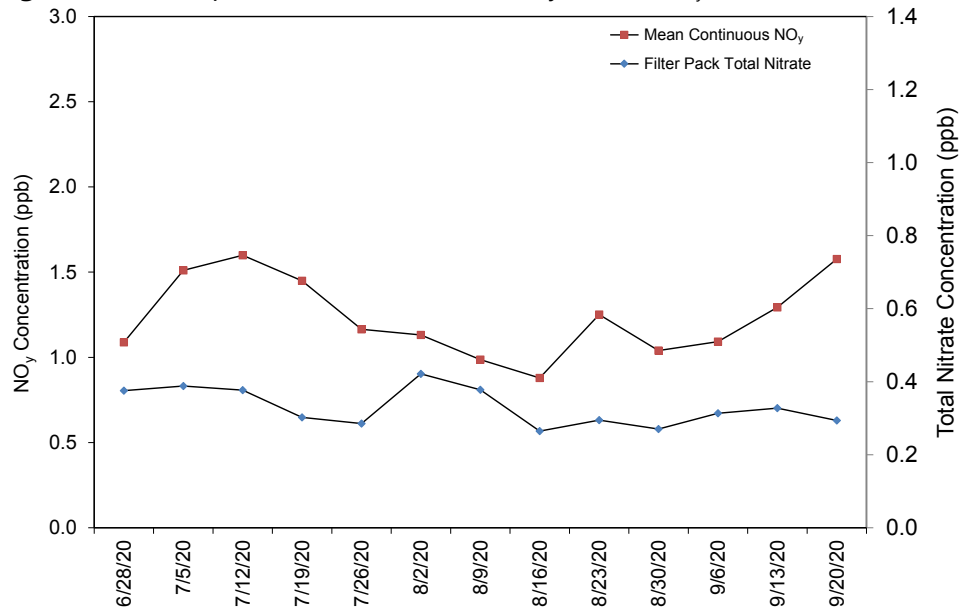


Figure 32. Comparison of HWF187 Weekly Mean NO_y and Total NO_3^- Concentrations

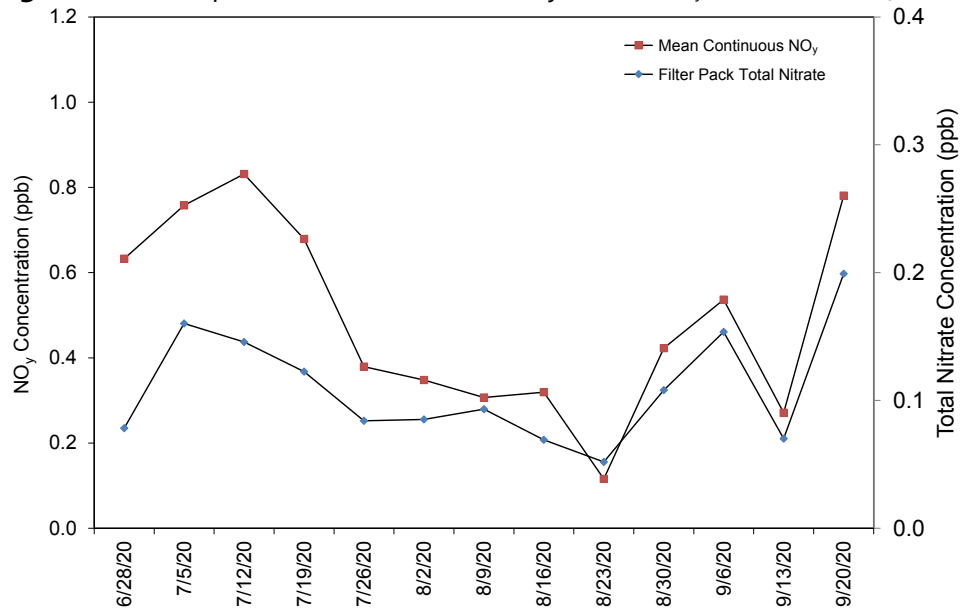


Figure 33. Comparison of GRS420 Weekly Mean NO_y and Total NO₃ Concentrations

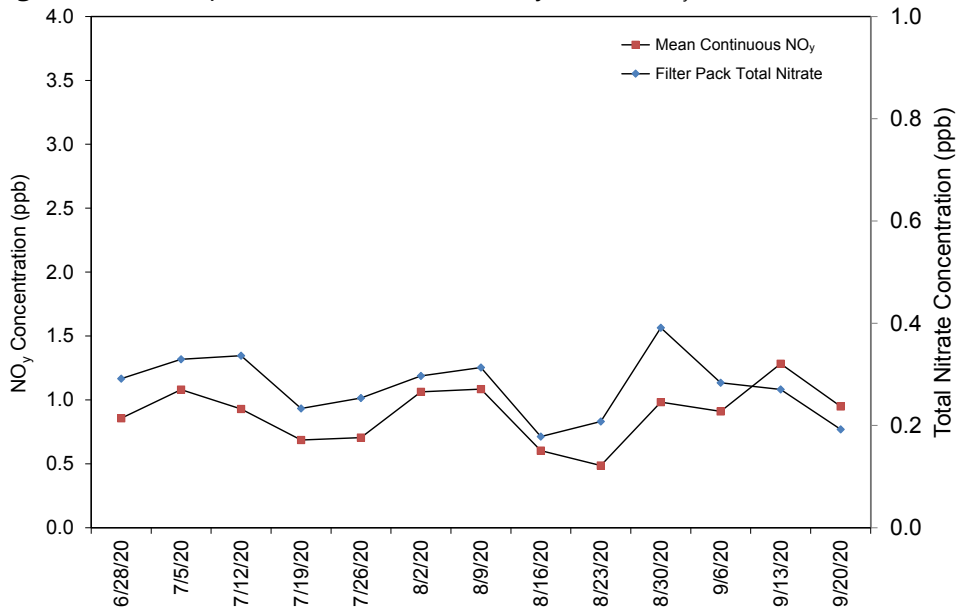


Figure 34. Comparison of PNF126 Weekly Mean NO_y and Total NO₃ Concentrations

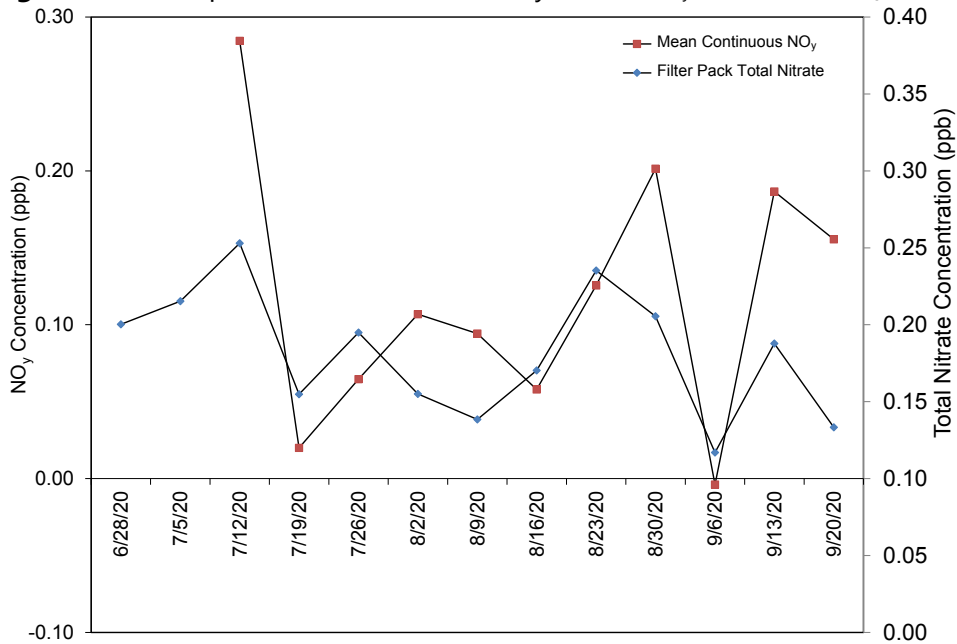


Figure 35. Comparison of PND165 Weekly Mean NO_y and Total NO_3^- Concentrations

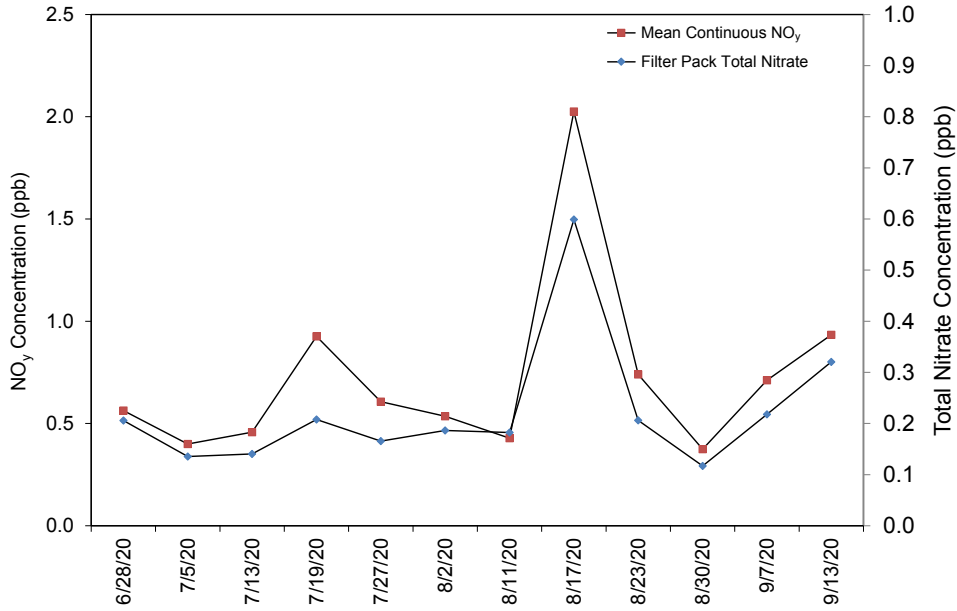
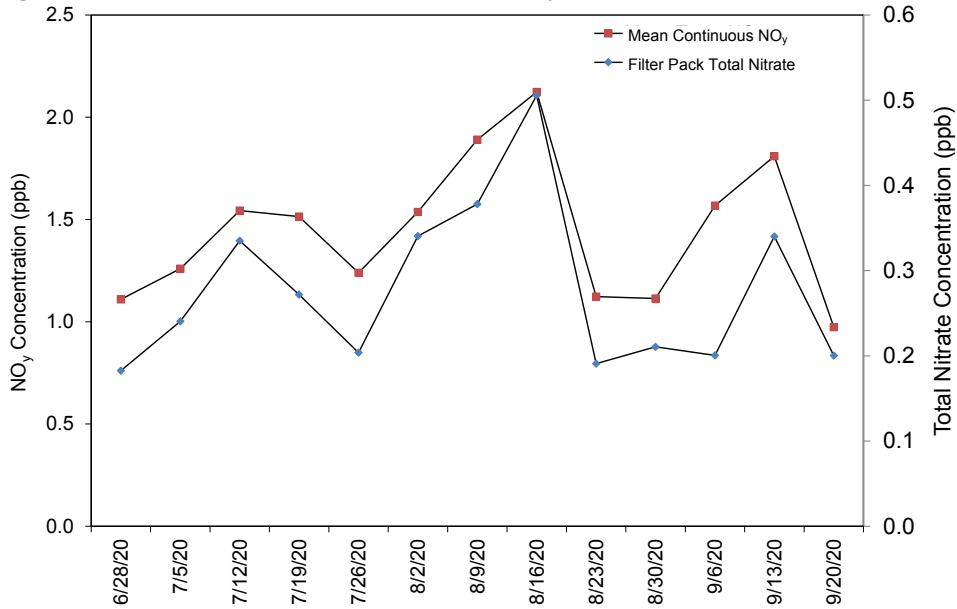


Figure 36. Comparison of ROM206 Weekly Mean NO_y and Total NO_3^- Concentrations



Filter Pack and Continuous Trace-level Gas Sulfur Dioxide Concentrations

Figures 37 through 39 provide diagrams that compare weekly filter pack SO₂ 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. The sample pump had failed and was replaced in late June. The site was calibrated late August. The SO₂ concentrations were comparable at MAC426 and GRS420.

Figure 37. Comparison of BVL130 Weekly Mean SO₂ Concentrations

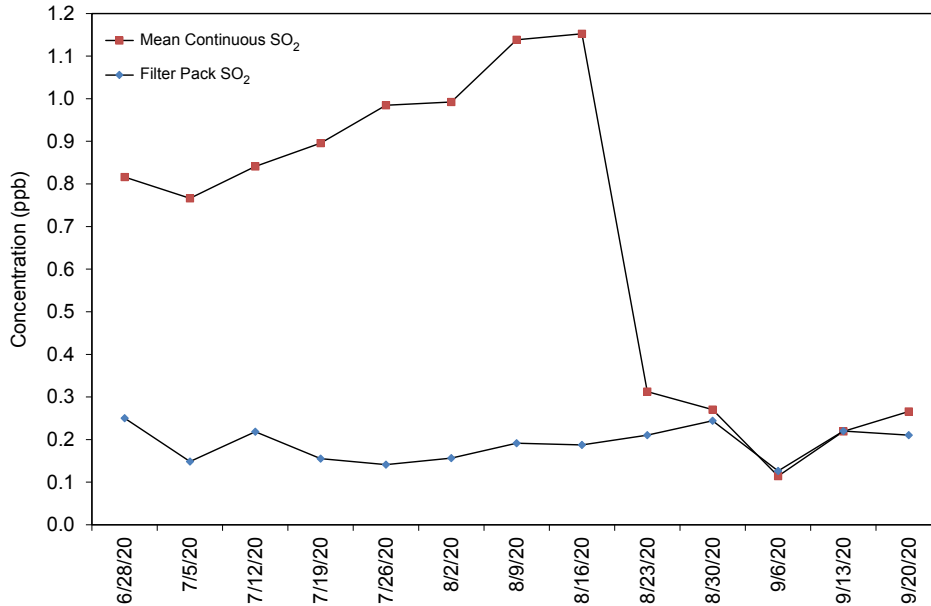


Figure 38. Comparison of MAC426 Weekly Mean SO₂ Concentrations

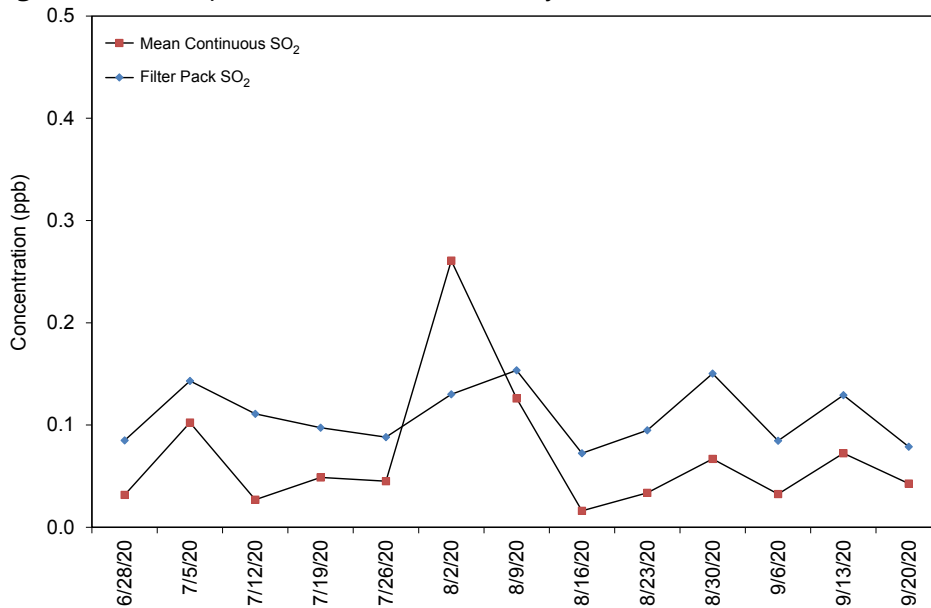
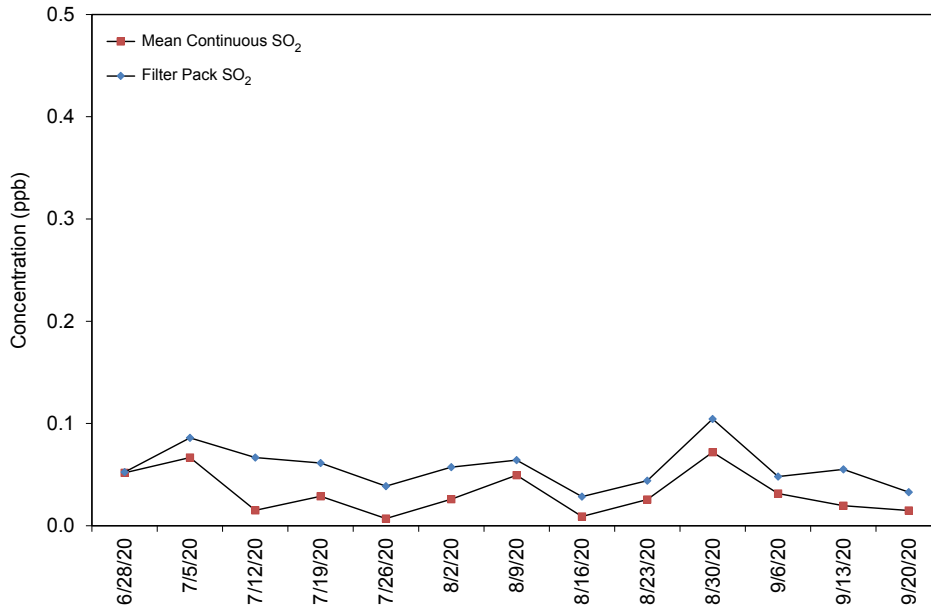


Figure 39. Comparison of GRS420 Weekly Mean SO₂ Concentrations



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 third 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

Site ID	Parameter*	Q3 2020	Q4 2019 – Q3 2020	Comments
BVL130, IL	CO	34	38	The analyzer calibration drifted and required calibration in August and September. The voltage regulator was replaced in August.
	NO	86	93	
	NOY	86	93	The solenoid malfunctioned in July and was replaced.
	NOYDIF	86	93	
	SO2_GA	85	86	ZPS QC checks failed in August.
CHC432, NM	NO	97	98	
	NOX	97	98	
	NOXDIF	97	98	
DUK008, NC	HNO3	62	63	ZPS QC checks failed in August.
	NH3	62	63	
	NO	75	71	
	NO2_TRUE	72	69	
	NOX_TRUE	72	70	
	NOY	62	65	
	NOY_MINUS	77	69	
	NOYDIF	62	65	
GRS420, TN	CO	97	90	
	NO	98	92	
	NOY	98	92	
	NOYDIF	98	93	
	SO2_GA	98	91	
HWF187, NY	NO	94	89	
	NOY	94	83	
	NOYDIF	94	83	
MAC426, KY	CO	86	88	The flow pump was failing in late July. It was replaced on 8/5/20.
	NO	97	94	
	NOY	97	88	
	NOYDIF	97	88	
	SO2_GA	97	96	
PND165, WY	NO	82	88	The analyzer calibration drifted in September requiring recalibration.
	NOY	84	89	
	NOYDIF	82	88	
PNF126, NC	NO	80	89	A pneumatic leak inside the bypass box affected data from June to mid-July when the leak was repaired.
	NOY	80	77	
	NOYDIF	80	77	
ROM206, CO	NO	92	93	
	NOY	92	93	
	NOYDIF	93	93	

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) Third Quarter 2020 Quality Assurance Report*.
<https://java.epa.gov/castnet/documents.do>